Czech University of Life Sciences in Prague

Faculty of Economics and Management

Department of Economy

DIPLOMA THESIS

Renewable Sources of Energy - Economic Analysis of Biomass Utilization in the Czech Republic

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DIPLOMA THESIS ASSIGNMENT

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Thesis title

Renewable Sources of Energy - Economic Analysis of Biomass Utilization in the Czech Republic

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Objectives of thesis

Diploma Thesis is focused on renewable sources especially on biomass and it's utilization in the Czech Republic. Main aim is to characterize the biomass as a renewable source and analyze the economical view.

Methodology

Main objective of the theoretical part of the thesis is to define the term renewable source, especially the term biomass and also define the differences at all renewable sources such as hydropower, geothermal power, wind energy, solar energy.
In this diploma thesis are used methods of both quantitative and also qualitative research. Data are taken from Ministry of Industry and Trade and also internal data from particular company - Benko spol. s.r.o.
In the literature review is used basic method of text study. The analysis of available information sources, synthesis, induction, deduction, abstraction and methods of text study are used. Comparison with different biomass products is made.
The case study on the company Benko spol. s.r.o. is based on determination of briquettes production. The financial analysis is computed, also net present value, internal rate of return, and pay back period.

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Recommended information sources

[1] BERANOVSKÝ, J., TRUXA, J. Alternativní energie pro váš dům. 2. Vyd. Praha: EkoWATT, ERA group spol. s.r.o., 2004. 125 s. ISBN 80-865517-89-6

[2] MURTINGER, K., BERANOVSKÝ, J. Energie z biomasy. 1. Vyd. Praha: EkoWATT, ERA group s.r.o., 2006. 94 s. ISBN 80-7366-071-7

[3] JANOUCH, F., SCHLEICHER, S. Energy for sustainable development. 1. Edition. Havlíčkův Brod: Charles University in Prague, 2005. 279 s. ISBN 80-239-4809-1

[4] Nonrenewable energy sources [online]: [cit. 29.8.2011]. Available at WWW: http://www.eia.gov/energyexplained/index.cfm?page=nonrenewable_home

[5] Renewable energy sources [online]: [cit. 28.8.2011]. Available at WWW: http://nationalatlas.gov/articles/people/a_energy.html#six

[6] Hydropower [online]: [cit. 30.8.2011]. Available at WWW: http://www.eia.gov/cneaf/solar.renewables/page/hydroelec/hydroelec.html

[7] Hydropower [online]: [cit. 30.8.2011]. Available at WWW: http://nationalatlas.gov/articles/people/a_energy.html#one

[8] Pros of hydropower [online]: [cit. 31.8.2011]. Available at WWW: http://www.energeticky.cz/64-vodni-energie.html

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Declaration of Integrity:

I declare that I have worked on my diploma thesis titled "Renewable Sources of Energy - Economic Analysis of Biomass Utilization in Czech Republic" by myself on the management of my supervisor and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis I claim that I have not violated any copyright rules and author rights of the third parties.

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Jana Nováková

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Obnovitelné Zdroje Energie – Ekonomická Analýza využití Biomasy v České republice

SOUHRN:

Hlavním cílem této diplomové práce je zhodnocení využití obnovitelných zdrojů, zejména obnovitelný zdroj – biomasa a její využití v České republice. Dalším cílem je zhodnocení produkce biomasy a také zhodnocení produkce ve vybrané společnosti, kterou je společnost Benko spol. s.r.o., která poskytla svá interní data pro vyhotovení investiční analýzy.

Diplomová práce je rozdělena na dvě hlavní časti. Teoretická část se zabývá především charakteristikou pojmů neobnovitelné zdroje, obnovitelné zdroje a především pojmem biomasa a zhodnocuje výhody těchto zdrojů. Praktická část začíná analýzou užití biomasy v České republice, kde zobrazení je v jednotlivých grafech.

Případová studie o vybrané společnosti zhodnocuje budoucí potenciál produkce briket. Investiční analýza v případové studii vyhodnocuje potenciál investice konkrétního stroje, který je vhodný pro výrobu briket v dané společnosti.

KLÍČOVÁ SLOVA:
Neobnovitelné zdroje
Obnovitelné zdroje
Vodní energie
Geotermální energie
Solární energie
Větrná energie
Biomasa

Renewable Sources of Energy - Economic Analysis of Biomass Utilization in the Czech Republic

SUMMARY:

The main objective of the diploma thesis is to evaluate the renewable energy mix, especially renewable resource biomass and its utilization in the Czech Republic.
The second objective is to evaluate the production of biomass and the production of a selected producer in a case study. Company Benko spol. s.r.o. provided the internal data for the case study.

The thesis is divided into two main parts. Theoretical part characterizes terms nonrenewable resources, renewable resources, and biomass and shows the benefits of these resources. The practical part deals with the analysis of biomass utilization in the Czech Republic and includes results displayed in graphs.

The case study shows the future potential of the briquettes production. Investment analysis helps to evaluate the potential of investment of particular briquettes machine and its all related investments in the company.

KEY WORDS:
Nonrenewable resources
Renewable resources
Hydropower
Geothermal power
Solar energy
Wind energy
Biomass

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1 INTRODUCTION

Energy is a basic element that influences and limits our living standards and technological progress. It is a term that accompanies us at every step, especially in last two centuries. The humanity during this short time period has gone through a rapid development due to enormous amount of energy that was able to release and use in the form of fossil and nuclear fuels. However, energy is a term of the future because just future will show how people can resolve the increasing consumption of energy.

The renewable resources represent in our conditions a number of forms such as hydropower, geothermal power, wind energy, solar energy or biomass.

Nowadays the biomass concept is a very discussed topic and we can hear a lot of different opinions about this type of energy production. The renewable resource such as biomass is not anything new, people have been dealing with the cultivation of biomass for more than ten thousand years. Biomass in the wood form was a primary energy resource for millennia before the advent of fossil fuels. What is new and what is crossing the borders of the traditional agriculture is the right use of biomass for energy production.

Coal, oil and natural gas have lost their old reputation and their media image is environmentally below freezing. Unlike the biomass, which belongs to renewable energy resources like wind, sun and water because of the fact that trees and plants can grow again.

Biomass is generally referred to any substance of organic origin. It has a wide range of species including dendromass (wood biomass), phytomass (plant biomass) agricultural and energy crops) and animal biomass. One of the resources is biomass and biodegradable waste (clean and sorted from other components).

In connection with growing requirements for the use of biomass in energy, transport as a part of the fuel and also renewable raw materials in industry is useful to explore the potential possibilities and ways of efficient use of biomass in the future.

Biomass is currently about a half of the renewable energy used in the European Union and it is an important component in terms of the Renewable Energy Sources (RES) usage. In the Czech Republic residual biomass from forestry, agriculture and energy crops are mainly used.

Biomass used for electricity generation is often criticized for its inefficiency. The effectiveness of biomass in electricity production is estimated at 25-35%. Residual energy (65-75%), which is produced in the form of heat, remains unused.

The electricity production from biomass is seen as a future. One of the largest electricity Company in Central Europe, CEZ Group, plans to gradually increase the production of electricity from this resource.

2 OBJECTIVES OF THESIS AND METHODOLOGY

2.1 OBJECTIVES OF THESIS

The main objective of the theoretical part of the thesis is to define the term renewable resources, especially the term biomass and also define the differences at all renewable resources such as hydropower, geothermal power, wind energy, or solar energy.

The main objective of the practical part of the thesis is to characterize the utilization of biomass in the Czech Republic. In addition, the case study of the concept and its research will help to improve the view at the practical and economical biomass use.

Partial objectives are:

- Analyze the conditions of renewable sources
- Analyze the conditions of biomass
- Set up the information about renewable source, biomass in the Czech Republic and its utilization
- Find out the pros and cons of biomass utilization

2.2 METHODOLOGY

In this diploma thesis methods of both quantitative and qualitative research are used. The data are taken from the Ministry of Industry and Trade as well as from the researched company - Benko spol. s.r.o.

Basic method of text study is used in the literature review, further the analysis of available information sources, synthesis, induction, deduction, abstraction are used. The comparison of share of individual types of renewable resources in gross electricity production and thermal energy production in 2009 and 2010 in the Czech Republic is evaluated.

Briquettes and pellets production, import, export and supply at the domestic market in the Czech Republic are analyzed. The analysis helps to evaluate the biomass utilization in the Czech Republic.

The case study related to the company Benko spol. s.r.o. is based on determination of briquettes production. The production, export and domestic sales of briquettes from Benko are analyzed and graphs are drawn as a result in order to help evaluate the situation of the company. The specific values of investment analysis are computed, especially net present value, internal rate of return, and pay back period of particular briquette machine.

3 THEORETICAL BASIS

3.1 NONRENEWABLE RESOURCES

Energy sources are considered as nonrenewable sources if they cannot be refilled in a short period of time. Nonrenewable resources are natural resources that cannot be grown, produced or generated. When they are depleted they are not available anymore for future needs. Other criterion for the classification is that nonrenewable resources are consumed much faster than nature can produce them. On the other hand, renewable energy sources such as a wind or solar can be refilled naturally in a short period of time.

The four nonrenewable energy resources that are used most often:

- Oil and petroleum products – including gasoline, diesel fuel, heating oil and propane
- Coal
- Uranium (Nuclear energy)
- Natural Gas

Nonrenewable energy resources turn out of the ground as gases, liquids and solids. Crude oil (petroleum) is the only commercial nonrenewable fuel that comes out naturally in liquid form. Coal is a solid and Natural Gas and Propane are normally gases.

