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Методические указания к практическим занятиям по иностранному языку профессиональной направленности (английский) по теме «Альтернативная энергетика» по направлению «Электроэнергетика и электротехника»

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Методические указания к практическим занятиям по иностранному языку профессиональной направленности (английский) по теме «Альтернативная энергетика» по направлению «Электроэнергетика и электротехника»
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Методические указания состоят из современных аутентичных и частично адаптированных текстов на английском языке по теме «Альтернативная энергетика». Каждая лекция содержит текст, на основе которого составлены лексические и грамматические задания, а также вопросы для обсуждения. Лексические упражнения имеют разноплановый характер, организованы по степени сложности и направлены на изучение и закрепление специальной лексики. Грамматические упражнения разработаны с учётом специфики научных текстов. Коммуникативная часть указаний направлена на развитие разговорных навыков и построение собственных высказываний. Методические указания содержат также 6 дополнительных текстов для самостоятельного изучения, а также викторину по изучаемой тематике. Итогом работы является подготовка презентации, что способствует развитию навыков студентов освещать технические темы и высказываться по разным аспектам специальности на английском языке.

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I. Text

Although coal is a fossil fuel, it has little in common with oil. Oil is extremely scarce, but coal is relatively plentiful. Some experts predict that global coal reserves could last up to 119 years compared with only 46.2 and 56.8 years for oil and gas reserves. While oil is mostly found in unstable parts of the world, coal stocks are widely distributed on every continent.

Over 75 percent of global coal reserves are located in the United States, China, and India. Some scientists say that the United States has enough coal deposits last for 249 years, others think that reserves may only last for 119 years.

There is no coal shortage, but even coal, like other fuel resources, is unsustainable at current consumption levels.

Coal has long been an important element of the global energy mix, but there has been a great debate about its future role because the nations of the world try to reduce their harmful emissions. One coal-fired electricity plant, for example, provides enough power for 500,000 homes but also releases as much pollution as 750,000 cars.

The USA introduces the "clean coal" technologies to extract the resource in an environmentally sustainable way.

Clean coal technology is a term used to describe a series of processes that remove most of the pollutants when coal is burned, making it a more environmentally friendly energy source. There are three main processes: the integrated gasification combined cycle (IGCC), carbon capture, and carbon sequestration.

During the IGCC, coal is crushed and mixed with steam to produce a fluid that is clean of many pollutants such as sulfur and mercury. When this fluid is used to make electricity, which it does more efficiently than traditional coal-fired turbines, carbon dioxide is released as a byproduct and filtered out for later disposal.

An alternative to IGCC is carbon capture, a method by which normal coal-fired plants are equipped with special absorbers that soak up carbon dioxide for storage. Various capture techniques can also be used when oil or natural gas is extracted from the ground. At that stage, huge amounts of carbon dioxide are released into the atmosphere. The extraction process is one of the major sources of greenhouse gas emissions.

Once carbon dioxide has been isolated, it is then converted into a "highly concentrated stream" or "'supercritical' state between a liquid and a gas" and stored deep underground. Typically, these streams are pumped into the ocean floor or into old oil or gas reservoirs. Sites for storing carbon dioxide in this form must be "deep and covered by a layer of rock to prevent leakage."

There is some fear that earthquakes could destabilize the storage areas.

However, many supporters of renewable energy sources argue that clean coal and carbon sequestration technologies are untested and have limited potential in the near future.

II. Vocabulary

Word	**Transcription**	**Translation**
absorber	[əb'zɔːb(ə)]	абсорбер
amount	[ə'maunt]	количество
byproduct	['baɪˌprɔdʌkt]	побочный продукт
carbon capture	['kæpʧə]	захват карбона
coal-fired electricity plant	[kəul]	тепловая электростанция
consumption	[kən'sʌm(p)ʃ(ə)n]	потребление
to convert into	[kən'vɜːt]	преобразовывать
deposit, reserve, stock	[dɪ'pɔzɪt] [rɪ'zɜːv] [stɔk]	запас, резерв, склад
disposal	[dɪs'pəuz(ə)l]	утилизация, устранение
to distribute	[dɪ'strɪbjuːt]	распределять
earthquake	['ɜːθkweɪk]	землетрясение
energy source	['enəʤɪ] [sɔːs]	источник энергии

environmentally friendly	[ɪnˌvaɪər(ə)n'ment(ə)li] ['frendlɪ]	не загрязняющий окружающую среду
to equip with	[ɪ'kwɪp]	оборудовать, оснащать
to extract	[ɪk'strækt]	добывать, извлекать
extraction process	[ɪk'strækʃ(ə)n] ['prəuses]	процес добычи
fluid, liquid	['fluːɪd] ['lɪkwɪd]	жидкость
fossil fuel	['fɔs(ə)l fjuːəl]	ископаемое топливо
greenhouse gas	['griːnhaus] [gæs]	парниковый газ
harmful emissions	['hɑːmf(ə)l] [ɪ'mɪʃ(ə)n]	вредные выбросы
integrated gasification combined cycle	['ɪntɪgreɪtɪd] [ˌgæsɪfɪ'keɪʃ(ə)n] [kəm'baɪnd] ['saɪkl]	комбинированный цикл интегрированной газификации
to isolate	['aɪsəleɪt]	изолировать
leakage	['liːkɪʤ]	утечка
mercury	['mɜːkjərɪ]	ртуть
percent	[pə'sent]	процент
plentiful	['plentɪf(ə)l]	обильный, изобилующий
pollution	[pə'luːʃ(ə)n]	загрязнение
to pump into	[pʌmp]	закачивать
to reduce	[rɪ'djuːs]	уменьшать
to release carbon dioxide	[rɪ'liːs] ['kɑːb(ə)n] [daɪ'ɔksaɪd]	выбрасывать углекислый газ
to remove pollutants	[rɪ'muːv]	удалять загрязняющие вещества
renewable energy	[rɪ'njuːəbl]	возобновляемая энергия
reservoir	['rezəvwɑː]	резервуар
rock	[rɔk]	порода, скала
scarce	[skɛəs]	недостаточный, скудный
sequestration	[ˌsiːkwes'treɪʃ(ə)n]	изолирование

shortage	['ʃɔːtɪʤ]	нехватка, недостаток
to soak up	[səuk]	впитывать, поглощать
steam	[stiːm]	пар
to store	[stɔː]	аккумулировать, хранить
storage	['stɔːrɪʤ]	накопление, хранение
stream	[striːm]	поток
sulfur	['sʌlfə]	сера
sustainable	[sə'steɪnəbl]	(экологически) устойчивый
technology	[tek'nɔləʤɪ]	технология
term	[tɜːm]	термин
turbine	['tɜːbaɪn]	турбина

III. Lexical Tasks

1. Add the missing letters and pronounce the words correctly.

ST_R_G_

RE_ _ RV_ _ R

EAR_ _ Q_ AK_

SU_T__N_ _ L E

C_ _ SUM_ _ _ ON

PL_ _ TI_ _L

TEC_ _ _ _ OGY

_ OLLU_ _ _ T

EL _ _ _ _ICITY

C_PT_ _ E

2. Using a dictionary provide all the synonyms of the following words:

e.g. deposits – reserves, stock

fluid –

to emit –

shortage –

sequestration –

area –

reservoir –

3. Find 6 words across and 6 words down in the table:

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

4. Match notions with their definitions.

Word	**Definition**
1. Carbon	a) a glass building in which plants that need protection from cold weather are grown
2. Coal	b) substances that pollute the environment, especially gases from vehicles and poisonous chemicals produced as waste by industrial processes
3. Greenhouse	c) a machine for producing continuous power in which a wheel or rotor, typically fitted with vanes, is made to revolve by a fast-moving flow of water, steam, gas, air, or other fluid
4. Leakage	d) (especially of food, money, or some other resource) insufficient for the demand; occurring in small numbers or quantities; rare
5. Pollutants	e) a combustible black or dark brown rock consisting chiefly of carbonized plant matter, found mainly in underground seams and used as fuel
6. Renewable	f) a state or situation in which something needed

resources	cannot be obtained in sufficient amounts
7. Scarce	g) able to be maintained at a certain rate or level sustainable economic growth; (especially of development, exploitation, or agriculture) conserving an ecological balance by avoiding depletion of natural resources
8. Shortage	h) the accidental admission or escape of liquid or gas through a hole or crack
9. Sustainable	i) the chemical element of atomic number 6, a non-metal which has two main forms (diamond and graphite) and which also occurs in impure form in charcoal, soot, and coal
10. Turbine	j) natural resources such as wind, water, and sunlight, which are always available

5. *What are nouns of the following verbs?*

Verb	**Noun**	**Verb**	**Noun**
to store		to pollute	
to extract		to consume	
to absorb		to sustain	
to leak		to produce	

6. *Match parts of word combinations and use them in the sentences of your own:*

1) fossil	a) dioxide
2) coal	b) from the ground
3) greenhouse	c) effect
4) coal-fired	d) gas
5) to release	e) fuel
6) to extract	f) deposits
7) carbon	g) into the atmosphere

8) natural	h) plant

IV. Grammatical Tasks

1. *Consider the following sentence:*

e.g. One coal-fired electricity plant, for example, provides enough power for 500,000 homes but also releases as much pollution as 750,000 cars.

What tense form is used and what action does it denote?

Find other examples of the Present Simple Tense in the text and put them into the interrogative form.

e.g. How much energy DOES one coal-fired electricity plant PROVIDE?

2. *Find English equivalents of the following word combinations and use them in the sentences of your own in the Present Simple Tense.*

иметь что-то общее, глобальный энергетический микс, ископаемое топливо, глобальные запасы угля, уровень потребления, удалять загрязняющие вещества, обеспечивать достаточно энергии, изолирование карбона, смешивать с паром, дробить уголь, оснащать специальными абсорберами, поглощать диоксид карбона для накопления, фильтровать карбон для утилизации, закачивать в дно океана, покрывать пластом породы.

3. *Put the verbs in the correct forms.*

Coal _____ (to be) the most important fuel producing electricity around the world, but it _____ (to be) also the most controversial. As the greatest source of carbon dioxide of all fuels, environmentalists ____ (to say) it is critical to reduce the world's dependence on it in order to stem global warming.
Coal is primarily used as a fuel source for power; power plants ____ (to burn) coal to make steam, which then _____ (to turn) turbines. It is also used for metallurgical applications. The high temperatures created by the use of baked coal, known as coke, _____ (to give) steel its strength and flexibility. The paper and concrete industries also ____ (to use) coal in manufacturing. In a few places, particularly South Africa, gasification of coal _____ (to produce) synthetic fuels.

4. *Translate the following sentences:*

1. Запасы угля в мире достаточно обильны, а залежи нефти находятся в политически-нестабильных районах.
2. Учёные прогнозируют, что угля хватит ещё на 119 лет.
3. Многие страны стремятся уменьшить выбросы CO2 в атмосферу.
4. Технология чистого угля включает процессы, которые удаляют большинство загрязняющих агентов, когда уголь сжигается, превращая его в источник энергии, не загрязняющий окружающую среду.
5. Одна тепловая электростанция обеспечивает 500 000 домов, однако же и производит столько выбросов, сколько 750 000 машин.
6. Изолированный углекислый газ закачивают в дно океана или в резервуары для нефти и газа.

V. Discussion

1. Continue the sentence:

- Although coal is a fossil fuel …
- While oil is mostly found in unstable parts of the world, coal stocks …
- The largest reserves of coal are in…
- There is no coal shortage, but …
- Clean coal technology is a term used to describe...
- Typically, these CO2 streams are pumped into …
- Sites for storing carbon dioxide in this form must be …

2. *In what reference are these figures used in the text:* 46.2 and 56.8, 75, 249, 119, 500,000, 750,000.

3. Say if the statements are TRUE or FALSE and correct the FALSE ones:

- Oil is plentiful and can be found on every continent.
- Coal reserves are enough for 3000 years.
- Oil is plentiful in unstable parts of the world.
- Over 90 percent of global coal reserves are located in Russia, Ukraine and Poland.
- The nations of the world try to reduce their harmful emissions.

- Coal-fired plants release no harmful emissions.
- During the IGCC, coal is crushed and mixed with steam to produce a fluid that is clean of many pollutants such as sulfur and mercury.
- At the stage of extraction, huge amounts of carbon dioxide are released into the atmosphere. The extraction process is one of the major sources of greenhouse gas emissions.
- Sites for storing carbon dioxide in this form must be "on the surface."
- Earthquakes secure the storage areas.

4. Answer the following questions:

1. How is oil and coal distributed on the planet?
2. What are scientists' predictions as for the coal reserves?
3. What are the coal richest countries?
4. What does clean coal technology include?
5. What happens during the integrated gasification combined cycle?
6. What is a carbon capture method?
7. Where is carbon dioxide stored after capturing?
8. What do you think about clean coal technology? Can it be used in domestic coal-fired plants?

5. Look at the pictures below and discuss them with your partner.

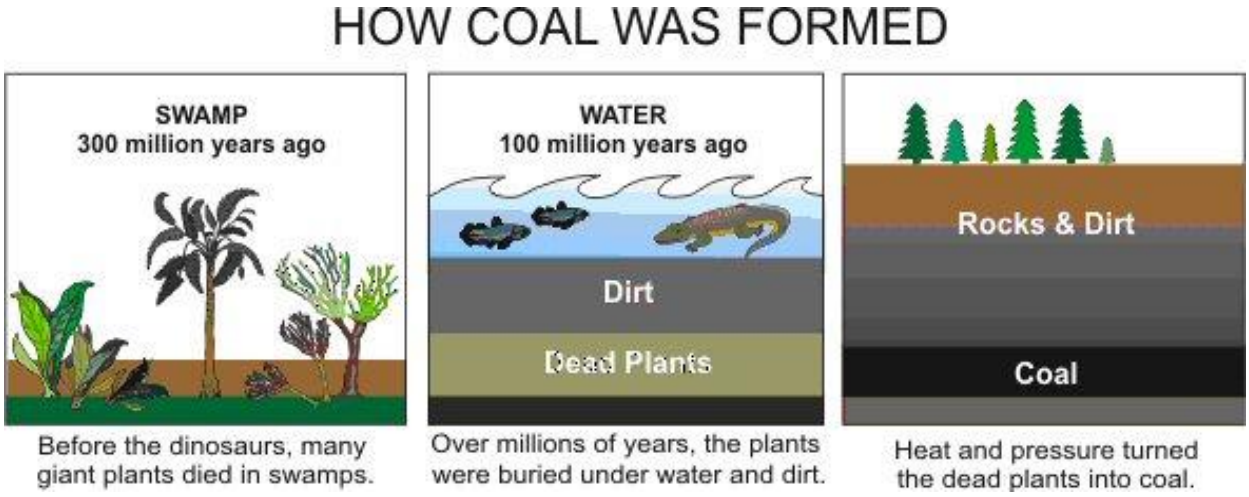


Fig.1. Coal Formation.

