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ENERGY MANAGEMENT

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1. INTRODUCTION

Debate topics

- Debate topic 1: Cars powered by electricity generated from fossil fuels are more environmentally friendly than those running on petrol.
- Debate topic 2: Everybody should allow wind turbines to be erected in their backyards.
- Debate topic 3: It is better to generate electricity with solar panels than wind turbines.

Definitions

Non-renewable energy source is a resource whose use results in it depleting more rapidly than it can recover (such as oil shale, natural gas, peat, coal, lignite, oil and the ore used to produce nuclear energy)
Renewable energy reserve is an energy resource which can be used continuously (such as solar, wind and hydroelectric power) or which recovers relatively quickly in an ecosystem's biogeochemical cycle (such as biomass – timber, short-rotation coppicing, etc.)
Wind turbine (also wind power station or wind generator) transforms the kinetic energy of the movement of the wind, i.e. the air, into energy for rotating a turbine. This in turn is transformed into electricity.
Solar panel is a source of electricity which comprises numerous solar cells i.e. large photovoltaic cells, each of which transforms solar energy into electricity.
Biomass energy is organic material originating from living organisms (such as woodchips, sawdust, reeds and straw) when used e.g. by burning.
Hydroelectric energy is the energy of water i.e. hydropower derived under gravitational force from freely falling water which is transformed at a hydropower plant into electricity.
Nuclear energy is produced by splitting heavy atomic nuclei at a nuclear power plant.
Thermonuclear energy is produced with the help of the fusion reactions of light atoms. This type of energy is not yet used, but scientists are investigating and testing ways in which it could be produced so that it can be adopted.
Small-scale energy production is production of electricity in homes with the help of renewable types of energy.

Introductory questions

1. How does your daily life depend on electricity consumption?
2. What can you do to reduce your electricity consumption?
3. Discuss how much electricity and where can be used to produce jeans?

Look at the short video lecture:
https://www.youtube.com/watch?v=Hzi5oAelZSU&t=6s

2. INFORMATION CARD

2.1 Humankind needs more energy

Humankind's energy consumption is on the rise, including in richer countries where it is taking place at a slower rate. The main rise in consumption is occurring now and will occur in the future in countries where the population is increasing and people are pursuing a welfare society.

In 2018, global energy consumption increased by more than ever before – 2.8%.

In addition to everyday amenities, more equipment is constantly being developed and implemented that also needs electricity to work. For example, next to electric scooters, there are electric cars as well as electric trains and trams.

Global warming and extreme weather conditions are also increasing energy consumption in welfare societies – air that is too hot is fought by excessive air conditioning and long unexpected cold spells in winter with electric heating. This all further increases people's need for energy.

2.2 What can we produce energy from?

Energy can be produced from renewable and non-renewable energy sources. Non-renewable energy sources are considered resources whose quantity decreases faster than it recovers when being used. Stocks which have taken shape over the course of millions of years will be depleted over the next 200 years.

In order to avoid energy shortages in the future, it is important to introduce alternatives. Non-renewable energy sources are oil shale, natural gas, peat, coal, lignite and naphtha. Also, ore used for nuclear production is not renewable.

Renewable energy is an energy resource that can either be used continuously (e.g. solar, wind or hydropower) or which is renewable relatively fast in the ecosystem cycle (e.g. biomass energy wood, energy bush, etc.).

Renewable and alternative energy resources are becoming increasingly attractive. Stockholm Environment Institute in Tallinn has analysed the possible options for Estonia to achieve climate neutrality by the year 2050. According to the analysis, it makes most sense to replace oil shale energy with wind, solar and nuclear power and hydraulic pumping stations. However, Estonia's Ministry of Economic Affairs and Communication currently does not think the same, they consider biomass to be of importance instead.

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2.3 Means of energy production: oil shale

Oil shale is considered the most important mineral resource in Estonia. It is a sedimentary rock of organic material and inorganic mineral compounds originating from around 450 million years ago. Oil shale is widespread on earth but, in terms of calorific value and other properties, remains lower than naphtha and coal. Therefore, oil shale is not widely used around the world. Large quantities must be mined to produce energy.

In Lääne- and Ida-Viru counties, an average of 20 million tonnes of oil shale is mined annually, which is almost 80% of the world's production of oil shale volume. It is estimated that oil shale can be mined in Estonia for around another 50 years.

Energy production from oil shale has a very negative impact on the environment of mining areas: air, groundwater quantity and quality. During and after mining, in the mining areas, the peace and health of the people living there as well as their sense of security and property are endangered. The production of oil shale energy ruins natural diversity, destroys habitats and inhibits other industries (e.g. agriculture).

In 2002, environmental pollution was assessed in Estonia. The results showed that 97% of air pollution, 86% of waste and 23% of water pollution is directly related to the oil shale energy sector.