Fossil fuels are nonrenewable, but not all of them are nonrenewable energy sources. Coal, petroleum, natural gas, and propane are all taken as fossil fuels because they were formed from the buried remains of plants and animals that lived millions of years ago. The solid of Uranium ore is mined and converted to a fuel used at nuclear power plants. Uranium is a nonrenewable fuel even if is not a fossil fuel. [1]

3.2 RENEWABLE RESOURCES (RES)

Renewable energy resources are energy sources that are continually refilled. They include energy from wind, water, the sun, geothermal sources, and biomass sources such as energy crops.

The renewable resources in contrast with the uranium and fossil fuels are called renewable because they are regenerated with solar radiation and also because of other processes that are used. They are also inexhaustible in meaning of human existence and also in a part of our natural environment and form of our eco-system.

Renewable resources of energy are widely different in the effectiveness of their cost and also in their availability. Although wind, water, and other renewables may look for free, their cost is coming from harnessing, collecting and transporting of the energy to have them useful. For getting the energy from water a dam with electric generators and transmission lines has to be built.

Renewables are nonpolluting by themselves, when the structures are built to use them, they can have positive or negative environmental effects. For example, dams may affect fish migration but may also make nature environment. [2]

3.2.1 HYDROPOWER

3.2.1.1Basic characteristic of Hydropower

Water is currently the major renewable resource of energy used by electric utilities to generate the electric power. Many hydroelectric power plants use a dam on a river to store water. Hydroelectric plants came across on all waterways whose are available. Many of the best sites have been already developed. Hydropower is one of the least expensive resources of electricity and areas with good resources of hydropower tend to attract industries with large needs for electricity.

In addition, because there is no fuel combustion, there is little air pollution in comparison with fossil fuel plants and limited thermal pollution compared with nuclear plants. Like other energy resources, the use of water for generation has limitations, including environmental impact caused by damming rivers and streams, which affects the habitats of the local plant, fish, and animal life.

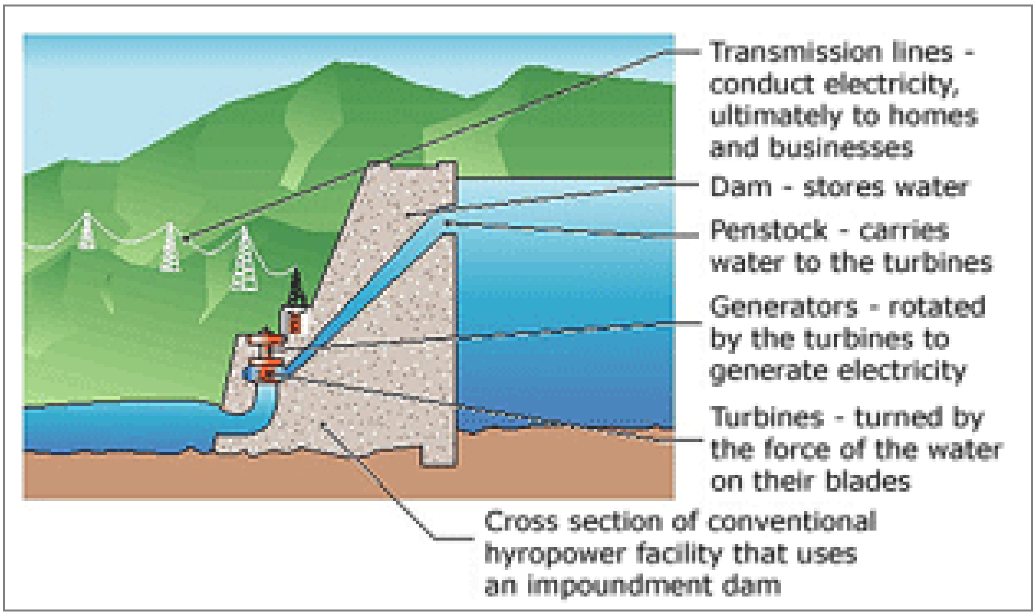
The hydropower has the largest share of renewable energy in terms of the Czech Republic. While the energy of the water wheel was used for a wide variety of different human activities, modern water turbines are utilized for the production of electricity.

Hydropower is promising especially in areas of steep streams with large gradients.

In the Czech Republic there are not natural conditions for the construction of hydropower for perfect working. Our flows do not have the required fallout and enough water quantity. Therefore, the share of electricity production from hydropower in the total production is relatively low in Czech Republic, in 2010 it was only 4%.

The main reason for the existence of the hydropower in the Czech Republic is to work as an additional source of major sources such as coal-fired power plant, nuclear power plant Dukovany, Temelín. It is also helpful in the ability to use it as a fast start-up of high power. [3,4]

Figure no. 1: The hydropower plant dams with water in reservoir



Source: http://nationalatlas.gov/articles/people/a_energy.html#one

In Figure no. 1 it is possible to see the hydropower plant dams with the water in reservoir. The transmission lines are to conduct the electricity to homes. The stored water is in the dam and the turbines turned by the force of the water are rotating with the generators to generate the electricity.

3.2.1.2Pros of Hydropower

The major advantage is that water is a resource of cheap power. In addition, because there is no fuel combustion, there is little air pollution in comparison with fossil fuel plants and limited thermal pollution compared with nuclear plants.

In addition to power, dams often provide other benefits such as recreation opportunities on upstream reservoirs, habitat for a wide variety of aquatic and terrestrial species, diversion of water for irrigation, and control of destructive flooding and environmental damage downstream.

Hydropower is one of the least expensive resources of electricity and areas with good sources of hydropower tend to attract industries with large needs for electricity.

- Coverage of their own electricity consumption
- Possibility of electricity sale to major distributors sites, "Green bonuses" drawing
- Reduce dependence on energy supplies from major distributors
- Usability of older dams (mills, saws)
- Grant support from Czech republic and European Union
- Ecologically clean energy production [5]

3.2.1.3Cons of Hydropower

Like other energy resources, the use of water for generation has limitations, including environmental impact caused by damming rivers and streams, which affects the habitats of the local plant, fish, and animal life. [5]

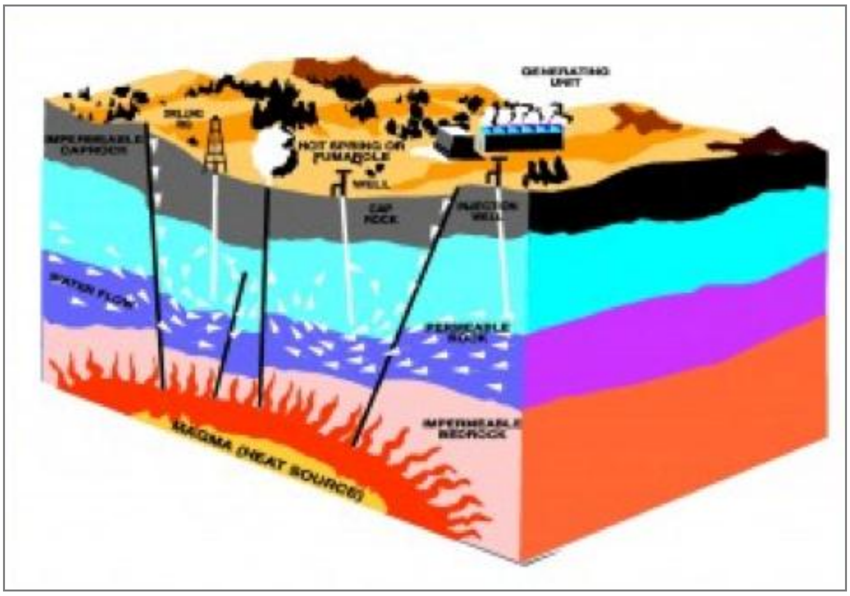
- Dependence on the season and the weather
- Technical installation demands of equipment
- Remains a dependence on energy supplies from major distributors
- Long payback period
- Building interventions into the surrounding natural environment [6]

3.2.2 GEOTHERMAL POWER

3.2.2.1Basic characteristic of Geothermal Power

In general terms, geothermal energy consists of the thermal energy stored in the Earth’s crust. Thermal energy in the earth is distributed between the constituent host rock and the natural fluid that is contained in its fractures and pores at temperatures above ambient levels. These fluids are mostly water with varying amounts of dissolved salts, typically, in their natural or they are present as a liquid phase but sometimes may consist of a saturated, liquid-vapor mixture or superheated steam vapor phase. [7]

Figure no. 2: Geothermal Energy Electricity



Source:http://myecoproject.org/get-involved/energy-conservation/renewable-energy-sources/geothermal-energy/

Figure no. 2 represents the display of geothermal energy electricity. The heat source of geothermal energy is magma.

3.2.2.2Geothermal Energy Uses

Geothermal fluids of natural origin have been used for cooking and bathing since before the beginning of recorded history, but it was not until the early 20th century that geothermal energy was harnessed for industrial and commercial purposes. In 1904, electricity was first produced using geothermal steam at the vapor-dominated field in Larderello, Italy. Since that time, other hydrothermal developments, such as the steam field at The Geysers, California; and the hot-water systems at Wairakei, New Zealand; Cerro Prieto, Mexico; and Reykjavik, Iceland; and in Indonesia and the Philippines, have led to an installed world electrical generating capacity of roughly 4.428 Giga watts in 2007, with forecasts of installed world electrical capacity to the year 2035 of 7.009 Giga watts.

The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs, but only a very small fraction may be profitably exploited. Drilling and exploration for deep resources is very expensive. Forecasts for the future of geothermal power depend on assumptions about technology, energy prices, subsidies, and interest rates.