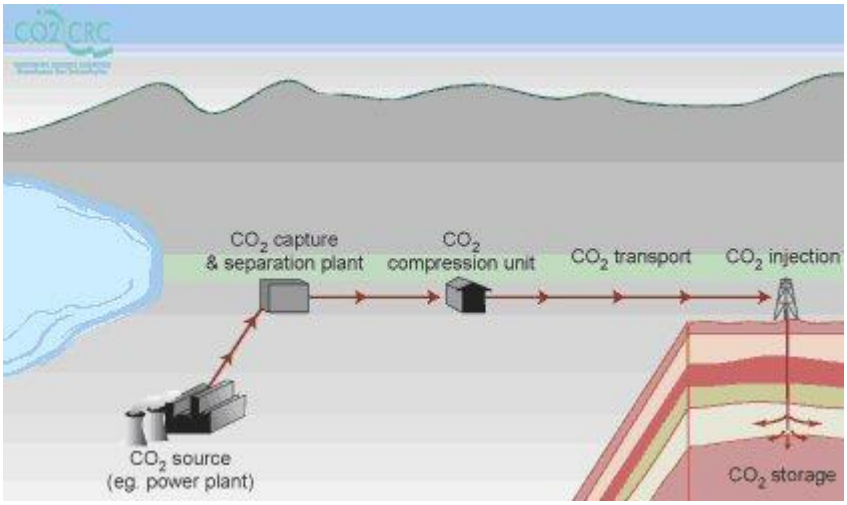


Fig.2. Clean Coal Technology.

Lecture 2. Solar Power

I. Text

Every hour the sun beams onto Earth more than enough energy to satisfy global energy needs for an entire year. Solar energy is the technology used to harness the sun's energy and make it useable. Solar power has experienced a boom since 2002. Energy from the sun's rays can be manipulated in many ways in order to perform a variety of functions. The most common means of capturing solar energy is the photovoltaic (PV) cell. These cells are made of silicon semiconductors that absorb sunlight and channel it, exciting the electrons contained in the chips to rapid motion and generating electricity.

When a collection of photovoltaic cells is encased in glass and installed, it is known as a solar panel. These panels can be connected to a battery for local usage and storage or to a larger electricity grid for distribution elsewhere. The world's leaders of grid-connected PV power are Germany, Spain, Japan, the United States, and Italy.

Efficiency and Storage Technology

There are two main problems of solar energy development: efficiency and storage technology. For all of solar energy's benefits, current methods of capturing sunlight are only between 14 percent and 20 percent efficient. New materials for making more efficient semiconductors are under development, but it remains unclear when or whether they will become commercially available.

Partially because of the poor efficiency, partially because of the unpredictability of weather conditions (clouds, storms, etc.), and partially because of the absence of sunlight at night, storage is a particularly important element of solar energy production. Battery technology must also continue to improve. There have been recent breakthroughs in which some solar cells reached a 40 percent conversion efficiency rate. Japanese and European companies are planning to achieve an efficiency rate of 45 percent. The problem now is the ability to efficiently store this energy.

Scalable Energy for Development

One of the unique benefits of solar energy is its scalability. Solar panels can be installed on a house-by-house basis and do not require the same level of capital investment as some other renewable technologies such as wind power.

This is an expensive proposition for any homeowner, but solar panels hold great potential for communities that are remotely located and widely dispersed. More than 2 million villages worldwide are without electric power for water supply, refrigeration, lighting and other basic needs. In developing nations, where kerosene is expensive and there is no national electricity grid, those who are self-installing solar panels in their houses and communities are saving much needed resources and money.

Despite the drawbacks, solar energy use has surged at about 20 percent a year over the past 15 years, thanks to rapidly falling prices and gains in efficiency. Solar electricity can pay for itself in five to ten years.

II. Vocabulary

Word	**Transcription**	**Translation**
battery	['bætərɪ]	батарея, аккумулятор
to beam	[biːm]	излучать, испускать (лучи)
breakthrough	['breɪkθruː]	прорыв, достижение
to channel	['ʧæn(ə)l]	проводить, направлять
commercially available	[ə'veɪləbl]	коммерчески доступный
conversion	[kən'vɜːʃ(ə)n]	превращение, изменение
current method of	['kʌr(ə)nt] ['meθəd]	современный метод
to disperse	[dɪ'spɜːs]	рассеивать, рассредоточивать
efficiency	[ɪ'fɪʃ(ə)n(t)sɪ]	эффективность
efficiency rate	[reɪt]	коэффициент эффективности
electricity grid	[grɪd]	энергетическая система
to encase in glass	[ɪn'keɪs]	помещать в стекло
to excite the electrons	[ɪk'saɪt] [ɪ'lektrɔn]	возбуждать электроны
to experience a boom	[ɪk'spɪərɪən(t)s]	переживать подъём

to generate electricity	['ʤen(ə)reɪt]	генерировать электричество
to harness energy	['hɑːnɪs]	приспосабливать, использовать энергию
to improve	[ɪm'pruːv]	улучшать
to install	[ɪn'stɔːl]	устанавливать
kerosene	['kerəsiːn]	керосин
lighting	['laɪtɪŋ]	освещение
to perform a variety of functions	[pə'fɔːm] [və'raɪətɪ] ['fʌŋkʃ(ə)n]	выполнять разнообразные функции
photovoltaic (PV) cell	[ˌfəʊtəʊvɒl'teɪɪk] [sel]	фотогальванический элемент
rapid motion	['məuʃ(ə)n]	быстрое движение
ray	[reɪ]	луч
refrigeration	[rɪˌfrɪʤ(ə)'reɪʃ(ə)n]	охлаждение
to satisfy energy needs	['sætɪsfaɪ] [niːdz]	удовлетворять потребности в энергии
to save resources	[seɪv] [rɪ'zɔːs]	сохранять ресурсы
scalability	[skeilə'biləti]	масштабируемость
silicon semiconductor	['sɪlɪkən] [ˌsemɪkən'dʌktə]	кремниевый полупроводник
solar panel	['səulə] ['pæn(ə)l]	солнечная батарея, панель
water supply	['wɔːtə] [sə'plaɪ]	водоснабжение

III. Lexical Tasks

1. *Find the synonyms of the following words.*

a beam –

to capture –

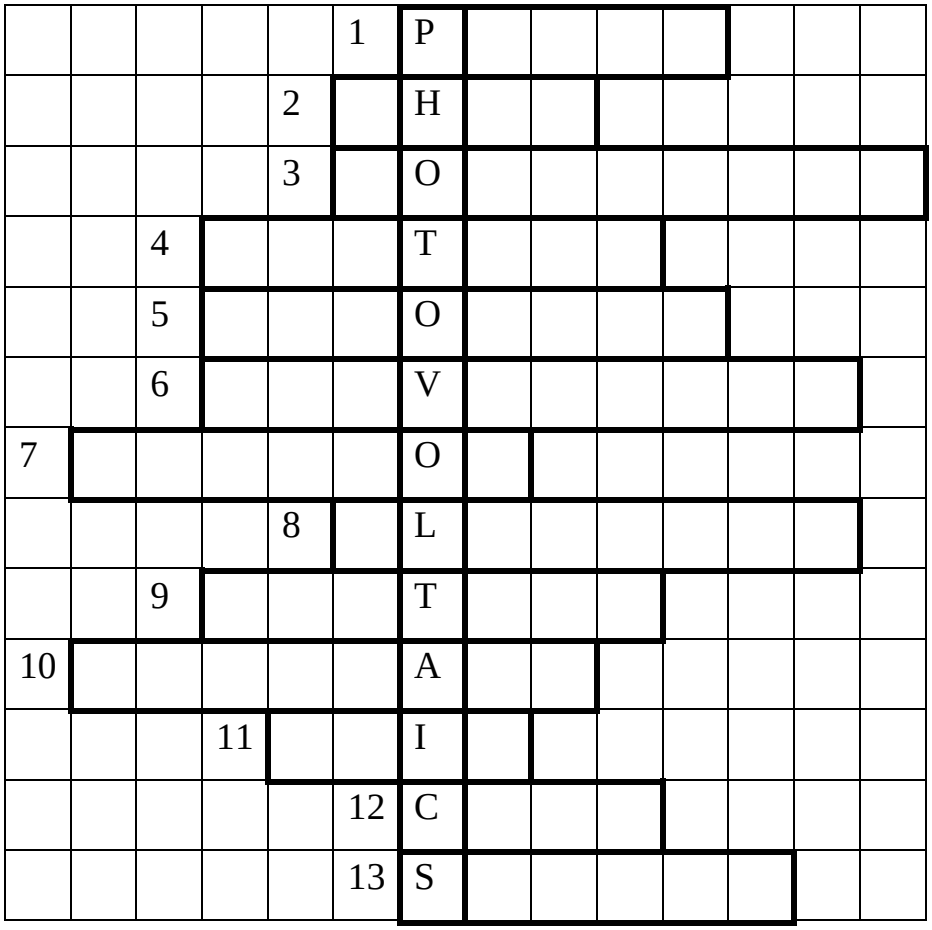
to absorb –

to channel –

to install –

to fall –

2. *Do the crossword puzzle.*



1) a typically rectangular piece of wood or glass forming or set into the surface of a door, wall, or ceiling;
2) a tiny wafer of semiconducting material used to make an integrated circuit;
3) a material or device that conducts or transmits heat or electricity, especially when regarded in terms of its capacity to do this;
4) place or fix (equipment or machinery) in position ready for use;
5) a country's collective means of supporting itself or becoming wealthier, as represented by its reserves of minerals, land, and other natural assets;
6) the process of changing or causing something to change from one form to another;
7) the chemical element of atomic number 14, a non-metal with semiconducting properties, used in making electronic circuits. It exists in a shiny dark grey crystalline form and as an amorphous powder;

8) a stable subatomic particle with a charge of negative electricity, found in all atoms and acting as the primary carrier of electricity in solids;
9) a container consisting of one or more cells, in which chemical energy is converted into electricity and used as a source of power;
10) produce (energy, especially electricity);
11) power system of the country;
12) a unit in a device for converting chemical or solar energy into electricity;
13) a stock or amount of something supplied or available for use.

3. Build words with the same root:

Verb	**Noun**	**Adjective**
to power	power	powerful
to conduct		
to absorb		
to store		
to produce		
to improve		
to scale		
to collect		
to generate		
to convert		
to renew		
to encase		
to develop		

4. Match parts of word combinations and use them in the sentences of your own.

1. solar	a) power
2. sun’s	b) electrons

3. a fast-growing	c) cell
4. to require	d) solar energy
5. silicon	e) grid
6. to install	f) market
7. electricity	g) rays
8. to excite	h) investment
9. to capture	i) on houses
10. photovoltaic	j) semiconductors

5. Fill the gaps with appropriate prepositions.

1. Solar power has experienced a boom _____ 2002. 2. The most common means _____ capturing solar energy is the photovoltaic (PV) cell. 3. These cells are made _____ silicon semiconductors that absorb sunlight and channel it. 4. These panels can be connected _____ a battery _____ local usage and storage. 5. Partially because _____ the poor efficiency, partially because _____ the unpredictability ____weather conditions storage is a particularly important element of solar energy production. 6. Battery technology must also continue _____ improve.

6. Fill the gaps with appropriate words.

atoms semiconductor photovoltaic generate spacecraft electrons

Many people are familiar with so-called _____ cells, or solar panels, found on things like _____, rooftops, and handheld calculators. The cells are made of _____ materials like those found in computer chips. When sunlight hits the cells, it knocks _____loose from their _____. As the electrons flow through the cell, they _____ electricity.

steam nuclear plants coal concentrate

Solar power _____use various techniques to _____the sun's energy as a heat source. The heat is then used to boil water to drive a _____ turbine that generates electricity in much the same fashion as _____ and _____ power plants.

storage inexhaustible collect expensive

Solar energy is an _____ fuel source that is pollution and often noise free. But solar energy doesn't work at night without a _____ device such as a battery, and cloudy weather can make the technology unreliable during the day. Solar technologies are also very _____ and require a lot of land area to _____ the sun's energy at rates useful to lots of people.

IV. Grammatical Tasks

1. *The text contains several examples of the Present Perfect Tense:*

e.g. Solar power has experienced a boom *since* 2002.

Find the other examples and make the sentences negative and interrogative.

2. *Open the brackets putting the verbs in the Present Perfect Tense.*

- I don't know what a solar panel is. I never (read) about it before.
- Where is that chip? – She just (take) it.
- Is he a good engineer? – Oh, yes! He (help) me a lot with the installation of PV cells.
- I know the storage technology perfectly well. I (write) a doctoral thesis about it.
- You (hear) of solar energy scalability? – I recently (study) this point.
- Mr Simons (not install) a solar panel on the rooftop yet.
- The sunlight already (excite) the electrons contained in the chips to rapid motion.
- Germany (become) a world leader in grid-connected PV power.
- There always (be) two main problems of solar energy development: efficiency and storage technology.
- This remotely located community (save) much needed resources and money after the installation of solar panels.

3. *Make questions in the Present Perfect Tense.*

to install/ solar panels

to be/ problem/ efficiency

to generate/ electricity

be under development/ semiconductors

to excite electrons/ sunlight

to encase/ in glass

to make efficient/ new materials

to harness/ sun's energy

to reach/ solar cells/ 40 percent/ efficiency rate

to connect/ a battery/ panels

4. Translate the following sentences using the Present Perfect Tense:

1. С 2002 года солнечная энергетика переживает расцвет.
2. Эта страна уже давно использует энергию солнца для разнообразных целей.
3. Фотогальванический элемент уже давно стал обычным способом утилизации солнечной энергии.
4. Солнечный свет привел электроны в движение, и батарея сгенерировала электричество.
5. Инженеры уже подключили солнечные панели к батарее для местного использования и накопления.
6. Они только что подключили солнечные панели к большей системе для рассредоточения электричества в другие места.
7. Недавно произошли инновационные прорывы, в которых некоторые солнечные элементы достигали 40% эффективности.
8. Германия, Испания, Япония, США и Италия стали мировыми лидерами в солнечной энергетике.
9. За последние 15 лет потребление солнечной энергии выросло на 20%.

V. Discussion

1. Answer the following questions.

When did solar energy become popular?

What is a photovoltaic cell? What is its construction?

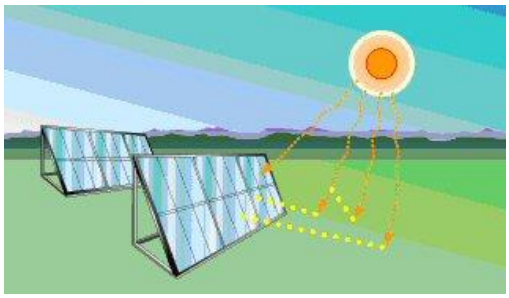
What is a solar panel?

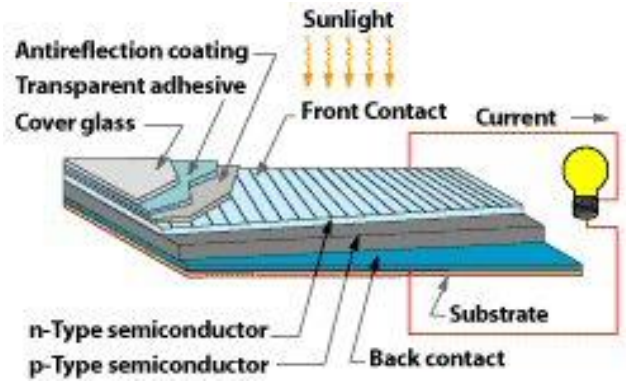
Which countries are leaders in photovoltaic power?

