RENEWABLE ENERGY SOURCES

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Ljubljana, 2014
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Key words:
Renewable energy, Energy production, Environment, Renewable energy in Czech Republic.

Abstract:

The aim of the work is to acquaint readers with the various renewable technologies for energy production, thus how they work and what their impacts on the environment, as positive and negative those.

Work also includes current use of renewable energy sources in the Czech Republic and their potential use in the future, all this is explained using graphs and tables that are in the work.
# Content

1. **Authors**.................................................................................................................. 1
2. **Energy policy in Czech Republic**................................................................. 2
3. **Technologies**......................................................................................................... 4
   3.1 **Solar Energy** ........................................................................................................ 4
      3.1.1 Photovoltaic energy ...................................................................................... 5
      3.1.2 Solar thermal energy .................................................................................... 5
      3.1.3 Environmental impact ................................................................................ 5
      3.1.4 Advantages of Solar energy ........................................................................ 6
      3.1.5 Disadvantages of Solar Energy .................................................................. 6
   3.2 **Geothermal Energy** .......................................................................................... 6
      3.2.1 Geothermal Power Plants ............................................................................ 7
      3.2.2 Environmental impact ................................................................................ 10
      3.2.3 Advantages of Geothermal Energy ............................................................. 11
      3.2.4 Disadvantages of Geothermal Energy ......................................................... 11
   3.3 **Wind Energy** ..................................................................................................... 12
      3.3.1 Windmill ....................................................................................................... 12
      3.3.2 Wind turbines ............................................................................................... 13
      3.3.3 Technology ................................................................................................... 14
      3.3.4 Environmental impact ................................................................................ 15
      3.3.5 Advantages of Wind Energy ....................................................................... 16
      3.3.6 Disadvantages of Wind Energy .................................................................. 16
   3.4 **Ocean Energy** .................................................................................................. 16
      3.4.1 Thermal Energy Oceans and Seas ............................................................... 17
      3.4.2 Wave Energy .............................................................................................. 18
      3.4.3 Tidal energy ................................................................................................. 18
      3.4.4 Environmental impact ................................................................................ 19
      3.4.5 Advantages of Ocean energy ..................................................................... 19
      3.4.6 Disadvantages of Ocean energy ................................................................. 20
   3.5 **Biomass** ............................................................................................................. 20
      3.5.1 Basic types of biomass: ............................................................................... 21
      3.5.2 Thermal conversation .................................................................................. 22
      3.5.3 Chemical conversion ................................................................................... 24
      3.5.4 Biochemical conversion .............................................................................. 24
      3.5.5 Environmental impact ............................................................................... 26
      3.5.6 Advantages of Biomass .............................................................................. 27
8 List of figures ........................................................................................................... 53
9 List of tables ........................................................................................................... 54
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Renewable Energy Sources | Authors
2 Energy policy in Czech Republic

The National Energy Policy's vision specifies the state's priorities and sets targets for the state in influencing the development of the energy economy over the next 30 years. The National Energy Policy is one of the basic components of the economic policy of the Czech Republic. National Energy Policy of Czech Republic was approved by the Government 3rd. 10. 2004. The concept defines the priorities and objectives of the Czech Republic in the energy sector and describes the specific implementation measures energy policy. There is also an outlook to 2030. This document was updated in 2009.

Obligation to draw up National Energy Policy is set by the ministry of industry and trade. It is a strategic document with a view to expressing the 30 years of state targets in the energy sector in line with the needs of economic and social development, including environmental protection. The Department must at least once every 5 years to evaluate the implementation of the National Energy Policy and, if necessary, prepare proposals to amend the National Energy Policy and submit them for approval.

Thus defined long-term vision for energy CR is summarized in the top strategic objectives, these are:

Vision of National Energy Policy from year 2004:
- sustainable development
- security
- independence

But updated version from year 2009 has 4 principles:
- sustainable development
- competitiveness of the economy CR
- energy security and resistance to failures
- social and economic cohesion

As we can see new was the principle of social and economic cohesion. In this document are 3 targets, but in new updated version are 3 more.

Targets of National Energy Policy:
- maximizing energy efficiency (2003)
- ensure effective amount and structure of primary energy sources (2003)
- maximum respect for the environment (2003)
- support research (2009)
- increase energy security (2009)
- development of the network infrastructure of the Czech Republic, to strengthen cooperation in the region (2009)

As we can see the basic priorities are to strive for independence from foreign energy sources; maximize the safety of energy sources, including nuclear; and promote sustainable development. Since the last in depth review in 2005, the Czech Republic has further
liberalized its electricity and gas markets and has made commendable efforts to enhance oil and gas security. The Czech Republic is the third largest net electricity exporter in the European Union, after France and Germany. Electricity generation is largely composed of domestic coal (60%) and nuclear (32%), whereas natural gas (3.5%) is mainly used as complementary fuel in multi fired units and for peaking purposes.

Combined heat and power (CHP) constitutes one third of electricity generation and over 40% of overall heat production, making the country the third largest in CHP use after Denmark and Finland. The Czech Republic imports nearly all of its oil and gas requirements, but imports are reasonably well diversified. Possibilities to exploit new coal resources are currently limited by past decisions taken on environmental grounds and the concerns of local populations. Taking into account the importance of the coal industry and its long term contribution to the country’s security of supply, there is increasing pressure to revoke the original decision of the government to limit exploitation of brown coal reserves. According to the Kyoto Protocol, the Czech Republic is committed to reduce its greenhouse gas (GHG) emissions by 8% by 2008 – 2012 compared to 1990 levels. In 2007, GHG emissions were down by almost 22% below 1990 levels, and there should be no difficulties for the country to meet its Kyoto commitments. Despite a significant drop in total GHG emissions since 1990, per capita emissions are still higher than the EU average and much higher than the global average.

In the field of electricity generation is a priority:

- Strengthening the core role in energy production and maximum utilization of waste heat from JE (construction of two new units at Temelin NPP, extended use of the current four blocks and construction of a new fifth unit at Dukovany, territorial demarcation of sites for possible further development is after 2040).
- The development of cost-effective renewable energy sources with the gradual removal of financial support for new resources, and effective government support in terms of access to the network, permitting processes, supporting technology development and pilot projects and the public acceptability of RES development in order to achieve an increase (RES) in electricity production over 15 %.
- A significant increase in the use of the facility for energy recovery of waste in order to reach 80 % utilization of combustible components of the waste sorting in 2040.
- Maintaining production of electricity from coal in a decreasing scale (with a value in the range of 15-20 TWh /year), partial recovery of coal resources to ensure the supply of coal, new and renewed sources no longer exclusively with high performance and cogeneration.
- Maintaining slightly export balance of trade in electricity (target to 10 % of domestic consumption, with variations depending on the development of resources).
- Network development, including managing and measuring elements of smart grids.
- Ensuring sufficient energy and commodity inputs to our economy is a fundamental strategic area of the state's existence. In today's difficult economic situation, the extra help restart economies of EU Member States, as energy and mining industries have a large multiplier ability to create business opportunities related to the positive impact on employment.
3 Technologies

Renewable energy source is a source; in which drawdown can theoretically continue for another thousand years or more. The main power sources are derived from thermonuclear burning of hydrogen in the center of the Sun, the Earth's inner heat and momentum of the Earth-Moon system. Mankind is drawn in forms such as solar radiation, wind energy, hydro energy, tidal energy, geothermal energy, biomass and others.

3.1 Solar Energy

Solar power is by far the Earth's most available energy source, easily capable of providing many times the total current energy demand.

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar power is a technical device that converts the energy of sunlight into electrical energy.

Solar energy can be used in 2 ways:

- **Passive solar energy** - Direct use for heating, lighting, drying purposes.
- **Active solar energy** - Conversion of solar energy to heat or electricity with the aid of electrical or mechanical equipment (fans, pumps...).

![Fig. 1 - Installed capacity for solar power: 29,665 MW in total (installed in 2011; Unit: MW)](image)

![Fig. 2 - Passive Solar Energy](image)

![Fig. 3 - Active Solar Energy](image)
Two methods exist by which sunlight can be converted into directly usable energy:

### 3.1.1 Photovoltaic energy

Uses photovoltaic (PV) = solar cells convert sunlight directly to electricity.

Solar cells are devices that take light energy as input and convert it into electrical energy. They must face south to get the maximal sun, if on a roof. Some systems have the ability to rotate to follow the sun through the day.

![Photovoltaic cells are Converts of Energy](image)

### 3.1.2 Solar thermal energy

Uses solar collectors to transform solar radiation to heat and transfer that heat to a medium (water, air...). Mirrored surface collectors reflect sunlight to heat up liquid to make steam to generate electricity.

Flat-plate collector consists of an absorber, a transparent cover, a frame and insulation. Flat-plate collectors are the most common solar collector for solar water-heating systems in homes and solar space heating.

![Water heating](image)

### 3.1.3 Environmental impact

The sun provides a tremendous resource for generating clean and sustainable electricity without toxic pollution or global warming emissions.

The potential environmental impacts associated with solar power – land use habitat loss, water use, and the use of hazardous materials in manufacturing – can vary greatly depending on the technology, which includes two broad categories: photovoltaic (PV), solar cells or concentrating solar thermal plants (CSP).
The scale of the system – ranging from small, distributed rooftop PV arrays to large utility – scale PV and CSP projects – also plays a significant role in the level of environmental impact.

CSP plants that use wet-recirculating technology with cooling towers withdraw between 2,200 and 2,500 liters of water per megawatt-hour of electricity produced, but water is not lost as steam.

The PV cell manufacturing process includes a number of hazardous materials, most of which are used to clean and purify the semiconductor surface. These chemicals, similar to those used in general semiconductor industry, include hydrochloric acid, sulfuric acid, nitric acid, hydrogen fluoride.