For commercial use a geothermal reservoir capable of providing hydrothermal (hot water and steam) resources is necessary. Geothermal reservoirs are generally classified as being either low temperature (<150°C) or high temperature (>150°C). [7]

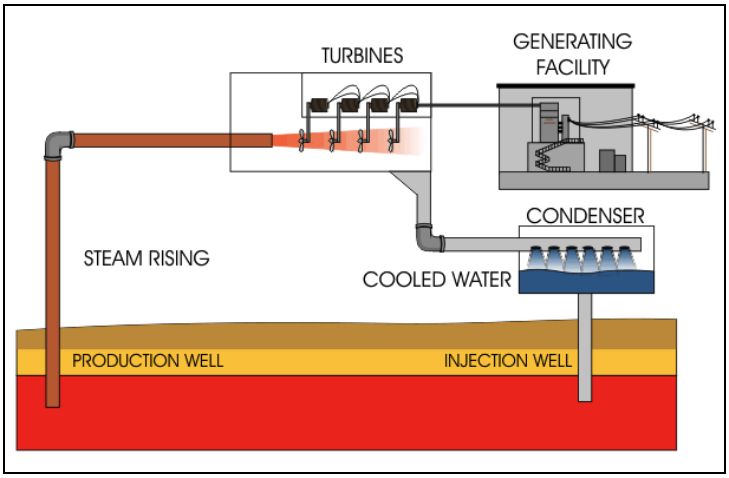
3.2.2.3Dry Steam Geothermal Power Plant

Geothermal Power Plant operations tend to be of three types: Dry-Steam Plants, Flash Plants, applied to high-energy geothermal resources, and Binary Plants, typically used in low-temperature resource situations.

This is the oldest type of geothermal power plant. It was first used at Lardarello in Italy in 1904, and is still very effective.

Steam plants use hydrothermal fluids that are primarily steam. The steam goes directly to a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine. [7]

Figure no. 3: Dry Steam Geothermal Power Plant



Source: http://www.digtheheat.com/geothermal/dry_steam_plant.html

Figure no. 3 shows the dry steam geothermal energy power plant and its processes. The steam is rising and thru turbines the generated power is going to the generating facility.

3.2.2.4Flash Steam Geothermal Power Plant

Flash steam plants are the most common type of geothermal power generation plants in operation today. They use water at temperatures greater than 182°C (360°F) that is pumped under high pressure to the generation equipment at the surface.

Upon reaching the generation equipment, the pressure is suddenly reduced, allowing some of the hot water to convert or “flash” into steam. This steam is then used to power the turbine/generator units to produce electricity. [7]

3.2.2.5Binary Cycle Geothermal Power Plant

According to the closed-loop system, almost nothing is emitted to the atmosphere. Moderate-temperature water is by far the most common geothermal resource, and most geothermal power plants in the future will be binary-cycle plants.

Most geothermal areas contain moderate-temperature water (below 204°C). Energy is extracted from these fluids in binary-cycle power plants.

Hot geothermal fluid and a secondary (hence, “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 flash to vapor, which then drives the turbines. [7]

3.2.2.6Geothermal Energy in the Czech Republic

Geothermal energy in the Czech Republic is being used for heating buildings. In Děčín a half of the city has been heated by geothermal energy for several years. In the Czech Republic only dry rocks can be used for the production of electricity from geothermal energy. Construction of geothermal power plants is planned in Liberec and Litoměřice.

In the Czech Republic the geothermal energy is used only for heating of houses, buildings, or zoos. The technical solution and implementation of geothermal power plants are very demanding and the investments are very high. Until the first wells are finished it is not possible to count the returns.

In the whole area of our country there is no place where hot water would be a suitable resource for power generation. The hot springs that bubble up in the spa towns cannot be used for those commercial purposes. The construction solutions of geothermal power plant are therefore very difficult. [8]

3.2.3 WIND ENERGY

3.2.3.1Basic characteristic of Wind Energy

The terms wind energy or wind power describes the process by which the wind is used to generate mechanical power or electricity.

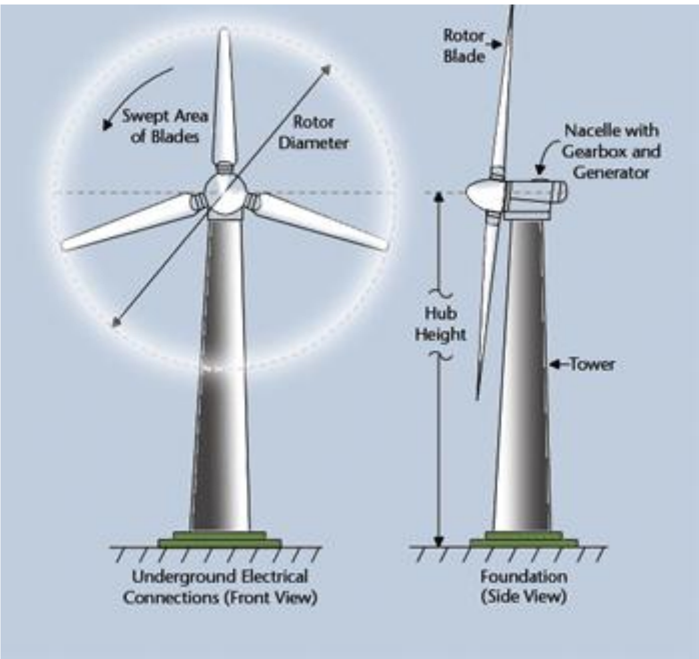
Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks such as grinding grain or pumping water or a generator can convert this mechanical power into electricity to power homes, businesses, schools, etc. [9]

3.2.3.2Principles of wind energy

Wind in the atmosphere arises from the difference of atmospheric pressure as a result of uneven heating of the Earth's surface. Warm air rise, its place is pushing by cold air. The Earth's rotation causes the coiling wind currents; their other influences are caused by landscape morphology, vegetation cover, water areas.

By aerodynamic forces on the rotor blades, the wind turbine mounted on the mast converts the wind energy to rotational mechanical energy. It is then by the generator source of electric energy. Along the rotor blade aerodynamic forces arise, leaves must therefore be specially shaped profile, very similar to that wing aircraft. It is therefore necessary to ensure effective and fast working regulating performance of the rotor so as to prevent mechanical and electrical overload true power. [9]

Figure no. 4: Wind Energy



Source: http://ec.europa.eu/research/energy/eu/research/wind/index_en.ht

The Figure no. 4 shows the windmill, which is producing the wind energy. The rotor blades are rotating and the electric energy is produced through the generator.

3.2.3.3Wind Energy in the Czech Republic

The use of windmills in our country has own tradition. Historically, the position of the first windmill in Bohemia, Moravia and Silesia is documented in 1277, in the garden of the Strahov Monastery, in Prague. The period of use of wind turbines to power water pumps in this country falls into the first twenty years of the twentieth century. The production of modern wind power is dated back to the end of the eighties the last century.

Currently, wind turbines operate in dozens of locations in the Czech Republic, its nominal power ranges from small power (300 kilo Watts - kW) for private use up to 2 Mega Watts (MW). In late September 2011 217.1 MW in total have been installed in the CR according to the Energy Regulatory Office. [10]

3.2.4 SOLAR ENERGY

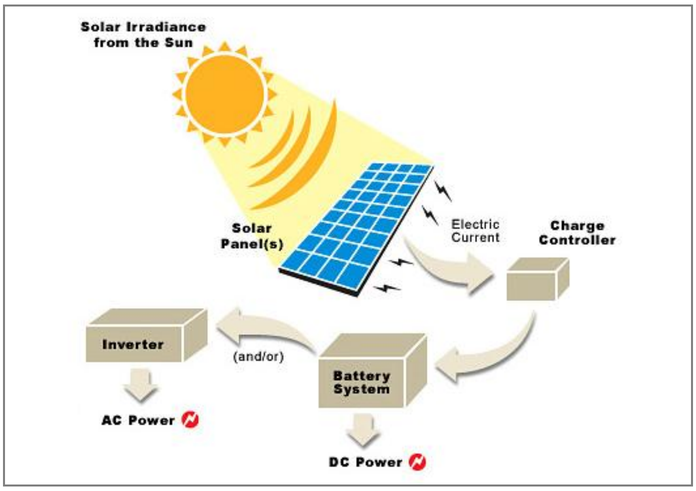
3.2.4.1Basic characteristic of Solar Energy

Direct usage of solar energy includes the protection of the environment of the cleanest and most environmentally friendly methods of electricity production. It is the energy source, which is long enough in nature. At present, it can be obtained from one meter up to the active area of only 110 kilowatt hour (kWh) of electricity per year. In comparison with other resources of energy in our electricity production using solar energy (photovoltaic) systems are still too expensive.

Solar power exceeds the theoretical consumption of mankind forty trillion times but it can be used only a part. About a quarter of the total incident radiation 180 000 terawatt is reflected back into space, less than one fifth is absorbed in the atmosphere and almost a half is converted into heat in the Earth's surface. About a half per mille (90 terawatt) varies across the photosynthesis of green plants and phytoplankton in the chemical energy stored in biomass.

The amount of energy, which now obtains the total energy of solar radiation is negligible. Although the current share of total production of photovoltaic electricity in the world is only about 0.01%, the use of solar technologies have great growth potential and developed countries with the renewable resource in the future count. [11]

Figure no. 5: Solar Energy



Source: http://www.alternative-energy-news.info/technology/solar-power/

The figure no. 5 displays the system of solar energy. The solar irradiances from sun are shinning to solar panels and charging the battery system.