2.4 Means of energy production: wind energy

Wind turbine energy production is one of the most cost-effective ways to produce energy. The technology is getting cheaper, the power output is getting bigger and people trust wind energy more and more. Wind generators are increasingly more visible on coasts. The average annual wind speed on the west coast of Estonia is 6-7 m/s, so this area is promising for the development of wind energy.

The potential of offshore wind farms is even greater because wind speeds are higher, and larger wind turbines can be used. However, the cost of offshore wind turbines can become significantly higher over time than onshore wind turbines because they are more expensive to build and maintain at sea since they are more difficult to access. Offshore windmills also need more maintenance.

The safety or danger of wind farms to nearby residents is unclear – many of the problems raised by humans may be caused by other environmental impacts or their way of life. Serious research has so far found no direct link between complaints and wind farm operations.

2.5 Means on energy production: solar energy

More solar energy could be used in Estonia. Actually, the potential of solar energy in Estonia could be compared to that in Germany, where the annual amount of solar radiation is only a little greater than in Estonia. As the lower temperatures characteristic to the Estonian climate increase the efficiency of the panels, the amount of energy available would be similar.

The challenge is the technology used for solar energy. Efforts are currently being made to develop materials that have as small an ecological footprint as possible, are environmentally friendly and are made with chemical elements that have sufficient reserves in the earth's crust. Although solar energy production does not emit CO2, we cannot look past the fact that high-quality solar panel production is a resource-intensive undertaking.

It is important that the panels can be applied in a variety of places (e.g. car surfaces, windows). Currently, solar panels only produce 2% of the world's electricity.

The efficiency of industrial silicone panels currently reaches up to 22%, but efforts are being made to increase this. Industrial solar panels based on other materials still remain under the level of efficiency of silicon panels, but not so significantly anymore.

2.6 Means of energy production: bioenergy

Estonia has enough biomass to sustainably cover at least one third of Estonia's energy needs. For this, contribution to heat and electricity co-production is needed. Today, 35% of heat energy in Estonia is produced from biomass; however, it is possible to produce up to two-thirds of heat energy from local biomass.

From the biogas produced by the anaerobic digestion of organic matter, it is possible to produce electricity, heat and transport fuels, but so far it is an undervalued source of renewable energy in Estonia. Although the transition to renewables in the transport sector is very difficult, it can be used to produce bio methane, which could be used as motor fuel.

If we want the transport sector to be 100% renewable, domestic electric vehicles and flex-fuel internal combustion engines (which can run on fuel blended with ethanol or methanol) and the development of public transport should be priority actions.

According to Estonia's Energy Economy Development Plan, the production of biogas could be enough to replace all natural gas imported from Russia.

2.7 Means of energy production: hydropower

The wider use of hydropower resources in Estonia is not forecasted, as the development of hydropower plants is accompanied by environmental problems. In addition, Estonia has a problem with finding suitable rivers – our landforms are rather similar and it is more profitable to produce hydropower in places with large fast-flowing rivers, whose headwaters are much higher than the mouth. It is not possible to find this on flat land, like in Estonia.

When compiling the Energy Economy Development Plan, it was found that up to 15 megawatts of hydropower can be achieved. As for other forms of energy production, the question is how to store the energy produced. In addition to production, hydropower allows a new innovative way to store energy – pumped storage.

2.8 Means of energy production: nuclear power

Nuclear power plants produce energy through the nuclear fission of heavy atomic nuclei.

The advantage of a nuclear power plant is that you can get a lot of energy from a small amount of fuel that is easy to transport. It is possible to produce energy reliably and continuously until nuclear fuel, which is non-renewable, runs out. With the development of technology, the current 3rd generation nuclear power plant fuel can also be reused in the future in the so-called 4th generation nuclear power plants.

However, nuclear waste is radioactive; it must be handled and stored somewhere safely. Although you can implement strict security measures and safety requirements for the prevention of failures and accidents during production and handling if stored, there is a risk of accidents, which, as a rule, are serious and extensive.

Nuclear power generators require plans for the construction of plants and waste storage plans – large investments are needed. The laws also need to be changed because Estonian legislation does not allow the production of nuclear energy.

Finding a location for a nuclear power plant can be difficult – there are many political, economic and social issues that need to be discussed. Costs will also be incurred to build infrastructure. 4th generation nuclear power plants are generally considered safe and viable in Estonia.

2.15 Producing energy from other resources

The means of energy production can be quite different in different parts of the world as the resources which can be used might be quite different.

Tidal energy is produced by the surge of ocean waters during the rise and fall of tides. It is a renewable source of energy but the amount of power that has been produced so far is quite small. First tidal power plant was located in France. The largest in the world is in South Korea. There are not many places where this type of energy could be used. In addition to aforementioned, England, Canada and Russia are the only ones that could really benefit from it.