3.1.4 Advantages of Solar energy

Solar power is a renewable resource. As long as the Sun exists, its energy will reach Earth.

Solar power generation releases no water or air pollution, because there is no combustion of fuels. Non-polluting and safe.

Solar energy can be used very efficiently for heating (solar ovens, solar water and home heaters) and day lighting. Direct use of heat for water and space heating, cooking, drying crops, desalination of water, evaporation to produce salt. Considerable potential for space cooling; water pumping; conversion of sunlight to electricity through solar cells and use of photosensitive materials such as silicon; possible use for extraction of hydrogen from water.

Solar energy can save money by heating or lighting buildings passively. It can heat water, saving energy needed for water heaters. Solar energy can regulate electricity and produces no pollution.

3.1.5 Disadvantages of Solar Energy

It doesn’t work well on cloudy days and at night. Solar Energy is less effective the further north you go. It is difficult to store large amounts of energy in batteries.

Solar collectors can only provide low-grade heat on a small scale. Technical difficulties in using on a large scale:

• conversion and collection techniques must be improved
• back-up plant is required to ensure non-tituity of supply from such an intermittent source

Power systems entail high initial costs and at present can only supplement other sources of energy.

3.2 Geothermal Energy

Geothermal (from the Greek words geo, meaning earth, and thermal meaning heat) energy is the natural expression of heat the Earth’s core that forms decay of radioactive materials and the action of tidal forces. Its symptoms are eruptions of volcanoes and geysers,
hot springs and steam vents. It is used in the form of thermal energy (heating) or to produce electricity in geothermal power plants. Usually among the renewable sources of energy, but it does not always apply. Some geothermal energy resources will be exhausted in the next decades.

![Geothermal Reservoirs at the Earth](image1)

### 3.2.1 Geothermal Power Plants

All geothermal power plants use steam to turn large turbines, which run electrical generators. In the Geysers Geothermal area, dry steam from below ground is used directly in the steam turbines. In other areas of the stat super-hot water is „flashed“ into steam within the power plant, and that steam turns the turbine.

![Geothermal Power Plant](image2)
3.2.1.1 **Dry Steam Power Plant**

Dry Steam Plants use hydrothermal fluids that have to be dry steam. The dry steam will be directed to a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine. (Also eliminating the need to transport and store fuels!) This is the oldest type of geothermal power plant. It was first used at Lardarello in Italy in 1904, and is still very effective. Conventional turbine generator sets are driven by dry steam directly taken from the geothermal resources. This approach to utilizing geothermal energy is limited because dry-steam hydrothermal resources are extremely rare. The Geysers, in northern California, for example, is the only dry steam field in the United States. The Geysers is the world’s largest single source of geothermal power. These plants emit only excess steam and very minor amounts of non-condensable gases.

For dry steam resources either atmospheric exhaust turbines or condensing steam turbines are used. New developments of Enhanced Geothermal Systems (EGS) are focusing on enhanced systems, using existing deep reservoir resources Deep Drilling Projects (DDP) in a depth Draft TNA Geothermal of 4 to 5 km. The aim of such projects (i.e. in Iceland and New Zealand) is the exploitation of supercritical fluid reservoirs with steam temperatures up to 400-600°C.

![Dry Steam Power Plant](image)

**Fig. 9 - Dry Steam Power Plant**

Atmospheric exhaust steam turbines are the simplest and, in capital cost, the cheapest of all geothermal cycles. With this type of plant the geothermal steam obtained either directly from dry steam wells, or after flash separation from wet wells, is fed through a conventional axial flow steam turbine which exhausts directly to the atmosphere.

3.2.1.2 **Flash Steam Power Plant**

Hydrothermal fluids above 182°C can be used in flash plants to make electricity. Fluid is sprayed into a tank held at a much lower pressure than the fluid, causing some of the fluid...
to rapidly vaporize, or “flash”. The vapor then drives a turbine, which drives a generator. If any liquid remains in the tank, it can be flashed again in a second tank to extract even more energy.

Flash power plants can be distinguished in single flash and multiple flash plants: Single flash in a single flash plant the liquid dominated brine steam mixture will be flashed in a separator before the dried steam will be fed to the condensing steam turbine. Condensing cycles have more auxiliary equipment compared to atmospheric exhaust units. This significantly increases the costs of the total plant as well as construction and installation time. Furthermore, the presence of non-condensable gases in the geothermal steam, which accumulate in the condenser, requires the installation of a gas extraction system, which will in smaller quantities emit GHG such as NO2 and CO2 (but in very small quantities only compared to a fossil fired power plant).

![Flash Steam Power Plant Diagram](image)

**Multiple Flashes**

The above sections consider conventional steam turbines supplied with geothermal steam obtained either directly from dry steam wells, or after flash separation from wet wells. However in the case of lower enthalpy well discharge it can become attractive to flash the separated water from the first separator to a lower pressure and obtain an additional Draft TNA Geothermal quantity of steam, at a lower pressure. Multi-flash systems are similar to
the single-flash apart from additional flash tanks for the production of further steam from the hot water coming from the separator. The steam produced during the first flash stage is sent to the first stage of the turbine, while the steam produced from the following flashes is admitted in intermediate turbine stages. The decision regarding the use of a multiple flash system is a simple economic one whereby the value of the increased generation is balanced against the increased capital cost of the additional flash separation plant.

3.2.1.3 Binary Cycle Power Plant

Most geothermal areas contain moderate-temperature fluids (well below 150°C). In order to use the low temperature of the brine, steam cannot be used to drive the turbine. Energy is extracted from these fluids in binary-cycle power plants. The warm geothermal fluid (brine or a steam-brine mixture) and a secondary (“binary”) fluid – with a much lower boiling point than water – pass through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to evaporate, this vapor then drives the turbines. Because this is a closed-loop system, virtually nothing (hence no GHG) is emitted to the atmosphere. Moderate-temperature brine is by far the more common geothermal resource, and most geothermal power plants in the future will be binary-cycle plants.

![Binary Cycle Power Plant](image)

In a binary plant the geothermal working fluid is not exposed to the environment, a secondary fluid is evaporated to produce steam at low temperatures. Binary technology allows the use of low temperature reservoirs, thus increasing the number of reservoirs that can be used and its application even in geologic “cold” zones.

3.2.2 Environmental impact

Geothermal power plants can have impacts on both water quality and consumption. Hot water pumped from underground reservoirs often contains high levels of sulfur, salt, and other minerals. Water is also used by geothermal plants for cooling and re-injection.
Depending on the cooling technology used, geothermal plants can require between 6,500 and 15,000 liters of water per megawatt-hour. However, most geothermal plants can use either geothermal fluid or freshwater for cooling; the use of geothermal fluids rather than freshwater clearly reduces the plants overall water impact.

In closed-loop systems, gases removed from the well are not exposed to the atmosphere and are injected back into the ground after giving up their heat, so air emissions are minimal. In contrast, open-loop systems emit hydrogen sulfide, carbon dioxide, ammonia, methane, and boron. Hydrogen sulfide is the most common emission.

Hydrogen sulfide changes into sulfur dioxide (SO2) in the atmosphere. This contributes to the formation of small acidic particulates that can be absorbed by the bloodstream and cause heart and lung disease. Sulfur dioxide also causes acid rain, which damages crops, forests, and soils, and acidifies lakes and streams. However, SO2 emission from geothermal plants are approximately 30 times lower per megawatt-hour than from coal plants. Some geothermal plants also produce small amounts of mercury emissions.

In open-loop geothermal systems, approximately 10% of the air emissions are carbon dioxide, and a smaller amount of emissions are methane, a more potent global warming gas. Estimates of global warming emissions for open-loop systems are approximately 0.045 kg of carbon dioxide equivalent per kilowatt-hour. In closed-loop systems, these gases are not released into the atmosphere, but there are a still some emissions associated with plant construction and surrounding infrastructure.

3.2.3 Advantages of Geothermal Energy

The energy harnessed is clean and safe for the surrounding environment and it is abundant. It is also sustainable because the hot water used in the geothermal process can be re-injected into the ground to produce more steam.

Geothermal power plants are unaffected by changing weather conditions, work continuously, day and night, making them base load power plants.

From an economic view, geothermal energy is extremely price competitive in some areas and reduces reliance on fossil fuels and their inherent price unpredictability.

Can generate electricity and provide heat for domestic, agricultural and industrial purposes. Can be used to desalinate water and it can generate electricity economically in relatively small power units.

3.2.4 Disadvantages of Geothermal Energy

Found principally in areas of tectonic activity. Environmental pollution possible: release of sulphur components; highly mineralized hot waters confining toxic materials may have to be re-injected into the field; thermal pollution may be created when used to generate electricity.

Hot water and steam must be used close to source. Technology for obtaining energy from geopressure zones and hot rocks not yet developed.
3.3 Wind Energy

In the history of the place of transfer to electricity directly held some mechanical work. Windmill such as ground corn, wind machine, drew water, pressed oil, churning felt or powered cutters. Wind is also used to power vehicles, most of the boats (sailboats).

The wind energy is the name for the technology involved in using wind as an energy source. The wind is caused by the uneven heating of the surface of our earth by the sun.

The most common use today is wind turbines that use wind power to spin the propeller (wind turbine). Wind turbine is connected to an electric generator. Theoretically obtainable power is directly proportional to the square of the speed of the flowing air masses. As the wind speed varies greatly, they do not wind power for most of the denominations generated power.

It is the fastest growing source of renewable energy today. According to the World Wind Energy Report 2012, currently launched by the World Wind Energy Association (WWEA), the worldwide wind power capacity reached 282 GW.