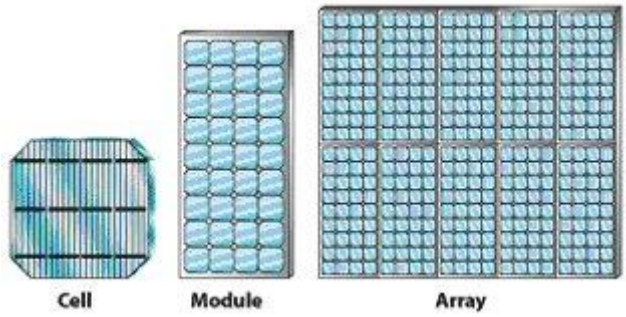
What are the two main problems of solar energy?

What are benefits and drawbacks of solar energy technology?

2. Comment on the organization of PV cells.







Lecture 3. Wind Power

I. Text

Wind has been harnessed to produce energy for hundreds of years. Windmills were used to catch air currents and translate that force into mechanical energy centuries ago. Today wind power is the second fastest growing energy source in the world. In 2011, 50 countries installed wind power capacity. The top five global producers of wind energy in 2011 were China, the United States, Germany, Spain, and India.

These days, wind power is used to produce electricity using turbines. Most of these turbines are oriented on a horizontal axis (HAWT) that have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.

Turbines used in wind farms for commercial production of electric power are usually three-bladed and pointed into the wind by computer-controlled motors. These have high tip speeds of over 320 km/h, high efficiency, and low torque ripple, which contribute to good reliability. The blades range in length from 20 to 40 metres or more. The blades rotate at 10 to 22 revolutions per minute.

Wind turbines built around a vertical axis (VAWT) have the main rotor shaft arranged vertically. With a vertical axis, the generator and gearbox can be placed near the ground, using a direct drive from the rotor assembly to the ground-based gearbox, hence improving accessibility for maintenance. When a turbine is mounted on a rooftop, the building generally redirects wind over the roof and this can double the wind speed at the turbine.

Key advantages of this arrangement are that the turbine does not need to be pointed into the wind to be effective. The key disadvantages include the low rotational speed with the higher torque and higher cost of the drive train, the lower power coefficient, the highly dynamic loading on the blade, etc.

Wind power generation facilities are generally land-based, though the number of offshore facilities has been rising in recent years, especially in Europe. Locating wind turbines offshore is more expensive, but it also allows for the construction of larger facilities and increases their capacity to generate power. Moreover, many of the best land locations are already occupied.

Despite its benefits, expanding wind power also has costs. The industrial materials and processes needed to build wind farms require a lot of conventional energy. However production costs for a turbine are recovered within six months of the start of operations.

There is also the problem of intermittency and storage. Wind energy is only as reliable as the wind itself. Wind farms require sophisticated methods of managing and storing energy.

More serious concerns about wind power center on its aesthetics and environmental/ecological impact. Some people consider wind turbines to be a form of "visual pollution".

Wind farms require far more territory than conventional power plants to produce the same amount of energy. Especially in more remote areas, this footprint can interfere with the local ecology, disrupting the habitats of both plants and animals.

In addition, the action of the blades on a turbine poses serious safety risks to birds, especially during the night.

II. Vocabulary

Word	**Transcription**	**Translation**
accessibility	[əkˌsesɪ'bɪlətɪ]	доступность
to arrange	[ə'reɪnʤ]	устраивать, располагать
arrangement	[ə'reɪnʤmənt]	расстановка, расположение
assembly	[ə'semblɪ]	монтаж, сборка
axis, pl. axes (horizontal, vertical)	['æksɪs] [ˌhɔrɪ'zɔnt(ə)l] ['vɜːtɪk(ə)l]	ось (горизонтальная, вертикальная)

blade	[bleɪd]	лопасть
capacity	[kə'pæsətɪ]	мощность, нагрузка
to catch air currents	['kʌr(ə)nt]	ловить потоки воздуха
conventional energy	[kən'ven(t)ʃ(ə)n(ə)l]	традиционная энергия
to couple with	['kʌpl]	соединять, сцеплять, связывать
direct drive	[dɪ'rekt]	прямая передача
to disrupt the habitat	[dɪs'rʌpt] ['hæbɪtæt]	нарушать ареал
to double	['dʌbl]	удваивать(ся)
to drive an electrical generator	[draɪv] [ɪ'lektrɪk(ə)l] ['ʤen(ə)reɪtə]	приводять генератор в действие
drive train	[draɪv] [treɪn]	цепь привода, кинематическая цепь
efficiency	[ɪ'fɪʃ(ə)n(t)sɪ]	эффективность
environmental/ ecological impact	[ɪnˌvaɪər(ə)n'ment(ə)l] [ˌi:kə'lɔʤɪk(ə)l] ['ɪmpækt]	экологическое воздействие, влияние
to expand	[ɪk'spænd]	расширять, увеличивать, развивать
facility (land-based; offshore)	[fə'sɪlətɪ] [lænd] [beɪst] [ˌɔf'ʃɔ:]	средства обслуживания, оборудование, приспособления, аппаратура
footprint	['futprɪnt]	след, отпечаток
gearbox	['gɪəbɔks]	редуктор
to interfere with	[ˌɪntə'fɪə]	вмешиваться, мешать, препятствовать
intermittency	[ˌɪntə'mɪtən(t)si]	перемежаемость
loading	['ləudɪŋ]	нагрузка
maintenance	['meɪnt(ə)nən(t)s]	техническое обслуживание

mechanical energy	[mɪ'kænɪk(ə)l] ['enədʒɪ]	механическая энергия
to mount	[maunt]	устанавливать, монтировать
to point into	[pɔɪnt]	направлять, наводить
power coefficient	['pauə] [ˌkəuɪ'fɪʃ(ə)nt]	коэффициент мощности
to range from…to	[reɪndʒ]	колебаться с …до
to recover costs	[rɪ'kʌvə]	покрывать расходы, издержки
to redirect	[ˌri:dɪ'rekt]	перенаправлять, переориентировать
reliability	[rɪˌlaɪə'bɪlətɪ]	надёжность
reliable	[rɪ'laɪəbl]	надёжный
remote area	[rɪ'məut] ['ɛərɪə]	отдалённая местность
revolution	[ˌrev(ə)'lu:ʃ(ə)n]	оборот
ripple	['rɪpl]	пульсации, колебания (небольшой амплитуды)
to rotate	[rəu'teɪt]	вращаться
rotation	[rə'teɪʃ(ə)n]	вращение
rotational speed	[rə'teɪʃ(ə)n(ə)l] [spi:d]	скорость вращения
sensor	['sɛnsə(r)]	сенсор, датчик
servo motor	['sɜ:vəu] ['məutə]	сервопривод
shaft	[ʃɑ:ft]	вал
tip speed	[tɪp] [spi:d]	окружная скорость
to translate… into	[trænz'leɪt]	преобразовывать
to turn …into	[tɜ:n]	превращать
torque	[tɔ:k]	вращающий момент
tower	['tauə]	вышка
turbine	['tɜ:baɪn]	турбина
vane	[veɪn]	лопасть, крыло, лопатка
visual pollution	['vɪʒuəl] [pə'lu:ʃ(ə)n]	визуальное загрязнение
wind farm	['wɪn(d)fɑ:m]	ветровая электростанция

windmill	['wɪn(d)mɪl]	ветряк, ветроустановка

III. Lexical Tasks

1. *Find 8 words across and 9 words down in the table.*

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

2. *Match notions with their definitions.*

axis, blade, coefficient, torque, rotor, wind farm, speed, gearbox

?	the flat, wide section of an implement or device such as an oar or a propeller
?	a force that tends to cause rotation
?	a place where windmills are used to convert the power of the wind into electricity.
?	the armature of an electric motor
?	a set of gears with its casing, especially in a motor vehicle; the transmission
?	the rate at which someone or something moves or operates or is able to move or operate
?	an imaginary line about which a body rotates
?	a multiplier or factor that measures a particular property

3. *Match parts of word combinations:*

1. energy	a) a rooftop
2. conventional	b) turbines
3. to require	c) a horizontal axis
4. ecological	d) loading
5. visual	e) sophisticated methods
6. wind	f) source
7. to orient on	g) impact
8. to range in	h) length
9. to mount on	i) pollution
10. power	j) energy
11. dynamic	k) coefficient

4. *Put in appropriate prepositions.*

- Windmills are used to catch air currents and translate that force ____mechanical energy.
- Most of these turbines are oriented ____a horizontal axis.
- Horizontal turbines must be pointed _____the wind.
- Large turbines generally use a wind sensor coupled _____ a servo motor.
- The blades rotate ____ 10 to 22 revolutions per minute.
- The blades range ____ length _____20____ 40 metres.
- When a turbine is mounted_____ a rooftop, the building generally redirects wind over the roof and this can double the wind speed at the turbine.
- Locating wind turbines offshore allows ____ the construction of larger facilities. Production costs for a turbine are recovered _____six months of the start of operations.
- Serious concerns _____ wind power center ____ its environmental impact.

5. *Fill the gaps with appropriate words.*

kinetic machinery device pumping charger electricity

A wind turbine is a_____ that converts _____ energy from the wind into mechanical energy. If the mechanical energy is used to produce _____, the device may be called a wind turbine or wind power plant. If the mechanical energy is used to drive_____, such as for grinding grain or _____water, the device is called a windmill or wind pump. Similarly, it may be referred to as a wind when _____used for charging batteries.

vertical shaft propellers electricity turbines blades

Most wind energy comes from_____ that can be as tall as a 20-story building and have three 200-foot-long (60-meter-long) _____. These contraptions look like giant airplane _____on a stick. The wind spins the blades, which turn a _____ connected to a generator that produces _____. Other turbines work the same way, but the turbine is on a _____axis and the blades look like a giant egg beater.

development free pollution operational renewable

Wind is a clean source of _____energy that produces no air or water _____. And since the wind is_____, _____costs are nearly zero once a turbine is erected. Mass production and technology advances are making turbines cheaper, and many governments spur wind-energy _____.

6. *Using a dictionary find synonyms of the following words.*

to harness –

to produce –

to translate –

to install –

shaft –

motor –

rotation –

speed –

blade –

to drive –

7. *Join words in one sentence.*

windmills mechanical energy	technological innovation costs of constructing	wind turbines energy capacity	to install global producers
a vertical axis to harvest winds	offshore facilities expensive	land-based locations to recover costs	rotor shaft a turbine

IV. Grammatical Tasks

1. *The text abounds in the passive voice forms. Find all the forms and comment on their tense:* Wind has been harnessed to produce energy for hundreds of years. (Present Perfect)
2. *Open the brackets using the Passive Voice forms.*

Wind turbines (design) to exploit the wind energy that exists at a location. Aerodynamic modelling (use) to determine the optimum tower height, control systems, number of blades and blade shape. Conventional horizontal axis turbines (can divide) into three components: the rotor component; the generator component; the structural support component.

The rotor (design) aerodynamically to capture the maximum surface area of wind in order to spin ergonomically. The gear box (situate) directly between the rotor and the generator. A rotor rotates the generator (which (protect) by a nacelle), as directed by the tailvane.

Vertical-axis wind turbines are a type of wind turbine where the main rotor shaft (set) vertically and the main components (locate) at the base of the turbine. Among the advantages of this arrangement are that generators and gearboxes (can place) close to the ground, VAWTs (can install) on roofs, along highways, in parking lots and (can scale) more easily – from milliwatts to megawatts.

3. *Change the following sentences from Active → Passive.*

e.g. Wind turbines convert the kinetic energy in the wind into mechanical power.
→ The kinetic energy in the wind is converted into mechanical power.

1. People can use mechanical power for specific tasks.

→_____

2. Since recorded history people have used wind power to move ships, grind grain and pump water.

→_____

3. The United States erected millions of windmills as the American West was developed during the late 19th century.

→_____

4. And while today, one associates windmills with the Netherlands where people use them for pumping water, it is in Denmark that wind is an effective source of energy.

→_____

5. In Chennai at the Centre for Wind Energy Technology, scientists do the research to check out various wind sites where they can tap wind energy.

→_____

6. The engineers also check wind turbines of various sizes.

→_____

7. The government says they will build windmills along the coast over the next two years.

→_____

8. As wind power becomes more popular, they will cover hills in Spain with windmills.

→_____

9. There are places in the world where wind power provides nearly all of the electric power used.

→_____

10. Sometimes a wind turbine will make no power at all.

→_____

4. *Translate the following sentences into English paying attention to the Passive Voice forms.*

Энергия ветра используется человечеством с давних пор. Ветряные мельницы для переработки зерна были разработаны ещё в средневековье. Считается, что первые ветряные мельницы были построены в Систане, где-то между современным Ираном и Афганистаном, между девятым и седьмым столетиями до н.э. и использовались как мельницы и насосы для воды. В последние годы энергия ветра всё шире применяется для получения электроэнергии. Создаются ветряки с высокой мощностью и устанавливаются на местности, где дуют частые и сильные ветра.

В Украине, например, действуют семь ветровых электростанций, оснащённых собственными ветроустановками. Среди разнообразных установок, которые преобразовывают энергию ветра в механическую работу, в большинстве случаев применяются лопастные машины с горизонтальным валом, установленным по направлению ветра. Намного реже используются установки в вертикальным валом.

Ветрогенетаторы можно условно разделить на две категории: промышленные и домашние (для частного использования). Промышленные устанавливаются государственными органами или большими энергетическими компаниями. Как правило, их объединяют в сеть.

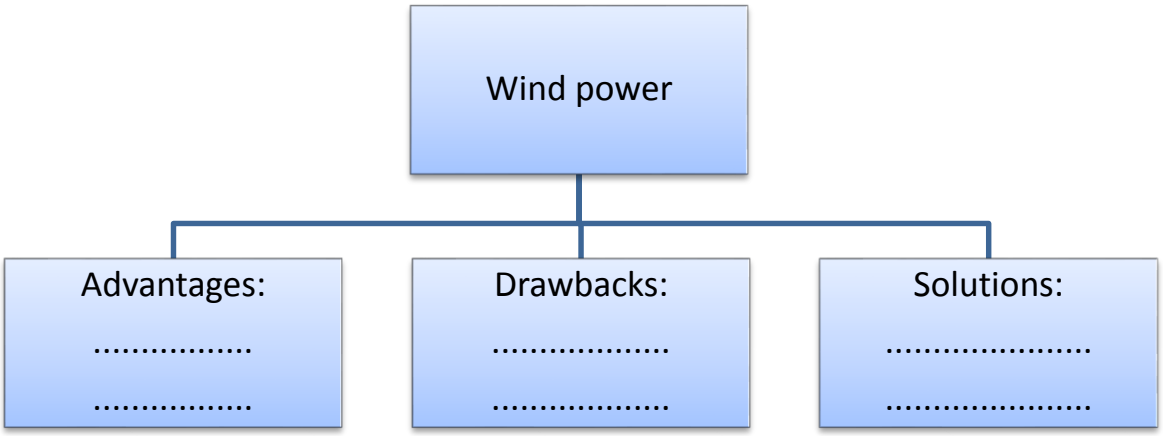
V. Discussion.