Electricity can be produced from geothermal energy. This is the heat that comes from the sub-surface of the Earth. It originates from the formation of the planet and the radioactive decay of materials within the Earth's core. There are different ways to produce power from geothermal energy. In Iceland and Italy hot underground water is used to produce electricity. In many countries the heat is directly used for heating water, greenhouses aquaculture and industry. In the US, which is the largest producer of electricity from geothermal energy, deep wells are dug into underground reservoirs to access the steam and hot water there.

Another way of producing heat and electricity is by using coal. For example, Germany and Poland are among the top 10 coal users in the world. Others in the list are Australia, South Korea, South Africa, Japan and Russia. The US and India make it to the top 3 together with China which has the largest consumption of coal. Coal is a fossil fuel and several environmental issues are related to producing and using it.

Albeit not used for energy production in cities, the oil is used for fuel. Thus, it is an important energy resource. Most of the oil is produced by the US, Saudi Arabia, Russia, Canada and China. In Europe the UK and Norway produce oil. As with other fossil fuels the environmental toll must be considered here, also.

2.9 Small-scale production of energy

In the case of wind and solar energy production, we can discuss not only industrial energy production at the national level but also small domestic producers. There are plenty of households with a wind generator or solar panels. In both cases, the issue of storing the energy needs to be resolved.

Conditions for energy production can be better when demand is lower. For example, on a cold but sunny winter day solar panels can produce energy very successfully. If these panels are by a school or an office building, it is very suitable for daily energy production and consumption. In a private house, energy consumption is generally higher when all the inhabitants are at home together, so there should be a way to store the energy for the evening.

In small-scale domestic production, a system that monitors the energy flow of the household can help direct the surplus to energy storage and to an electrical network, taking into consideration energy market prices. A system that monitors prices and household consumption, for example, saves 80% a year on electricity costs in Germany.

2.10 Ways to store renewable energy

Since renewable energy production by many production methods can be volatile, it is important not only to direct energy to the electricity grid but also store the energy. In addition, storage is needed because the power available from renewable energy sources can fluctuate; however, the consumer needs energy constantly.

Types of storage are very different. The type also dictates the battery life, the possible lifespan of the accumulator (depending on the number of charges), how quickly the accumulator is emptied and, depending on the construction cost, the price.

In the field of hydropower, the storage problem in large-scale production can be partially helped with pumped storage stations, which are energy storage equipment that can be built in Estonia deep in the reservoirs of the earth's crust. With their help, the height difference required for hydropower production can be simulated by moving seawater up and down.

In essence, this would save energy that is not currently in use and it would make it possible to obtain energy from wind farms even at a time when there is no wind.

Electric cars mostly use lithium-ion batteries.

2.11 Is global warming causing the rise in energy consumption?

Against the background of global warming, the volume of energy consumption is forecasted to increase.

By 2050, in addition to population growth and economic development, energy consumption is expected to increase due to the increased need for cooling.

In the tropics, as well as in Europe, China and the United States, there are regions where temperatures are rising substantially as a result of climate change. In order to ensure the continued functioning of industry and the service sector, these regions would need to have cooling. It is believed that as the lower average temperature increases, energy consumption by cooling increases by 11-27% and, in the case of higher temperatures, even by 25-58%.

The actual rise in temperature is dependent on how the emission of greenhouse gases changes, how national energy consumption changes in a changing environment where the population is growing and the economy continues to develop.

2.12 The price of green energy

Against the background of the transition to renewable energy, there is a danger of falling into the utopia of green economic growth, which would seem to allow increased growth if fossil fuels are phased out. This will likely not be possible. Although renewable energy sources are so-called 'clean', there is no infrastructure to produce them. The transition to renewable energy is possible, but it cannot happen if our consumption continues to grow.

In order to build stations that allow electricity to be extracted from renewable sources, it is necessary to extract a lot of metals and rare earth metals. If current consumption growth continues, mining should take place in significantly higher volumes than it does currently.

For example, the neodymium needed for wind turbines should be mined 35% more than it is currently mined worldwide. For solar panels, 920% more indium should be produced. For energy storage accumulators, we should produce 2700% more lithium. Although the problem is not primarily the depletion of resources, mining has a social as well as an ecological price. We are already extracting 82% more than is sustainable.

No energy is innocent. The only fundamentally safe way to 'produce' energy is to reduce energy consumption.

2.13 Electric cars

Compared with a normal car, the electric car's engine is more efficient and its cost is lower because it is simpler in build. The lifespan of electric cars could be longer and they should be produced less. But high-tech batteries make them expensive.

Using renewable energy would reduce emissions of greenhouse gases when driving an electric car and we would be less dependent on fossil fuels. The problem with electric cars is the battery, for which materials, including rare earth metals, that cannot be sufficiently recycled need to be mined.