![Fig. 12 - Totally installed wind power capacity worldwide](image)

3.3.1 Windmill

A windmill is a device whose main component is a wind turbine which can convert wind energy into kinetic energy. In many countries it was used to grind grain and pumping water.

If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill.
3.3.2 Wind turbines

A wind turbine is a machine for converting the kinetic energy in wind into mechanical energy.

Wind turbines are classified into two general types: horizontal axis and vertical axis. A horizontal axis machine has its blades rotating on an axis parallel to the ground. A vertical axis machine has its blades rotating on an axis perpendicular to the ground. There are a number of available designs for both and each type has certain advantages and disadvantages. However, compared with the horizontal axis type, very few vertical axis machines are available commercially.

3.3.2.1 Horizontal axis Wind Turbine

A horizontal Axis Wind Turbine is the most common wind turbine design. In addition to being parallel to the ground, the axis of blade rotation is parallel to the wind flow.

- Up-Wind Turbines

Some wind turbines are designed to operate in an upwind mode (with the blades upwind of the tower). Large wind turbines use a motor-driven mechanism that turns the machine in response to a wind direction. Smaller wind turbines use a tail vane to keep the blades facing into the wind.
• Down-Wind Turbines

Other wind turbines operate in a downwind mode so that the wind passes the tower before striking the blades. Without a tail vane, the machine rotor naturally tracks the wind in a downwind mode.

3.3.2.2 Vertical axis Wind Turbine

Although vertical axis wind turbines have existed for centuries, they are not as common as their horizontal counterparts. The main reason for this is that they do not take advantage of the higher wind speeds at higher elevations above the ground as well as horizontal axis turbines.

Fig. 15 - Vertical axis Wind Turbine

3.3.3 Technology

The nacelle contains the key components of the wind turbine, including the gearbox, and the electrical generator. The tower of the wind turbine carries the nacelle and the rotor. Generally, it is an advantage to have a high tower, since wind speeds increase farther away from the ground. The rotor blades capture wind energy and transfer its power to the rotor hub. The generator converts the mechanical energy of the rotating shaft to electrical energy the gearbox increases the rotational speed of the shaft for the generator.
3.3.4 Environmental impact

The impact of wind turbines on wildlife, most notably on birds and bats, has been widely documented and studied. Birds and bat deaths from collisions with wind turbines and due to changes in air pressure caused by the spinning turbines, as well as from habitat
disruption. But these impacts are relatively low and do not pose a threat to species populations. Additionally, research into wildlife behavior and advances in wind turbine technology have helped to reduce bird and bat deaths.

Sound and visual impact are the two main public health and community concerns associated with operating wind turbines. Most of the sound generated by wind turbines is aerodynamic, caused by the movement of turbine blades through the air. There is also mechanical sound generated by the turbine itself. Overall sound levels depend on turbine design and wind speed.

There is no water impact associated with the operation of wind turbines. As in all manufacturing processes, some water is used to manufacture steel and cement for wind turbines.

Estimates of total global warming emissions depend on a number of factors, including wind speed, percent of time the wind is blowing, and the material composition of the wind turbine. Most estimates of wind turbine life-cycle global warming emissions are between 0.0091 and 0.018 kg of carbon dioxide equivalent per kilowatt-hour.

### 3.3.5 Advantages of Wind Energy

Wind power produces no water or air pollution that can contaminate the environment, because there are no chemical processes involved in wind power generation.

Power from the wind does not contribute to global warming because it does not generate greenhouse gases. Wind generation is a renewable source of energy, which means that we will never run out of it.

Farming and grazing can still take place on land occupied by wind turbines. Due to the ability of wind turbines to coexist within agricultural fields, siting costs are frequently low.

Traditionally used in many rural areas (for pumping water, turning millstones). Small wind generators can supply electric energy in isolated regions.

### 3.3.6 Disadvantages of Wind Energy

Not all places are windy enough. Sometimes the wind slows or stops. It can kill birds in migratory paths.

Storage of electricity when wind velocity changes are expensive. For large-scale production suitable sites with adequate wind power are hard to find. Can only be complementary to other sources of energy.

### 3.4 Ocean Energy

There is a huge energy potential in oceans, almost 1,500 million cubic kilometers of water cover the Earth, more than 70% of its surface, representing 360 million square kilometers of the planet. The ocean can produce two types of energy: thermal energy from the sun's heat, and mechanical energy. The world's ocean may eventually provide us with energy to power our homes and businesses. Right now, there are very few ocean energy power plants and most are fairly small. Whole mass of the world's oceans are in constant movement, not only on the surface but also at depth. The most important movement of water particles on the
surface of the oceans and the seas waves caused by wind, tidal action of the moon and sun, tributary of rivers, moving earth plates etc.

### 3.4.1 Thermal Energy Oceans and Seas

It is the use of the temperature difference between the warm water at the surface and cold water deep sea. Oceans and seas are huge battery thermal energy, which is caused by sunlight reflected from the water surface with less intensity than the mainland.

Temperature gradient using experimental small power **MINI OTEC** (Ocean Thermal Energy conversion). In the year 1881 had French Engineer Jacques D'Arsonval first idea how to get energy from ocean with use thermo energy. A difference of at least 38 degrees Fahrenheit is needed between the warmer surface water and the colder deep ocean water.

Hot water evaporates ammonia vapor which then powers the turbine. After passing through the turbine, the steam condenses again using cold deep water and the cycle repeats. The device is installed on a ship, where is over 60 m long hose which goes to deep. With it is pumped cold water which we need to condense ammonia vapor.

![Fig. 18 - MINI OTEC](image)

**Legend:**

1) marine plant looks like a buoy, 2) telescopic tube to a depth of 1000 m, 3) marine supply hot water to the heat exchanger, 4) of the chamber evaporator where is ammonia or propane to steam, 5) the turbine and generator, 6) capacitor from which the condensate is returned to the circulation pipeline, 7) hot water outlet from the plant, 8) the entry hole to cold water, 9) carrier floats, 10) control switchboard plants, 11) cable wiring to the coast.
3.4.2 Wave Energy

The kinetic energy (movement) exists in the moving waves of the ocean. This energy can be used to drive the turbine.

Fig. 19 - Ocean power plant

The wave rises into the chamber. Rising water pushes the air out of room. Moving the air spins the turbine, which can turn off the generator. When the wave goes down, air flows through the turbine and back into the room through doors that are normally closed. This is just one type of wave energy system. We can see Principe in picture. Others actually use the up and down motion wave to power a piston that moves up and down inside the cylinder. This piston can also turn on the generator.

Fig. 20 - Scheme of ocean power plant

3.4.3 Tidal energy

This technology is based on tides. Principle is easy: when tides come into the shore, waves can be trapped in reservoirs behind dams. Then when the tide drops, the water behind the dam can be let out just like in a regular hydroelectric power plant. The first tidal power station was built in 1913 in England.
Fig. 21 - La Rance Tidal Power Station, France

The contribution is very small because there are only a limited number of places where you can build them. Their advantage is that the tides are more predictable than the behavior of wind or shine, on the other hand, the production of energy cannot be controlled.

3.4.4 Environmental impact

The environmental impact of wave and tidal energy is still pretty much in unknown territory, simply because these two energy sources are yet to move beyond the stage of prototype projects used for demonstration purposes and become widely deployed technologies.

The possible negative environmental effects of tidal and wave power include:

- the frames of the turbines could lead to disruption in movement of large marine animals and ships through the channels on which the barrage is built

- construction of tidal power plant can also disrupt fish migration in the oceans, and even kill fish population when passing through the turbines.

- the possibility of noise pollution

3.4.5 Advantages of Ocean energy

It is clean, free, renewable and sustainable energy. Tides are more predictable than wind energy and solar power.
3.4.6 Disadvantages of Ocean energy

Possible only in areas where difference in tide levels is high enough to generate electricity. Output is intermittent and depends on tide cycles. Installations are complicated and costly.

3.5 Biomass

Biomass is a summary of the substances making up the body of organisms as plants, bacteria, fungi and animals. This term means that the available plant biomass for energy purposes. Biomass energy has its origin in the sunlight and photosynthesis, so it is a renewable source of energy.

The great advantage of biomass is that it serves as solar battery energy, relatively easy to store and its treatment can use of available wood and agricultural technology. The disadvantage is relatively small energy content of the fuel (one ton of dry wood has about twice the volume of one ton of brown coal, which contains about the same amount of energy).

Biomass is defined as mass of organic origin. In relation to energy, the most used are wood and wood waste, straw and other agricultural residues including livestock excrement.

![Fig. 22 - Trends in the top five countries generating electricity from biomass.](image)

We distinguish biomass "dry" (eg wood) and "wet" (eg the manure - liquid and solid manure of farm animals mixed with water). Basic processing technologies can be divided into dry processes (thermochemical conversion) such as incineration, gasification and pyrolysis and wet processes (biochemical conversion), which include anaerobic digestion (methane fermentation), alcohol fermentation and production of bio hydrogen. A special group then forms stamping oils and their subsequent treatment, which is essentially a mechanical-chemical conversion (for example, production of biodiesel and natural lubricants).
3.5.1 Basic types of biomass:

3.5.1.1 Plants suitable for cultivation for energy use

Wood

For biomass used a fast-growing tree species, which are species cultivated in the short term and with weight gain significantly in excess of normal increment. These trees are grown on surplus agricultural land.

Non wood plants (herbs)

Plant herbaceous character is a large amount; we divide them into annual, perennial and hardy. Their advantage is that they are only sown after the harvest and immediately land can be used as an agricultural. Some plant species: pigweed, hemp, safflower, crown vetch and energy grasses (Bent big, Miscanthus)

Basic types of solid biomass: Wood briskets, wood pellets, wood chips, energy crops.

