RENEWABLE ENERGY

WORKING IN RENEWABLE ENERGY SECTOR

GDAŃSK, 2020

BALTIC SOUTH BRIDGE

FOR GREEN TECH FUTURE!

Materials developed within the framework of the " SB Bridge – building bridges for green-tech future" Project.

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President of Polish Ecological Club Pomeranian Branch (PKE OP) for two terms 2008-2011 and 2012-2015. Co-author of many international educational projects with members of PKE OP, e.g. "Green Academy", „Microplastics in Baltic Sea ", „Plastic Free Baltic", "Plastic free oceans" promoting knowledge of the plastic flood and other threats to species diversity in the Seas and Oceans and many educational activities addressed to the young people and local community.

Interreg South Baltic
EUROPEAN UNION

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Introduction

Our civilization's development bases on electricity.

The increasing demand for energy caused by the economic growth of countries limited access to natural resources in the world.

Nonrenewable sources of energy (coal, oil and gas reserves) are only available in limited amounts (the equivalent of around 150 (coal), 50 (oil) and 52 (gas) years at current production levels).[1]
Nonrenewable energy sources are also found only in specific parts of the world. This makes the countries poorer in fossil fuels energetically dependent on the countries with large deposits of those (e.g. Russia). Countries of the Baltic Sea, such as Poland and Germany are coal deposits. Denmark has gas and oil, and Lithuania and Sweden are poor in those fossil fuels. This is one of the reasons for the individual approach to energetic safety in those countries.[2]

Introduction

Use of nonrenewable energy sources results in the growing pollution of the environment, especially in huge pollutants emission to air (e.g. greenhouse gases, dust etc.). These facts result in the growing interest in "green" (alternative, friendly to the environment and human health) technologies of acquiring energy that allows the generation of energy in each place all over the world from renewable sources. Renewable energy sources come from natural sources or processes that are constantly replenished, and energy production by "green" technology is safe to the environment and human health. Every country has access to sunshine and wind, even if their availability depends on time and weather.

A renewable energy source is defined as a source using in transformation process energy of wind, solar radiation, geothermal, waves, sea currents and tides, river's falls as well as energy produced from biomass, landfill biogas and biogas produced in the processes of discharge or sewage treatment or decomposition of plant and animal remains.[3]

Solar energy can be converted to heat or electricity and it is available only by day. The amount of obtainable solar energy depends on specific sunlight conditions of the country.

The best places for wind farms are in coastal areas (onshore farms), at the tops of rounded hills, open plains and gaps in mountains - places where the wind is strong. Some wind farms are offshore. European leadership in using offshore farms has the United Kingdom followed by Germany, Denmark, Belgium and the Netherlands.[4]

In Poland over 80% of electricity comes from either hard coal or lignite, while renewables account for 14% of electricity generation (2017), mostly from wind energy. Biomass utilization and photovoltaic solar plants application are also able to expand.[3]

In Germany, coal is a source of around 30% of total energy generation. The renewables are a preferable energy source including wind at 24%, followed by biomass at 8,6% and photovoltaic solar plants at 9%. In 2019, renewable energy-based electricity generation reached 46% in the country.[6]

Due to the lack of crude oil and hard coal deposits, the hydroelectric power plants system was strongly developed in Sweden. Over 40% of Sweden's total energy demand comes from hydropower, especially in the north part of the country, where are excellent natural conditions with a large number of rivers. Nuclear power plants cover around 40% of the total electricity demand, and 18% comes from wind power.[7]

In 2016, the main source of electricity from a renewable source in Lithuania was wind accounting for over 63%, while hydro (15.8%) and solar (9%) were the other major sources.[8]

In Denmark, around 40% of electricity supplies are sourced from the wind; which is a remarkable achievement given wind's unpredictable nature.

Case study

GERMANY

The wind plants: Borkum Riffgrund 2 offshore plant, Germany, 450 MW;

LITHUANIA

Pagėgiai 13 is the largest wind park in Lithuania and the Baltic States (the park started operating in 2016, 73,5 MW);

The Lithuanian Business Support Agency (LSBA) has granted 235,000 euros to support the development of an experimental floating solar photovoltaic (PV) power plant at the existing 900 MW ***Kruonis pumped-storage hydroelectric plant*** (PSHP) in Lithuania. [9]

DENMARK

Horns Rev is an offshore wind farm in Danish waters in the North Sea - 406,7 MW).

SWEDEN

Harsprånget is a hydroelectric power station located in northern Sweden, with a power of 977 MW; it's the largest hydroelectric power station in Sweden, and also the fourth largest in the Nordic countries. The total fall height is around 107m.

POLAND

In Poland, Solar collectors (transformation of solar light to heat) are the second, after the biomass heating plants, source of "green heat". The largest photovoltaic system in Poland with a capacity of 3.77 MW is in ***Czernikowo***. [10]

References:

[1] World Coal Association: Where is coal found?

RETRIEVED 19.06.2020

[2] Energy Market Study in the Baltic Sea Regio, Nordic Council of Ministers 1999, Copenhagen

RETRIEVED 19.06.2020

[3] Renewable Energy in Poland, Landers Investment & Trade Market Survey, 2019

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[4] The future of offshore wind in Poland, PWEA Report, May 2019

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[5] Public Net Electricity Generation in Germany 2019:Share from Renewables Exceeds Fossil Fuels, Fraunhofer Institute for Solar Energy Systems ISE, January 15, 2020

RETRIEVED 19.06.2020

[6] Energy in Sweden 2018 – An overview

[7] Lithuania's electricity consumption: highest in a quarter of a century, Central Europe Energy Partners, Feb 22, 2017

RETRIEVED 19.06.2020

[8] Lithuania to experiment with floating solar power plant, News & Analysis, March 6, 2019

RETRIEVED 19.06.2020

[9] P. Szmitkowski, S. Zakrzewska, A. Gil, P. Swiderski, Capabilities of Polish power plants - advantages and threats, Przegląd Elektrotechniczny, ISSN 0033-2097, NR 5/2019

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EXERCISE (1)

IS OUR CIVILIZATION ADDICTED TO ENERGY?