1. *Say if the statement is TRUE or FALSE and correct the FALSE ones.*

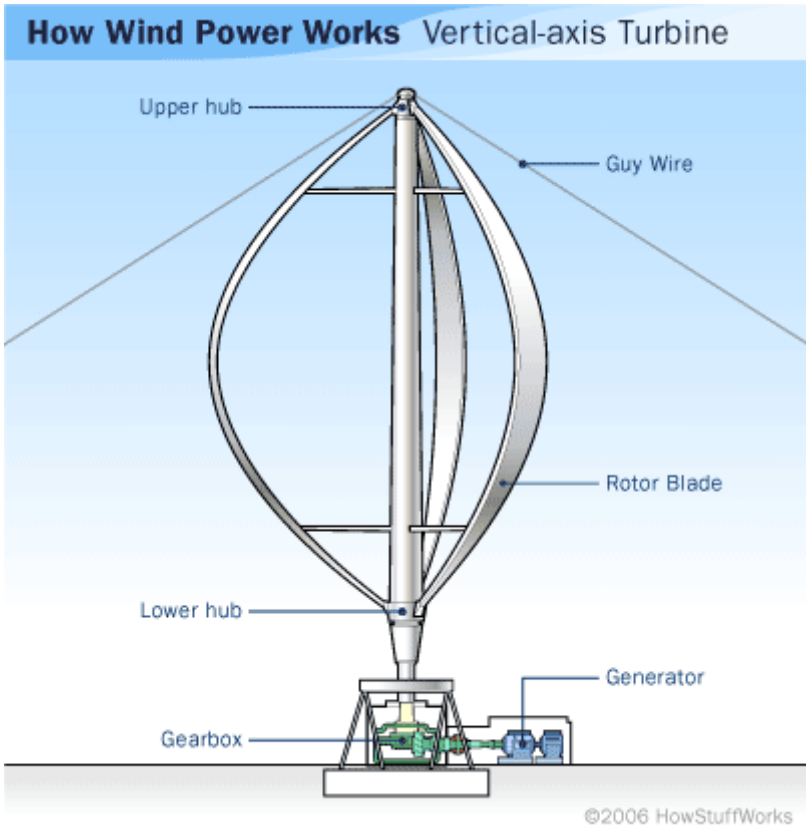
- The windmills catch air currents and translate that force into chemical energy.
- Today wind power is the slowest growing energy source in the world.
- The top five global producers of wind energy in 2010 were China, the United States, Germany, Spain, and India.
- Wind power generation facilities are generally offshore.
- Many of the best land locations are already occupied.
- Wind energy is the most reliable energy source.

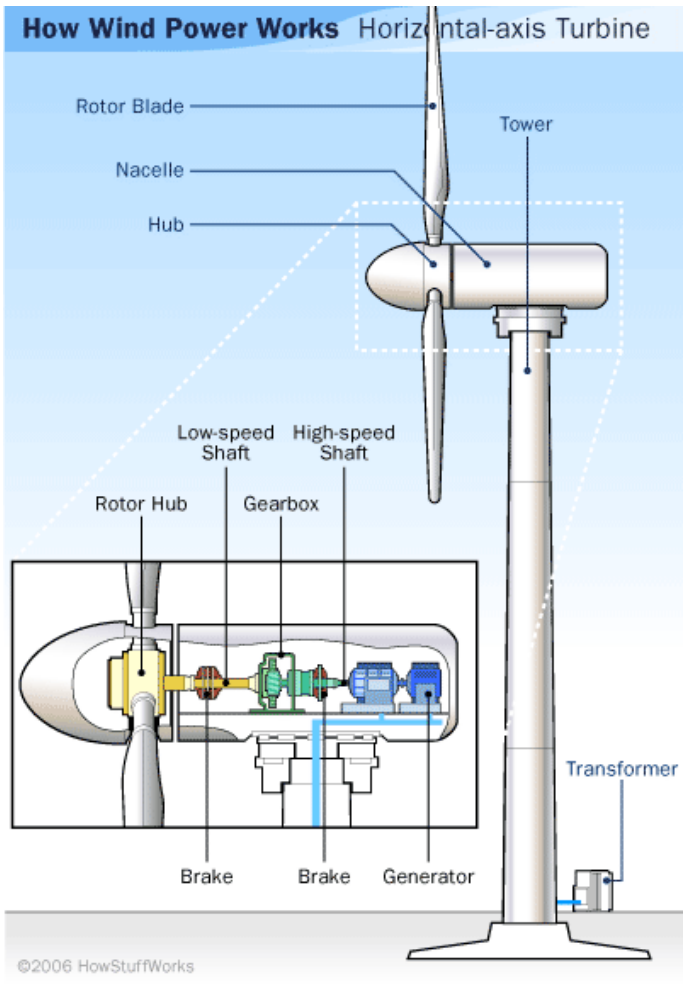
2. *Summarize each paragraph with one sentence and retell the text according to your summary.*

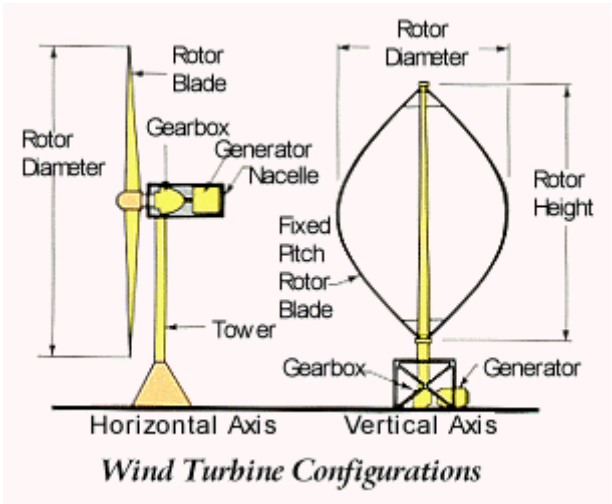
3. *Skip through the text and fill in the chart. Suggest your own ideas as for the solution of the emerging problems in the sphere of wind power.*



4. *Comment on the construction of horizontal and vertical axis wind turbines and on the mechanism of energy conversion.*







Wind Turbine Configurations

Lecture 4. Hydropower

I. Text

Hydropower (from hydro, meaning water) is energy that comes from the force of moving water. The fall and movement of water is part of a continuous natural cycle called the water cycle. Energy from the sun evaporates water in the Earth's oceans and rivers and draws it upward as water vapor. When the water vapor reaches the cooler air in the atmosphere, it condenses and forms clouds. The moisture eventually falls to the Earth as rain or snow, replenishing the water in the oceans and rivers. Gravity drives the water, moving it from high ground to low ground. The force of moving water can be extremely powerful.

A typical hydro plant is a system with three parts: an electric plant where the electricity is produced; a dam that can be opened or closed to control water flow; and a reservoir where water can be stored. The water behind the dam flows through an intake and pushes against blades in a turbine, causing them to turn. The turbine spins a generator to produce electricity.

The amount of electricity that can be generated is determined by two factors: head (the distance from the highest level of the dammed water to the point where it goes through the power-producing turbine) and flow (how much water moves through the system). Generally, a high-head plant needs less water flow than a low-head plant to produce the same amount of electricity which is then transported over long-distance electric lines to homes, factories, and businesses.

Hydroelectric power stations from over a few hundred megawatts to more than 10 GW are generally considered large hydroelectric facilities e.g. Three Gorges Dam in China. Small hydro is the development of hydroelectric power on a scale serving a small community or industrial plant with a generating capacity of up to 10 megawatts (MW). Micro hydro is a term used for hydroelectric power installations that typically produce up to 100 KW of power. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks. Pico hydro is a term used for hydroelectric

power generation of under 5 KW to power, for example, one or two fluorescent light bulbs and a TV or radio for a few homes.

Hydropower is the cheapest way to generate electricity today. No other energy source, renewable or nonrenewable, can match it. Once a dam has been built and the equipment installed, the energy source—flowing water—is free. Hydro plants are about 90 percent efficient at converting the kinetic energy of the moving water into electricity. It's a clean fuel source that is renewable yearly by snow and rainfall. Furthermore, hydro plants do not emit pollutants into the air because they burn no fuel. Hydropower is also readily available; engineers can control the flow of water through the turbines to produce electricity on demand. In addition, reservoirs may offer recreational opportunities, such as swimming and boating.

But damming rivers may destroy or disrupt wildlife and other natural resources. This may permanently alter river systems and wildlife habitats. Fish may be prevented from swimming upstream. Hydro plant operations may also affect water quality by churning up dissolved metals that may have been deposited by industry long ago. Hydropower operations may increase silting, change water temperatures, and lower the levels of dissolved oxygen.

II. Vocabulary

Word	**Transcription**	**Translation**
to affect water quality	[ə'fekt] ['wɔːtə] ['kwɔlətɪ]	влиять на качество воды
to alter river systems	['ɔːltə] ['rɪvə] ['sɪstəmz]	изменять системы рек
available	[ə'veɪləbl]	доступный
to burn fuel	[bɜːn] [fjuːəl]	сжигать топливо
capacity	[kə'pæsətɪ]	мощность
to churn	[ʧɜːn]	перемешивать, встряхивать
to condense	[kən'den(t)s]	конденсировать
to connect to electric	[kə'nekt] ['netwɜːk]	подключать к

power network		электрической сети
dam	[dæm]	дамба
demand	[dɪ'mɑːnd]	требование, спрос
to destroy, disrupt wildlife	[dɪ'strɔɪ] [dɪs'rʌpt] ['waɪldlaɪf]	разрушать, нарушать дикую природу
to determine	[dɪ'tɜːmɪn]	обуславливать, определять
to dissolve metals, oxygen	[dɪ'zɔlv] ['met(ə)lz] ['ɔksɪʤən]	растворять металлы, кислород
distance	['dɪst(ə)n(t)s]	расстояние
to emit pollutants	[ɪ'mɪt] [pə'luːt(ə)nt]	выделять загрязняющие агенты
to evaporate	[ɪ'væp(ə)reɪt]	испарять(ся)
fluorescent light bulb	[flɔː'res(ə)nt] [laɪt] [bʌlb]	флюоресцентная лапма
gravity	['grævɪtɪ]	сила тяжести, тяготение
head	[hed]	напор, высота напора
high-head (low-head) plant	[haɪ] [ləu] [hed] [plɑːnt]	высоконапорная (низконапорная) станция
hydropower	['haɪdrəu] ['pauə]	гидроэнергия
to increase silting	[ɪn'kriːs] [sɪltɪŋ]	усиливать заиливание
to install equipment	[ɪn'stɔːl] [ɪ'kwɪpmənt]	устанавливать оборудование
installation	[ˌɪnstə'leɪʃ(ə)n]	установка, устройство
intake	['ɪnteɪk]	впускное устройство
kinetic energy	[kɪ'netɪk] ['enəʤɪ]	кинетическая энергия
to lower	['ləuə]	понижать
moisture	['mɔɪsʧə]	влага
natural cycle	['næʧ(ə)r(ə)l] ['saɪkl]	природный цикл
(non) renewable	[rɪ'njuːəbl]	возобновляемый

to replenish	[rɪ'plenɪʃ]	пополнять
reservoir	['rezəvwɑː]	резервуар
scale	[skeɪl]	шкала
to serve a community	[sɜːv] [kə'mjuːnətɪ]	обслуживать сообщество, поселение
to spin	[spɪn]	вращать(ся), крутить(ся)
to transport over electric lines	[træn'spɔːt] ['əuvə] [ɪ'lektrɪk] [laɪnz]	передавать по линиям электропередач
to turn blades	[tɜːn] [bleɪdz]	вращать лопасти
vapour	['veɪpə]	пар, испарения
water cycle	['saɪkl]	круговорот воды
water flow	[fləu]	поток воды
wildlife habitat	['hæbɪtæt]	дикая среда обитания

III. Lexical Tasks

1. *Noughts and Crosses. Students are divided into two teams that take turns giving the definitions to the words in a 3×3 grid. The team who succeeds in defining three respective notions in a horizontal, vertical, or diagonal row wins the game.*

EVAPORATE	ELECTRIC LINE	CONDENSE
INTAKE	DAM	TURBINE
BLADE	RESERVOIR	GRAVITY

2. *Find the odd one out and explain your choice, providing its definition.*

e.g. to spin; to stop; to turn; to rotate. Stop is an odd word since it denotes *to break an action* while the rest of the verbs mean *to move in a circle round an axis or centre.*

a) to extract; to renew; to replenish; to restore
b) wildlife; nature; habitat; power plant
c) energy; power; dam; force
d) to affect; to dissolve; to influence; to impact
e) flow; stream; torrent; vapor
f) to absorb; to emit; to give off; to release
g) to alter; to change; to stabilize; to reform
h) to remove; to equip; to mount; to install
i) to lower; to decrease; to reduce; to rise
j) to serve; to demand; to provide; to supply

3. Match prefixes and suffixes with the roots to build words.

-ion (2); -ing; -able; -ful; -ment; re-; -ous; in-;-ure
move; continue; moist; power; take; generate; new; operate; silt

4. The text includes words which can be united into several groups. Distribute the words under the following headings.

General scientific vocabulary	*Energy*	*Water*
cycle, system…	hydropower, energy…	water; ocean…

5. Complete the sentences with the correct options a-c.

1. Hydropower is the most widely used form of _____ energy.

a) chemical; b) renewable; c) conventional

2. Hydropower accounts for 16 percent of global electricity_____.

a) generation b) consumption c) usage

3. Hydro is also a flexible source of electricity since plants can be ramped up and down very quickly to adapt to changing energy_____.

a) supplies b) dependency c) demands

4. Once a hydroelectric complex is constructed, the project produces no direct_____.

a) garbage b) waste c) litter

5. Hydropower plant has a considerably lower output level of the _____ gas carbon dioxide (CO_2) than fossil fuel powered energy plants.

a) greenhouse b) stove c) polluting

6. _____ created by hydroelectric schemes often provide facilities for water sports, and become tourist attractions themselves.

a) reservoirs b) places c) views

7. The dam places an artificial obstruction in a flowing waterway to create the pressure that turns a_____.

a) valve b) engine c) turbine

8. Today there are 556 hydropower plants in Switzerland that each have a_____ of at least 300 kilowatts.

a) frequency b) capacity c) voltage

9. Turbines and generators _____the energy into electricity, which is then fed into the electrical grid to be used in homes, businesses, and by industry.

a) reorganize b) adapt c) convert

6. *Put in appropriate prepositions and use these phrases in the sentences of your own.*

the force _____ moving water

to fall ____ the Earth as rain or snow

to move water ____ high ground ___ low ground

to be determined ____ two factors

to transport _____ long-distance electric lines

____ a scale

a generating capacity of ___ ___10 megawatts (MW)

to be efficient ___ converting the kinetic energy of the moving water ___ electricity

to emit pollutants ___ the air

to produce electricity ___demand

7. *Translate into English.*

Гидроэлектростанция – электростанция, которая при помощи гидротурбины преобразовывает кинетическую энергию воды в электроэнергию.

Принцип работы ГЭС достаточно прост. Цепь гидротехнических установок обеспечивает необходимый напор воды, который поступает на лопасти гидротурбины, которая приводит в действие генераторы, вырабатывающие электроэнергию.

ГЭС делятся в зависимости от мощности на:

мощные – вырабатывают от 25 МВт до 250 МВт и выше;

средние - до 25 МВт;

малые гидроэлектростанции - до 5 МВт.