3.5.1.2 Waste biomass

It is a waste of crop and livestock production and forest harvesting. The main reason why the use of the possibility to obtain from local sources independent of fuel prices. Residues from agricultural production - corn, rape and wheat straw, waste disposal scrubland and forest raids
Livestock waste - manure from animal farms, food leftovers, the dairy and associated capacity

Forest waste - shreds, stumps, biomass from forest thinning, bark, branches, twigs and firewood

Organic fraction of municipal solid waste - municipal organic waste from rural areas, sludge from sewage treatment plants, waste organic residues from maintenance green and grassy areas.

Organic wastes from food and industrial production - waste from slaughterhouses, dairies, wine, food and timber operations.

3.5.1.3 Municipal waste

They are waste materials generated by residential unit’s solid waste from household’s street sweepings and waste from parks and gardens management of services of small plants waste from schools, offices and small institutions.

We can use three basic types of how to deal with biomass: thermal conversion, chemical conversion and biochemical conversion.

3.5.2 Thermal conversion

Thermal conversion processes use heat as the dominant mechanism to convert biomass into another chemical form. The basic alternatives of combustion, Torre faction, pyrolysis, and gasification are separated principally by the extent to which the chemical reactions involved are allowed to proceed (mainly controlled by the availability of oxygen and conversion temperature).

3.5.2.1 Pyrolysis

Pyrolysis is the thermal decomposition of biomass occurring in the absence of oxygen. It is the fundamental chemical reaction that is the precursor of both the combustion and gasification processes and occurs naturally in the first two seconds. The products of biomass pyrolysis include biochar, bio-oil and gases including methane, hydrogen, carbon monoxide, and carbon dioxide.

Depending on the thermal environment and the final temperature, pyrolysis will yield mainly biochar at low temperatures, less than 450 °C, when the heating rate is quite slow, and mainly gases at high temperatures, greater than 800 °C, with rapid heating rates. At an intermediate temperature and under relatively high heating rates, the main product is bio-oil.
Pyrolysis can be performed at relatively small scale and at remote locations which enhance energy density of the biomass resource and reduce transport and handling costs. Pyrolysis offers a flexible and attractive way of converting solid biomass into an easily stored and transported liquid, which can be successfully used for the production of heat, power and chemicals.

3.5.2.2 Combustion

The oldest and most common way of converting biomass to electricity is to burn it to produce steam.

This turns a turbine that produces electricity. The problems with direct combustion of biomass are that much of the energy is wasted and that it can cause some pollution if it is not carefully controlled. Direct combustion can be done in a plant using solely biomass (a “dedicated plant”) or in a plant made to burn another fuel, usually coal.

3.5.2.3 Gasification

Gasification is not a new technology; it was originally developed in the 1800s and is the processes used to make town gas for lighting and cooking. Small scale gasifiers were also used to power internal combustion engine vehicles during fuel shortages during the Second World War.
Gasification is a partial oxidation process whereby a carbon source such as biomass, is broken down into carbon monoxide (CO) and hydrogen (H₂), plus carbon dioxide (CO₂) and possibly hydrocarbon molecules such as methane (CH₄).

This mix of gases is known as 'producer gas' or product gas (or wood gas or coal gas, depending on the feedstock), and the precise characteristics of the gas will depend on the gasification parameters, such as temperature, and also the oxidizer used. The oxidizer may be air, in which case the producer gas will also contain nitrogen (N₂), or steam or oxygen.

3.5.3 Chemical conversion

A range of chemical processes may be used to convert biomass into other forms, such as to produce a fuel that is more conveniently used, transported or stored, or to exploit some property of the process itself. Many of these processes are based in large part on similar coal-based processes, such as Fischer-Tropsch synthesis, methanol production, olefins (ethylene and propylene), and similar chemical or fuel feedstock. In most cases, the first step involves gasification, which step generally is the most expensive and involves the greatest technical risk. Biomass is more difficult to feed into a pressure vessel than coal or any liquid. Therefore, biomass gasification is frequently done at atmospheric pressure and causes incomplete combustion of biomass to produce a combustible gas consisting of carbon monoxide, hydrogen, and traces of methane. This gas mixture, called a producer gas, can provide fuel for various vital processes, such as internal combustion engines, as well as substitute for furnace oil in direct heat applications. Because any biomass material can undergo gasification, this process is far more attractive than ethanol or biomass production, where only particular biomass materials can be used to produce a fuel. In addition, biomass gasification is a desirable process due to the ease at which it can convert solid waste (such as wastes available on a farm) into producer gas, which is a very usable fuel.

3.5.4 Biochemical conversion

As biomass is a natural material, many highly efficient biochemical processes have developer in nature to break down the molecules of which biomass is composed, and many of these biochemical conversion processes can be harnessed.

Biochemical conversion makes use of the enzymes of bacteria and other microorganisms to break down biomass. In most cases micro-organisms are used to perform the conversion process: anaerobic digestion, fermentation and composting. Other chemical processes, such as converting straight and waste vegetable oils into biodiesel, are trans esterification. Another way of breaking down biomass is by breaking down the carbohydrates
and simple sugars to make alcohol. However, this process has not been perfected yet. Scientists are still researching the effects of converting biomass.

3.5.4.1 Fermentation

Fermentation is an anaerobic process (occurs in the absence of oxygen) that breaks down the glucose within organic materials. It is a series of chemical reactions that convert sugars to ethanol.

The basic fermentation process involves the conversion of a plant’s glucose (or carbohydrate) into an alcohol or acid. Yeast or bacteria are added to the biomass material, which feed on the sugars to produce ethanol (an alcohol) and carbon dioxide. The ethanol is distilled and dehydrated to obtain a higher concentration of alcohol to achieve the required purity for the use as automotive fuel. The solid residue from the fermentation process can be used as cattle-feed and in the case of sugar cane; the bagasse can be used as a fuel for boilers or for subsequent gasification.

The most common forms of biomass that are used in the production of bio-ethanol are high in sugar and include sugarcane, corn and sweet potatoes. Other forms of biomass that are used in fermentation processes are starchy materials such as wheat, barley, oat and rice along with lignocellulose materials such as agricultural wastes and woody materials.

Lignocellulose biomass is slightly different because, along with consisting of cellulose and hemicellulose that can be converted to sugars, it also contains a non-fermentable fraction called lignin. Lignin, however, is high in energy content and can be utilized for the production of electricity and/or heat. Although the decomposition of the material into fermentable sugars is more complicated, the fermentation, distillation and dehydration process steps are basically identical for bio-ethanol from either agricultural crops or lignocellulose biomass.

![Fig. 29 - Diagram of different types of waste for fermentation](image-url)
3.5.4.2 Composting

Similarly to anaerobic digestion, though making use of different bacteria, composting is the anaerobic decomposition of organic matter by microorganisms. It is however typically performed on relatively dry material rather than slurry.

Using composting for heat and power instead of, or in addition to, collecting the flammable biogas emitted, the exothermic nature of the composting process can be exploited and the heat produced used, usually using a heat pump.

3.5.5 Environmental impact

Energy crops purposefully established for optimal biomass production can maintain or even improve the quality of the soil and to fulfill other functions, especially soil conservation, erosion control and forming the landscape.

With suitably chosen access, controlled production can benefit biodiversity in the landscape and care for her.

Burning biomass does not lead to an increase in CO2 in the atmosphere, because the amount of CO2 that biofuel combustion process releases into the atmosphere, is offset by the amount of CO2 that the plants have established themselves during their life cycle in the process of photosynthesis and stored in the form of biomass.

Culm contain more ash matter (4-8%) than the species (1-3%). From the viewpoint of the content of emissions is important content of nitrogen and sulfur, which is for example in the grain to a hundred times smaller than for coal.

Some plants are able to bound heavy metals in the soil, which after burning may occur in the ash. This ability of plants can be appropriately applied, for example during reclamation industrial zones. The ash of biofuel (from uncontaminated vegetation) can be used as a high quality mineral fertilizer containing the essential elements such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), potassium hydroxide, silica, phosphoric acid and essential trace elements.

Study by the European Environment Agency (EEA) in the cultivation of energy crops increases the risk of soil erosion and reduces the ability of the landscape to retain water, thereby increasing the risk of flooding. In addition, there is a restriction of the field of biodiversity birds. According to the authors of the document is due to the intensive use of renewable energy sources to increase the pressure on land, forests and water resources. Economic pressure on energy crops may also lead to an increase in greenhouse gases that cause global warming. Utilized agricultural area is bound less carbon than natural forests or...
meadows. Finally, biomass combustion also leads to emissions of fine dust particles that pose a risk to human health.

3.5.6 Advantages of Biomass

Biomass used as a fuel reduces need for fossil fuels for the production of heat, steam, and electricity for residential, industrial, and agricultural use. Biomass is always available and can be produced as a renewable resource.

Biomass fuel from agriculture wastes maybe a secondary product that adds value to agricultural crop. Growing biomass crops produce oxygen and use up carbon dioxide. The use of waste materials reduce landfill disposal and makes more space for everything else.

Carbon Dioxide which is released when Biomass fuel is burned is taken in by plants. Less money spent on foreign oil.

3.5.7 Disadvantages of Biomass

Agricultural wastes will not be available if the basic crop is no longer grown. Additional work is needed in areas such as harvesting methods. Land used for energy crops maybe in demand for other purposes, such as farming, conservation, housing, resort or agricultural use.

Some biomass conversion projects are from animal wastes and are relatively small and therefore are limited. Research is needed to reduce the costs of production of biomass based fuels. Is in some cases is a major cause of pollution.