3.2.4.2Solar Energy in the Czech Republic

The first solar power plant of 10 kW was put into operation in 1998 on a mountaintop Mravenečník in Jeseníky. Today it is positioned as a demonstration facility in the area Dukovany as part of the Information Centre. Since 2000 the state introduced a tool to promote photovoltaic, in support of demonstration projects and supporting research and development. The support culminated in 2010, it reached the highest degree of disproportion between the amount of the purchase price of electricity from photovoltaic installations and the cost of photovoltaic panels. This caused a huge boom in the construction of photovoltaic devices by domestic and foreign investors. The state limited the support during the year on the recommendation of ČEPS to protect the energy grid from possible damages. The Czech republic in late 2010 became the third largest operator of solar power plants in the world. [11]

3.3 BIOMASS

3.3.1 Basic characteristic of biomass

Biomass, so matter of organic origin could not exist without solar radiation. Biomass is defined as a substance of organic origin, which is cultivated or it is waste from agriculture, food or forest production.

From the energetic point of view, energy of biomass can be gained just only from burning process, thermo-chemical conversion (It is also possibility of using it as “fuel” as “traction” for farm animals and change it straight to mechanical work). Biomass is burned straight; it also depends on the type. Biomass is used as a heat resource and resource of electricity. [12]

3.3.2 Types of Biomass

Biomass is either deliberately planted or treated as waste.

1) Waste Biomass

- Vegetable waste from agriculture and landscape maintenance (straw, hay, orchards of waste, waste from greenery.)
- Forest wood waste from the extraction (roots, branches, cones)
- Organic wastes from industrial production - waste timber plants (sawdust, bark), waste from processing plants crop production (sugar), waste from dairies, slaughterhouses, and more.
- Municipal organic waste - sludge, municipal solid waste
- Waste from livestock - manure, fodder and other

2) Purposely grown biomass for energy production (energy crops, phytomass)

- Lignocellulose
    - Trees (willows, alders, poplars, acacias)
    - Cereals
    - Grass (elephant grass, permanent grassland)
    - Other plants (hemp, fodder sorrel, knotweed and others)

- Oil
    - Seeds (oilseed rape, flax, sunflower, pumpkin)

- Starch-sugary
    - Sugar beets, potatoes, wheat, corn, sugarcane

Selection of energy crops is determined by many factors such as soil type, method and purpose of use, the possibility of harvesting and transport, plant species composition in the area, climate conditions. Costs of cultivation and production are compared (energy gain).

At present, energy is extracted mainly from biomass burning. Biomass is burned, either directly or incinerated gaseous or liquid products resulting from processing. [13]

3.3.3 General Classification of Solid Biofuels by Origin

Classification is based on origin of biofuel sources. Hierarchic classification system divides the main classes of biofuel.

- Woody Biomass
    - Forest and plantation wood
    - Wood industry, residues
    - Used wood
    - Mixture

- Herbaceous Biomass
    - Agricultural and garden herbs
    - Herbs processing industry
    - Mixture

- Fruit Biomass

- Orchard and garden fruit
- Fruit industry, residues
- Mixture [14]

3.3.4 Processing Technologies of Biomass

Biomass is in two types, “dry” biomass and “wet” biomass. Basic technology of its processing is divided also into “dry” process and “wet” processes.

Division of technology, processing and preparation of biomass burning is as follows:

- Dry Processes
  - Combustion
  - Pyrolysis (production of gas, pyrolysis oil)
  - Gasification (gas production)
- Wet Processes
  - Fermentation, alcoholic fermentation (ethanol production)
  - Anaerobic digestion, methane fermentation
- Mechanical - Chemical Conversion
  - Oil extraction (production of liquid fuels, oils)
  - Esterification of crude bio-oils
  - Chipping, grinding, pressing, grinding (solid fuels production) [15]

3.3.4.1Direct combustion and gasification

Effects of high temperatures on dry biomass, flammable gaseous components – wood gas is released. In case that air is present, it will burn - it is a simple combustion. However, if the air is not available, the wood gas is moving into the combustion chamber where it burns as well as other gaseous fuels. Part of the heat is then used for further gasification of biomass.

Advantages:

- Easy to control performance
- Lower emissions
- Higher efficiency [15]

3.3.4.2Biochemical Conversion

Bioethanol – Production of ethanol is provided by fermentation of sugar solutions (from sugar beet, wheat, corn, fruit, potatoes, or also vegetables or cellulose). Fermentation can take place only in a wet environment. Formed, separated by distillation of alcohol is highly valuable liquid fuel for combustion engines.

Advantages

- Ecological purity

Disadvantages

- The ability to bind water and cause corrosion of the engine

Landfill Gases - At landfills the complicated biological processes are taking place and landfill gas is formed

Biogas – Is formed during decomposition of organic matter (manure, green plants, etc.) in tanks, without any oxygen. This process works by anaerobic bacteria. Residues of digestion process are a valuable fertilizer or compost.

For example: The use of biochemical conversion of biogas plants especially in wastewater treatment plants. [15]

3.3.4.3Mechanical - Chemical conversion

Biodiesel - is pressed from rape oil such as rapeseed methyl ester ("the first generation of biodiesel"). Production of biodiesel is more expensive than production of diesel fuel. In that case biodiesel is mixed with some other oil that could compete with the price of regular diesel fuel ("the second generation of biodiesel fuel") - retains its biodegradability, but the heating value is more close to diesel fuel). [15]

3.3.5 Guarantee of the Quality of Solid Biofuels

Standard CSN EN 15234-1 (83 8204) sets procedures to meet the requirements on quality and describe precautions, which guarantee the specific properties of biofuels. The main goal of the quality is to provide the warranty that the quality is stable in accordance with customer requirements. Measures for ensuring the quality helps to provide the system for producers and suppliers.

The main function is to make sure that:

- Traceability exist
- Demands, which influence the quality of biofuel are under control
- The final user can trust to the quality of biofuels

Demands on production of biofuels differ based on complexity of the production process, also on demands on resultant quality of biofuel. This leads different measures and requirements to ensure the quality. The methodology to ensure the quality has to be used in all production processes.

Suitable transport, manipulation and storage are very important factors for final quality of biofuel. These factors should guarantee that fuel is kept in right conditions. [16]

3.3.6 Specifications of Biofuels based on Business Forms and Properties

Different sizes and shapes of biofuels are at the market. Size and shape influence manipulation with biofuels and also the combustion properties. Biofuels can be supplied in the forms listed in the table.

Table no. 1: The main commercial form of solid biofuels

Name of the fuel	Typical size	Method of preparation
Briquettes	Average > 25 mm	Mechanical compression
Pellets	Average < 25 mm	Mechanical compression
Fine dust fuel	< 1 mm	Grind
Sawdust	1 mm to 5 mm	Cut with sharp tools
Wood chips	5 mm to 100 mm	Cut with sharp tools
Crushed wood fuel	Different	Cut with blunt tools
Logs	100 mm to 1 000 mm	Cut with sharp tools
All wood	> 500 mm	Cut with sharp tools
Small bales of straw	0.1 m3	Pressed and tied to square
Large bales of straw	3.7 m3	Pressed and tied to square
Round bales of straw	2.1 m3	Pressed and tied to round bale
Pack	Different	Bounded
Bark	Different	Debarked residues from trees
Straw chop	10 mm to 200 mm	Chopped during harvesting
Grain or seed	Different	Without preparation or dry
Fruit peels and seeds	5 mm to 15 mm	Without preparation

[16]

3.3.7 Briquettes

Briquettes are a fuel artificially adjusted by pressing a bulk material without adding any binders. Briquettes are made by pressing of various components(stems, leaves). In this case it cannot be called homogenous product.

The density of briquettes depends on:

- Pressing pressure
- Material structure

- Material humidity [16]

3.3.7.1Wood Briquettes

High-pressure treated wood dry dust, chippings or sawdust usually to the form of small or large rollers with a hole and without a hole, prisms, four, six, or octahedrons with a diameter of 40-100 mm. There are also purely bark briquettes. Real average calorific value of briquettes in the original sample is about 16.5 gigajoules per ton (GJ/t) (or more - depends on humidity and material of which are pressed). Wood briquettes are placed in the lower VAT rate. [16]

3.3.7.2Plant Briquettes

High pressure processed dried, crushed or cut short culm (straw of cereals and oil plants, grasses and energy herbs in the form of cylinders, prisms or hexahedron with a diameter of 40-100 mm). Heating 12 to 19 GJ/t. At the market cylinders with a hole are mainly made in the screw presses. Cylinders without holes or square briquettes are less frequent. Briquettes of sunflower are offered from imports. Plant Briquettes are placed in the higher VAT rate. [16]

3.3.7.3Paper Briquettes

Briquettes are made from waste paper or cardboard, but also of inappropriately colored leaflets and magazines. They are manufactured and blended briquettes from plant materials and paper, or paper and sawdust. The shape is usually a small cylinder, or a little skewed prism, cube exceptionally. Calorific value is 12-15 GJ/t. Paper Briquettes are placed in the higher VAT rate. [16]

3.3.7.4Brown Coal Briquettes

Brown coal briquettes are compressed from coal-dust. Any binder is not added to the briquettes. At the market there are domestic Sokolov briquettes "Triumph" from Vřesová (prism 7 "; Cube 3.5"). The calorific value of briquettes is 23.75 GJ/t. Schwarze Pumpe briquettes "Record", the heating value is 19 GJ/t. are imported from Germany, and "Union" briquettes from Frechen in the Rhineland with the calorific value 19.8 GJ/t. Brown coal briquettes are placed in the higher VAT rate, they are taken as a fossil fuel. [16]

3.3.7.5Peat Briquettes

High pressure compressed suitable types of industrially harvested peat. Peat briquettes offered on the domestic market are manufactured mostly in large-scale fuel plants in Ukraine and Belarus. Calorific value is 15-19 GJ/t depends on the quality - moisture briquettes. Briquettes have high disintegration. Peat briquettes are placed in the higher VAT rate, they are taken as a fossil fuel. [16]

Figure no. 6: Squared Briquettes

Figure no. 7: Round Briquettes

Source: www.jirgensons.eu

Figures no. 6 and no. 7 are examples of biomass briquettes that are produced in different shapes, such as squared briquettes and round briquettes.