FOR GREEN TECH FUTURE!

Background for the teacher:

We use the electricity for almost all daily activities. The electricity is necessary to cook our meal, protect our food, wash our clothes, enjoy entertainment, keep our homes comfortable. However, nonrenewable sources of energy including fossil fuels such as oil, gas, and coal are available in limited amount, and take a long time to replenish, much more longer than a human's lifetime. These are the reasons why we look for the alternative sources of energy. Renewable energy is produced using natural, inexhaustible sources - even if their availability depends on time and weather. The examples of renewable, clear energy include wind, solar, geothermal, biomass, and hydropower.

EXERCISE (1)

Time: 20 min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	IS OUR CIVILIZATION ADDICTED TO ENERGY?
2	TARGET OF THE EXERCISE:	Exercise helps students to realize: • How does widespread access to electricity affect our habits/lives? • How has electricity improved people's lives? • How much energy do we consume every day? • What are the main sources of energy in students' country?
3	DETAILED DESCRIPTION OF THE EXERCISE:	Pre-homework: Talk to your grandparents or any senior citizens about the kind of electrical and electronic devices that were available in their childhood. Divide board in four columns "Electrical and electronic devices in 2020", "Sources of electricity in 2020", "Electrical devices in grandparents' childhood", "Sources of electricity in grandparents' childhood". Ask students to think about yesterday; the time from when they woke up until they went to bed. What electrical and electronic devices did they use? Ask students to write down everything they can think of.

Ask students to think about the past.

- What were the electrical and electronic devices available in grandparents childhood?
- What were the sources of electricity available in the past?

Discuss about the role of energy in our life. Ask students to divide the sources of energy into categories: the renewable and nonrenewable. Which source of renewable energy is a crucial in students' country and why.

Students can look for the information on the internet (5 min work) or can discuss based on their knowledge.

4 MATERIALS NEEDED: INTERVIEW GRANDPARENTS OR MATERIALS PREPARED BY TEACHER

5 EFFECTS:

1. Students understand the need for technological progress in the field of energy acquisition.
2. They are realizing how the demand for energy has increased over the last 50 years and how much our life has become dependent on electricity.
3. They are aware about progress in technology of energy generation in their country.

EXERCISE (1)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
ELECTRICITY GENERATION IN POLAND FROM 1990 TO 2018, BY ENERGY SOURCE	Energy & Environmental Services, 2020 RETRIEVED 19.06.2020
CLEAN ENERGY IS A DENMARK	Pioneers in clean energy, Green thinking RETRIEVED 19.06.2020
ELECTRICITY GENERATED FROM RENEWABLE SOURCES	30% of electricity generated from renewable sources, Eurostat, 21/09/2018 RETRIEVED 19.06.2020

EXERCISE (1)

ELECTRICITY GENERATION IN LITHUANIA	Electricity Generation in Lithuania, worldmeter RETRIEVED 19.06.2020
RENEWABLES HIT RECORD 77% OF GERMAN POWER ON EASTER MONDAY	Renewables hit record 77% of German power on Easter Monday, Clean Energy Wire, Apr 24, 2019 RETRIEVED 19.06.2020
SOLAR PV AND WIND TO LEAD SWEDISH RENEWABLE GROWTH OVER NEXT DECADE	Solar PV and wind to lead Swedish renewable growth over next decade, Power Technology, Aug 4, 2019 RETRIEVED 19.06.2020

TABLE 1. Example of list

IN 2020		IN THE PAST	
ELECTRICAL DEVICES	SOURCES OF ENERGY	ELECTRICAL DEVICES	SOURCES OF ENERGY
Mobile phone	Onshore wind farm	~~Mobile phone~~	Coal combustion
Computer	Solar photovoltaic plant	~~Computer~~	Biomass (Wood) combustion
Electrical kettle	Biogas plant	~~Electrical kettle~~	etc.
Electric hob	Solar collector	~~Electric hob~~	▲ NONRENEWABLE SOURCES
Induction hob	Offshore wind farm	~~Induction hob~~	
Refrigerator	▲ RENEWABLE SOURCES	Refrigerator	
Hair dryer	Coal combustion	Hair dryer	
Water boiler	Gas combustion	Water boiler	
Microwave	Nuclear energy	~~Microwave~~	
Train	etc.	Train	
Air conditioning	▲ NONRENEWABLE SOURCES	~~Air conditioning~~	
Ring bell		~~Ring bell~~	
bulb		bulb	
TV set		TV set	
Radio		Radio	
Dishwasher		Dishwasher	
etc.		etc.	

EXERCISE (2)

HOW MANY SOLAR PANELS DO YOU NEED AT YOUR HOME?

Background for the teacher:

Statistics show a very unequal level of electricity consumption per household in the EU. It is around 1600 kWh/year in Romania, 2000 kWh/year in Poland and Baltic countries, around 4000 kWh/year for the EU average to 8,000-10,000 kWh/year in Finland and Sweden, and even 17,000 kWh/year in Norway. You can assume that the average energy consumption in Baltic countries is 170 kWh/month, and in Sweden, it is 750 kWh/month. The data on average energy consumption per month is necessary to calculate the number of solar panels needed.

The solar panels work best when the sun's rays hit directly on them. It means that solar panels don't operate at maximum efficiency at all times. The intensity of sunlight will be higher in the summer months than in winter months. Moreover, the same size solar array in Stockholm will produce less energy than one in Warsaw. It is because locations farther south will generally see more intensity of sunlight than areas farther north.

Wind is the movement of air molecules in the atmosphere, a natural movement of air of any velocity especially. It has two important characteristics—direction and speed. Wind tends to blow stronger over the sea than over land, due to the sea presents a smooth surface, while hills, mountains, and forests tend to slow the wind down or change its direction.