Batteries also make electric cars heavy – wear and tear of tires, roads and brakes from polluting dust. However, recuperative braking is used in electric cars, i.e. kinetic energy is re-used, so the brakes should wear less. As with most production, the problem with electric cars is the CO_2 emitted during production.

Electric cars are considered more economical than other modes of transport. They are very suitable for driving in the city or its vicinity – one charge gets you around 150 km. Charging time with a 230 V grid is 6-8 hours, a quick charger can charge 80% of the battery in 30 minutes.

Therefore, it would be necessary to develop a network of fast chargers. Households which generate their own electricity from the sun could be produce enough energy to charge your electric car.

2.14 Energy hungry data volumes

Developments in information technology have been expected to limit carbon emissions thanks to increased work efficiency and reduced waste generation. Unfortunately, the situation has reversed.

Devices connected to the Internet, streaming high-quality photos and videos, security cameras, smartphones and smart TV equipment require ever better and more extensive data connections and higher data storage volumes. Energy consumption of information technology was estimated at 3-5% of total electricity consumption in 2015, which grows annually by around 20%. By 2020, it is estimated that the IT sector will use up to 20% of the world's electricity and produce more than 5% of global carbon emissions.

In the near future, energy consumption will be boosted by the Internet of Things, the development of self-driving cars, robots and artificial intelligence and the rising Internet consumption of evolving countries. The number of mobile Internet users is estimated to increase from 3.6 billion (2018) to 5 billion by 2025, while the number of Internet of Things connections should triple (from 7.5 billion to 25 billion) (GSM Association, 2019).

Large data centres with huge server capacities use much more energy than small towns. There are also several data centres planned around Tallinn. The planned center of Saue municipality will cost around €100 million in order to provide server space for IT companies around the world. When completed, it must have space for 40,000 servers and a capacity of 20 megawatts.

3. STORY CARD

3.1 Windmills impact on earthworms

The effects of wind turbines on organisms are multifaceted: they generate low-frequency noise and vibration that cause sleep disturbances, headaches, nausea and hallucinations in humans. Birds and bats die in collisions with windmill blades, but local birds generally learn to overcome obstacles quickly. Little research has been done on the impact of wind turbines on soil life.

In 2019, students submitted their papers to the national research competition on two boys from Saaremaa who studied the effect of wind generators on earthworms. Earthworms are very important soil organisms and their abundance indicates the health status of the soil. The Estonian record is 400 earthworms per square metre, but there are also areas where no earthworms have been found. These are generally sandy areas that are not suitable as a place for earthworms to live.

The young men studied the base of the windmills around the Sikassaare polder area, 1 km from Kuressaare. A total of 36 test squares were built under the two wind generators at different distances. Earthworms were found in 15 test squares, a total of six species, including earthworm species sensitive to environmental effects. It turned out that the number of earthworms depended on the number of plant species rather than the proximity of a wind turbine. The most species- and specimen-rich test sites were those located directly under the wind turbines. So, they came to the conclusion that the abundance of earthworms does not depend on the presence of wind turbines.

3.2 A nuclear plant and a tsunami

In the afternoon of 11 March 2011, Japan was hit by the strongest earthquake in the last 140 years, with a magnitude of 9. As a result, a tsunami rose at sea with a peak of 40 metres. Due to the tsunami, nearly 16,000 people died, 2500 went missing and more than 6000 were injured.

More than a million buildings and four nuclear power plants were damaged, as a result of which the Fukushima I station disaster occurred. An earthquake and a tsunami cut off the power supply to the station. The station was surrounded by a 10-metre-high barrage, but the height of the tsunami was 14 metres, so it took out the back-up generators. This left the plant itself without electricity, the cooling systems did not work and the nuclear fuel overheated and exploded.

A total of three explosions and fires took place at the station, the surrounding area of the station got contaminated with radioactive cesium and 80,000 people had to leave their homes.

Following the Fukushima disaster, the Japanese government planned to give up on nuclear energy. Decreased production led to an increase in the use of renewable energy (especially solar energy), but also to an increase in (imported) fossil fuels. It was soon decided to continue the development of nuclear energy because for Japan it is a matter of energy independence and security as well as an environmental issue. However, more is being invested in safety than before.

3.3 Tallinn Power Plant

At the turn of the 20th century, everything related to electricity developed as quickly as information technology 100 years later. First, industry began to use electricity, which then shined in the windows of some wealthier private houses and was followed by the desire to switch to electric street lighting. In this respect, Tartu and Pärnu pulled ahead of Tallinn, but on 24 March 1913, the Tallinn City Central Power Station started working in the current Energy Discovery Centre building.

First, the coal-fire steam turbines of the power plant were fueled with English coal. The start of World War I made it difficult to obtain fuel, and boilers were fueled with both peat and wood. But as electricity became more popular, more power was needed, preferably from domestic raw materials. So, they started using oil shale from 1924, which was a moving force in the development of oil shale energy in Estonia.