3.6 Biofuels

As a biofuel called fuels that are largely or entirely produced from renewable sources - wind and sun, water, soil, air, biomass or biogas. In the field of automotive fuel we mean liquid biofuels. Already at that time, the conventional fuels bio-component admixed - less than 5% ethanol in gasoline and less than 7% FAME in diesel. By 2020, this proportion under the European Union has increased to at least 10%.

3.6.1 Bioethanol

3.6.1.1 Production

Bioethanol is a label for ethanol produced using the alcoholic fermentation of biomass, which is used as a biofuel. It is usually made from plants containing a larger amount of starch and other carbohydrates. In addition to products containing starch such as corn, wheat and potatoes are the most commonly used raw
sugar cane and sugar beets. While plants containing sugar is fermented directly must be in plants containing starch first enzymatically converted to sugar. Made bioethanol can be used directly in internal combustion engines as a propellant.

3.6.1.2 Using bioethanol in vehicles

If we want use this fuel in vehicle. It is recommended that the vehicle be equipped with a conversion kit. This option shall only use E85 fuel. You can have it entered into a technical license and use and reduced road tax for entrepreneurs. It also does not limit you to the entrance to the underground garage as in the case of LPG or CNG, plus you can fully programmable unit whenever reinstalled in another vehicle. Fuel petrol stations can be found under the designation E85 is also admixed in an amount of 5% to 10% in conventional petroleum fuels. Bioethanol produced from maize is also used as an additive to the majority of automotive gasoline in the U.S.A. The content of alcohol in the USA is typically 10%. The benefits of bioethanol fuel is disputed - there are views both for the development of hybrid drive systems, and critical studies, which in turn complain small overall contribution to reducing CO2 emissions, the impact on prices of crops, which produces bioethanol, etc.

3.6.2 Biodiesel

Biodiesel (FAME - fatty acid methyl ester) is an environmentally friendly fuel for diesel engines based on methyl esters of unsaturated fatty acids of vegetable origin. Is produced by refining a process called trans esterification. It can be used as fuel without any modification in diesel engine (diesel). Meaning and consumption of biodiesel in the European Union continues to grow. Nowadays, manufacturers mandatory 5% biodiesel blended into diesel produced from petroleum.

3.6.2.1 Production

Biodiesel can be produced from any vegetable oil (rapeseed, sunflower, soybean, used cooking oil ...). The Czech Republic is most commonly used to produce oil from rapeseed. Rape is a difficult plant to grow that needs a lot of nutrients, and therefore should cultivate the fields, only every third to fourth year [source?]. Economics of rape: the yield for us is about 3t/ha, of which is pressed into ca. 1t/ha oil. On one hectare is used 140-160 kg of nitrogen fertilizer.

Ongoing chemical reaction called trans esterification is being catalyzed. Individual production processes differ mainly the catalyst used and the reaction conditions. Developing new production processes: conversion of vegetable oils using enzymatic catalysts, using special catalysts and solid production without the use of a catalyst.

3.6.2.2 Using biodiesel in vehicles

Most vehicle manufacturers publish lists of cars that can run on pure biodiesel. In the UK, many automobile provides a guarantee to the engine, which burns up to 5% biodiesel blended with 95% conventional diesel - although this attitude considered overly cautious. Peugeot and Citroen are exceptions, as recently announced that their HDI engines can burn a mixture of 30% biodiesel. Other exceptions are Scania and Volkswagen, whose engines can use one hundred percent biodiesel. On the market in the Czech Republic can meet the blended diesel (also rarely SMN or eco diesel), which contains 31% biofuel and 69% traditional fossil diesel fuel.
3.6.3 **Environmental impact**

Biofuels grown in the Europe, for example, produce about 70 percent more greenhouse gas emissions than fuel oil. The burning of biofuels from rapeseed or corn is released into the air nitrous oxide. The climate destroys three hundred times more than the most common greenhouse gas - carbon dioxide. The destruction of the wild nature (forests, etc.) for the establishment of a field on the cultivation of maize or sugar cane for the production of biodiesel, or palm oil and soybean for bioethanol, is released into the atmosphere from 17 to 420 times more carbon dioxide than the annual savings from replacing fossil fuels. Combustion of high blends of biofuels released into the air two carcinogens - formaldehyde and acetaldehyde. Moreover increase in ozone concentration that leads to inflammation of the lungs, worsens asthma, and damaging the immune system.

3.6.4 **Advantages of Biofuels**

Biofuels have the potential to be significantly cheaper than gasoline and other fossil fuels. This is particularly true as worldwide demand for oil increases, oil supplies dwindle, and more sources of biofuels become apparent. Oil is a limited resource than comes from specific materials; biofuels can be manufactured from a wide range of materials including crop waste, manure and other byproducts. This makes it an efficient step in recycling.

Renewability takes a very long time for fossil fuels to be produced, but biofuels are much more easily renewable as new crops are grown and waste material is collected. Biofuels can be produced locally, which decreases the nation’s dependence upon foreign energy. By reducing dependence on foreign fuel sources, countries can protect the integrity of their energy resources and make them safe from outside influences.

Biofuel manufacturing plants can employ hundreds of thousands of workers, because biofuels are produced locally, it is creating new jobs in rural areas. Biofuel production will also increase the demand for suitable biofuel crops, providing economic stimulation to the agriculture industry.

When biofuels are burned, they produce significantly less carbon output and fewer toxins, making them a safer alternative to preserve atmospheric quality and lower air pollution.

3.6.5 **Disadvantages of Biofuels**

Biofuels have a lower energy output than traditional fuels and therefore require greater quantities to be consumed in order to produce the same energy level. This has led some noted energy analysts to believe that biofuels are not worth the work. Food shortage may become an issue with biofuel use.

There is concern that using valuable cropland to grow fuel crops could have an impact on the cost of food and could possibly lead to food shortages. Massive quantities of water are required for proper irrigation of biofuel crops as well as to manufacture the fuel, which could strain local and regional water resources.

Several studies have been conducted to analyze the carbon footprint of biofuels, and while they may be cleaner to burn, there are strong indications that the process to produce the fuel – including the machinery necessary to cultivate the crops and the plants to produce the fuel – has hefty carbon emissions.
To refine biofuels to more efficient energy outputs, and to build the necessary manufacturing plants to increase biofuel quantities, a high initial investment is often required.

### 3.7 Hydropower Energy

In hydropower energy, the gravitational descent of a river is compressed from a long run to a single location with a dam or a flume. This creates a location where concentrated pressure and flow can be used to turn turbines or water wheels, which drive a mechanical mill for an electric generator.

There are several types of hydroelectric facilities; they are all powered by the kinetic energy of flowing water as it moves from a higher to a lower elevation. Turbines and generators convert the energy into electricity, which is then fed into the electrical grid to be used in homes, businesses, and by industry.

#### 3.7.1 The water cycle

Water is constantly moving. It describes a cycle called „the water cycle“. The energy of this cycle, which is driven by the sun, can be tapped for mechanical tasks like grinding grain or to produce electricity. The water cycle is an endless source of energy because it is in constantly moving recharging system, so hydropower is considered a renewable energy.
3.7.2 **Topical Hydropower Plant**

Dams hold large amounts of water back. Water flowing through forces turbines to spin and create electricity. Gravity dams create a vertical displacement and water is dropped into the turbines.

Run of the river dam uses force of the river to push turbines. A run-of-river power station continuously produces electricity from flowing water in an impounded river. With a flow rate of, for example, 600 cubic meters of water per second it achieves an output of around 26 Megawatt.

![Fig. 33 - Topical Hydropower Plant](image)

**Legend:**

1. **Diffuser** – The shape and diameter of the inflow and diffuser have a decisive effect on the water flow and therefore on the efficiency of the turbine.
2. **Water level**
3. **Traiwater**
4. **Bypass or fish ladder** – Enables fishes and other aquatic animals to pass the weir.
5. **Level difference** – Between 4 and 30 meters.
6. **Weir** – Controls the water level and flow rate.
7. **Power house**
8. **Impounded river course**
9. **Turbine** – In river power stations mostly a vertical Kaplan turbine, which has the best efficiency at high flow and small head.
10. **Inflow**
11. **Headwater**  
12. **Water level**  
13. **Generator**  
14. **Electricity**  
15. **Transformer**  
16. **Electricity**  
17. **Powerhouse**

3.7.3 **Environmental impacts**

Flooding land for a hydroelectric reservoir has an extreme environmental impact: it destroys forest, wildlife habitat, agricultural land, and scenic lands. In many instances, such as the Three Gorges Dam in China, entire communities have also had to be relocated to make way for reservoirs.

Hydroelectric facilities can have a major impact on aquatic ecosystems. There are a variety of methods to minimize the impact (including fish ladders and in-take screens), fish and other organisms can be injured and killed by turbine blades.

Reservoir water is usually more stagnant than normal river water. As a result, the reservoir will have higher than normal amounts of sediments and nutrients, which can cultivate an excess of algae and other aquatic weeds. These weeds can crowd out other river animal and plant-life, and they must be controlled through manual harvesting or by introducing fish that eat these plants. In addition, water is lost through evaporation in dammed reservoirs at a much higher rate than in flowing rivers.

If too much water is stored behind the reservoir, segments of the river downstream from the reservoir can dry out. Thus, most hydroelectric operators are required to release a minimum amount of water at certain times of year. In addition, reservoir water is typically low in dissolved oxygen and colder than normal river water. When this water is released, it could have negative impacts on downstream plants and animals.

Global warming emissions are produced during the installation and dismantling of hydroelectric power plants, but recent research suggests that emissions during a facility’s operation can also be significant. Such emissions vary greatly depending on the size of the reservoir and the nature of the land that was flooded by the reservoir.