One peak sun hour = 1000 W/m2 of sunlight
REMEMBER 1KW = 1000W

For example, if a given location Warsaw or Stockholm receives a total of 3,300 and 2,900 W/m2 of solar radiation over a day, then that location gets respectively 3.3 and 2.9 peak sun hours. It is easy to calculate. We divide solar radiation of 3,300 W/m2 for Warsaw per 1000 W/m2 and it gives 3.3 peak sun hours.
The peak sun hours for European countries are presented at the map of global horizontal irradiation **(FIG.1)**
The average daily energy demand is the number of kWh you need to cover 100% of your expected energy consumption. However, it's important to note that weather conditions such as clouds, rain, snow etc., can reduce the efficiency of the solar system. Therefore, it is recommended to add a 25% margin to your target daily average to ensure you can generate all the "green" energy you need.

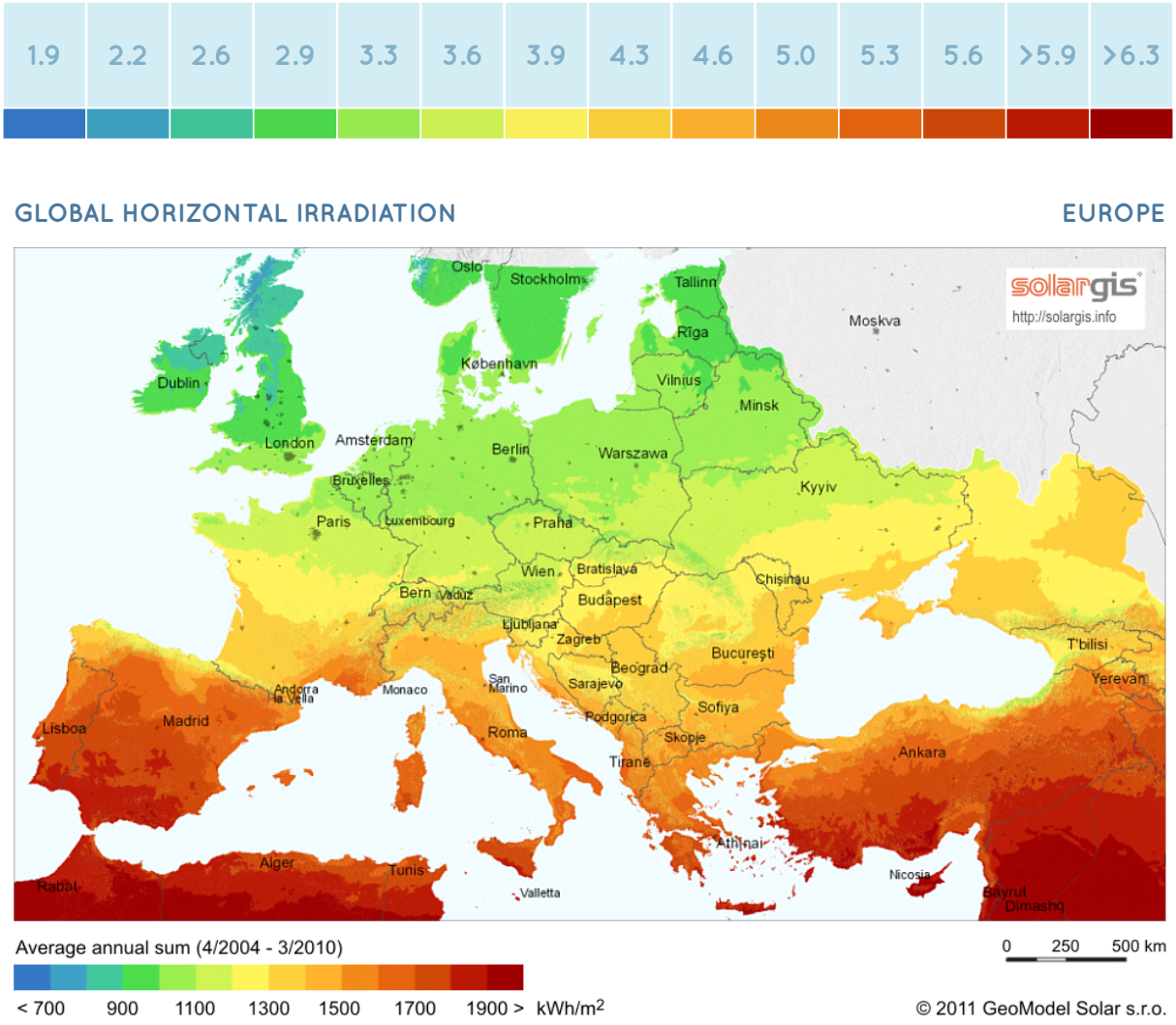

FIG. 1. MAP OF GLOBAL HORIZONTAL IRRADIATION, EUROPE AVERAGE DAILY SOLAR HOURS (SOLAR INSOLATION), HOTSPOT ENERGY, RETRIEVED 19.06.2020

EXERCISE (2)

Time: 30 min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	HOW MANY SOLAR PANELS DO YOU NEED AT YOUR HOME?
2	TARGET OF THE EXERCISE:	Exercise helps students realize: • How can the number of panels be calculated based on energy demand? • What are the factors which influence the production of solar energy?
3	DETAILED DESCRIPTION OF THE EXERCISE:	Ask students to think about the appliances of electricity at home. How much electricity is used by them? Estimate with the students the average energy consumption at home/school or take the energy consumption from the bill/ information from internet etc. Divide the students into small groups. Each group will calculate the number of solar panels for the same energy consumption but in different locations in the Baltic Sea Region e.g. Warsaw, Stockholm or Berlin. Explain to students that solar panels produce electricity during several hours of the day, but work best when the sun's rays shine directly on them. Ask students to think about how many hours a day does that happen?

Explain that the number of hours when the solar panels work best is different in winter and summer, in North and South.