Oil shale also caused several problems. Boilers were not reliable and, to the displeasure of the surrounding residents, the smoke from chimneys turned into thick black smoke. Also, transportation of oil shale and storage of ash in the middle of the city was not an easy task. Technology was developed, chimneys were built higher, ash was stored in the sea and the area on top of which Linnahall was built was created later.

However, electricity was found to be easier to transport than oil shale and new power plants were being built near oil shale mines in Ida-Viru County. Electricity production at the plant ceased in 1979. Science and culture have found a place in the former industrial buildings.

3.4 Road to the source of energy of the stars

In the south of France, the European Union, along with China, India, Japan, South Korea, Russia and the United States, is building a huge plasma donut, which is one of the most ambitious energy projects in the world.

ITER (Latin for 'the way', originally abbreviated from international experimental fusion reactor) is intended for the development of future nuclear power plants, i.e. for testing fusion reactions.

Nuclear power plants around the world use nuclear energy, where heavier atomic nuclei (usually uranium) are fissioned and, as a result, energy is released, but the problem is the process and the radioactivity of the waste. Fusion reactions split atoms and release a lot of energy. Such reactions take place in stars, (including the sun), where hydrogen atoms combine in the plasma at hundreds of millions of degrees and under extremely high pressure.

Similar conditions have been caused on Earth, with the explosion of a hydrogen bomb and in circular plasma containers (tokamak), where a strong magnetic field keeps the heat inside the plasma container. Unfortunately, it is very energy-intensive and no nuclear reactor has been built so far that produces more energy than it takes.

ITER is trying to solve this problem. The director of ITER estimates that the project will cost $22 billion to launch. Plasma should circulate in the ITER tokamak for the first time in December 2025.

4. QUESTION CARDS

QUESTION CARD 1	QUESTION CARD 2	QUESTION CARD 3	QUESTION CARD 4
Why should private houses use renewable energy?	How is it possible to reduce the usage of electric energy in Estonia? (describe the areas such as households, industry, transport etc).	Can you imagine only being able to recharge or use electrical equipment in your home for a few hours a day when renewable energy sources are available?	How would it affect people's life if there was a wind or solar farm or nuclear power plant nearby?
QUESTION CARD 5	**QUESTION CARD 6**	**QUESTION CARD 7**	**QUESTION CARD 8**
Imagine that the only cars in Estonia were electric. What would be different?	Are there any shortcomings or problems related to the production of renewable energy?	How much of Estonia's electricity consumption takes place in people's homes? Try to find out.	Should Estonia produce all of its own energy or is it okay to purchase energy from other countries?

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5. WORKSHEETS

Topic
ENERGY MANAGEMENT
Resolution
Choose the debate resolution

Prepare a set of arguments and group them into those that are clearly PRO the resolution, AGAINST the resolution and those arguments that can be used by both sides. Enter them in the appropriate places in the table.

PRO	DEBATABLE	CON

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Prepare arguments for the discussion. One group of students prepares arguments supporting the resolution, the other one has contradictory arguments. Use the proposed scheme.

ARGUMENT NO. 1.

Argument	Foreseen rebuttals of the other group	Answers to rebuttals

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ARGUMENT NO. 2.

Argument	Foreseen rebuttals of the other group	Answers to rebuttals

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Worksheet for the public

Name and surname: ……………………………………… Class: ……. Team: proposition/opposition

During the debate, hear and observe carefully the speeches of the debates from the other team. Then, evaluate which speech convinced you the most and which areas of your opponents' speech should be improved.

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1. In terms of **argumentation (**e.g. the quality of the arguments presented, credibility of the data and scientific evidence) in the rival team I was most convinced by the speaker No. ....

Reason:

………

………

………

2. In terms of **the style of presentation and communication with the audience** (e.g. confident, persuasive, authentic and dynamic posture, moderate gestures, assertive voice variety, good eye contact with the audience, use of moderate humor, friendly and professional approach to all participants, effective use of body language) in the rival team I was most convinced by the speaker No. ....

Reason:

………

………

………

Indicate the element of the rival team's performance that requires improvement. Justify your answer.