3.3.7.6Pellets

Pellets are generally granules that have round cross-section and diameter is from 6 mm to 20 mm in length 1 to 5 cm. Pellets are made exclusively from organic material, biomass (wood, wood waste, sawdust) without any chemical additive. They are pressed under high pressure. [16]

Figure no. 8: Pellets

Source: www.nazeleno.cz

Figure no. 8 shows the different variants of pellets. The sizes depend on pellets machine and color of the pellets depends on the wood material, which is treated in specific production company.

3.3.8 Environmental positive aspects of biomass

What has been said is that the biomass has a major importance as a direct resource of renewable energy. In terms of environmental impact, use of biomass is more significant than the use of other renewable energy resources; biomass has the most positive impact on the environment. [17]

3.3.8.1 Saving Fossil Fuels

The main benefit is that it reduces the depletion of nonrenewable energy resources (fossil fuels), so the fossil fuels could stay as an energy resource as well for future generations, which is the main reason why the use of RES is extended. [17]

3.3.8.2 Reduction of Emission

When the conventional fossil fuel is burned into the atmosphere large quantities of pollutants that burdened the atmosphere escape. In biomass combustion, these values are very low. The value of carbon oxide is often close to zero, the sulfur content in biomass is negligible and also sulfur dioxide almost does not arise. The values of nitrogen oxide depend on the temperature of combustion and nitrogen compounds in biofuel. If the limits of the amount and temperature of combustion are observed, the emissions of nitrogen oxide are about half of the allowed limits. [17]

3.3.8.3 Reducing the greenhouse effect

Increasing consumption of fossil fuels adds to the atmosphere large quantities of carbon dioxide, which is a greenhouse gas. The increasing concentration along with other greenhouse gases (methane, nitrous oxide, CFCs) prevents leakage of accumulated heat in the Earth back into space, resulting in global warming and climate change.

Increasing temperature (over the last 30 years about for 0.5 ° C) results in a variety of natural disasters (cyclones, floods, droughts, heat, fire, etc.) and subsequent sea level rise will cause that coastal residents move to inland areas.

Global warming is a big threat and just using biomass as a renewable energy resource can reduce it. Biomass has a closed carbon cycle, which means that although the production of energy also produces carbon dioxide, but that was previously bound in the form of photosynthesis by plants. This means that with proper combustion of biomass it appears only such amount of carbon dioxide, which is absorbed back by other growing plants. The greenhouse effect does not increase. The more intensive cultivation of energy plants, the more carbon dioxide from the atmosphere is absorbed and greenhouse effect is more reduced. [17]

3.3.8.4 Waste

Another positive influence on the environment is that the waste from the combustion of biomass can be used as fertilizer, it solves the problems related to often asked questions, what to do with the waste. [17]

3.3.9 Environmental negative aspects of biomass

Besides the positive aspects there are also negative aspects on the environment of biomass combustion. The biomass combustion is not without any risk. One of the risk is that during the combustion large amount of pollutants is produced, especially polycyclic dibenzodioxins and dibenzofurans. Some other limitations are on the proper biomass combustion. If the biomass is burned at a temperature below 500°C the tar gas appears.

Another disadvantage is that the energetic plants are demanding for annexation land, they have a relatively low "density" of energy, so the space where the energy is concentrated must be created, and these areas are not often in place of consumption. [17]

3.3.10 Energy Use of Biomass in the Czech Republic

Biomass was considered from the beginning just as an interesting alternative fuel used in addition to traditional fuels. In recent years, however, biomass reached the level of an attractive energy resource for all types of users. Even in terms of CR it is considered a renewable resource with the highest available potential.

Biomass therefore plays a major role in future predicted growth of the usage of RES. The reason is the already mentioned sufficient available potential in the form of comparative abundance of land potentially suitable for the deliberate cultivation of biomass for energy purposes, while less favorable natural conditions are for the usage of other types of RES. [13]

3.3.11 National Energy Policy

National energy policy is one of the basic components of economic policy CR and was approved by the government on 10th March 2004. It defines the goals and priorities in the energy sector CR and describes the specific tools of state energy policy. The objectives are with the priorities and should be met by 2030.

The Ministry of Industry and Trade will evaluate the implementation of priorities and objectives in three-year intervals, and if necessary the proposals will be submitted to the Government. The long-term goals of national energy policy include achieving 15-16% of renewables in primary energy consumption by 2030. [18]

3.3.12 "EFEKT 2012" Publication of the State program to promote energy saving and renewable energy for year 2012

Minister of Industry and Trade, announced the State program to promote energy conservation and renewable energy sources, "EFEKT 2012". The program budget is 30 million CZK and offers fourteen types of supported activities for a wide range of applicants.

State program is established under Act No. 406/2000 Coll. Energy management, and its provisions are a direct implementation of European legislation. The program "EFEKT" is designed to promote energy savings and renewable energy resources in the Czech Republic.

The specialty of the program is the possibility to draw the subsidies in advance, not after the finished project as it is with most other programs. [18]

3.3.13 Energy Legislation of Renewable Resources in the Czech Republic

Act No. 406/2000 Coll.
Energy management.

The main aim is to increase energy efficiency in generation, transmission, transportation, distribution, energy consumption, including gas storage and related activities.

It defines obligations of natural and legal person in energy management, energy audits, as well as rules for the creation of the State Energy Policy, territorial energy concepts and the National Program for economical energy management and use of renewable and secondary sources.

Act No. 180/2005 Coll.
Supporting the use of renewable resources.

It defines the promotion of RES. It regulates the rights and obligations at the market of electricity from renewable sources and conditions of purchase and registration support of electricity from renewable sources. It determines the rules for the pricing of electricity from renewable sources

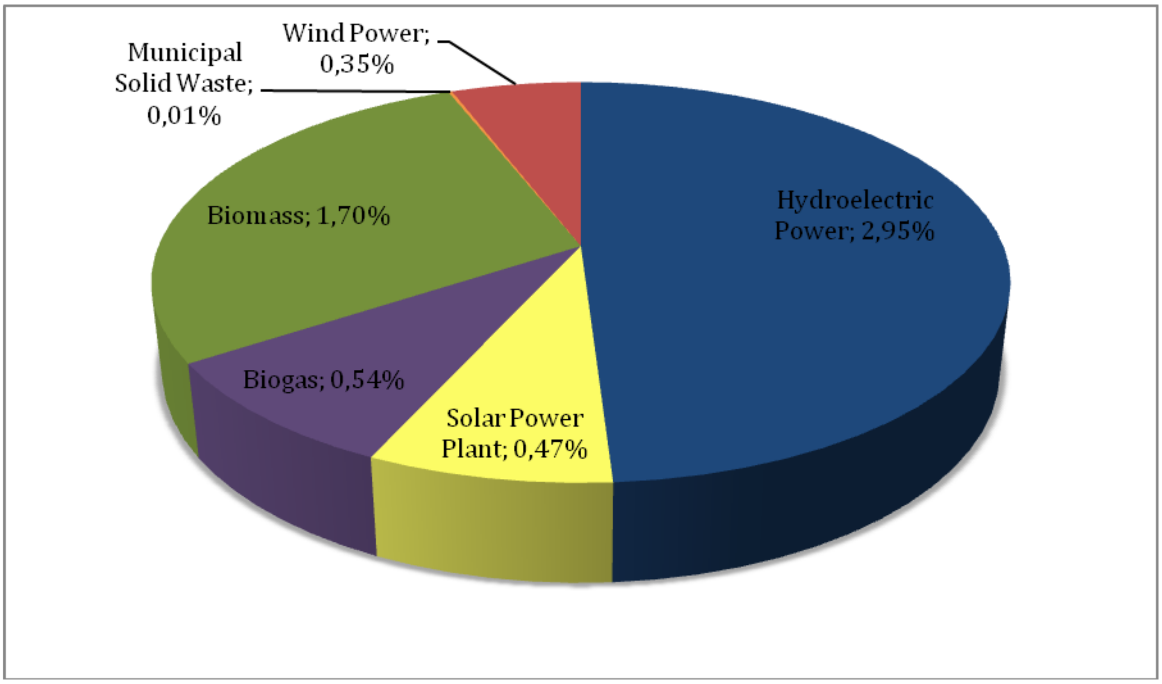
The main aim is to support renewable resources energy utilization i.e.- wind energy, solar energy, geothermal energy, hydropower, biomass energy, etc.

The other purpose of the Act is a permanent increase in the share of renewables in primary energy consumption of resources, prudent use of natural resources and meeting the indicative target for the share of renewable electricity in gross electricity consumption in the Czech Republic. [18]

3.3.14 Comparison of Share of individual types of RES in gross electricity production in CR (2009 and 2010)

Graph no. 1 shows the share of individual types of renewable resources in gross electricity production in 2009 in the Czech Republic.