Explain the term "peak sun hours". Show the map of global horizontal irradiation, and explain how to read it. Then, ask them to calculate how many solar panels do they need at home to cover 100% of their energy consumption?

Instructions for calculation task:

Example:
Energy consumption for the month (Q) is 350 kWh/month

- Read from the map of global horizontal irradiation (Fig. 1) "peak sun hours" (H) e.g. Warsaw (3.3), Stockholm (2.9), Budapest (3.9) etc.
- Multiply the number of days in a month per the number of "peak sun hours" (H) found for your localization (S= 30 days x peak sunlight hours)
- Divide the amount of energy consumption Q by value of S. (L= Q/S)
- Divide value of L by the value of solar panel's wattage solar panels on the market range from 250 Watts to 400 Watts
- Add a 25% more to your target daily average to ensure you can generate as much energy as you need

After 10 min. of work in groups take the class together.
Ask the leader of each group to share their calculations.
Write down the results on the board.
e.g. Warsaw – 14 panels; Stockholm – 16 panels etc.
Discuss the results. Ask students "Where are the best conditions for solar energy generation in the Baltic Sea Region?"

4	MATERIALS NEEDED:	MAP OF GLOBAL HORIZONTAL IRRADIATION (FIG.1) CALCULATOR, INSTRUCTIONS
5	EFFECTS:	1. Students understand the relationship between localization and solar irradiation conditions. 2. They understand the term "peak sun hours", and "average daily energy demand". 3. They can estimate how many solar panels do they need at home.

EXERCISE (2)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
SOLAR PANELS CALCULATION	How Many Solar Panels Will I Need? Coastal Solar RETRIEVED 19.06.2020

EXAMPLE OF CALCULATION

ASSUMPTION:

Energy consumption for the month (Q) is 350 kWh/month

- READ FROM THE MAP OF GLOBAL HORIZONTAL IRRADIATION THE PEAK SUN HOURS E.G. WARSAW, STOCKHOLM, ETC.

Example:
Peak sun hour for Stockholm is 2.9 for Warsaw is 3.3.

- MULTIPLY THE NUMBER OF DAYS IN A MONTH PER THE AMOUNT OF PEAK SUN HOURS (H) FOR YOUR AREA (S)

Example:
S = 30 DAYS X H
Warsaw S = 30 days x 3.3h = 99h/month
Stockholm S= 30 days x 2.9h = 87h/month

- DIVIDE VALUE OF ENERGY CONSUMPTION Q BY VALUE OF S. YOU OBTAIN THE AMOUNT OF ENERGY REQUIRED IN KW

Example:
L= Q/S.
Warsaw L= 350kWh/month / 99 h/month = 3.5 kW
Stockholm L= 350kWh/month / 87 h/month = 4.0 kW

- DIVIDE VALUE OF L BY A VALUE OF SOLAR PANEL'S WATTAGE (FROM 250 WATTS TO 400 WATTS PER PANEL)

Example:
for Warsaw L / 250 W panel = 3.5 kW/250W = 14 panels;
for Stockholm L / 300 W panel 4.0 kW/250W = 16 panels
1KW = 1000W

- ADD A 25% MARGIN TO YOUR TARGET DAILY AVERAGE TO ENSURE YOU CAN GENERATE AS MUCH ENERGY AS YOU NEED.

Example:
Warsaw 14 x 1.25 = 18 panels;
Stockholm 16 x 1.25 = 20 panels;

EXERCISE (3)

WE CONSTRUCT A SOLAR COLLECTOR

FOR GREEN TECH FUTURE!

Background for the teacher:

A solar collector is a device that collects and/or concentrates solar radiation. The function of this device is to capture the sun's energy in the form of heat and storage it in the fluid in the collector. The fluid circulating in the system transfers the heat to the water. These collectors allow for heating domestic water potentially reducing energy costs. They also can be applied as a solar swimming pool heating. It is the cost-effective use of solar energy in many climates. The flat solar collectors are generally mounted on the roof and must be very sturdy as they are exposed to a variety of different weather conditions.

EXERCISE (3)

Time: 20 min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	WE CONSTRUCT SOLAR COLLECTOR
2	TARGET OF THE EXERCISE:	Students learn how solar thermal collector works and how it is build. They know that solar thermal collector can be applied for heating domestic water and swimming pool.
3	DETAILED DESCRIPTION OF THE EXERCISE:	Show students: copper pipe, glass pipe, black and white sheet of paper or textile, aluminum foil, piece of plywood, a piece of mineral wool, sheet of glass, plastic foil etc. Open the discussion to the entire class: • What are the properties of presented materials. • What role do they play in a solar thermal collector? • How is heat conducted through these materials? *(check with students by experiment)* Write down the appropriate properties of materials in table (Table 2). Ask students to split into the 3-person groups. Based on the information collected in Table 2, students build or design (draw on a sheet of paper) solar thermal collector from chosen materials.

	Allow students 10 minutes of working time. After the students' projects are completed, each group shares their final product with the class. The class votes for the best project. Ask the students to explain, why they chose these materials to build their solar collector.	
4	MATERIALS NEEDED:	COPPER PIPE, GLASS PIPE, PLASTIC PIPE, BLACK AND WHITE SHEET OF PAPER , ALUMINUM FOIL, A PIECE OF PLYWOOD, A PIECE OF MINERAL WOOL, A PIECE OF STYROFOAM, A PIECE OF METAL SHEET, A PIECE OF GLASS SHEET, PLASTIC FOIL
5	EFFECTS:	1. Students know construction of flat solar collector. 2. They understand how flat solar collector works in practice. 3. They know the properties of different materials.