Мощность ГЭС зависит от напора воды, а также от КПД используемого генератора. Из-за того, что по законам природы уровень воды постоянно изменяется, в зависимости от сезона и из-за ряда других причин, в качестве выражения мощности ГЭС принято брать циклическую мощность.

ГЭС также делятся в зависимости от максимального использования напора воды:

высоконапорные - свыше 60 м;

средненапорные - от 25 м;

низконапорные - от 3 до 25 м.

Ценность ГЭС состоит в том, что для выработки электрической энергии они используют возобновляемые источники энергии.

IV. Grammatical Tasks

1. *The text abounds in the examples of participial usage: both single participles and participial phrases. Fill the following table with the examples from the text.*

Participle I (Present)/ phrase	Participle II (Past)/ phrase
hydro, meaning water (phr.) moving water the moisture falls to the Earth, replenishing the water in the oceans and rivers (phr.)…	cycle, called the water cycle (phr.)…

2. *Choose the correct form of the participle and translate the text.*

Hydropower is considered/ considering the "granddaddy of green energy" because of its long and distinguishing/ distinguished history. Hydropower's most common incarnation is the dam, which places an artificial obstruction in a flowing/ flowed waterway to create the pressure that turns a turbine.

The first dam designed/ designing to produce electricity was built in Cragside, England in 1878. The United States soon followed suit, eventually experienced/ experiencing a boom in dam construction in the 1930s and 1940s that produced the famous Hoover and Grand Coulee dams.

The Three Gorges Dam in China will be the largest dam in the world, about five times the size of the Hoover Dam. However, protesters object to the fact that more than one million people in the surrounding/ surrounded environs have been displacing/ displaced and many more adversely affecting/ affected by flooding further up the Yangtze River directly caused/ causing by the changing water flows.

3. *Translate the following sentences paying special attention to the use of participles and participial phrases.*

1. Гидроэнегретика (от гидро, что значит «вода») – это энергия, происходящая от силы движущейся воды.
2. Вода за дамбой движется через впускное отверстие и толкает лопасти турбины, приводя её в движение.
3. Микрогидро – термин, использующийся для гидроэлектрических сооружений, обычно генерирующих до 100 КВ энергии.
4. Количество генерируемой энергии определяется двумя факторами: напором и потоком.

5. Гидроэлектростанции средней мощности обеспечивают электроэнергией изолированные здания или маленькие сообщества и могут быть подключёнными к линиям электропередач.
6. Выпадение и движение воды есть частью постоянного природного цикла, который называется круговоротом воды.
7. Влага выпадает на землю в виде снега или дождя, пополняя воду в океанах и реках.

4. *Complete the text about Pumped-storage Hydropower Stations with Participle I or Participle II.*

Pumped-storage hydroelectricity (PSH) is a type of hydroelectric power generation (use) by some power plants for load balancing. The method stores energy in the form of potential energy of water, (pump) from a lower elevation reservoir to a higher elevation. During periods of high electrical demand, the (store) water is released through turbines to produce electric power.

At times of low electrical demand, excess generation capacity is used to pump water into the higher reservoir. When there is higher demand, water is released back into the lower reservoir through a turbine, (generate) electricity.

(Take) into account evaporation losses from the (expose) water surface and conversion losses, approximately 70% to 85% of the electrical energy (use) to pump the water into the (elevate) reservoir can be regained. The technique is currently the most cost-effective means of storing large amounts of electrical energy on an (operate) basis, but capital costs and the presence of appropriate geography are critical decision factors.

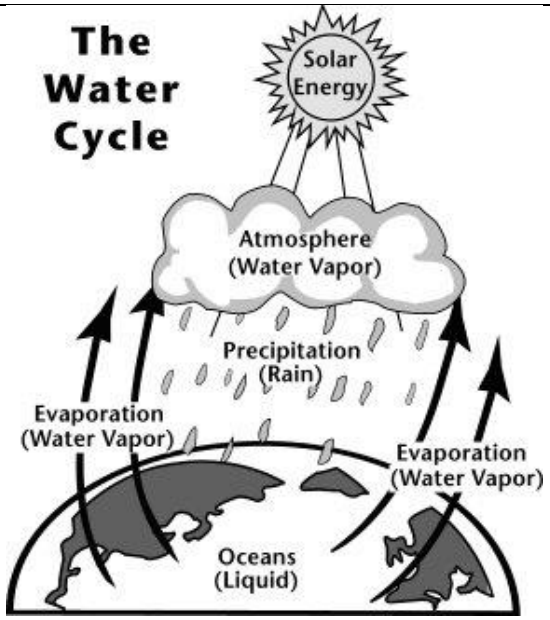
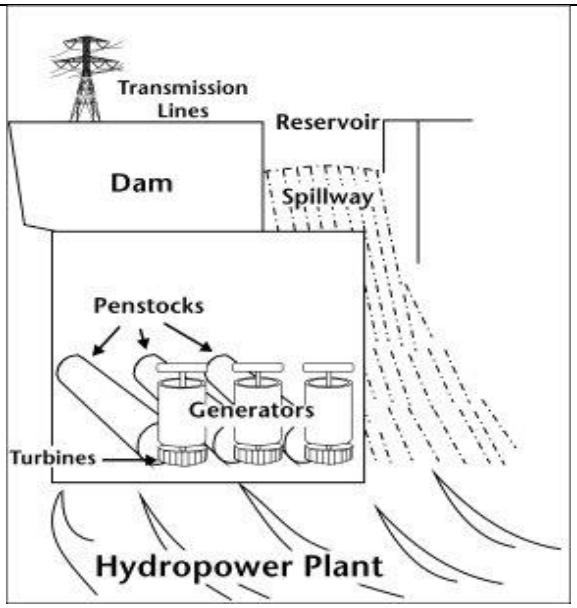
The relatively low energy density of pumped storage systems requires either a very large body of water or a large variation in height. The only way to store a significant amount of energy is by having a large body of water (locate) on a hill relatively near, but as high as possible above, a second body of water. In some places this occurs naturally, in others one or both bodies of water have been man-(make).

V. Discussion

1. *Consider the following subheadings and match them to the corresponding paragraphs.*

- advantages of hydropower stations;
- generating capacity;
- natural water cycle; 1
- drawbacks of damming rivers;
- hydro installations;
- factors determining electricity generation;

2. *Using the pictures below comment on the following aspects of hydropower:*

1) The water cycle	2) Hydropower plant operation
	

3. *Students are divided into two groups and act out a discussion. The first group concentrates on the advantages of hydropower; the second one focuses on its drawbacks.*

Lecture 5. Biofuel and Ethanol

I. Text

Biofuels come from recently living organisms as opposed to fossil fuels that are made from decomposed plants and animals that have been buried in the ground for millions of years. Biofuels can be manufactured from animals or their byproducts, but are usually made from plant matter. The highest profile biofuel in discussions about both globalization and the environment is ethanol.

Ethanol is another name for ethyl alcohol, a chemical compound produced from a wide variety of feedstocks including corn, sugar, and cellulosic materials such as switchgrass, straw, and plant waste. To produce ethanol, enzymes are first added to the feedstock to isolate the valuable sugars. This mixture is then combined with yeast, which causes the sugars to ferment and create a substance containing alcohol. This substance is distilled to raise the alcohol content to the 85-95 percent range.

Ethanol is by no means a recent discovery. At the start of the 20th century, Henry Ford planned to fuel his Model Ts with ethanol, and early diesel engines were shown to run on peanut oil. He also predicted that ‘ethyl alcohol is the fuel of the future.’ Rarely used on its own, ethanol typically serves as a fuel additive to gasoline. Combining ethanol with traditional fuels optimizes engine performance and enables fuel to burn cleaner, thus decreasing emissions of carbon monoxide and ozone. Ethanol can be mixed with gasoline to any percentage. Most existing car petrol engines can run on blends of up to 15% bioethanol with petroleum/gasoline. Ethanol has a smaller energy density than that of gasoline; this means it takes more fuel (volume and mass) to produce the same amount of work. An advantage of ethanol (CH_3CH_2OH) is that it has a higher octane rating than ethanol-free gasoline available at roadside gas stations, which allows an increase of an engine's compression ratio for increased thermal efficiency.

Countries around the world are using various kinds of biofuels. For decades, Brazil has turned sugarcane into ethanol, and some cars there can run on pure

ethanol rather than as additive to fossil fuels. And biodiesel—a diesel-like fuel commonly made from palm oil—is generally available in Europe.

On the face of it, biofuels look like a great solution. Cars are a major source of atmospheric carbon dioxide, the main greenhouse gas that causes global warming. But since plants absorb carbon dioxide as they grow, crops grown for biofuels should suck up about as much carbon dioxide as comes out of the tailpipes of cars that burn these fuels. And unlike underground oil reserves, biofuels are a renewable resource since we can always grow more crops to turn into fuel.

However, there are several factors that make ethanol's continued expansion problematic. The process of growing the crops, making fertilizers and pesticides, and processing the plants into fuel consumes a lot of energy. Also, because much of the energy used in production comes from coal and natural gas, biofuels don't replace as much oil as they use. Globally, powering all the world's vehicles with biofuels would mean doubling the amount of land devoted to farming. Another problem is high transportation cost. Ethanol corrodes the pipelines used to carry it and is therefore often diluted by water when traveling long distances. While it can be hauled by trucks, trains, or barges, cost dictates that it is mostly refined and consumed close to the main feedstock suppliers.

For the future, many think a better way of making biofuels will be from grasses and saplings, which contain more cellulose. Cellulose is the tough material that makes up plants' cell walls, and most of the weight of a plant is cellulose. If cellulose can be turned into biofuel, it could be more efficient than current biofuels, and emit less carbon dioxide.

II. Vocabulary

Word	**Transcription**	**Translation**
additive	['ædətɪv]	добавление, добавка
alcohol content	['ælkəhɔl] ['kɔntent]	содержание алкоголя
biofuel	[ˌbaɪəu'fjuːəl]	биотопливо
blend	[blend]	смесь

to bury	['berɪ]	закапывать, хоронить, зарывать
cell	[sel]	клетка (биол.)
cellulose	['seljuləus]	целлюлоза, клетчатка
chemical compound	['kemɪk(ə)l] ['kɔmpaund]	химическое соединение
to combine	[kəm'baɪn]	объединять, компоновать, соединять
compression ratio	[kəm'preʃ(ə)n] ['reɪʃɪəu]	коэффициент сжатия
to consume	[kən'sju:m]	потреблять, расходовать
to contain	[kən'teɪn]	содержать, вмещать
corn	[kɔ:n]	зерно, пшеница
to corrode	[kə'rəud]	ржаветь, корродировать
crops	[krops]	посевы
to decompose	[ˌdi:kəm'pəuz]	разлагаться, гнить
to decrease	[dɪ'kri:s]	уменьшать
diesel engine	['di:z(ə)l] ['endʒɪn]	дизельный двигатель
to dilute	[daɪ'lu:t]	разжижать, разбавлять
discovery	[dɪ'skʌv(ə)rɪ]	открытие
to distill	[dɪ'stɪl]	дистилировать, очищать
energy density	['enədʒɪ] ['den(t)sɪtɪ]	плотность энергии
enzyme	['enzaɪm]	энзим, фермент
ethanol, ethyl alcohol	['ɛθənɒl] ['eθɪl] ['ælkəhɔl]	этанол, этиловий спирт
feedstock	[‘fɪ:dstok]	сырьё
to ferment	[fə'ment]	вызывать брожение, бродить
fertilizer	['fɜ:tɪlaɪzə]	удобрение
to fuel	[fju:əl]	запрявлять топливом
gasoline	['gæs(ə)li:n]	газолин, бензин
grass	[grɑ:s]	трава

to include	[ɪn'klu:d]	включать в себя, содержать
to isolate	['aɪsəleɪt]	изолировать
to manufacture	[mænju'fækʧə]	производить, изготовлять
matter	['mætə]	вещество, материал
mixture	['mɪksʧə]	смесь, смешивание
monoxide	[mə'nɔksaɪd]	одноокись
octane rating	['ɔkteɪn] ['reɪtɪŋ]	октановое число
oil reserves	[ɔɪl] [rɪ'zɜ:vz]	запасы, резервы нефти
to optimize	['ɔptɪmaɪz]	оптимизировать
ozone	['əuzəun]	озон
palm oil	[pɑ:m] [ɔɪl]	пальмовое масло
peanut oil	['pi:nʌt] [ɔɪl]	арахисовое масло
performance	[pə'fɔ:mən(t)s]	исполнение, выполнение, работа, функционирование
pesticide	['pestɪsaɪd]	пестицид
petrol	['petr(ə)l]	бензин, газолин, моторное топливо
pipeline	['paɪplaɪn]	трубопровод
plant waste	[plɑ:nt] [weɪst]	растительные отходы
to power with smth	['pauə]	приводить в действие, движение; питать
to process	['prəuses]	обрабатывать
pure	[pjuə]	чистый, без примесей
to refine	[rɪ'faɪn]	очищати, рафинировати
to replace	[rɪ'pleɪs]	заменять, замещать
to run on	[rʌn]	работать на (топливе)
sapling	['sæplɪŋ]	побег, отводок
solution	[sə'lu:ʃ(ə)n]	решение, разрешение (проблемы)
straw	[strɔ:]	солома
substance	['sʌbst(ə)n(t)s]	вещество

sugar	['ʃugə]	сахар
sugarcane	['ʃugəˌkeɪn]	сахарный тростник
supplier	[sə'plaɪə]	поставщик
switchgrass	['switʃˌgras]	просо
tailpipe	['teɪlpaɪp]	всасывающая труба (насоса), выхлопная труба
thermal efficiency	['θɜːm(ə)l] [ɪ'fɪʃ(ə)n(t)sɪ]	тепловой КПД
to turn smth into smth	[tɜːn]	превращать в
vehicle	['viːɪkl]	транспортное средство
volume	['vɔljuːm]	объём
yeast	[jiːst]	дрожжи

III. Lexical Tasks

1. *Choose the correct meaning of the following verbs.*

- to decompose

make a choice from a number of alternatives

arrive at a specified place

make or become rotten; decay

- to bury

have or include (something) as a necessary or integral part or result

put or hide underground

control or maintain the rate or speed of (a machine or process) so that it operates properly

- to isolate

obtain or extract (a compound, micro-organism, etc.) in a pure form

become or make greater in size, amount, or degree

cause to cover a wider area; make larger

- to ferment

be in or assume a horizontal or resting position on a supporting surface

(of a substance) undergo fermentation

take (a liquid) into the mouth and swallow

- to distill

inform someone in advance of a possible danger, problem, or other unpleasant situation

make or manufacture from components or raw materials

purify (a liquid) by vaporizing it, then condensing it by cooling the vapor, and collecting the resulting liquid

- to discover

(of a living thing) undergo natural development by increasing in size and changing physically

find unexpectedly or during a search

behave so as to make it appear that something is the case when in fact it is not

- to optimize

lower the character or quality of

make the best or most effective use of (a situation or resource)

design or make a plan of (something to be made or built)

- to emit

produce and discharge (something, especially gas or radiation)

make (something) on a large scale using machinery

function in a specified manner

2. *Make up compound nouns and using a dictionary comment on each component.*

_____fuel

_____stock

_____grass

_____nut

_____oxide

_____side

_____cane

_____house

_____pipe

_____line

What does the root *bio* mean? Find 3 words from the text containing it.