Graph no. 1: Share of individual types of RES in gross electricity production in 2009

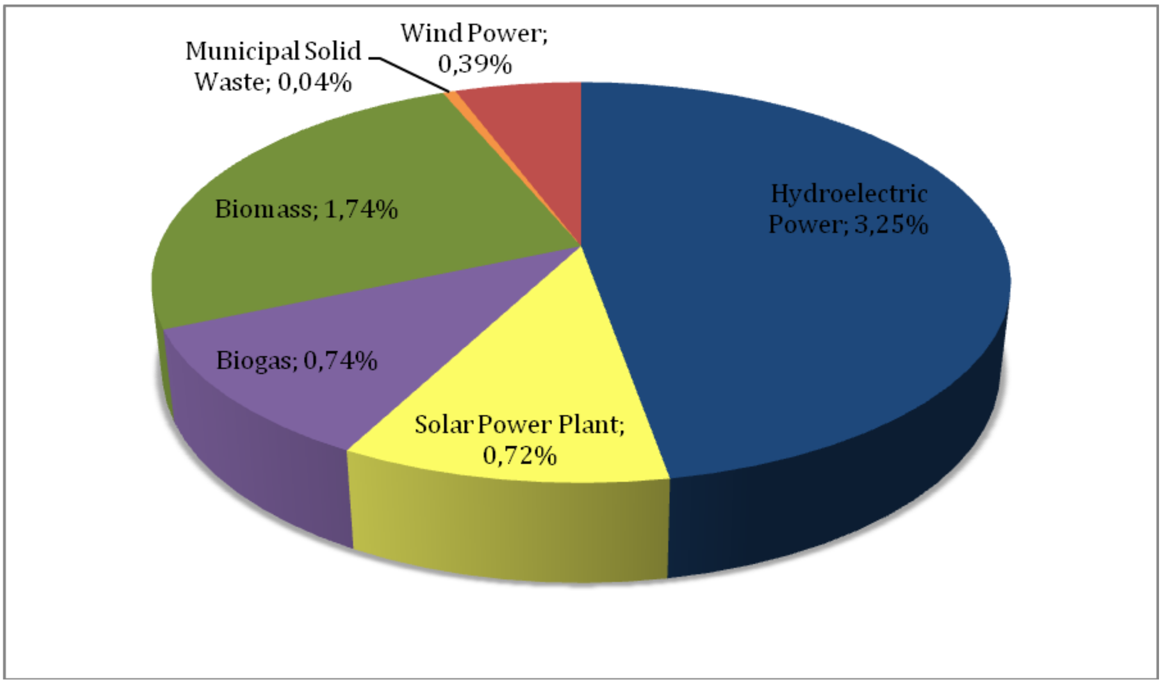


Source: Report on the Implementation of the indicative target of electricity from renewable resources in 2009, Ministry of Industry and Trade.

Graph no. 1 shows the gross production of electricity from renewable resources in 2009 participated in the national gross electricity consumption by 6.8%. The national indicative target share of the Czech Republic is set at 8% in 2010. The total domestic gross electricity production, gross production of electricity from renewable resources contributed 5.7%. [19]

Graph no. 2 shows the share of individual types of renewable resources in gross electricity production in 2010 in the Czech Republic.

Graph no. 2: Share of individual types of RES in gross electricity production in 2010



Source: Report on the Implementation of the indicative target of electricity from renewable sources in 2010, Ministry of Industry and Trade.

Graph no. 2 shows the indicative target share of energy from renewable resources in gross final energy consumption in the Czech Republic in 2010 of 8% was achieved.

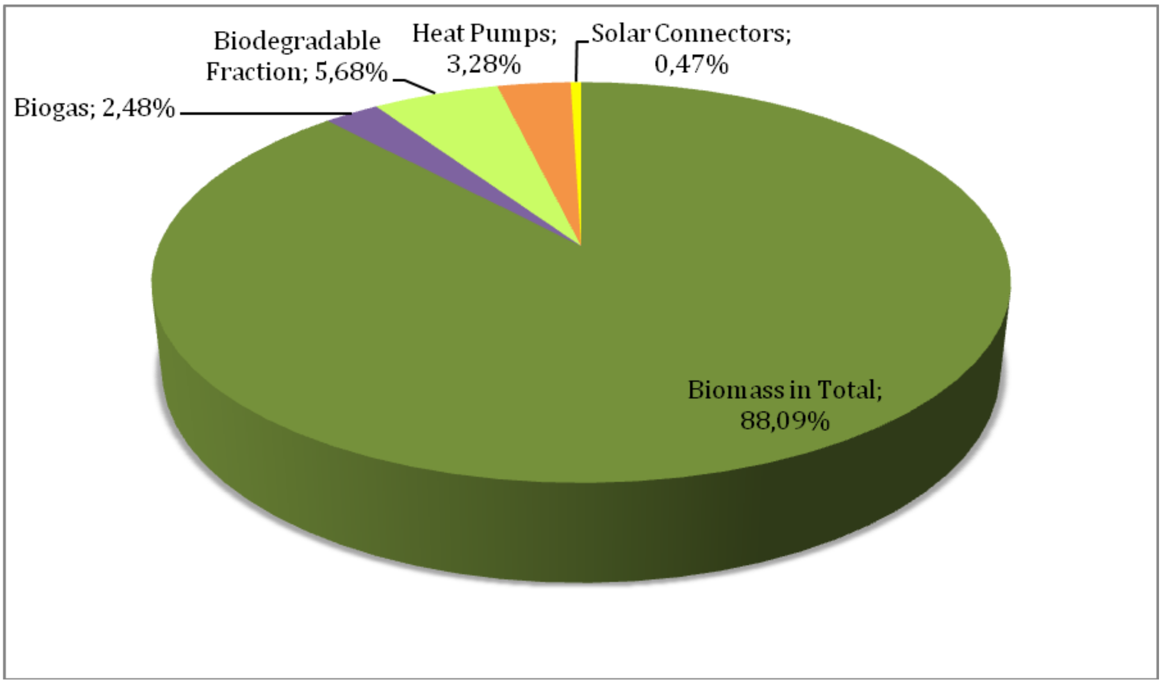
Gross production of electricity from renewable resources in 2010 participated in the national gross electricity consumption on 8.32%. The gross electricity production (including exports), the gross production of electricity from renewable energy resources contributed 6.87%.

The highest production of electricity from RES in 2010 was from hydroelectric power plants (2 789 GigaWatt hour - GWh). The production realized from wind power compared to last year significantly increased by 359 GWh. Followed by biomass (1 492 GWh) increased by 96 GWh. The use of biogas (635GWh) can even be considered as more significant resource of electricity from renewable energy resources. It experienced an increase's third and photovoltaic power plants (615 GWh) for the first time in 2010 produced more electricity than wind power (335 GWh). Waste incinerators (36 GWh) production tripled, but in terms of overall electricity production from renewable energy resources are still only marginal significance. [20]

3.3.15 Comparison of Share of Thermal energy Production from RES (2009 and 2010)

Graph no. 3 is shown the share of thermal energy production from renewable resources in 2009 in the Czech Republic.

Graph no. 3: Share of Thermal energy Production from RES in 2009

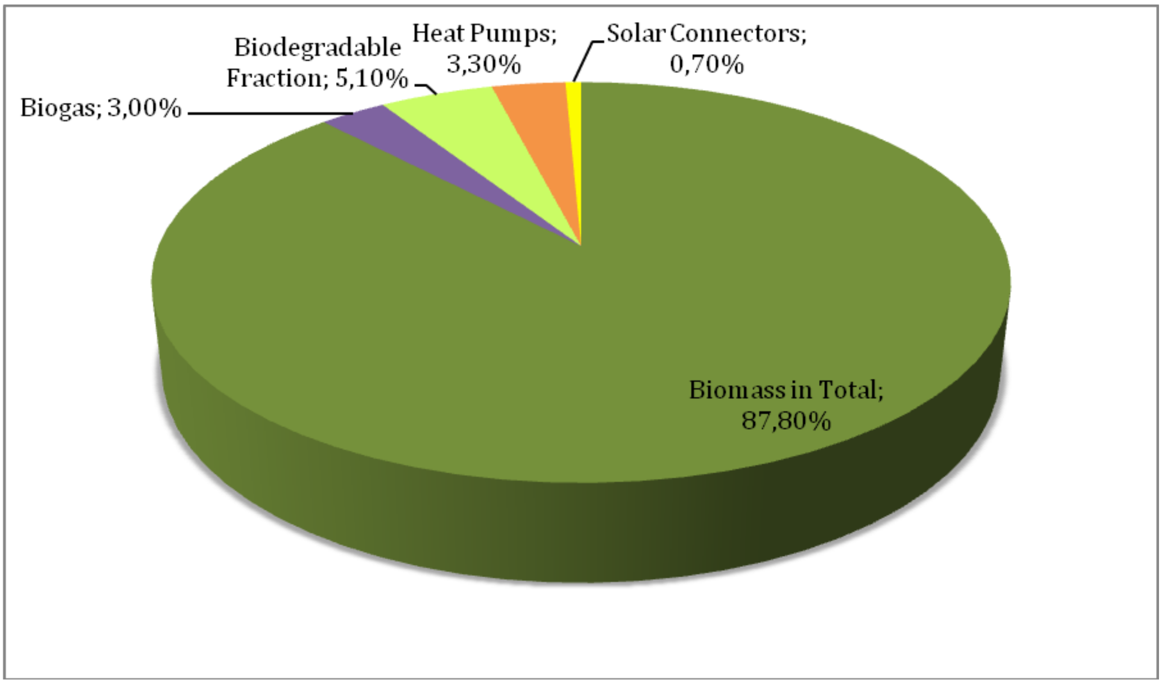


Source: Renewable resources in 2009, Ministry of Industry and Trade.

Graph no. 3 shows that the total of gross production of thermal energy from RES was 48 822 187.6 Giga Joul (GJ). The gross production of biomass was 43 007 154.1 GJ, which is 89.09% on share of total thermal energy production. Biogas production was 1 210 968.6 GJ, which is 2.48%. Biodegradable Fraction was 2 774 064.9 GJ (5.68%). Heat Pumps was 1 600 000 GJ (3.28%). Solar Connectors was 230 000 GJ (0.47%). [21]

Graph no. 4 shows the share of thermal energy production from renewable resources in 2010 in the Czech Republic.

Graph no. 4: Share of Thermal energy production from RES in 2010



Source: Renewable resources in 2010, Ministry of Industry and Trade.