EXERCISE (3)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
FIG. 1. PICTORIAL VIEWS OF A FLAT-PLATE COLLECTOR INCLUDING COMPONENTS: (A) CROSS-SECTIONAL VIEW AND (B) ISOMETRIC VIEW	A.Sözen T. Menlik, S.Ünvar, Determination of efficiency of flat-plate solar collectors using neural network approach Expert Systems with Applications, 35 (2008) 1533-1539 RETRIEVED 19.06.2020
SOLAR THERMAL COLLECTORS BASICS	Solar thermal collectors, EIA RETRIEVED 19.06.2020

EXERCISE (3)

CONSTRUCTION OF FLAT SOLAR COLLECTOR	Solar Water Heater, 24 March 2013, tutorvista RETRIEVED 19.06.2020
WATER HEATER YOU CAN SHOW THIS SHORT FILM TO STUDENTS BEFORE THEY START TO DESIGN THEIR COLLECTOR	Water heating by solar collectors Bosch RETRIEVED 19.06.2020
SOLAR DISTRICT HEATING IN EUROPE - CASE STUDY	Guideline for end-user feed-in of solar heat, SDH plus, June 2015 RETRIEVED 19.06.2020

TABLE 1. Properties of materials

MATERIAL	PROPERTIES	POSSIBLY ROLE IN FLAT SOLAR COLLECTOR
Copper pipe	IS A GOOD CONDUCTOR OF HEAT, IT DOESN'T CORRODE AND HAS A HIGH MELTING POINT	HEAT EXCHANGERS – PIPE WITH FLOWING MEDIUM
Glass pipe	IN COMPARISON OF METALS, GLASS IS A POOR CONDUCTOR OF HEAT	
Plastic pipe	PLASTICS ARE BAD CONDUCTORS OF HEAT	
Black sheet of paper	BLACK COLOR EXTENSIVELY ABSORBS RADIATION	ABSORBER
White sheet of paper	WHITE COLOR BOUNCES SUNLIGHT RADIATION AWAY	
Aluminum foil	ALUMINUM FOIL REFLECTS HEAT	ALUMINUM FOIL CAN BE USED AS LIGHT/HEAT REFLECTION
Piece of plywood	IT IS AN INSULATOR OF HEAT	INSULATION BACK OF THE BOX OF SOLAR COLLECTOR
Piece of mineral wool	IT IS A BETTER INSULATOR OF HEAT THAN PLYWOOD	HEAT STORAGE
Straw	GLASS, WOOD AND PLASTIC ARE ALL EXCELLENT INSULATORS	
Sheet of glass	GLASS, WOOD AND PLASTIC ARE ALL EXCELLENT INSULATORS	TRANSPARENT COVERING
Plastic foil	GLASS, WOOD AND PLASTIC ARE ALL EXCELLENT INSULATORS	
C-section		CONSTRUCTION ELEMENT
Silicone rubber		TO SEAL THE INSTALLATION

TABLE 1. Properties of materials

MATERIAL	PROPERTIES	POSSIBLY ROLE IN FLAT SOLAR COLLECTOR
Copper pipe	.....	.....
Glass pipe	.....	.....
Plastic pipe	.....	.....
Black sheet of paper	.....	.....
White sheet of paper	.....	.....
Aluminum foil	.....	.....
Piece of plywood	.....	.....
Piece of mineral wool	.....	.....
Straw	.....	.....
Sheet of glass	.....	.....
Plastic foil	.....	.....
C-section	.....	.....
Silicone rubber	.....	.....

EXERCISE (4)

SOLAR, WIND OR HYDRO ENERGY

FOR GREEN TECH FUTURE!

Background for the teacher:

Every country has access to sunshine and wind, even if their availability depends on time and weather. Use of renewable energy can improve national security by reducing a country's reliance on exports from fossil fuel–rich nations.

The amount of solar radiation delivered to the earth's surface varies based on the sun's position in the sky and other atmospheric conditions. When the sun is highest in the sky, peak solar radiation occurs. Sunrise and sunset deliver less energy. Sun-hours increase during the summer and decrease in the winter. Solar energy is more concentrated near the equator and less concentrated near the Poles.

Wind is the movement of air molecules in the atmosphere, a natural movement of air of any velocity especially. It has two important characteristics—direction and speed. Wind tends to blow stronger over the sea than over land, due to the sea presents a smooth surface, while hills, mountains, and forests tend to slow the wind down or change its direction.

EXERCISE (4)

Time: 30 min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	SOLAR, WIND OR HYDRO ENERGY
2	TARGET OF THE EXERCISE:	Students explore the geographic conditions that favor or restrict the use of various renewable energy technologies in a particular place. Which country in Baltic Sea Region (BSR: Sweden, Denmark, Estonia, Finland, Germany, Latvia, Lithuania and Poland) has s strongest potential for solar, wind and hydro energy ?
3	DETAILED DESCRIPTION OF THE EXERCISE:	Students look for two maps on the internet: global map of global horizontal radiation and annual full-load hours for onshore wind energy in the EU (links in table below). Students divided into small groups pick one name of a city in the region of Baltic Sea. They analyze the maps and discuss about a potential for different sources of renewable energy in this place. Allow students 6 minutes of working time. Teacher writes down on the board the name of the city and the renewable source of energy which was chosen.

	Each group has a 60 second to explain its decision. Explore with the students the relation between geographical localization, climate conditions and renewables, which has the strongest potential in this place. Discuss: What renewable energy source is best suited to your country? How the geographical localization, climate conditions and the natural resources effect diversity and development of the renewables?	
4	MATERIALS NEEDED:	FIG. 1. GLOBAL MAP OF GLOBAL HORIZONTAL RADIATION RETRIEVED 19.06.2020 FIG. 2. ANNUAL FULL-LOAD HOURS FOR ONSHORE WIND ENERGY IN THE EU RETRIEVED 19.06.2020
5	EFFECTS:	Students explore the geographic conditions that favor or restrict the use of various renewable energy technologies / sources in a particular locations of Baltic Sea Region