3.7.4 **Advantages of Hydropower energy**

Hydroelectric power produces no primary waste or pollution – clean method. Hydropower is a renewable resource and electricity can be generated constantly, so long as sufficient water is available.

3.7.5 **Disadvantages of Hydropower energy**

Damming the water may cause changes in the environment, backwater sedimentation and rapid silting. It floods lands, alters rivers temperature and character and can kill fish species. May involve high initial construction cost. Growing shortage of natural sites.
4 Potential of renewable energy in Czech Republic

Biomass is the only additional and wider system available renewable energy source in the Czech Republic for the purpose of heating. Other forms of renewable energy are, whether technical or administrative reasons, for the purpose of heating limited. Geothermal energy has the potential CR inadequate and high cost of wind and water is not suitable for heating and use of solar energy has the potential to centralized supply. Expected growing importance of the use of biogas especially in agriculture. In general, the promotion of biomass pro-growth measures from the perspective of Czech manufacturers.

Long time in the Czech Republic using water. The possibilities are already currently however largely exhausted and their proportion, which is currently about 3%, will no longer significantly increase. What is important is the flexibility of these resources that can parry intermittent outages sources. Several pumping stations that we are the only source in the Czech Republic buffer type. Along with other water sources, assuming sufficient water level, the resources for peak demand. Certain options are as small a number of potential sources of major dams, which should be gradually utilized.

Czech Republic has given its geographical conditions of relatively limited use of wind and solar energy. Areas with regular, sufficiently strong and stable wind are limited and are rather in mountain natural and protected areas. The use of solar energy for electricity production due to inadequate support spikes. This increase hitting nets and protection of agricultural land and resulted in limiting the costs of support. In the future it will be a particularly appropriate to use solar energy as a power source for small buildings.

Geothermal energy is in the Czech Republic only limited potential, especially in the heating and air conditioning. Geothermal power plants that would need us in extremely deep wells are feasible in our country in a very limited range. Economically justifiable use of geothermal energy on a large scale in central Europe will possibly matter more distant future.

4.1 Potential of renewable energy sources in the CZ

In the past, the potential of renewable energy sources in the Czech Republic is estimated several times. Only in 2003 the in-depth research related to economic evaluation. The purpose of was to provide an authoritative basis for the preparation of the State Energy Policy and to prepare a draft law on the promotion of energy from renewable sources.

The potential was measured the 5 basic primary sources of renewable energy: solar energy, biomass, hydropower, wind power and geothermal energy, incl. low potential energy environment. Each type of renewable energy is specific options for use and thus exploring its potential. One of the bases of the investigation was divided into potential technical, application and available and economical, even so defined potentials could not be used for all types of renewable universally. The theoretical potential expresses the physical flows of energy, was not considered for practical use. Interestingly, however, examples include the value of total solar radiation incident per year in the Czech Republic, which represents about 90,000 TWh. This energy is delivery of further transformed living processes (together with CO2 is essential vegetable matter) partly also on hydro, wind, etc.
4.1.1 Why do we need renewable energy

In terms of sustainable development are renewable energy sources (RES hereinafter) the only way, as they have been throughout the existence of mankind, except last about two hundred years. Physical constraints and limits of this planet other virtually eliminate the possibility of long-term, regardless of how any of us the context of sustainable development and quality of life.

4.1.2 Why are not renewable energy sufficiently attractive

The causes are many; the key lies in our wasteful way of handling of natural resources, including energy. The relatively easy availability of non-renewable resources in the last 300 years virtually ousted the RES in the industrialized countries siding. World energy consumption at the same time increased, while the number of population of "only" 10 times. The use of non-renewable resources has been adapted all the infrastructure and support to their directed 90% of public funds (support) and funding for science and research.

Renewable energy density is much lower than the "conventional" sources, therefore requiring somewhat different loading and above all a change of mindset. Only then may come on the way take advantage of the fact that the current world energy consumption corresponds to about 0.01 per thousand annual energy incident solar radiation.

Fig. 34 - Map of the solar radiation in the CZ
4.2 Current situation

4.2.1 The potential of electricity from the sun

The technical potential for electricity production from solar energy was determined under the following conditions:

- will be used only suitable built-up areas
- is calculated with the existing efficiency technologies
- is calculated for the purposes of thermo-solar systems

<table>
<thead>
<tr>
<th>Potential</th>
<th>Total area m²</th>
<th>Power MWe</th>
<th>Production GWhe / year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>210 000 000</td>
<td>22 000</td>
<td>23 000</td>
</tr>
<tr>
<td>Available</td>
<td>50 200 000</td>
<td>5 300</td>
<td>5 500</td>
</tr>
</tbody>
</table>

Production of electrical energy from the sun is likely to be given the expected increase efficiency technologies significantly higher. But it also expects to expand the available technologies for storing energy produced, probably mainly based technologies in the production, storage and use of hydrogen.

4.2.2 Production potential of solar thermal

The potential use of thermal solar energy is the demand for low potential warm. Technical possibilities of location technologies (solar collectors) are determined by the availability of suitably oriented surfaces. Their connection to existing and new heating systems can be easily performed.

<table>
<thead>
<tr>
<th>Potential</th>
<th>Total area m²</th>
<th>Production (TJ / year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>13 000 000</td>
<td>25 000</td>
</tr>
<tr>
<td>Available</td>
<td>9 000 000</td>
<td>17 000</td>
</tr>
</tbody>
</table>

4.2.3 The potential of biomass for energy purposes

The energy potential of biomass grown biomass in the Czech Republic is given the sum of income categories for commonly grown for energy crops, taking into account the use of agricultural land for the production of food and industrial crops. Considering potential production of biomass for direct energy use and production of biofuels. Currently located in the Czech Republic about 0.5 mil. ha fallow land. Over the next 30 years can be utilized to 1.5 mil. ha, is about 35% of agricultural land in the Czech Republic, in accordance with crop rotation and good agricultural practice.
Table 3 - The potential of biomass for energy purposes

<table>
<thead>
<tr>
<th>Potential</th>
<th>Production of biomass (10^3 t)</th>
<th>Energy (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available</td>
<td>9 037</td>
<td>136</td>
</tr>
<tr>
<td>Usable</td>
<td>13 693</td>
<td>205</td>
</tr>
<tr>
<td>Technical</td>
<td>18 384</td>
<td>275</td>
</tr>
<tr>
<td>Theoretical</td>
<td>27 385</td>
<td>411</td>
</tr>
</tbody>
</table>

The potential of forest biomass energy recoverable includes residues from wood industry, pruning, thinning, and remnants of the forest after harvesting and fuel wood.

When increasing the extraction, is from the current 14 million m3 for long-term sustainable about 16 million m3 can be calculated with the increase in potential.

Table 4 - The potential of forest biomass energy

<table>
<thead>
<tr>
<th>Potential</th>
<th>Energy (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>77.6</td>
</tr>
<tr>
<td>Available</td>
<td>44.8</td>
</tr>
</tbody>
</table>

4.2.4 The potential use of biogas

The potential use of biogas is based on review of available material for anaerobic digestion.

Production and use of biogas helps greatly in the field of waste management and significantly reduces greenhouse gas emissions. They are used primarily animal and vegetable waste in agriculture, food processing industry and biodegradable municipal and industrial wastes.

Table 5 - The potential use of biogas

<table>
<thead>
<tr>
<th>Potential</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>Total</td>
</tr>
<tr>
<td>Biogas (10^3 m^3)</td>
<td>1 510 600</td>
</tr>
<tr>
<td>i. e. energy</td>
<td>33</td>
</tr>
<tr>
<td>Available</td>
<td>Total</td>
</tr>
<tr>
<td>Biogas (10^3 m^3)</td>
<td>625 000</td>
</tr>
<tr>
<td>i. e. energy</td>
<td>16</td>
</tr>
<tr>
<td>Electricity (GWh)</td>
<td>1 200</td>
</tr>
</tbody>
</table>

4.2.5 Hydropower potential

The potential is quantified in the expected installed capacity, number of installations and the average annual energy production. So far unused sites are economically less advantageous option is often limited their use by other interests or protection.

The potential additional annual production in the years 2005 - 2050 is about 450 GWh.
Table 6 - Hydropower potential

<table>
<thead>
<tr>
<th>Potential</th>
<th>Annual production [GWh]</th>
<th>Power [MW]</th>
<th>Number of power plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical</td>
<td>13 100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Available</td>
<td>2 280</td>
<td>1 134</td>
<td>1 618</td>
</tr>
<tr>
<td>Usable</td>
<td>1 850</td>
<td>1 004</td>
<td>1 188</td>
</tr>
<tr>
<td>Unused</td>
<td>410</td>
<td>130</td>
<td>430</td>
</tr>
<tr>
<td>Repowering</td>
<td>40</td>
<td>15</td>
<td>200</td>
</tr>
</tbody>
</table>

4.2.6 The potential for wind energy

Technical potential is based on climatological model. Fulfilling the available potential is still significantly limited; inter alia, lack of trust in this technology, in the long run it can be estimated at about one quarter of the technical potential.

Wind energy potential should not be neglected both in terms of diversification of sources (in the future use of hydrogen energy) and from educational and awareness reasons.