Graph no. 4 shows that the total of gross production of thermal energy from RES was 53 235 131 GJ. The gross production of biomass was 46 736 280 GJ, which is 87.80 % on share of total thermal energy production. In comparison with production in year 2009 is the percentage share lower but total production in GJ is higher. Biogas production was 1 610 361 GJ which is 3.00 %. Biodegradable Fraction was 2 746 320 GJ (5.68%). Heat Pumps was 1 775 703 GJ (3.28%). Solar Connectors was 366 468 GJ (0.47%). [22]

3.3.16 Objectives in the use of Biomass Potential

A large number of studies were conducted in the area of biomass potential and other renewable resources in recent years in the CR and EU countries. The results of these various studies can be summarized into main conclusion:

- Czech Republic belongs to countries with relatively high biomass potential

- If the potential of waste and grown biomass fully utilized, biomass could be 12 % in share of total balance of energy consumption in CR, in term of the next decades. (About to 2030)

- Residual and waste biomass is about 2.2 to 6.5 million tons per year which about 2 million tons is used, which is about 1/3 of the potential of waste biomass and about 1/5 of the total available biomass potential.

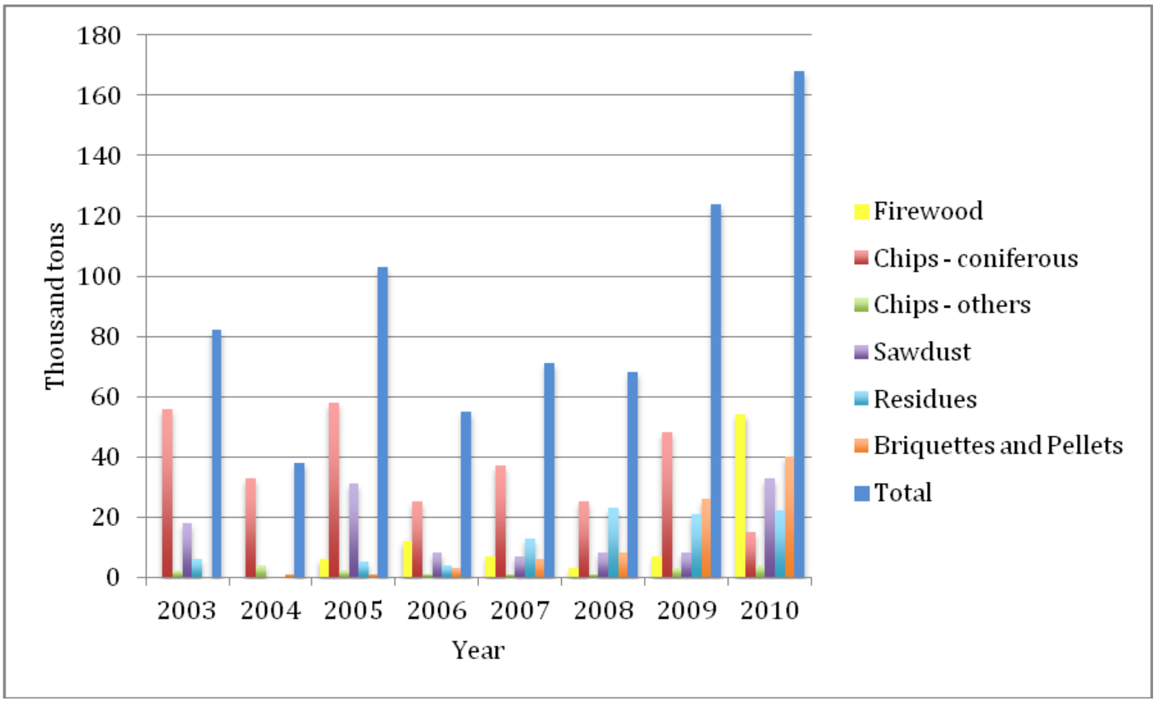
- Deliberately cultivated biomass potential is about 4-9 million tons per year and could be used in 20 to 30 years. [18]

4 ANALYSIS OF BIOMASS UTILIZATION IN THE CZECH REPUBLIC

4.1 FOREIGN TRADE WITH BIOMASS FOR ENERGETIC PURPOSES IN THE CZECH REPUBLIC

4.1.1 Imports of suitable biomass for energy production in the Czech Republic

Graph no. 5: Imports of suitable biomass for energy production in the Czech Republic

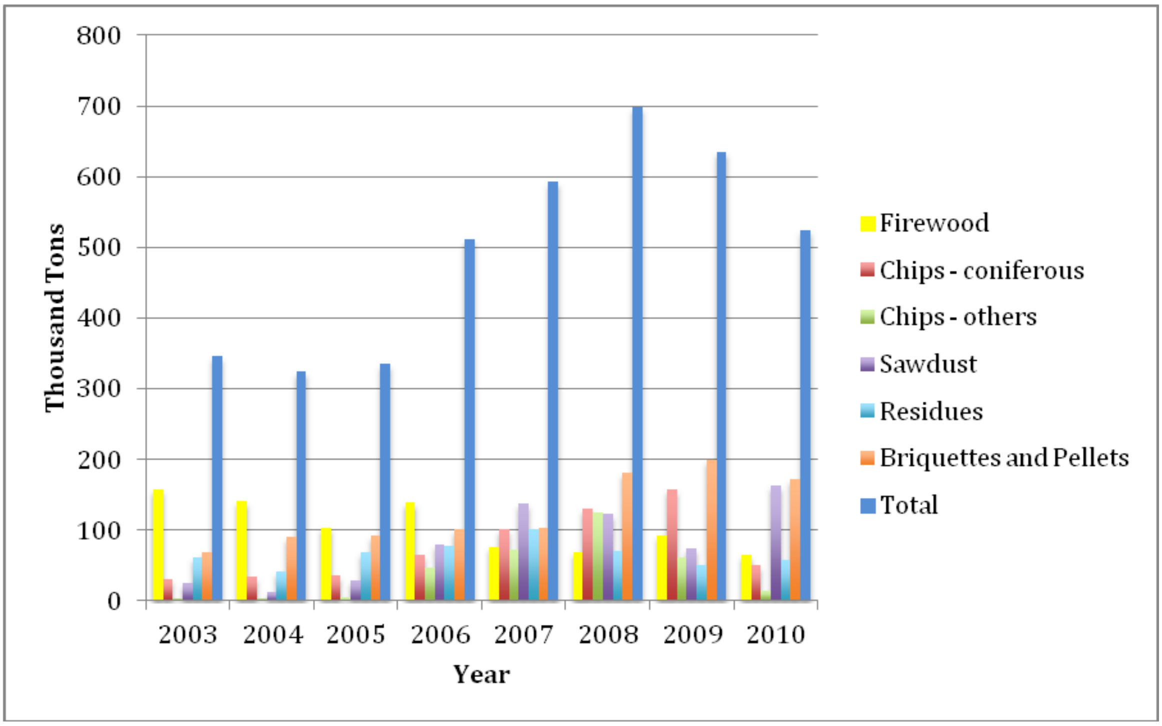


Source: Renewable energy resources in 2010, Ministry of Industry and Trade

In the 2003 were imported 56 000 tons of coniferous chips. In the 2010, it was only 15 000 tons. The import of coniferous chips is decreasing. The big changes are recorded on firewood import. The import of firewood is firstly seen in 2005, where 6 000 tons were imported. In the 2010 the import of firewood was 54 000 tons, which is nine times more than it was recorded in 2005. The import of briquettes and pellets is also increasing. The first import was recorded in 2004, where 1 000 tons of briquettes and pellets were imported. The import was gradually increasing and in 2010 were imported 40 000 tons. As it is possible to see the development of import of biomass suitable for energy production the total of imports is gradually increasing.

4.1.2 Exports of suitable biomass for energy production in the Czech Republic

Graph no. 6: Exports of biomass suitable energy for energy production in the Czech Republic