3. Add the missing letters.

ET_ANOL

ETH_L

STR_W

GA_OLINE

RENE_ABLE

VE_ICLE

PESTI_IDE

DI_SEL

DEN_ITY

COR_ODE

P_PELINE

4. Match sentence halves and translate the sentences.

1. A biofuel is a fuel…	a) to energy security, greenhouse gas (GHG) emissions and rural development.
2. Biofuels can be made from…	b) the use of alternative feedstocks such as cellulosic feedstocks, including fast-growing, high-yielding energy grasses.
3. Biofuels can be used in vehicles…	c) that are on the road today, without engine modifications.
4. Biofuels done well make a positive contribution …	d) made from biomass – organic material with

	stored chemical energy.
5. Conventional biofuels are usually blended into…	e) fuel in small proportions (5-10%), providing useful, but limited, reductions in net greenhouse gas emissions.
6. Advanced biofuel conversion technology will enable…	f) plant materials such as sugarcane, corn, vegetable oils, agricultural residues, grasses, wood and algae.

5. *Put in the missing preposition and use the phrases in the sentences of your own.*

- to manufacture _____ animals or their byproducts
- to add _____ the feedstock
- to combine _____ yeast
- to fuel the Model Ts _____ ethanol
- to run _____ peanut oil
- to serve _____ a fuel additive
- emissions _____ carbon monoxide
- to turn sugarcane _____ ethanol
- _____ the face _____ it
- to dilute _____ water

6. *Translate the following sentences into English.*

Биотопливо – это топливо, которое получают из биологического сырья (сахарный тростник или семена кукурузы, сои). Могут также использоваться целлюлоза и разные типы органических отходов.

Биоэтанол – это обычный этанол, который получают путём переработки растительного сырья и используют как биотопливо. Существует два основных способа получения этанола – микробиологический и

синтетический. Результатом брожения является раствор, который содержит не более 15% этанола, поскольку в более концентрированных растворах дрожжи обычно погибают. Полученный таким образом этанол требует очищения и концентрирования, обычно путём дистилляции. В промышленных масштабах этиловый спирт получают из сырья, которое содержит целлюлозу (древесина, смола). Смесь, образовавшуюся в результате, подвергают спиртовому брожению. Этанол по сравнению с бензином является менее «энергонасыщенным» источником энергии.

IV. Grammatical Tasks

1. *The text contains sentences with modal verbs CAN/ COULD and SHOULD. Find all the forms of modal verbs and distribute them into the following columns.*

CAN/ COULD	SHOULD

2. *Change the following sentences into the negative and interrogative ones.*

- Sugar cane *should be used* immediately once juiced.
- After the initial inoculation of yeast, fermentation *should occur* completely within 48 hours.
- The fermented liquid, called “beer,” contains a low percentage of alcohol by volume, and *must go* through a distillation process to increase the percentage needed to produce a high-proof ethanol.
- Sugars for ethanol fermentation *can be obtained* from cellulose.
- Studies have estimated that ethanol and other biofuels *could replace* 30% or more of U.S. gasoline demand by 2030.
- In the US flex-fuel vehicles *can run* on 0% to 85% ethanol (15% gasoline) since higher ethanol blends are not yet allowed or efficient.

3. *Complete the following sentences with modal verbs CAN, MAY, MUST in the appropriate form and learn more about feedstock for biofuel.*

One of the wonderful things about biofuel is that you (можете сделать) it yourself. Alcohol fuel (может вырабатываться) on a very small scale.

With today's technology and the rising cost of agricultural products and energy, the traditional models of ethanol production, i.e., using corn-derived starch as a feedstock and natural gas as boiler fuel, (должны быть переоценены) with a critical eye.

In theory at least, most plants and agricultural products (могут быть использованы) as a feedstock. Some **crops** readily yield the simple sugars needed to make alcohol; others are **starches** and (должны быть разбиты) from their complex form to produce those sugars. Certain crops have a high yield per acre but (могут требовать) special harvesting equipment. Usable crops suitable for forage (можно вырастить) on marginal land, and still others are suitable for ethanol production.

Sugar beets tolerate a wide range of soil and climatic conditions and are widely cultivated. They are especially suited to cooler climates where other crops (не могут процветать).

Sugarcane (не может процветать) at temperatures below 45°F, so its potential as a small-scale ethanol crop in most of the US and Canada is limited.

Fruit crops (должны оцениваться) on an individual basis because of their potential market value for products other than alcohol.

Like sugar cane, the residual matter from sweet **sorghum** [сорго] (можно сжигать) as a heat source for ethanol processing.

4. *Translate the following sentences paying special attention to the use of modal verbs.*

a) Этанол можно производить из различного сырья: сахар, растительные отходы, солома, просо.

b) Для того, чтобы произвести этанол, ферменты необходимо добавить к растительному сырью, чтобы изолировать растительный сахар.

c) Это вещество необходимо дистиллировать, чтобы поднять содержание алкоголя до 85-95%.

d) Генри Форд предвидел, что этиловый спирт может быть топливом будущего.

e) Поскольку растения при росте абсорбируют углекислый газ, культуры, которые выращиваются для биотоплива, должны впитывать столько же углекислого газа, сколько выделяют выхлопные трубы машин, работающих на биотопливе.

f) Бразилия перерабатывает сахарный тростник в этанол, и некоторые машины там уже умеют работать на чистом этаноле, а не на добавлении его к ископаемому топливу.

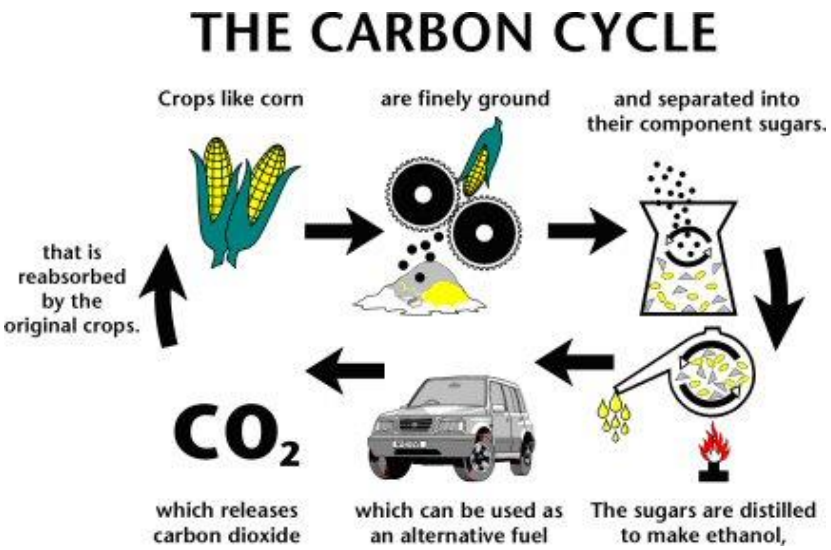
g) Биотопливо может казаться хорошим решением, поскольку это возобновляемый источник энергии и мы всегда можем вырастить больше культур для его получения.

h) Если целюлозу можно было бы перерабатывать в биотопливо, оно бы было более эффективным, чем многие современные виды биотоплива.

V. DISCUSSION

1. Put 10 questions based on the content of the text and retell it.

2. Analyze the scheme below showing the carbon cycle.



3. Comment on the advantages, drawbacks and perspectives of biofuels in detail. What is your opinion about the further development of biofuels?

Lecture VI. Hydrogen Power and Fuel Cells

I. Text

The potential of hydrogen as an alternative fuel source has been well-known for many years. Hydrogen is a naturally-occurring element that is found in abundance in many common chemicals, such as water. An atom of hydrogen consists of only one proton and one electron. Hydrogen is also found in many organic compounds, notably the hydrocarbons that make up many of our fuels, such as gasoline, natural gas, methanol, and propane. But hydrogen is difficult to obtain on its own. It must first be isolated using various processes. This is frequently done by passing an electrical current through water using a technique known as "reverse electrolysis" or by applying steam to natural gas using a process known as "reforming." The main benefits of hydrogen energy are that, when used as a fuel, it greatly simplifies the process of combustion and gives off completely clean emissions.

The great hope for hydrogen is that it could eventually supplant gasoline as a means of powering automobiles. In order to do so, hydrogen-based fuel would need to be stored in a fuel cell that would be incorporated into the car's engine design. A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. Fuel cells are often compared to batteries. Both convert the energy produced by a chemical reaction into usable electric power. However, the fuel cell will produce electricity as long as fuel (hydrogen) is supplied, never losing its charge.

There are several different types of fuel cell but they are all based around a central design. A fuel cell unit consists of a stack, which is composed of a number of individual cells. Each cell within the stack has two electrodes, called the cathode and the anode. The reactions that produce electricity take place at the electrodes. Every fuel cell also has either a solid or a liquid electrolyte, which carries ions from one electrode to the other, and a catalyst, which accelerates the reactions at the electrodes. The electrolyte plays a key role - it must permit only the appropriate ions to pass between the electrodes. If free electrons or other substances travel

through the electrolyte, they disrupt the chemical reaction and lower the efficiency of the cell.

The fundamental advantages common to all fuel cell systems include the following: **1.** A potential for a relatively high operating efficiency, scalable to all size power plants. **2.** If hydrogen is used as fuel, greenhouse gas emissions are strictly a result of the production process of the fuel stock used. **3.** No moving parts, with the significant exception of pumps, compressors, and blowers to drive fuel and oxidizer. **4.** Multiple choices of potential fuel feedstocks, from existing petroleum, natural gas, or coal reserves to renewable ethanol or biomass hydrogen production. **5.** A nearly instantaneous and remote recharge capability compared to batteries.

Potential applications of fuel cells can be grouped into four main categories: transportation, portable power, stationary power, and niche applications. Perhaps where fuel cells show the most promise for near-term implementation is in portable power applications, such as cell phones and laptop computers.

There are three major concerns about the current emphasis on hydrogen as a potential replacement fuel capable of meeting the world's transportation needs. First are cost and technological uncertainty. Although automotive fuel-cell applications have a great potential, they are also probably the least likely to be implemented on a large scale in the near future. The existing combustion engine technology has a comparatively low cost, high durability, high power density, suitability for rapid cold start, and high existing degree of optimization. The second major concern involves net energy gains since significant amounts of energy must be expended to transform hydrogen in a state in which it is consumable as fuel. Finally, and perhaps most important on a practical level, is the problem of delivery infrastructure. Existing pipelines could not be used because hydrogen is highly corrosive. Special modes of transmission and new fueling stations would have to be built.

II. Vocabulary

Word	Transcription	Translation
abundance	[ə'bʌndən(t)s]	изобилие, избыток
to accelerate	[ək'seləreɪt]	ускорять
to apply smth to smth; application	[ə'plaɪ] [ˌæplɪ'keɪʃ(ə)n]	применять, применение
anode	['ænəud]	анод
atom	['ætəm]	атом
blower	['bləuə]	вентилятор
capability, capable of	[ˌkeɪpə'bɪlətɪ] ['keɪpəbl]	способность, способный
to carry ions	['kærɪ] ['aɪənz]	переносить ионы
catalyst	['kæt(ə)lɪst]	катализатор
cathode	['kæθəud]	катод
charge	[ʧɑːʤ]	заряд
chemicals	['kemɪk(ə)lz]	химический реактив, продукт, химикат
chemical reaction	['kemɪk(ə)l] [rɪ'ækʃ(ə)n]	химическая реакция
cold start	[kəuld] [stɑːt]	холодный запуск двигателя
combustion engine	[kəm'bʌsʧ(ə)n] ['enʤɪn]	двигатель внутреннего сгорания
to compose	[kəm'pəuz]	составлять
compressor	[kəm'presə]	компрессор
degree of optimization	[dɪ'griː] [ˌɔptɪmaɪ'zeɪʃ(ə)n]	степень оптимизации
durability	[ˌdjuərə'bɪlətɪ]	продолжительность, длительность, износостойкость
electrical current	[ɪ'lektrɪk(ə)l] ['kʌr(ə)nt]	электрический ток
electrode	[ɪ'lektrəud]	электрод
electrolysis	[ˌelɪk'trɔləsɪs]	электролиз

electrolyte	[ɪ'lektrəlaɪt]	электролит
electron	[ɪ'lektrɔn]	электрон
fuel cell	[fjuːəl] [sel]	топливный элемент
fueling station	[fjuːəlɪŋ] ['steɪʃ(ə)n]	автозаправочная станция
hydrocarbon	[ˌhaɪdrəu'kɑːb(ə)n]	углеводород
hydrogen	['haɪdrədʒən]	водород
to implement, implementation	['ɪmplɪment] [ˌɪmplɪmen'teɪʃ(ə)n]	выполнять, осуществлять, реализация
to incorporate	[ɪn'kɔːp(ə)reɪt]	заключать, содержать в себе
instantaneous recharge	[ˌɪn(t)stən'teɪnɪəs] [ˌriː'ʧɑːdʒ]	мгновенная перезарядка
a means of smth	[miːnz]	способ
methanol	['mɛθənɒl]	метанол
mode of transmission	[məud] [trænz'mɪʃ(ə)n]	метод, способ передачи
niche	[nɪʃ]	ниша
oxidizer	['ɔksɪdaɪzə]	окисляющий компонент
portable	['pɔːtəbl]	портативный
propane	['prəupeɪn]	пропан
proton	['prəutɔn]	протон
pump	[pʌmp]	насос, помпа
reforming	[rɪ'fɔːmɪŋ]	риформинг
replacement	[rɪ'pleɪsmənt]	замена, замещение
reverse	[rɪ'vɜːs]	обратный, противоположный
to simplify	['sɪmplɪfaɪ]	упрощать
solid	['sɔlɪd]	твёрдый

stack	[stæk]	стопка, штабель
stationary	['steɪʃ(ə)n(ə)rɪ]	стационарный
suitability	[ˌs(j)uːtə'bɪlətɪ]	пригодность, приемлемость, допустимость
to supplant	[sə'plɑːnt]	вытеснять
technique	[tek'niːk]	техника, технический приём, метод, способ

III. Lexical Tasks

1. *Match notions with their definitions.*

anode	
blower	
combustion	a
electrolysis	
fuel cell	
ion	
propane	
pump	

a. the process of burning something;
b. an atom or molecule with a net electric charge due to the loss or gain of one or more electrons;
c. the positive electrode of a device;
d. an electrochemical device that continuously converts chemical energy into electric energy (and heat) for as long as fuel and oxidant are supplied;
e. a mechanical device using suction or pressure to raise or move liquids, compress gases, or force air into inflatable objects such as tyres;
f. a flammable hydrocarbon gas of the alkane series, present in natural gas and used as bottled fuel;

g. a mechanical device for creating a current of air used to dry or heat something;

h. chemical decomposition produced by passing an electric current through a liquid or solution containing ions;

2. Using the following key words give the definitions of the notions below.

Battery: a container, one or more cells, chemical energy, convert, electricity, a source of power.

Catalyst: substance, increases, chemical reaction, any permanent chemical change.

Electrical current: flow, electricity, ordered directional movement, charged particles.

Electrolyte: liquid, gel, to contain ions, to be decomposed, electrolysis.

To oxidize: to combine, oxygen.