EXERCISE (4)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
→ VARIABILITY CHARACTERISTICS OF EUROPEAN WIND AND SOLAR POWER RESOURCES — A REVIEW	I. Graabak, M. Korpås, Variability Characteristics of European Wind and Solar Power Resources — A Review, Energies 2016, 9(6), 449 RETRIEVED 19.06.2020
→ LONG TERM POTENTIALS FOR RENEWABLE ENERGY SOURCES IN EUROPE	Long term potentials for renewable energy sources in Europe RETRIEVED 20.06.2020

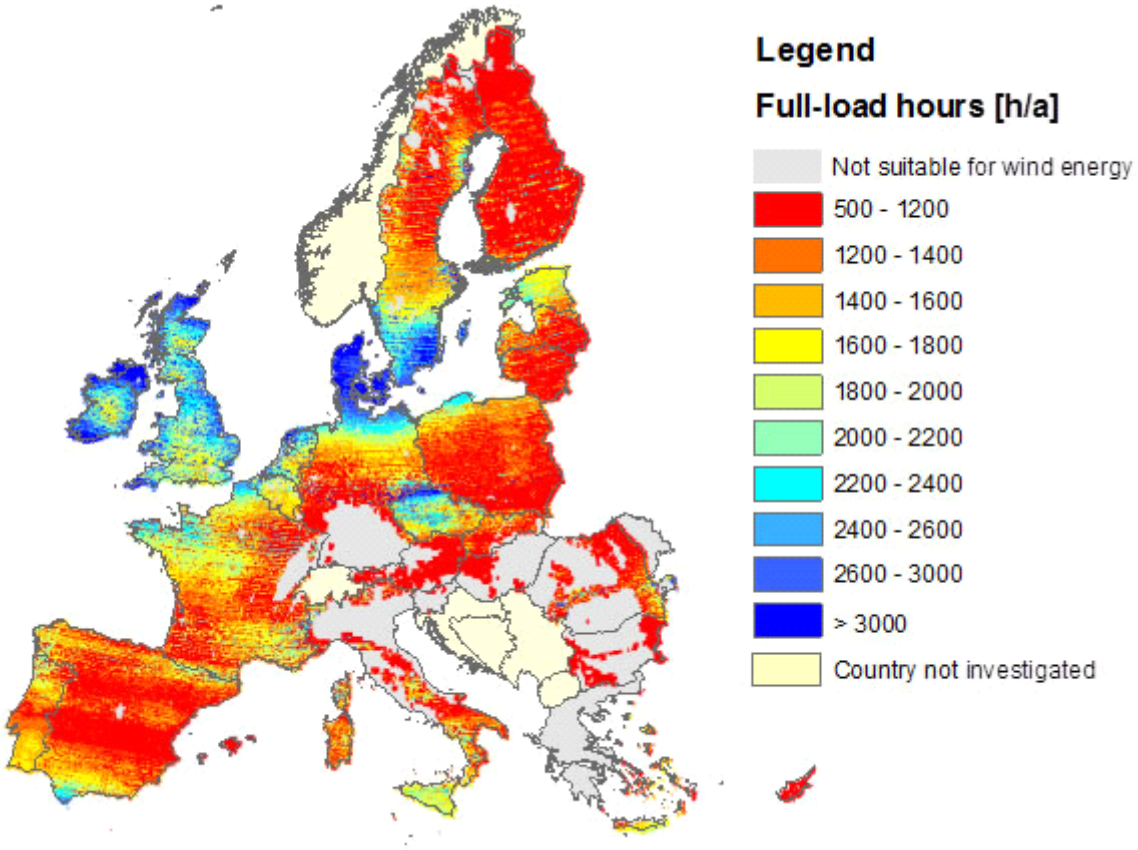

FIG. 2. ANNUAL FULL-LOAD HOURS FOR ONSHORE WIND ENERGY IN THE EU. LONG TERM POTENTIALS FOR RENEWABLE ENERGY SOURCES IN EUROPE, RETRIEVED 19.06.2020

Example:

FULL LOAD HOURS **is an convenient notion expressing the number of hours during one year during which the turbine would have to run at full power in order to produce the energy delivered throughout a year.**

PEAK SUN HOUR **– see definition in Exercise 2**

WARSAW:

PEAK SUN HOUR **– 3.3 (FIG. 1.); full-load hours 500-1200 h/year (FIG. 2.)**

STOCKHOLM:

PEAK SUN HOUR **- 2.9 (FIG. 1.); full-load hours 2600-3000 h/year (FIG. 2.)**

- Warsaw has low number of full load hours and as affect low potentials for the wind turbines, as it can be seen from the map "Annual full-load hours for onshore wind energy in the EU".
- Warsaw has moderate direct irradiation, as the Global Map of Global Horizontal Radiation indicates.
- Warsaw possesses more favorable solar conditions but wind energy is also possible to obtain.
- Stockholm has high number of full load hours and as affect high potentials for the wind turbines. There is relatively not high direct irradiation, therefore the conditions are more favorable for wind.

EXERCISE (5)

WHAT IS DISTRIBUTION OF SOURCES ENERGY IN BSR?

Background for the teacher:

- In **introduction.**

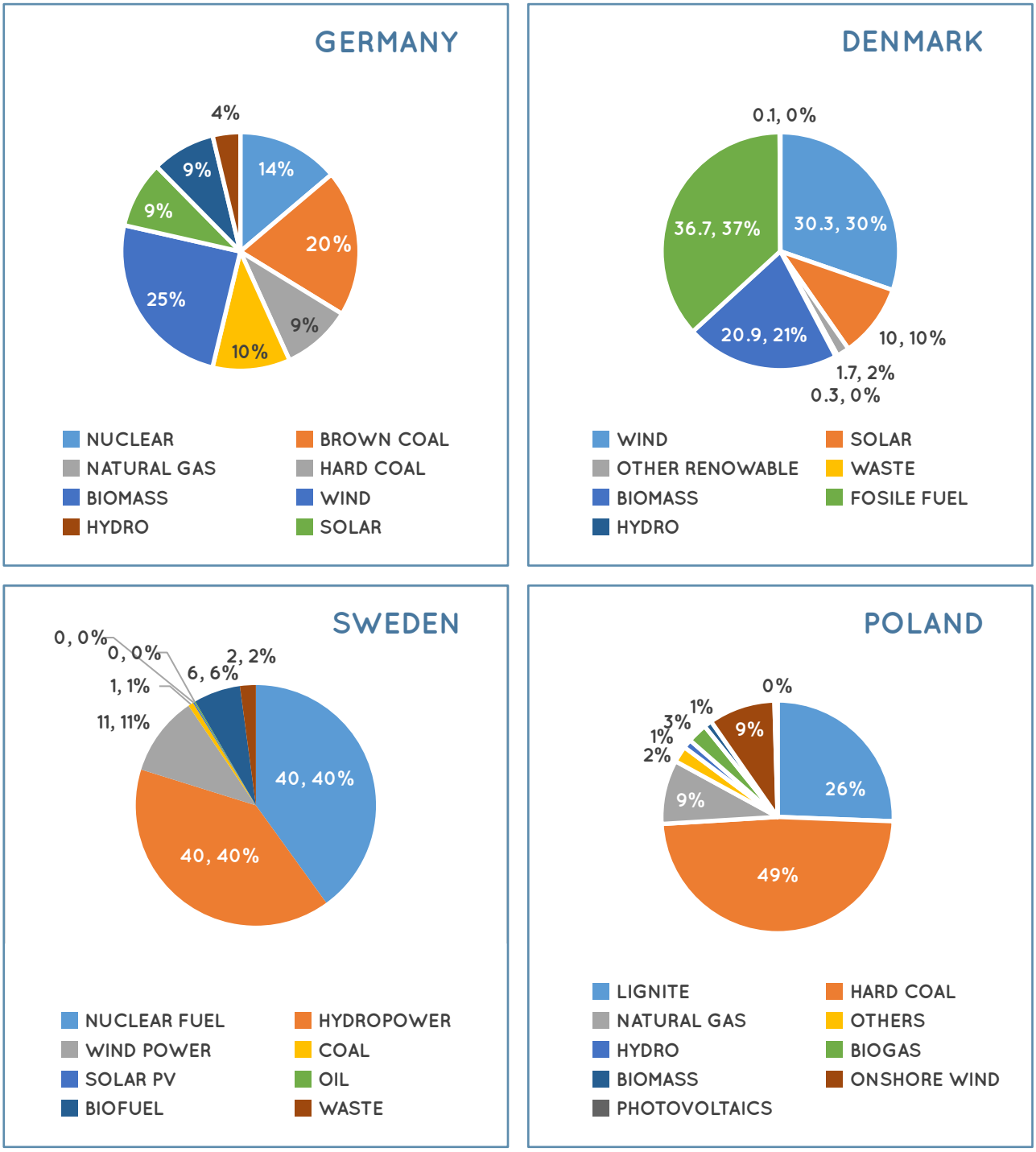

FIG. 3. PRODUCTION OF ELECTRICITY FROM DIFFERENT SOURCES ENERGY IN GERMANY [1], SWEDEN [2], POLAND [3] AND DENMARK [4].

References:

[1] Public Net Electricity Generation in Germany 2019: Share from Renewables Exceeds Fossil Fuels, Fraunhofer Institute for Solar Energy Systems ISE, January 15, 2020

RETRIEVED 19.06.2020

[2] The Energy System of Sweden, World Energy Data, December 7, 2019

RETRIEVED 19.06.2020

[3] Energy sector data 2019, Forum Energii

RETRIEVED 19.06.2020

[4] Denmark's electricity generation source totals for 28-Apr-2019, including 5475 MW of installed wind generation capacity. Reliable AB Energy

RETRIEVED 19.06.2020

EXERCISE (5)

Time: 20 min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	WHAT IS DISTRIBUTION OF SOURCES ENERGY IN BSR?
2	TARGET OF THE EXERCISE:	Students will learn the correlation between the presence of natural resources and the development of renewable energy technologies in a given country.
3	DETAILED DESCRIPTION OF THE EXERCISE:	Teacher distributes cards with the electricity production data from various sources of energy for Sweden, Poland, Lithuania, Denmark and Germany. Students divided into five groups analyze the data presented in Fig. 3. for a given country. They look for the presence of natural resources in the country in internet. They discuss in groups about the diversity of nonrenewable and renewable sources of electricity in this country. What nonrenewable/renewable energy source is mostly used in this country and why? Discuss the relation between geographical localization (South, North, mountains, rivers, fields etc.) and a renewable energy source, which is best suite in this place. Each group has a 30 seconds to present the sources usage distribution in given country.

	After presentations discuss with students: • Which countries use the most nonrenewable energy and why? • How the presence of natural resources effects diversity and development of the renewable energy sources used? Now students discuss in groups: • What arguments would you use to convince the government in given country to give up nonrenewable fuels. Each group has a 30 second to present its argumentation.
4	MATERIALS NEEDED: LINKS: IN INTRODUCTION
5	EFFECTS: Exercise helps students realize: 1. What nonrenewable energy sources are used in countries of the BSR? 2. Why do we still use nonrenewable energy sources in the BSR countries?