………

………

Reason:

………

………

………

………

………

………

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The Energy Management

Recommendations for teachers on using teaching materials

The educational package "The Energy Management" was developed within "Oxford debates for the education of young people in the field of mathematics and science" project.
It is a key material, facilitating the achievement of primary project goals, including increasing reasoning skills and interest in STEM, which in the future may result in taking up a scientific career.
When preparing students for the debate, one should not neglect the development of such skills as communication excellence, argumentation or public speaking. Students should improve their ability to persuade effectively, argue properly, reason accordingly and speak out correctly. Composition of texts, using rhetorical means in oral statements, speaking in accordance with the rules of language culture, text interpretation, public speaking and presentation of texts, discussions and negotiations are of equally high importance.
In order to achieve the abovementioned goals, the implementation of thematic educational packages should be preceded by classes dedicated to preparation for debating as such. This can be accomplished in consultation with teachers of other subjects and the class teacher. The development of basic communication skills can be included in the class teacher's work plan, and the prepared lesson plans can be used during regular classes. Auxiliary materials can be found in the following documents:

- Warm-up practice – Frameworks for implementation of Oxford debates in STEM in school practice ;
  This document includes the following exercises: active listening, public speaking and debating skills and lesson plans.
- Methodological Guide for Teachers. ODYSSEY: Oxford Debates for Youths in Science Education

The teaching material pack includes the following:

- Student worksheet for drafting arguments,
- Information, story and question cards
- links to additional materials
- scientists' video.

Ideally, 2-3 hours should be taken per pack in order for the students to grasp the essentials of fact-based debating. The first lesson should focus on what debating entails (assuming that the students have no experience of it). The second lesson should make use of the materials in one of the themed packs. For the second lesson there are two possible lesson plans - A) can be used if the students are already well familiar with the topic and/or debating, B) is more structured and better from starting from the very beginning. The third lesson should then include an actual debate. If you don't have enough time to give feedback on the debate during the lesson, you can do so during the following lesson.

Albeit the environmental topics within the materials are covered quite broadly, depending on your region you might need to give your student some additional information (links to newspapers, homepages, videos) regarding your own locally relevant topics. For example, the invasive species for biodiversity package in your region might be completely different or perhaps the energy can be produced by means other than the ones that have been covered in the materials (perhaps instead of oil shale in your region geothermal energy, oil or coal plays an important role).

Below you will find lesson plans you can use, adapting them to your group and your particular aims. Once the debates have been held, we look forward to your feedback on the themed packs and other materials. Enjoy some lively debating!

Lesson Plan 1: Introduction to Debating

During the first lesson, the students are introduced to the format of debates. We recommend that you practise drafting arguments and thinking about likely counter-arguments and how to rebut them. The student worksheet included in the pack will be of help.

Lesson aims:

By the end of the lesson, the students know:
- what debating is; and
- what an argument is.

By the end of the lesson, the students understand:
- how a debate is structured.

By the end of the lesson, the students are capable of:
- drafting, supporting and rebutting arguments.

Lesson preparation:

- Remind yourself of what you learnt during your debate training.
- Print out the student worksheets.
- If you wish to, laminate the worksheets (so that they can be re-used if the students write on them with felt-tips).

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Lesson Plan 2, Option A: An Introduction to Energy Management

For the second lesson you can prepare the materials of energy management. Remind the students of what they have learned so far in regard to them, explain the key terms and their definitions and set out the problem. You could also have the students watch the scientist's video lecture that forms part of the teaching materials. Look at the information, story and question cards together, which you will also find among the teaching materials. Point out that the students can use these cards, as well as their own notes, during the debate. You don't need to discuss the actual topic yet – simply provide an overview of the themed pack. At the end of the lesson, choose a specific topic for debate to continue with in the following lesson. As a home task, get the students to search for extra information. Links can also be added as part of the additional information for the topic in the e-school for them to investigate.

Lesson aims:

By the end of the lesson, the students know:
- the key terms associated with the topic and their definitions; and
- the nature of and background to the problems.

By the end of the lesson, the students understand:
- the structure and use of the materials in the themed pack.

By the end of the lesson, the students are capable of:
- navigating their way through the materials in the themed pack.

Lesson preparation:

- Prepare the video lecture (which you will find among the teaching materials).
- Print out the relevant information, story and question cards and cut them to size as indicated.
- Add links for the given topic to the e-school for the students to investigate at home.

Lesson Plan 2, Option B: An Introduction to Energy Management

Divide the class up into groups of three, who are then given topics for debate. The topics can be chosen from the student package but you are welcome to propose new ones.
Note: Keep one topic of debate as a spare – don't give it to the students.

Activities prior to preparing for the second lesson (i.e. up to the home task):
Distribute the information and story cards among the students so that each group has one of each. Depending on the age of the students, familiarity with the topic etc you can decide on if

you a) give each group all the cards; b) decide to divide the cards between the groups; or c) give each group just a specific selection of cards. You as the teacher know your student's abilities the best. Depending on your students you can have them work on the cards as a group by discussing all the cards together (this is preferred) or even have them divide the cards between them.

The links provided at the end of this document should also be made available to the students online ahead of the lesson. Additional links can be provided to support the understanding of the information cards.