3. Build nouns of the following verbs.

Verb	**Noun**	**Verb**	**Noun**
to abound		to combust	
to isolate		to emit	
to apply		to store	
to reform		to combine	
to simplify		to accelerate	
to oxidize		to compress	
to transport		to blow	
to implement		to replace	
to optimize		to deliver	
to consume		to suit	

4. Find antonyms of the following words.

alternative

abundance

reverse

to simplify

to produce

different

solid

to accelerate

remote

portable

5. *Translate the text below into English.*

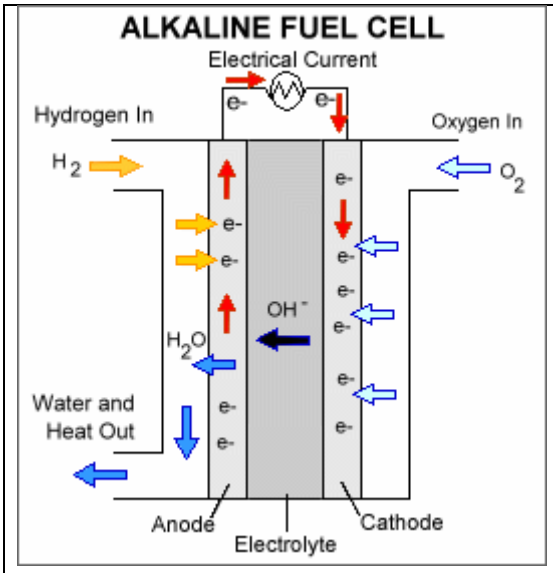
Топливный элемент — электрохимический генератор, который обеспечивает прямое преобразование химической энергии в электрическую. В отличие от традиционных электрических аккумуляторов, в которых происходят аналогичные преобразования, топливные элементы имеют две важные особенности: 1) они функционируют до тех пор, пока топливо и окислитель поступают из внешнего источника; 2) химический состав электролита в процессе работы не изменяется, то есть топливный элемент не нужно перезаряжать.

Возможны разные варианты комбинаций топлива и окислителя. Так, водородный топливный элемент использует водород в качестве топлива и кислород (обычно из воздуха) в качестве окислителя.

В топливных элементах идёт процесс, обратный электролизу. При этом водород и кислород соединяются химическим путём с выделением энергии и образованием воды.

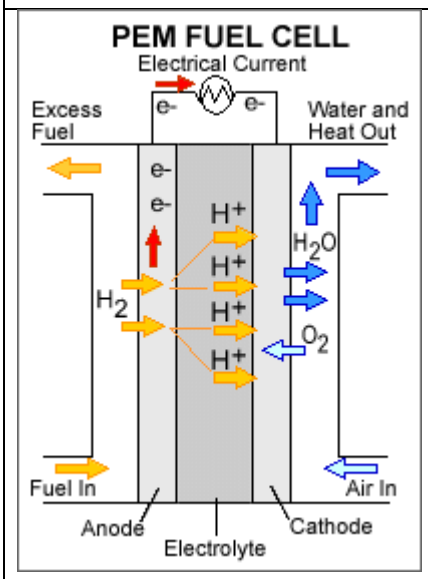
В Европе и Японии проходят испытания топливные элементы та твёрдом оксиде на автомобилях мощностью 100 кВт.

6. *Learn more about types of fuel cells filling the blanks with the suitable words.*



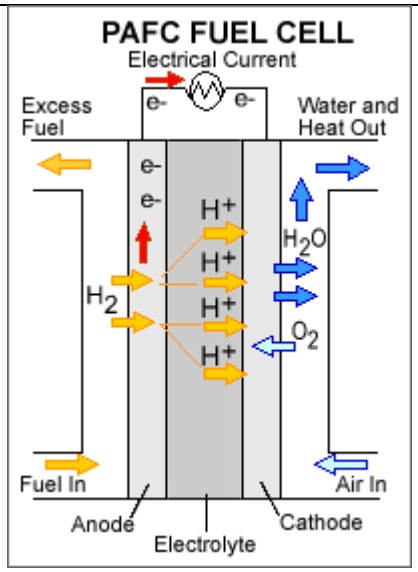
applications, hydrogen, fuel, power

alkaline fuel cell (AFC) A ____ cell that uses _____ fuel and can generate less than 5 kW of power. Because of its relatively low_____ output, the AFC is used in niche military and space_____.



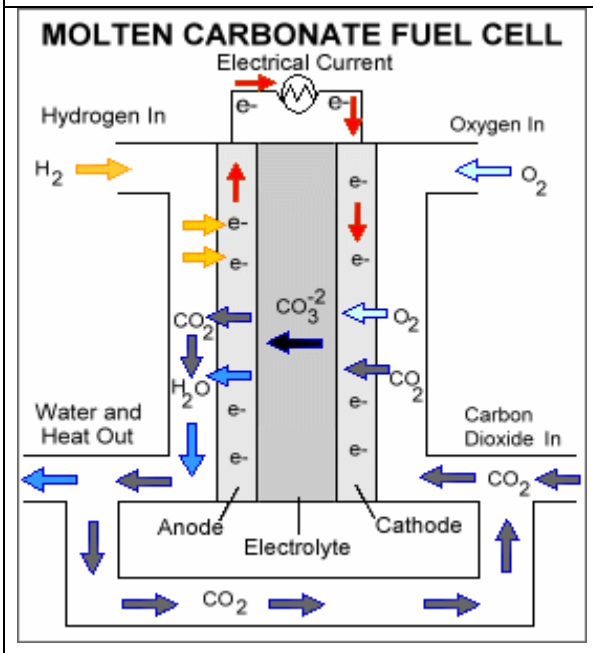
electrolyte, solid, plastic

proton exchange membrane fuel cell (PEMFC) a fuel cell that uses a _____ membrane as its_____. Also called _____ polymer fuel cell (SPFC).



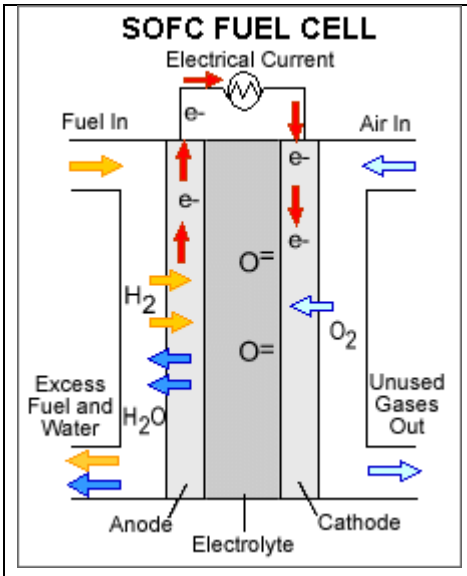
generate, acid, automotive, fuel

phosphoric acid fuel cell (PAFC) a fuel cell that uses hydrogen as_____, and phosphoric _____ as an electrolyte. It can _____ 5 to 250kW of power, and hence can be used in _____ applications.



potassium, used, various

molten carbonate fuel cell (MCFC) a fuel cell that uses _____ hydrocarbons as fuel, and lithium and _____ carbonate as an electrolyte. It can generate>200kWof power, and hence can be _____ in power generation.



oxide, hydrocarbons, electrolytes

solid oxide fuel cell(SOFC) a fuel cell that uses various _____ as fuel, and solid _____ _____. It can generate >200 kW of power, and hence can be used in power generation.

IV. Grammatical Tasks

1. *Group the subordinate clauses of the complex sentences from the text into the following types. Some of the types may not have examples from the text. Using the corresponding conjunction provide your own examples.*

Type of a subordinate clause	Conjunction or conjunctive word	Example
subject	that, if, whether, who, what, which, when, why, how	
predicative	that, if, whether, who, what, which, when, why, how	
attributive	that, who(m), which, whose, as, when, where	
object	that, who(m), which, whose, as, when, where	
adverbial clause of time	when, while, as, until, till, before, after, since, as soon as,	

	as long as	
adverbial clause of condition	if, in case, unless	
adverbial clause of concession	though, although, even if, even though	
adverbial clause of cause	because, as, since	
adverbial clause of place and direction	where	
adverbial clause of purpose	so that, that, in order that, lest	
adverbial clause of consequence (result)	that, so ... that, such ... that	
adverbial clause of comparison	than, as, as...as, not so (as)...as, as if and as though	
adverbial clause of manner	as, the way	

2. *Specify the types of complex sentences.*

- Fuel reformation technology must be advanced *if* a hydrocarbon fuel is to be used for hydrogen production.
- The cost of the catalyst no longer dominates the price of most fuel-cell systems, *although* it is still significant.
- A single cell can be made to achieve *whatever* current and power are required simply by increasing the size of the active electrode area and reactant flow rates.
- The current operating temperature of most SOFC systems is around 800–1000_C, *although* new technology has demonstrated 600_C operation, *where* vastly simplified system sealing and materials solutions are feasible.

- High electrolyte temperature is required to guarantee adequate ionic conductivity (of O2) in the solid-phase ceramic electrolyte and reduces activation polarization *so* much *that* cell losses are typically dominated by internal cell ohmic resistance through the electrolyte.
- *If* grid electricity is used, the hydrogen has a carbon footprint associated with it due to the coal or gas *that* must be burnt to produce the necessary electricity.
- However, *if* the electricity is obtained from renewable energy such as wind or solar power, the hydrogen can be produced in a completely carbon-free way.
- A major advantage of the MCFC compared to the PAFC is the lack of precious-metal catalysts, *which* greatly reduces the system raw material costs.
- Grove conducted a series of experiments *with what* he termed a gas voltaic battery, *which* proved *that* electric current could be produced from an electrochemical reaction between hydrogen and oxygen over a platinum catalyst.
- Portable fuel cells saw the most rapid rate of growth over the period since 2009 *as* increasing numbers of fuel cell educational kits were sold to consumers.

3. Match the subordinate clauses of a complex sentence and specify their types.

1. The term fuel cell was first used in 1889 by Charles Langer and Ludwig Mond,	a. *when* they are getting refueled.
2. Low temperature fuel cells (PEMFC, DMFC) have low heat transmission	b. then using fuel cells eliminates greenhouse gases over the whole cycle.
3. Unlike batteries, fuel cells have no "memory effect"	c. *since* there are few moving parts in the system.

4. The maintenance of fuel cells is simple	d. *where* there is water and a source of power, generation of fuel can be distributed and does not have to be grid-dependent.
5. *If* the hydrogen comes from the electrolysis of water driven by renewable energy,	e. *who* researched fuel cells using coal gas as a fuel.
6. *Since* hydrogen can be produced anywhere	f. *which* makes them ideal for military applications.

4. Translate the following into English.

1. Благодаря водородной энергетике новый вид топлива придёт на смену ископаемому топливу, *которое* сжигается в двигателях внутреннего сгорания и турбинах в качестве основного метода преобразования химической энергии в кинетическую или электрическую энергию.
2. Водородное топливо, *которое* используется сейчас в топливных элементах, обычно получается из парового риформинга метана, *хотя* подход может быть и более «зеленым», например, электролиз воды с использованием солнечной энергии.
3. *Если* топливные элементы будут иметь конкурентную цену по сравнению с двигателями внутреннего сгорания и турбинами, большие газовые электростанции могут внедрить эту технологию.
4. Необходимо различать так называемый водород «технического класса», *который* подходит для использования в топливных элементах, и водород «промышленного класса», *который* содержит серные примеси, но может изготавливаться более дешевым способом.
5. Для питания топливных элементов необходим водород высокой чистоты, *так как* примеси быстро выведут его из строя.

6. *Если* будет внедрён практический метод накопления водорода, а стоимость топливных элементов снизится, они могут стать экономически конкурентными по сравнению с автомобилями на

гибридных топливных элементах/батареях или на обычных двигателях.

V. Discussion

1. *Comment on the following points.*

a. Hydrogen as a fuel source. Its chemical composition.

b. Fuel cells vs. batteries.

c. Fuel cell design.

d. Electricity production within a fuel cell.

e. Advantages of fuel cells.

f. Main spheres of fuel cells application.

g. Major concerns of hydrogen fuel.

2. *Analyze the process of electricity generation within different types of fuel cells using the pictures from ex.6 and compare these types according to the chart below.*

Comparison of Fuel Cell Technologies

Fuel Cell Type	**Efficiency**	**Applications**	**Advantages**	**Disadvantages**
Polymer Electrolyte Membrane	60% transportation; 35% stationary	Backup power Portable power Distributed generation Transportation Specialty vehicles	Solid electrolyte reduces corrosion and electrolyte management problems; Low temperature; Quick start-up	Expensive catalysts; Sensitive to fuel impurities; Low temperature waste heat
Alkaline	60%	Military Space	Cathode reaction faster in alkaline electrolyte, leads to high performance;	Sensitive to CO2 in fuel and air; Electrolyte management

			Low cost components	
Phosphoric Acid	40%	Distributed generation	Increased tolerance to fuel impurities	Long start up time; Low current and power
Molten Carbonate	45-50%	Electric utility Distributed generation	High efficiency; Fuel flexibility; Can use a variety of catalysts	High temperature corrosion and breakdown of cell components; Long start up time; Low power density
Solid Oxide	60%	Auxiliary power Electric utility Distributed generation	High efficiency; Fuel flexibility; Can use a variety of catalysts; Solid electrolyte; Hybrid cycle	High temperature corrosion and breakdown of cell components; High temperature operation requires long start up time and limits

Additional Texts for Home Reading

Text 1 (Lecture 1). Coal

Coal is a dark brown to black sedimentary rock derived primarily from the unoxidized remains of carbon-bearing plant tissues. It is a complex, combustible mixture of organic, chemical, and mineral materials found in strata, or ‘‘seams,’’ in the earth, consisting of a wide variety of physical and chemical properties.

The principal types of coal, in order of metamorphic development, are lignite, subbituminous, bituminous, and anthracite. While not generally considered a coal, peat is the first development stage in the ‘‘coalification’’ process, in which there is a gradual increase in the carbon content of the fossil organic material, and a concomitant reduction in oxygen.

Coal substance is composed primarily of carbon, hydrogen, and oxygen, with minor amounts of nitrogen and sulfur, and varying amounts of moisture and mineral impurities.

Partial removal of impurities in coal such as ash and pyritic sulfur has been conducted since before 1900, although application and development has intensified during recent years owing to a number of factors, including the tightening of emissions standards, increasing use of lower quality seams, and increasing use of continuous mining machinery. Blending of two or more fuels to meet tight emissions standards, or other reasons, often requires that each of the fuels is of a consistent grade, which in turn may indicate some degree of coal cleaning.

Coal cleaning may be accomplished by physical or chemical means, although physical coal cleaning is by far the most predominant.

Primarily, physical processes rely on differences between the specific gravity of the coal and its impurities. Ash, clay, and pyritic sulfur have a higher specific gravity than that of coal.

The predominant commercial methods of coal cleaning use gravity separation by static and/or dynamic means. The extent and cost of cleaning naturally depends on the degree of end product quality desired, the controlling factors of which are

primarily sulfur, heating value, and ash content. Although dry means may be used for gravity separation, wet means are by far the more accepted and used techniques.

The first step in designing a preparation plant involves a careful study of the washability of the coal. ‘‘Float and sink’’ tests are run in a laboratory to provide data to be used for judging application and performance of cleaning equipment. In these tests the weight percentages and composition of materials are determined after subjecting the test coal to liquid baths of different specific gravities.