Table 7 - The potential for wind energy

<table>
<thead>
<tr>
<th>Wind speed (m/s)</th>
<th>Install power (MW)</th>
<th>Expected production (GWh/ year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,1 – 6,0</td>
<td>2 571</td>
<td>2 236</td>
</tr>
<tr>
<td>4,6 – 6,0</td>
<td>2 368</td>
<td>2 053</td>
</tr>
<tr>
<td>5,1 – 6,0</td>
<td>8 208</td>
<td>12 312</td>
</tr>
<tr>
<td>6,0</td>
<td>888</td>
<td>1 776</td>
</tr>
<tr>
<td>Total technical</td>
<td>11 667</td>
<td>16 324</td>
</tr>
<tr>
<td>Total available</td>
<td>3 000</td>
<td>4 000</td>
</tr>
</tbody>
</table>

4.2.7 The potential of geothermal energy

Geothermal energy is the energy of the Earth's deep heat that can in some geological profiles of energy use, now usually in depths of up to 3 km. This category includes also the potential for shallow geological environment usable by heat pumps (renewable energy component is in this case about 60-70%).
4.1 Future plans

The table is designed by conclusive analysis of the potential of various types of renewable energy sources in the Czech Republic. It is necessary to establish a specific strategy based on demonstrable economic evaluation and, where appropriate, other measures and instruments for the implementation of expected trends. The strategy must include policies and activities in agriculture, forestry, petrochemical and other industries that create conditions for growing biomass, biogas, biofuel, etc. In preparing these materials is necessary to cooperate with regional authorities.

<table>
<thead>
<tr>
<th>Type of energy (MW)</th>
<th>Type of energy</th>
<th>Technical (MW) available</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>Hydrothermal&gt; 130 °C</td>
<td>300</td>
<td>100 One drill hole is about 10 MW power</td>
</tr>
<tr>
<td></td>
<td>Dry heat rocks</td>
<td>35 000</td>
<td>3 400 One location is about power 4 MW needed two drill holes</td>
</tr>
<tr>
<td>Heat</td>
<td>Hydrothermal &lt;130 °C</td>
<td>250</td>
<td>25 Use linked to selected sites</td>
</tr>
<tr>
<td></td>
<td>Energy of shallow geological environment</td>
<td>30 000</td>
<td>4 000 Energy usable heat pumps, available potential would require resources electricity to the power installed 1000 MW</td>
</tr>
</tbody>
</table>

5 Current utilization of energy in Czech Republic

5.1 Introduction, RES in Czech Republic and EU

For renewable energy sources in the Czech Republic are considered non-fossil natural sources of energy like a hydropower, wind, solar, biomass and biogas energy, geothermal energy and liquid biofuels. Renewable energy sources have an in Czech Republic its own place. Science and technology are still finding new ways to increase efficiency renewable energy. Maximum use of renewable energy sources is one of the key energy policy of the European Union. In Europe Union are 90% of people thinking the government should increase part of RES on total energy production of states. The European Union in its energy policy has set a target to increase the share of energy from renewable sources to 20% in 2020.
The Czech Republic as an indicative target has set more than 13% of energy from renewable sources in 2020. On the chart you can see targets of states to increase share of Renewable energy sources.

For comparison, we can see on the picture energy prices in the Czech Republic and the European Union for every kind of RES.
In the Czech Republic are used this renewable energy sources:

- Hydropower plants
- Wind energy
- Solar energy
- Photovoltaic
- Geothermal energy
- Biomass
- Biogas
- Others

You can see their production in the table and every energy source is described in next chapters.
Table 10 - Current use of renewable energy sources in the Czech Republic (2011)

<table>
<thead>
<tr>
<th>Types of renewable energy sources</th>
<th>Electricity (MWh)</th>
<th>thermal energy (GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydropower energy</td>
<td>1 963 154</td>
<td>-</td>
</tr>
<tr>
<td>Wind energy</td>
<td>397 003</td>
<td>-</td>
</tr>
<tr>
<td>Solar heat system</td>
<td>-</td>
<td>478 275</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>2 182 018</td>
<td>-</td>
</tr>
<tr>
<td>Geothermal energy</td>
<td>0</td>
<td>0,2</td>
</tr>
<tr>
<td>Biomass</td>
<td>1 684 571</td>
<td>45 436 726</td>
</tr>
<tr>
<td>Biogas</td>
<td>928 715</td>
<td>2,5</td>
</tr>
<tr>
<td>Others</td>
<td>90 190</td>
<td>929 871</td>
</tr>
<tr>
<td>altogether</td>
<td>7 245 651</td>
<td>51 615 646</td>
</tr>
</tbody>
</table>

In Czech Republic is produced 7 245 651 MWh by renewable energy sources which is 8, 28% of total energy produce. By heating is that 53 023 795 GJ mostly with biomass which is 7, 6% of total energy production of Czech Republic.

In this map you can see all of power plants in Czech Republic. I would like to highlight our two nuclear power plants: Temelin and Dukovany. And you can see all hydropower plants which are discussed in Chapter Hydropower in Czech Republic in the tab.

Fig. 37 - Hydropowers in Czech Republic
5.2 Hydropower in CR

In the Czech Republic, the use of hydropower plants has long tradition. At first like mechanical combustion and then was change to electrical energy. However the natural conditions in the Czech Republic are not ideal to build large hydroelectric power works. We do not have the required gradient flows or quantity of water. Therefore is relation of electricity production in hydro power plant beside of total production in the Czech Republic is relatively low. However in our conditions are hydropower plants the biggest renewable source. As you can see in the chart quantity of hydropower plants is growing slowly during last years.

![Hydropower plants chart](image)

Fig. 38 - Hydropower plants

In tabs you can see 12 biggest power plants in the Czech Republic. All of them have power more than 10 MW, which means they are sorted like “big hydropower plants”.

Large hydroelectric power plants are called hydroelectric power plants with an installed capacity of 10 MW including.

<table>
<thead>
<tr>
<th>Name</th>
<th>Power [MW]</th>
<th>Type plant</th>
<th>Produce [GWh]</th>
<th>Spuštění</th>
<th>Place</th>
<th>River</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVE Dlouhé stráně I</td>
<td>650</td>
<td>pumped storage</td>
<td>403</td>
<td>1996</td>
<td>horní / dolní VN Dlouhé stráně</td>
<td>Divoká Desná</td>
<td>ČEZ</td>
</tr>
<tr>
<td>PVE Dalešice</td>
<td>450</td>
<td>pumped storage</td>
<td>273</td>
<td>1978</td>
<td>VN Mohelno / VN Dalešice</td>
<td>Jihlava</td>
<td>ČEZ</td>
</tr>
<tr>
<td>VE Orlík</td>
<td>364</td>
<td>accumulated</td>
<td>300</td>
<td>1962</td>
<td>VN Orlík</td>
<td>Vltava</td>
<td>ČEZ</td>
</tr>
<tr>
<td>VE Slapy</td>
<td>144</td>
<td>accumulated</td>
<td>256</td>
<td>1955</td>
<td>VN Slapy</td>
<td>Vltava</td>
<td>ČEZ</td>
</tr>
<tr>
<td>VE Lipno I</td>
<td>120</td>
<td>accumulated</td>
<td>90</td>
<td>1959</td>
<td>VN Lipno</td>
<td>Vltava</td>
<td>ČEZ</td>
</tr>
<tr>
<td>PVE Štěchovice II</td>
<td>45</td>
<td>pumped storage</td>
<td>23</td>
<td>1948</td>
<td>VN Homole / VN Štěchovice</td>
<td>Vltava</td>
<td>ČEZ</td>
</tr>
</tbody>
</table>
In the next chart you can see power of hydropower plants in Czech Republic and their distribution on three types:

- MVE < 1 MW – Small hydropower plant with power lower than 1 MW
- MVE 1 until < 10 MW - Small hydropower plant with power between 1 MW and 10 MW
- VVE > 10 MW – Big Power plants with higher power than 10 MW

5.3 Solar energy

On the Czech Republic hits 1000 kWh/m² of solar energy every year. In our conditions the photovoltaic system with power of 1 kW per year can produce about 700 - 1,000 kWh of electricity. During the last decade of the last century the use of solar energy in the Czech Republic was limited to stand-alone systems for building and independent power facilities in locations without access to the grid.
Turnover was after year 2000, when state and local government support photovoltaic in the form of grants research and development and demonstration of specific projects. Like other renewable energy sources helped to the photovoltaic Czech adoption of Act No. 180/2005 Sb. Around the middle of 2009 this effect was combined with the decreasing cost of modules worldwide. In the Czech Republic was extreme boom in the year 2010 when was very low prices for photovoltaic.

In early of year 2007, worked in the Czech Republic 28 solar power plants with a total installed power 0.35 MW, the end of 2009 had already been marked more than 6 000 power plants with a total installed capacity more than 460 MW. At the end of 2010 the total capacity of photovoltaic attacked border 2,000 MW as you can see in charts.
### 5.4 Wind energy

Historically it is built of the first windmill in Bohemia, Moravia and Silesia documented in 1277 in the garden of Strahov Monastery in Prague. The biggest growth has seen the wind milling in Bohemia in the 40th the 19th century, Moravia and Silesia and later. It was in the territory of today's Czech Republic registered and historically verified 879 windmills. The period using of wind turbines for propulsion water pumps fall into the first two decades of the 20th century.

Start of modern wind power stations dates back to the end of the 80s the last century. Their main boom was in years 1990 – 1995, then was period of stagnation (bad planning or bad technology).

![Wind turbines - 1. 1. 1012](image)

**Fig. 42 - Wind turbines**

Like other renewable energy sources helped them the approval of Act No. 180/2005 Sb. about the promotion of renewable energy sources. In 2004 had wind power plants all power 11, 5 MW in year 2010 that was 215 MW. In this time in Czech Republic is something about 100 localities where are wind power plants. Their power is from 300 W (private use) to 3 MW.
Fig. 43 - The development of production electricity of Wind turbines

One of the producers is one Czech company (Wikov Wind), but most of the machines currently installed in the Czech Republic comes mainly from Germany and Denmark.

Fig. 44 - Wind power installed in Europe by end of 2011
On the map of Europe you can see use of wind energy in every country of Europe. This map is from year 2011 and you can see there how many MWh producing every state. Some countries do not produce any MWh from wind energy.