Get the students to familiarise themselves with the topic on their cards. Set them the following task:

On your own, read your information and story cards. Read them through first, then take a look at some of the sources listed in the additional materials (such as watching a video or reading an article). Then note down the following about the card:

- *What are the 2-4 most important facts on the card?*
- *Look at the topic of debate given to your group. Decide whether the facts you have noted down support the topic or rebut it.*

During the lesson:

Have the students sit in their groups. Give each student two minutes to introduce to their group their card and the facts listed on it. Here, the students need to explain to the other members of their group what decision they came to regarding the facts, i.e. whether the facts support the topic or rebut it.

Remind the whole class what they have learned so far about the themed pack, repeat the key terms and their definitions and help the students link the information from their cards to the information they have obtained from the other members of their group. If needed use the "worksheet for the public" in the end of student's thematic packages where other students who listen to the debate can evaluate which speech convinced them the most.

Watch the scientist's video lecture (or other videos among the teaching materials that seemed the most interesting to the students) during the lesson.

By this point, the class should be quite familiar with the topic. Use the question cards to repeat what they have already learned from the information and story cards. Ask the students questions and let them take a standpoint in regard to them. If the classroom space allows, you can even do this physically – for example, dividing the room in two using tape on the floor, with one side being 'Yes' and the other side being 'No', and having the students choose one or the other depending on their standpoint. Give all of the students on the same side of the line 30 seconds to decide what their main argument is and why they think so.

Also take a couple of minutes to discuss whether the topic seems straightforward or complicated to them, giving them the chance to air their views and argue over them. Allow them the opportunity to say what the most interesting thing they have learned during the lesson is.

At the end of the lesson, inform the students what the topic of debate for the next lesson will be (i.e. the one you previously held back as a spare). Point out that the students can use the cards they looked at in the lesson, as well as their own notes, during the debate. Ask the students to start working on worksheet 1 and worksheet 2, so they can try to create the arguments, rebuttals and answers. At this point they can try it out for themselves and you can support them as they find out what is most difficult for them.

As a home task, get the students to search for extra information. Links can again be added as part of the additional information for the topic for them to investigate. The students should finalize the worksheets as groups as a home task (away from other groups that could otherwise hear their arguments).

Lesson aims:

By the end of the lesson, the students know:
- the key terms associated with the topic and their definitions; and
- the nature of and background to the problems.

By the end of the lesson, the students understand:
- the structure and use of the materials in the themed pack.

By the end of the lesson, the students are capable of:
- navigating their way through the materials in the themed pack.

Lesson preparation:

- Select the themed pack to investigate.
- Print out the relevant information, story and question cards and cut them to size as indicated.
- Put together three-member groups.
- Distribute the topics of debate among the groups. Note: Keep one topic as a spare.
- Distribute the cards within the groups.
- Add links for the given topic to the e-school for the students to investigate at home.

Lesson Plan 3: debate on „Everybody should allow wind turbines to be erected in their backyards. “

The third lesson sees the students start debating. Randomly divide the students up into 'Yes' and 'No' camps. You can use the information, story and question cards and the students' own notes on the student worksheet as supporting material. The duration of the Odyssey debate

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class format is 45 minutes, but factor in the time it will take to give feedback (giving it in the following lesson if possible). You can get the rest of the class involved in assessing the performance of individual debaters by getting the students to listen to them carefully and make notes during the debate. Worksheet 1 and Worksheet 2 are for the help for the teacher.

Lesson aims:

By the end of the lesson, the students understand:

- how a debate is structured; and
- their role in the debate.

By the end of the lesson, the students are capable of:

- applying topic-appropriate knowledge in a debate format;
- expressing themselves clearly and comprehensibly (including in terms of their diction);
- predicting counter-arguments; and
- supporting their own arguments and rebutting others.

Lesson preparation:

- Set up the classroom for the debate, rearranging the desks and chairs as necessary.
- Prepare the required information, story and question cards (using ones that have not already been used if possible, or printing out new ones).
- Prepare the student worksheets (using ones that have not already been used if possible, or printing out new ones).

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WORKSHEET NO 1 – answers

PRO	GREY AREA	CON
Why is it a good idea to install devices that generate renewable energy in private homes? When it comes to wind and solar energy, industrial production at the national level is complemented by small-scale production in people's homes. There are already quite a number of households with their own wind generators or solar panels. How the energy is stored once produced is also something that needs to be taken into account. The conditions for generating energy may be better precisely when there is less demand.	*Can you imagine only being able to recharge or use electrical equipment in your home for a few hours a day when renewable energy sources are available?* If electrical equipment couldn't be used at any other time, life would be severely disrupted. Energy consumption in private homes is generally greater when everyone who lives there is at home together, so the energy generated during the day would need to be stored for use during the evening and at night. In small-scale energy production at home, a system which monitors the flow of energy in the household and channels any unused energy into storage or the electricity network (taking into account energy market prices) could help coordinate the saving of energy. A system which itself monitors the price and household consumption saves people in Germany, for example, up to 80% each year on the cost of electricity.	*How might nearby facilities generating renewable energy affect people's lives?* How safe wind farms are for those living close to them – and conversely what dangers they may pose – remains unclear. A lot of the problems that people have raised may be caused by other environmental factors or their lifestyles. Credible studies have found no direct links to date between people's complaints and the operation of wind turbines.