EXERCISE (5)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
PRODUCTION OF ELECTRICITY IN LITHUANIA IN 2017	Sector Overview, MERL RETRIEVED 19.06.2020
PUBLIC NET ELECTRICITY GENERATION IN GERMANY 2019	Public Net Electricity Generation in Germany 2019: Share from Renewables Exceeds Fossil Fuels, Fraunhofer Institute for Solar Energy Systems ISE, January 15, 2020 RETRIEVED 19.06.2020
ENERGY SECTOR DATA 2019, POLAND	Energy sector data 2019, Forum Energii RETRIEVED 19.06.2020

EXERCISE (5)

THE ENERGY SYSTEM OF SWEDEN	The Energy System of Sweden, World Energy Data, December 7, 2019 RETRIEVED 19.06.2020

Effects

Students are realizing how the demand for energy has increased over the last 50 years and how much our life has become dependent on energy. Students realize that in EU most of the energy still comes from non-renewable energy sources that will run out or will not be replenished in our lifetimes. Fossil fuels are a valuable source of energy and are relatively inexpensive to extract. However, burning fossil fuels is harmful to the environment due to greenhouse gases emission.
Students know what is the share of renewable energy in the BSR countries. Students understand the need for technological progress in the field of energy acquisition all over the world, and they are aware of progress in the technology of energy generation from renewable sources in their countries. They recognize the relationship between geographical localization, climate conditions and the occurrence of fossil fuel resources and individual strategy of renewables technologies development in BSR countries. They understand the term "peak sun hours" used in solar energy calculation and "full-load hours" for wind energy estimation. Students know the construction of flat solar collector and how it works in practice. They know how the number of photovoltaic panels needed to satisfy total energy demand is calculated. Students understand that photovoltaics and offshore wind farms hold the greatest potential in BSR countries, while onshore wind farms and solar heat collectors have a much smaller potential. It is very important to assess renewable energy resource availability on a regional basis, due to electricity not being easily tradeable between different world regions. Students realize the advantages and disadvantages of using alternative energy sources.

Europe has access to a well-balanced mix of renewable energy resources with enough potential. Renewable energy technology development in the Baltic Sea Region has both ecological and socio-economic consequences. In the EU the number of jobs in the renewable energy sector is estimated at over 1.1 million, of which 1/3 is formed in Germany. The markets in Denmark and Ireland are dominated by wind power. In Poland, there has been rapid growth in wind and solar power employment. Given the EU's ambition to transform its energy system and become carbon neutral by 2050, the pace of the transformation can only accelerate **[1]**.

References:

[1] Renewable Energy and Jobs, IRENE 2018

RETRIEVED 19.06.2020

Main goal:

Classes focus on the renewable energy sources, and their development in the countries in BSR. They will show how important actions are on the development of renewable energy and that the strategy of development can be individual in various countries. How many countries of BSR are already forging ahead towards a low-carbon future? They will help to understand that using renewables (as opposed to fossil fuels) brings many advantages and opportunities, ranging from environmental to socio-economic and political.

Knowledge and skills:

THE STUDENT WILL FIND OUT:

- HOW HAS ELECTRICITY IMPROVED PEOPLE'S LIVES?
- HOW MUCH ENERGY DO WE CONSUME A DAY?
- WHAT IS A RENEWABLE SOURCE OF ENERGY?
- WHICH TYPE OF RENEWABLE ENERGY WOULD BE BEST FOR YOUR COUNTRY?
- WHAT TYPE OF ENERGIES ARE USED IN BSR COUNTRIES AND WHY?

THE STUDENT WILL BE ABLE TO:

- USE THE BASIC TERMINOLOGY RELATED TO RENEWABLE ENERGY USES
- INDICATE THE MOST IMPORTANT ISSUES RELATED TO RENEWABLE ENERGY
- DEMONSTRATE THE RELATIONSHIP BETWEEN GEOGRAPHIC LOCAL-IZATION AND THE VARIOUS TYPES OF RENEWABLE ENERGY USES
- UNDERSTAND THE INDIVIDUAL APPROACH TO ENERGETICAL STRATEGY IN THESE COUNTRIES
- DISCUSS THE ADVANTAGES AND DISADVANTAGES OF USING ALTERNATIVE ENERGY SOURCES
- ANALYZE DATA FROM A GRAPH TO DETERMINE THE POTENTIAL OF CURRENTLY USED SOURCES ENERGY IN BRS COUNTRIES

SCENARIO

Time	Goals, Objectives, Skills achieved	Materials, Contents	Working methods
	Warm up activities		
5	<u>Greeting students</u> The teacher asks students to write down on the board what are the energy sources (coal, biomass, wood, sunshine, wind, nuclear, oil, natural gas, water, etc.) How do these sources of energy contribute to the production of greenhouse gasses and global warming? Which energy sources are renewable? The teacher asks students to define "renewable'" and "nonrenewable" sources of energy.	BOARD, CHALK OR MARKERS	DISCUSSION, BRAINSTORM, MAKE A LIST ON A BOARD

Time	Goals, Objectives, Skills achieved	Materials, Contents	Working methods
	Development and practice		
30	The teacher divides students into five groups. Distributes cards with the data on electricity-generating sources in Sweden, Poland, Lithuania, Denmark and Germany and links to (i) map of the global horizontal irradiation, and (ii) map of the wind blowing hours. The teacher explains what is w task for groups and how to work with data on the maps. The students discuss in groups about non-renewable and renewable energy uses to electricity production in the given country **(Exercise 5).** *What is the most used renewable energy in this country?* *Which would be the best type of renewable energy in this country?* **(Exercise 4)** Each group has a 60 second to share their results.	ACCESS TO THE INTERNET MATERIALS PREPARED BY THE TEACHER SHEETS OF PAPER / FLIP CHART	ANALYZE DATA FROM A GRAPH AND MAPS, PRESENTATION OF THE CON-CLUSIONS BY THE LEADER OF THE GROUP, DISCUSSION

Time	Goals, Objectives, Skills achieved	Materials, Contents	Working methods
	Wrap up		
8	The teacher asks: "What are the advantages (not only for the environment) and/or disadvantages of using renewable energy sources?" The teacher summarizes the work of groups.	BOARD / SHEETS OF PAPER / FLIP CHART	PRESENTATION OF THE CON-CLUSIONS BY THE TEACHER AND A SHORT DISCUSSION
2	<u>Homework:</u> The teacher encourages students to write down a letter at home. What arguments would you use to convince authorities to give up nonrenewable fuels?		OUT OF SCHOOL STUDENTS' OWN WORK

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