5.5 Biomass

Czech Republic is the country with relative high area of agricultural land, (54, 2% of total area) and forests (38, 5%). Basic framework of renewable energy sources including biomass energy utilization is implemented by two documents: Act on the promotion of electricity from renewable sources (180/2005 Sb.) and the National Action Plan of the Czech Republic for Renewable Energy Sources. The National Action Plan for RES (approved by the Czech government on 25. August 2010) is designed to fulfil the EU required targets (minimally 13% share of energy from renewable sources in gross final energy consumption and 10% share of renewable energy in transport) by 2020.

According to the National Action Plan, biomass, as the primary renewable energy sources in the energy mix of the Czech Republic, plays the indispensable role. It is significant not only for increasing national energy self-sufficiency of the Czech Republic by using indigenous energy resources but it also helps create new jobs, mainly in those areas where it is usually the biggest problem with unemployment (rural areas), supports local economy and regional development. State Energy Concept of the Czech Republic considers biomass as a major renewable energy source too and there was also created the Biomass Action Plan for the Czech Republic 2012-2020 which shows real potential of various types of biomass for efficient energy use.

![Fig. 45 - Proportion of Biogas](image)

Biomass is one of the few renewable energy sources for which the Czech Republic has really good environmental conditions. Biomass covers the largest part of the total potential of
renewable energy sources in the Czech Republic. So it is expected that biomass may be the main part for the fulfilment of the objectives of the Czech Republic to the year 2020.

Biomass is renewable but local raw material. The best utilization of biomass is in the area where the biomass arises and consequently is also consumed. Biomass potential is divided mainly between woody biomass (wood chips are widely used in the Czech Republic) and agriculture biomass which use is still in its infancy (there are sufficient reserves in the emerging biomass on agricultural land and in the use of wood pellets).

In last chart you can see production of all this types of biomass in Czech Republic:

- Wood chips
- Plant materials
- Cellulose extracts
- Pellets
- Liquid biomass
- Other biomass

![Electricity production from Biomass 2011](image)

**Electricity production from Biomass 2011**

5.6 Other renewable energy sources

Geothermal energy

Direct use of geothermal heat is not use in the Czech Republic. Projects for the production of electricity from geothermal energy are still in the stage of are still in the stage of preparation and considerations. Currently furthest is project of use geothermal energy in
Litomerice. The success of this project, which is calculating with a combined production of electricity and thermal energy, dependent development of the use of this energy in other areas of the country. Plant should have a capacity of 4.4 MW and would serve primarily as a heating plant, which would replace all existing thermal power from fossil fuels. The success of this project, which envisages a mix of electricity and thermal energy depends the development of the use of this energy in Czech Republic. Power plant should have power 4.4 MW and it will primary serve like heating plant, which would replace all existing thermal power station from fossil fuels.

Specific is use of thermal waters in spas and water pools. In this age is geothermal energy used in 11 spa centers. Utilization of geothermal energy in spas and water pools is about 90 TJ/year with capacity 4, 5 MWt. Of course these values are not in statistics of utilization of Renewable energy sources.

**Ocean energy**

In Czech Republic is impossible to use ocean energy, because we do not have any access to see or ocean. We are using just hydropower plants.
6 Practical part

In this part of our work we use program Retscreen. Everyone picked one technology, which is used in Czech Republic and work on his own project. First technology was solar heating of water in family house and second is Wind turbine which will make power for grid.

The Retscreen Software Suit is a free clean energy software package developed by the Government of Canada. This software is made from macros in Microsoft Excel. This tool helps decision determine the technical and financial viability of potential renewable energy sources, energy efficiency and cogeneration projects. Last made version is Retcreen 4 which is available on web site of company: www.retscreen.net where you can select your language and register your e-mail address and you can free download this program. After installation you can see you installed Redscreen Plus too, which is for energy management.

6.1 Solar water heating

In Czech Republic solar water heating technologies use of aplenty because Czech government supports the construction of solar collectors by various grants.

My family house is situated in Prague – Ruzyně. This house will use solar heating just for hot water, number of occupant is 5 with occupant rate 70% and daily hot water use is approximately 200l. For this case was selected glazed type of heater which 6,06m² gross area. In this conditions is solar fraction 61% and for rest of the hot water we will use electricity. This are mains results and rest of them are in presentation.

6.2 Wind turbine

Wind turbine is the best to build to some place where is the highest wind speed, free place and it wants big investment. Average investment is approximately one million EUR for one MWt on the land and two MWt on the see.

I picked place near Prague – Prague Kbely, where are for my opinion good conditions for wind energy. For this project I picked like pattern project in Pchery, where is as first used technology where we don’t need too high wind speed. In Pchery is used two of wind turbines WinWind WWD-3 – D100, which means power 3 MWt and high 100m. This invention was for 7 000 000 Euros. I want just one turbine so I guess the investment will be higher than for just one turbine so I picked 4 000 000 EUR. I used the same model of wind turbine. Retscreen counted return of this investment, which should be in 3 years. My results are in our presentation of this work.
7 Sources

Global Market Outlook for Photovoltaic until 2016, EPIA, May 2012


http://www.zelenalouka.org/dokumenty/Zelene_technologie_nici_zivotni_prostredi.html


Obnovitelné zdroje energie a možnosti jejich uplatnění v ČR. 2007, 2.


8 List of figures

Fig. 1 - Installed capacity for solar power: 29,665 MW in total (installed in 2011; Unit: MW) ................................................... 4
Fig. 2 - Passive Solar Energy ................................................................................................................................. 4
Fig. 3 - Active Solar Energy .................................................................................................................................. 4
Fig. 4 - Photovoltaic cells are Converts of Energy .................................................................................................... 5
Fig. 5 - Water heating .................................................................................................................................................. 5
Fig. 6 - Glazed plate flat collector .......................................................................................................................... 5
Fig. 7 - Geothermal Reservoirs at the Earth .................................................................................................................. 7
Fig. 8 - Geothermal Power Plant ............................................................................................................................. 7
Fig. 9 - Dry Steam Power Plant ............................................................................................................................... 8
Fig. 10 - Flash Steam Power Plant ............................................................................................................................ 9
Fig. 11 - Binary Cycle Power Plant .......................................................................................................................... 10
Fig. 12 - Totally installed wind power capacity worldwide ....................................................................................... 12
Fig. 13 - Windmill ....................................................................................................................................................... 13
Fig. 14 - Horizontal axis Wind Turbine ...................................................................................................................... 13
Fig. 15 - Vertical axis Wind Turbine .......................................................................................................................... 14
Fig. 16 - How does a wind turbine work .................................................................................................................... 15
Fig. 17 - Scheme of Involvement of wind turbine to the electricity network and generating energy. ...................... 15
Fig. 18 - MINI OTEC ..................................................................................................................................................... 17
Fig. 19 - Ocean power plant ....................................................................................................................................... 18
Fig. 20 - Scheme of ocean power plant ...................................................................................................................... 18
Fig. 21 - La Rance Tidal Power Station, France .......................................................................................................... 19
Fig. 22 - Trends in the top five countries generating electricity from biomass ......................................................... 20
Fig. 23 - Biomass sources ........................................................................................................................................... 21
Fig. 24 - Types of biomass .......................................................................................................................................... 21
Fig. 25 - Waste biomass ............................................................................................................................................... 22
Fig. 26 - Pyrolysis – Biomass technology ................................................................................................................... 23
Fig. 27 - Combustion .................................................................................................................................................... 23
Fig. 28 - Gasification ................................................................................................................................................... 24
Fig. 29 - Diagram of different types of waste for fermentation ...................................................................................... 25
Fig. 30 - Composting process ................................................................................................................................... 26
Fig. 31 - Production of biofuels ................................................................................................................................. 27
Fig. 32 - The water cycle .............................................................................................................................................. 30
Fig. 33 - Topical Hydropower Plant .......................................................................................................................... 31
Fig. 34 - Map of the solar radiation in the CZ ............................................................................................................... 31
Fig. 35 - The price of electricity from RES in the EU - long-term marginal costs and purchase prices in the Czech Republic ................................................................................................................................. 39
Fig. 36 - Energy sources in Czech Republic ................................................................................................................ 40
Fig. 37 - Hydropowers in Czech Republic .................................................................................................................. 41
Fig. 38 - Hydropower plants ....................................................................................................................................... 42
Fig. 39 - The development of production electricity of hydropower plants .............................................................. 43
Fig. 40 - Solar power plants ......................................................................................................................................... 44
Fig. 41 - The development of production electricity of Photovoltaic power planes .................................................... 44
Fig. 42 - Wind turbines ................................................................................................................................................. 45
Fig. 43 - The development of production electricity of Wind turbines ....................................................................... 46
Fig. 44 - Wind power installed in Europe by end of 2011 ............................................................................................. 46
Fig. 45 - Proportion of Biogas ...................................................................................................................................... 47
Fig. 46 - Electricity production from Biomass 2011 ..................................................................................................... 48
9 List of tables

Table 1 - Current situation ................................................................. 35
Table 2 - Production potential of solar thermal ................................. 35
Table 3 - The potential of biomass for energy purposes ...................... 36
Table 4 - The potential of forest biomass energy ............................... 36
Table 5 - The potential use of biogas .................................................. 36
Table 6 - Hydropower potential ......................................................... 37
Table 7 - The potential for wind energy ............................................. 37
Table 8 - The potential of geothermal energy ..................................... 38
Table 9 - Future plans ................................................................. 38
Table 10 - Current use of renewable energy sources in the Czech Republic (2011) ................................. 41
Table 11 - List of big water power stations ....................................... 42