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WORKSHEET NO 2 – examples of argument

<table>
<tr><th>ARGUMENT</th><th>FORESEEN REBUTTALS OF THE OTHER GROUP</th><th>ANSWERS TO REBUTTALS</th></tr>
<tr><td rowspan="6">Installing wind turbines and ensuring that energy is stored increases energy independence from the main power network and is financially beneficial.

Energy consumption in private homes is generally greater when everyone who lives there is at home together. In sparsely populated areas, energy which is produced and stored locally can be used when there are faults in the main power network (which can be all too common in such areas). A system which itself monitors price and household consumption, and which uses energy that it itself has produced and stored, saves people in Germany, for example, up to 80% each year on the cost of electricity.

Therefore, erecting wind turbines in windy areas can boost independence and also save money in the long term. Especially if the residents themselves don’t have to pay for the turbines to be installed, but only give permission for them to be erected.</td><td rowspan="2">Wind turbines cause health problems for people and other flora and fauna living nearby.</td><td>The notion that wind turbines are dangerous has not been proven. A lot of the health problems people complain of may well be caused by other environmental conditions or their lifestyles.</td></tr>
<tr><td>A study of earthworms sensitive to changes in the environment revealed that the presence of wind turbines did not affect the worms’ numbers but rather the composition of the species living in the soil. Long-term studies ought to be continued based on the specific nature of people and other species, but in assessing impact on health, the indicators of appropriate control groups must also be taken into account to rule out environmental and lifestyle impact in the study.</td></tr>
<tr><td rowspan="2">Wind turbines spoil the look and feel of the natural environment. As such, they should not be erected in densely populated areas.</td><td>Densely populated areas are not suitable in any case for the installation of large wind turbines. Only micro- and small turbines can be erected in such areas. They must be less than 16 and 25 metres tall, respectively. Compare these to the heights of flag poles (6-12 metres), fir trees (usually up to 30 metres, but sometimes as much as 50-60 metres), linden trees (20-40 metres), five-storey apartment blocks (around 17 metres) and nine-storey apartment blocks (around 25 metres). As such, people’s willingness to allow construction does not mean it always makes sense to install a wind turbine for technical reasons.</td></tr>
<tr><td>Areas of cultural and historical value which are densely populated and feature green spaces also tend to lack conditions that are suited to the installation of micro- and small wind turbines. It also makes more sense to use such technology in sparsely populated areas.</td></tr>
<tr><td rowspan="2">Wind turbines cannot be erected in densely populated areas, so there is no point in even suggesting that everyone in Estonia allow them to be installed in their own back yards.</td><td>People’s general willingness to allow construction simplifies the adoption of technology in areas suited to it.</td></tr>
<tr><td>Integrated solutions could also be used in suburban areas, on the roofs of taller buildings, adding height to the wind turbines and enabling smaller wind parks to be developed in areas unsuited to large turbines. Air flow is also more stable higher up.</td></tr>
</table>

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Additional materials and links

A good resource is the webpage of David J. C. MacKay's book "Sustainable Energy – without the hot air" available online by topics https://www.withouthotair.com/

Additional resources according to information and story cards

2.1 Humankind needs more energy

• How much energy we produce and consume each year? https://en.wikipedia.org/wiki/World_energy_consumption

• How much energy is consumed right now?
https://www.theworldcounts.com/search?target=counters&query=Energy%20consumption

2.3 Means of energy production: oil shale

• Read more about shale oil extraction https://en.wikipedia.org/wiki/Shale_oil_extraction

2.7 Means of energy production: hydropower

• Video: „Hydropower 101" https://youtu.be/q8HmRLCgDAI

• „Hydropower explained" www.nationalgeographic.com/environment/global-warming/hydropower/

2.12 The price of green energy

• The Limits of Clean Energy https://foreignpolicy.com/2019/09/06/thepath-to-clean-energy-will-be-very-dirty-climate-change-renewables/

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- www.theguardian.com/environment/2017/dec/11/tsunami-of-data-could-consumefifth-global-electricity-by-2025
- www.gsma.com/futurenetworks/wiki/energy-efficiency-2/

3.2 A nuclear plant and a tsunami

- www.japantimes.co.jp/news/2019/07/16/business/future-nuclear-powerjapan/#.XdgOEi2B00o
- www.livescience.com/39110-japan-2011-earthquake-tsunami-facts.html

3.4 Road to the source of energy of the stars

- https://physicstoday.scitation.org/do/10.1063/PT.6.2.20180416a/full/