Text 2 (Lecture 2). What is Photovoltaics

Photovoltaics is the technology that generates direct current (DC) electrical power measured in Watts (W) or kiloWatts (kW) from semiconductors when they are illuminated by photons. As long as light is shining on the solar cell (the name for the individual PV element), it generates electrical power. When the light stops, the electricity stops.

Solar cells never need recharging like a battery. Some have been in continuous outdoor operation on Earth or in space for over 30 years.

What is the physical basis of PV operation? Solar cells are made of materials called semiconductors, which have weakly bonded electrons occupying a band of energy called the *valence band*. When the solar cell is exposed to sunlight, photons hit valence electrons, breaking the bonds and pumping them to the conduction band. There, a specially made selective contact that collects conduction-band electrons drives such electrons to the external circuit. The electrons lose their energy by doing work in the external circuit such as pumping water, spinning a fan, powering a sewing machine motor, a light bulb, or a computer. They are restored to the solar cell by the return loop of the circuit via a second selective contact, which returns them to the valence band with the same energy that they started with. The movement of these electrons in the external circuit and contacts is called the *electric current*.

Silicon (Si), one of the most abundant materials in the Earth's crust, is the semiconductor used in crystalline form (c-Si) for 90% of the PV applications today. Surprisingly, other semiconductors are better suited to absorb the solar energy spectrum. These other materials are in development today. Solar cells may operate under concentrated sunlight using lenses or mirrors as concentrators allowing a small solar cell area to be illuminated with the light from larger area. This saves the expensive semiconductor but adds complexity to the system.

Advantages and disadvantages of photovoltaics

Advantages of photovoltaics	Disadvantages of photovoltaics
Fuel source is vast and essentially infinite	Fuel source is diffuse (sunlight is a relatively low-density energy)
No emissions, no combustion or radioactive fuel for disposal (does not contribute perceptibly to global climate change or pollution)	
Low operating costs (no fuel)	High installation costs
No moving parts (no wear)	
Ambient temperature operation (no high temperature corrosion or safety issues)	
High reliability in modules (>20 years)	Poorer reliability of auxiliary (balance of system) elements including storage
Modular (small or large increments)	
Quick installation	
Can be integrated into new or existing building structures	
Can be installed at nearly any point-of-Use	Lack of widespread commercially available system integration and installation so far

Daily output peak may match local demand High public acceptance Excellent safety record	Lack of economical efficient energy storage

Text 3 (Lecture 3). Wind Power

The first use of wind power was to sail ships in the Nile some 5000 years ago. The Europeans used it to grind grains and pump water in the 1700s and 1800s. The first windmill to generate electricity in the rural U.S.A. was installed in 1890. Today, large wind-power plants are competing with electric utilities in supplying economical clean power in many parts of the world.

The average turbine size of the wind installations has been 300 kW until the recent past. The newer machines of 500 to 1,000 kW capacity have been developed and are being installed. Prototypes of a few MW wind turbines are under test operations in several countries, including the U.S.A.

Major factors that have accelerated the wind-power technology development are as follows:

• high-strength fiber composites for constructing large low-cost blades.

• falling prices of the power electronics.

• variable-speed operation of electrical generators to capture maximum energy.

• improved plant operation, pushing the availability up to 95 percent.

• economy of scale, as the turbines and plants are getting larger in size.

• accumulated field experience (the learning curve effect) improving the capacity factor.

The wind turbine captures the wind's kinetic energy in a rotor consisting of two or more blades mechanically coupled to an electrical generator. The turbine is mounted on a tall tower to enhance the energy capture. Numerous wind turbines are installed at one site to build a wind farm of the desired power production capacity. Obviously, sites with steady high wind produce more energy over the year.

Two distinctly different configurations are available for the turbine design, the horizontal axis configuration and the vertical axis configuration. The vertical axis machine has the shape of an egg beater, and is often called the Darrieus rotor after its inventor. It has been used in the past because of specific structural advantage. However, most modern wind turbines use horizontal-axis design. Except for the rotor, all other components are the same in both designs, with some difference in their placement.

The wind energy stands out to be one of the most promising new sources of electrical power in the near term. Many countries promote the wind-power technology by national programs and market incentives. The International Energy Agency (IEA), with funding from 14 countries, supports joint research projects and information exchange on wind-power development.

Text 4 (Lecture 4). Pumped Storage. Variable Solutions

Pumped storage projects are often the most efficient way of storing large amounts of electrical energy at acceptable costs.

In conventional pumped storage power stations, a salient pole synchronous motor-generator is coupled either to a separate pump and turbine or to a reversible pump turbine. The arrangement can be horizontal or vertical. Because the rotational direction of a separate pump and turbine arrangement is the same in both operation modes, this setup allows for a more rapid change from turbine to motor operation mode or vice versa. It is however more complex and leads to longer shaft arrangements resulting in higher costs, especially if the power station is located in a cavern.

In variable speed power stations static frequency converters are used to vary the speed of the electrical machine. For installations with a power lower than approximately 50MW, this can be realized using conventional synchronous generators linked to the grid by a static frequency converter. For larger units, this solution would be more difficult to justify economically. For units larger than

50MW, double fed induction machines with a static frequency converter feeding the rotor are the preferred solution.

The basic principle of the double fed induction machine consists in the creation of a rotating field on the rotor allowing the machine to be operated within a certain speed range around the synchronous speed. The relative difference in speed is called slip.

Usually, the slip range is within +- 10%. In first realizations of variable speed pumped storage projects, Cyclo converters were used to create the rotating field on the rotor. Cyclo converters are direct converters and, consequently, absorb reactive power. This power needs to be compensated by condensers or provided by the generator. Furthermore, the frequency range of such converters is limited. They cannot be used to start the unit in pump mode, which means an additional static frequency converter needs to be used to start the unit. Cyclo converters using Thyristors are a robust technology proven for many years. More recently, improvements in the power ratings of IGBTs and IGCTs allow for the construction of large voltage source inverters. This kind of static frequency converter is used in other applications like steel lamination production and can now be used instead of Cyclo converters. These converters do not absorb reactive power. Furthermore, they can be used to start the motor in pump mode. For this purpose the stator is short-circuited and a rotating field of increasing frequency is injected into the rotor.

The main advantage of variable speed is that the power absorbed in pumping mode can be varied over a certain range. Depending on the given head, the power absorbed from the network can be varied by approximately 30%. This gives the operator of the power station the possibility to contribute to the grid frequency regulation even in pump mode. In conventional pumped storage plants frequency regulation is only possible in turbine mode, which is economically interesting if the power demand is high. If power demand and prices are low, however, it is preferable to deliver the same service (frequency regulation) in pump mode to the grid operator while filling the upper reservoir.

Text 5 (Lecture 5). Ethanol Fuel

Cold-Weather Starting

Probably the single biggest issue facing ethanol fuel users is that engines have difficulty starting in temperatures below about 35°F to 50°F. The causes are related to ethanol's flash point and latent heat of vaporization. Both are significantly higher for ethanol than they are for gasoline, so in effect alcohol fuel is less volatile, which can induce starting difficulties in cold conditions.

Even gasoline itself isn't immune to this phenomenon, and in fact pump gas is "blended" for winter use by adding more volatile substances such as methyl butane in cold climates.

The common resolution to this problem is to start the vehicle on something other than ethanol—usually gasoline, though other, more aromatic fuels such as ether and propane can also be used. The booster fuel doesn't need to stay in the system long, just enough to kick the engine over. Once the engine is running, there's enough heat generated to vaporize ethanol sufficiently until it reaches operating temperatures, at which point the vehicle runs normally.

Slightly more sophisticated is a system in which the ethanol is preheated at the carburetor or manifold by an electric element, which eliminates the need for a separate starting fuel.

Before moving on, it's worth mentioning that the E-85 ethanol fuel blend sold at service station pumps — 85 percent gasoline and 15 percent ethanol — has enough gasoline in it to start an engine in cold weather without the help of cold-starting aids. Manufacturer-built Flex Fuel vehicles (FFVs, for which the fuel was developed) and converted vehicles alike can use E-85 without using cold-starting systems.

Corrosion and Degradation

Certainly, the ability of ethanol to corrode metal parts and degrade soft components such as fuel lines, seals, diaphragms and so forth is a legitimate concern. Fortunately, the corrosive effects of ethanol are related to its water content.

There are two important points to keep in mind. First, low-proof ethanol is the real culprit when it comes to corrosion. Though it's true that many engines—particularly carbureted types — will run on 160-proof ethanol, their components are still prone to deterioration over time. The movement of ions in the water carries a current that's capable of slowly dissolving metals such as aluminum alloys or zinc. These problems effectively go away when the water content in ethanol falls below 5 percent, the equivalent of 190-proof. Secondly, much of the reputation for corrosion that alcohol has gained over the years is erroneously attributed to ethanol when it is *methanol*, the toxic race fuel and octane-enhancer that is notoriously corrosive.

Text 6 (Lecture 6). Life Cycle Assessment of Hydrogen Fuel Cell and Gasoline Vehicles

The transportation sector is a significant contributor to major environmental concerns such as global warming, greenhouse gas (GHG) emissions, and climate change. The technology which provides a potential solution to major environmental concerns arising from the transportation sector is often referred to as polymer electrolyte membrane (PEM) fuel cell. However, to validly assess an emerging technology like PEM fuel cell-powered vehicle, the methodology must consider the total system over its entire life cycle. The LCA [life cycle assessment] of a vehicle technology can be classified into two major cycles, referred to as the "fuel cycle" and the "vehicle cycle".

The "fuel cycle" involves the following stages:

• Feedstock production: Energy consumption and GHG emissions during the production of primary energy sources (natural gas and crude oil) are quantified in this stage.

• Feedstock transport: The primary energy sources for hydrogen and gasoline have to be transported to the refineries and reforming plants. Energy consumption and GHG emissions during the transport of primary energy sources are counted in this stage.

• Fuel production: Energy consumption and GHG emissions during processing of primary energy sources (refining crude oil for gasoline and reforming natural gas for hydrogen) are quantified in this stage.

• Fuel distribution: Energy consumption and GHG emissions during distribution of hydrogen and gasoline to the tanks of the vehicles are counted in this stage.

Typically, distribution of gasoline follows a supply chain: from refineries to terminals by ship or pipeline, transfer to road tankers, to service stations, and finally to vehicle tank. Similarly, natural gas is transported through pipeline or road tankers to decentralized refueling stations, where hydrogen is produced through steam reforming.

On the other hand, the "vehicle cycle" consists of the following stages:

• Vehicle material production: Energy use and GHG emissions from vehicle materials production are counted in this stage. Typically, vehicle incorporates nearly 890 kg of ferrous metals, 100 kg of different types of plastics, roughly 80 kg of aluminum, and about 200 kg of other materials. And for PEM fuel cell-powered automobile, we need the materials for fuel cell components such as polymer membrane, platinum as catalyst, graphite, etc.

• Vehicle assembly: The energy required and GHG emissions for transport of vehicles during assembly are quantified here. Because of the complex supply chain in the automobile industry and the associated difficulty in estimating vehicle assembly energy requirements, assembly energy is typically estimated as a linear function of vehicle mass.

• Vehicle distribution: The energy needed and GHG emissions during the transport of a vehicle from the assembly line to the dealership are counted in this stage.

• Vehicle use: It coincides with the fuel use stage of the "fuel cycle." It includes energy consumption and GHG emissions during maintenance and repair over the lifetime, which is typically assumed to be 300,000 km.

• Vehicle disposal: After a vehicle's life, the vehicle is shredded. The disposal energy is the sum of energy needed to move the bulk from the dismantler to a shredder and the shredding energy.

The analyses of different stages of both cycles (fuel and vehicle) are combined to obtain the total life cycle energy consumption and GHG emissions of a vehicle.

Energy Quiz

1. Stored energy is correctly termed		
A radiant energy	B potential energy	C kinetic energy
2. Moving energy is correctly termed		
A kinetic energy	B thermal energy	C potential energy
3. The energy of a ball flying through the air is		
A only kinetic energy	B both kinetic and potential energy	C mostly sound and heat energy
4. My chemical name is Methane. I'm colorless and odorless. I'm the cleanest burning fossil fuel.		
A natural gas	B solar energy	C biomass
5. Ethanol can be made from me and used as a transportation fuel. Photosynthesis stores radiant energy in me. Burning me to produce electricity can produce air pollution. I get my energy from wood, garbage, and agricultural waste.		
A nuclear power	B solar energy	C biomass
6. My energy comes from the Earth's core. I get my energy as a result of radioactive decay. I can be used for home heating.		
A geothermal	B propane	C uranium
7. I convert my mechanical energy directly into electrical energy with no cost for the fuel. I'm caused by uneven heating of the Earth's surface. I produce noise pollution, but no air pollution.		
A solar energy	B petroleum	C wind
8. I'm not available at all hours of the day.		

I can be converted directly into electricity using photovoltaic cells. My energy is stored in fossil fuels. I'm great for water and home heating.		
A biomass	B solar energy	C propane
9. Solar cells are simple photovoltaic devices that convert solar energy directly into electricity and are manufactured from the second-most abundant element in the earth's crust. Name it.		
A silicon	B bauxite	C calcium
10. Wind energy is the kinetic energy associated with atmospheric air. It has been used for centuries for the following operation.		
A running cars	B generating electricity	C grinding grain
11. This energy is the heat generated by natural process within the earth. The main energy sources are the hot rocks, magma, geysers, and hot-springs. This form of energy is known as		
A solar energy	B geothermal energy	C ocean thermal
12. The ultimate energy source for the Earth is		
A the sun	B electricity	C natural gas
13. A non-renewable energy resource		
A can be used over again	B can be plugged in and recharged	C will eventually run out
14. Which of these is not a non-renewable energy resource?		
A coal	B oil	C wind
15. The remains of dead sea creatures have made		
A oil	B coal	C salt
16. At the moment renewable energy resources generate		
A more energy than fossil fuels	B less energy than fossil fuels	C the same amount of energy as fossil fuels
17. Which of these statements can be used to describe renewable energy?		
A most renewable energy	B they pollute the	C they will run out

resources do not need burning	environment	
18. Some people object to wind turbines because		
A they do not like windmills	B they get in the way of photographs	C they are often built in areas of natural beauty
19. Energy is measured in		
A newtons	B joules	C pascals
20. There are many places where wave energy can be produced. The best place to generate energy from waves is		
A sea	B lake	C a big river
21. People object to the burning of fossil fuels because		
A they produce a lot of energy	B they release polluting gases	C they are cheap
22. Within which country are the largest proven reserves of crude oil located?		
A Saudi Arabia	B Iraq	C Iran
23. Within which country are the largest proven reserves of natural gas located?		
A Iraq	B Saudi Arabia	C former USSR
24. Use of which energy source currently generates the largest amount of CO2 emissions in the world?		
A crude oil	B coal	C nuclear energy
25. Which of the following describes the process of clean coal?		
A several types of processes can remove pollutants when coal is burned.	B Coal from underwater reserves produces fewer pollutants when burned.	C Electricity produced from coal plants is more efficient when used than electricity from hydropower generation.
26. In which region is wind power usage most prevalent?		
A China	B United States	C Europe

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