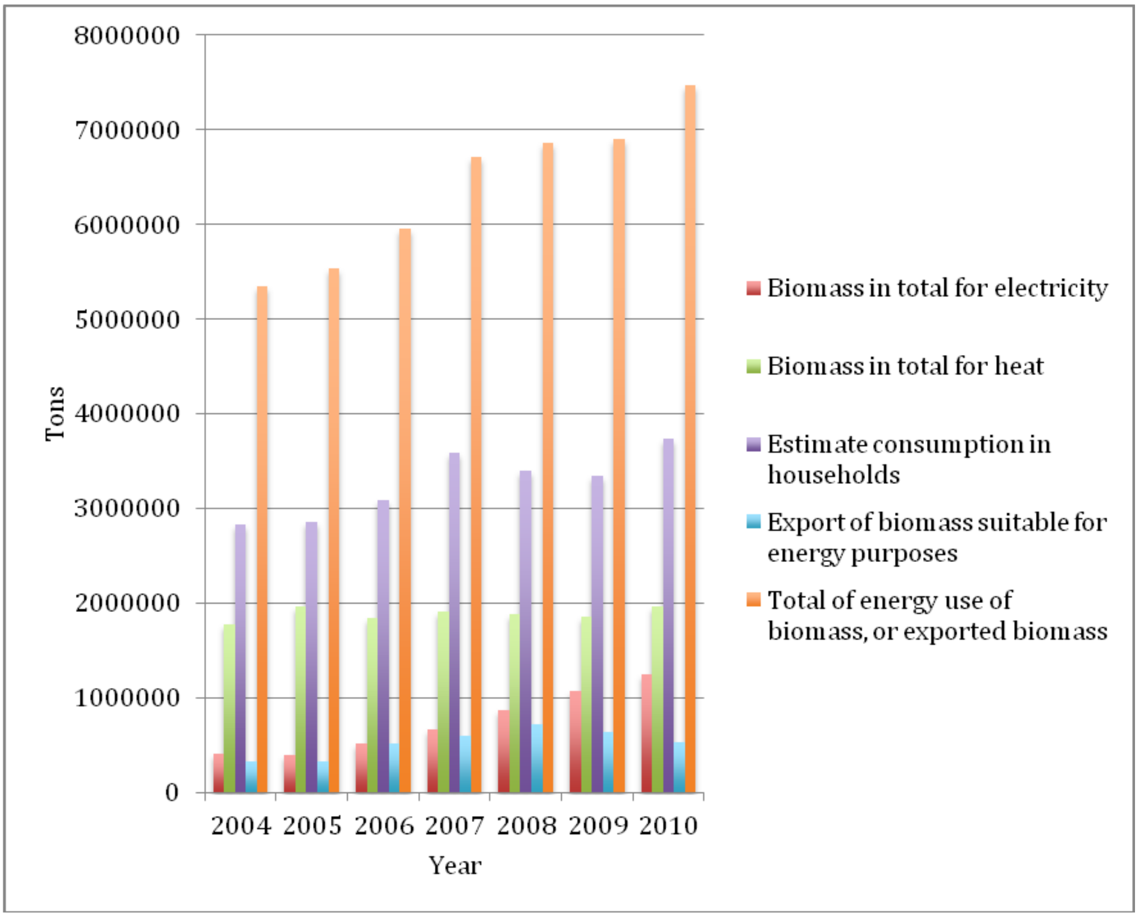


Source: Renewable energy resources in 2010, Ministry of Industry and Trade

The export of firewood in 2003 was 158 000 tons, but it is gradually decreasing and in 2010 the amount is lower more than a half. The export in 2010 was 65 000 tons. The export of coniferous chips increased to maximum of 157 000 tons in 2009 but rapidly decreased in the 2010 where the export was only 51 000 tons. The export of sawdust in 2003 was 25 000 tons, it was gradually increasing and the amount in 2010 was 164 000 tons. The export of residues is increasing till 2007 where it was 101 000 tons, the years after it was decreasing and in 2010 the export was 57 000 tons. The total exports is increasing till 2008 no matter what is happening with the individual parts where it was 698 000 tons. In 2010 the decline was to 525 000 tons.

4.2 THE OVERALL ENERGY BALANCE OF BIOMASS USE IN THE CZECH REPUBLIC

Graph no. 7: Energy use of biomass in the Czech republic



Source: Renewable energy resources in 2010, Ministry of Industry and Trade

Gross production of electricity from renewable sources in 2010 participated in the national gross electricity consumption by 8.3%. The national indicative target share of the Czech Republic was set at 8% in 2010. Based on domestic gross electricity production, gross production of electricity from renewable sources contributed 6.9%. In 2004 the total of energy use of biomass, or exported biomass was 5 341 669 tons. In 2010 the total of energy use of biomass, or exported biomass was 7 472 476 tons. The total of energy use of biomass, or exported biomass is gradually increasing.

4.3 DEVELOPMENT OF BRIQUETTES AND PELLETS PRODUCTION, IMPORT, EXPORT, AND SUPPLY ON DOMESTIC MARKET OF BIOMASS IN THE CZECH REPUBLIC

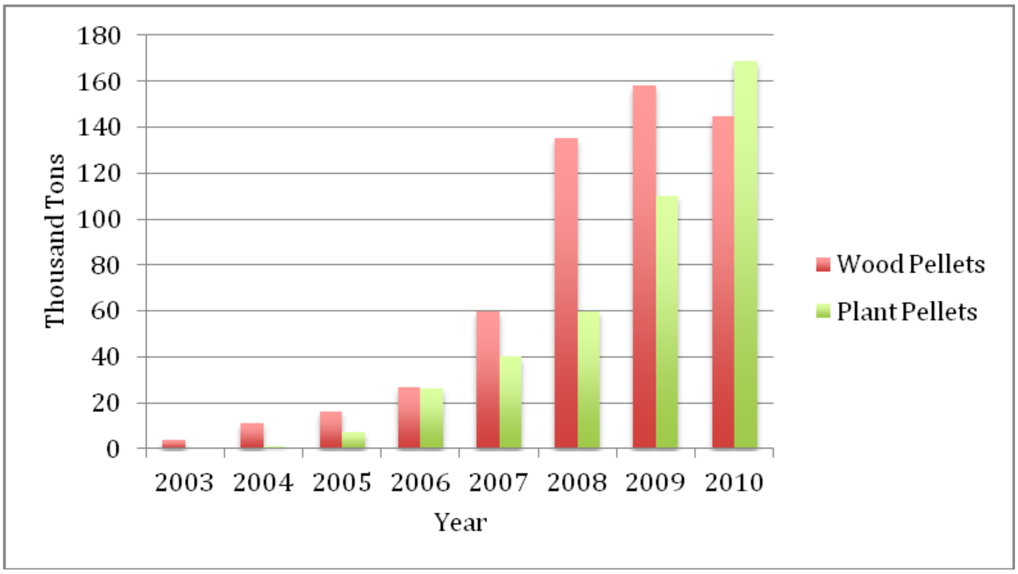
Our market is going thru significant changes in recent years. On the one side, increasing consumption of wood briquettes and pellets, on the other side, domestic producers still have difficulty in securing feedstock. Even though the huge amount of briquettes and pellets are exported and also imports are increasing.

Plant pellets are currently taken as a standard additional fuel in power and heating plants. Brown Coal briquettes have been discontinued in production at the end of 2010 in the Czech Republic, so the import from Germany is rapidly increasing.

On the market, there are also non-traditional fuels such as plant and paper briquettes. In recent years, investment has been supported by public funds for the construction of a large number of briquettes and pellets factories.

4.3.1 Development of Pellets Production in the Czech Republic

Graph no. 8: Development of pellets production in the Czech Republic

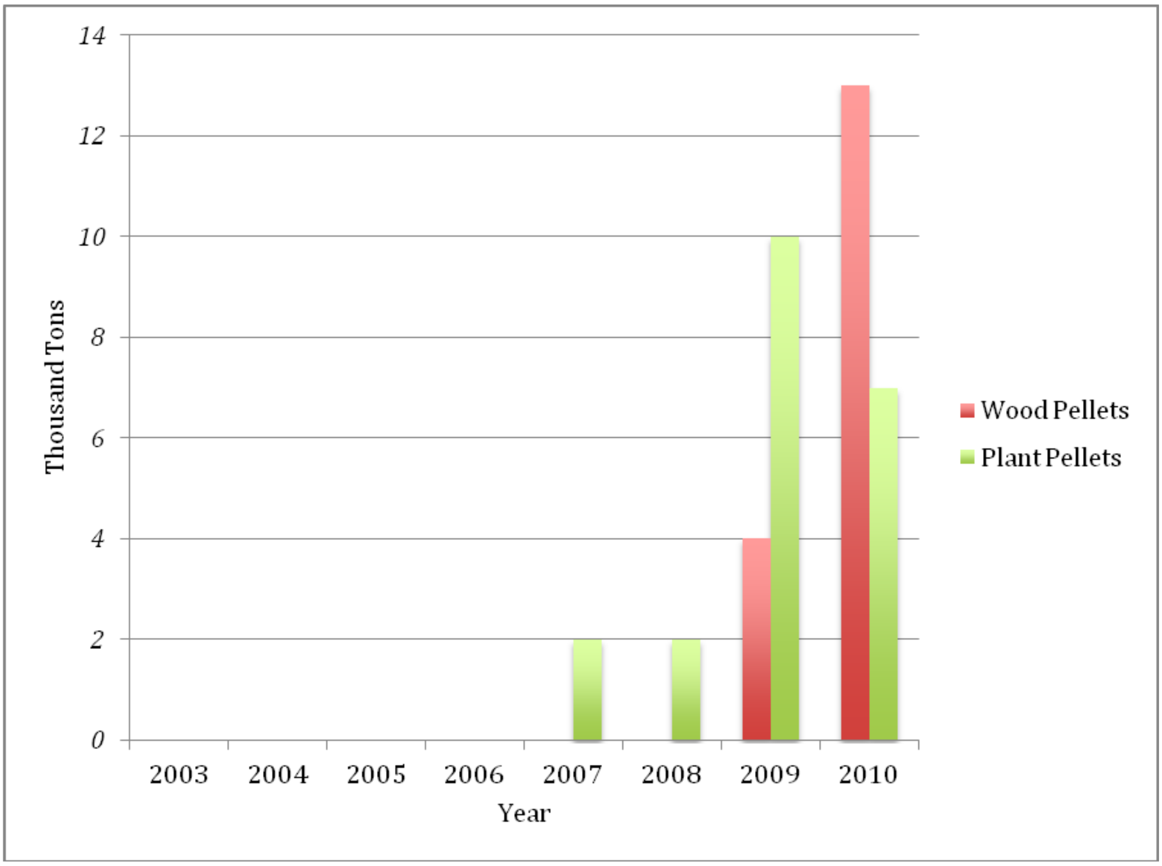


Source: Briquettes and Pellets in 2010, Ministry of Industry and Trade

The development of wood and plant pellets production is possible to see on the graph no.8. The production of wood pellets in 2003 was 4 000 tons. Till 2009 it was increasing and the production increased to 145 000 tons. In 2010 the production decreased to 145 000 tons. The production of plant pellets was recorded in 2004 when it was only 1 000 tons. The increasing of plant production is gradual and in 2010 it is 169 000 tons. The production of plant pellets is higher than wood pellets.

4.3.2 Development of Pellets Import in the Czech Republic

Graph no. 9: Development of pellets import in the Czech Republic



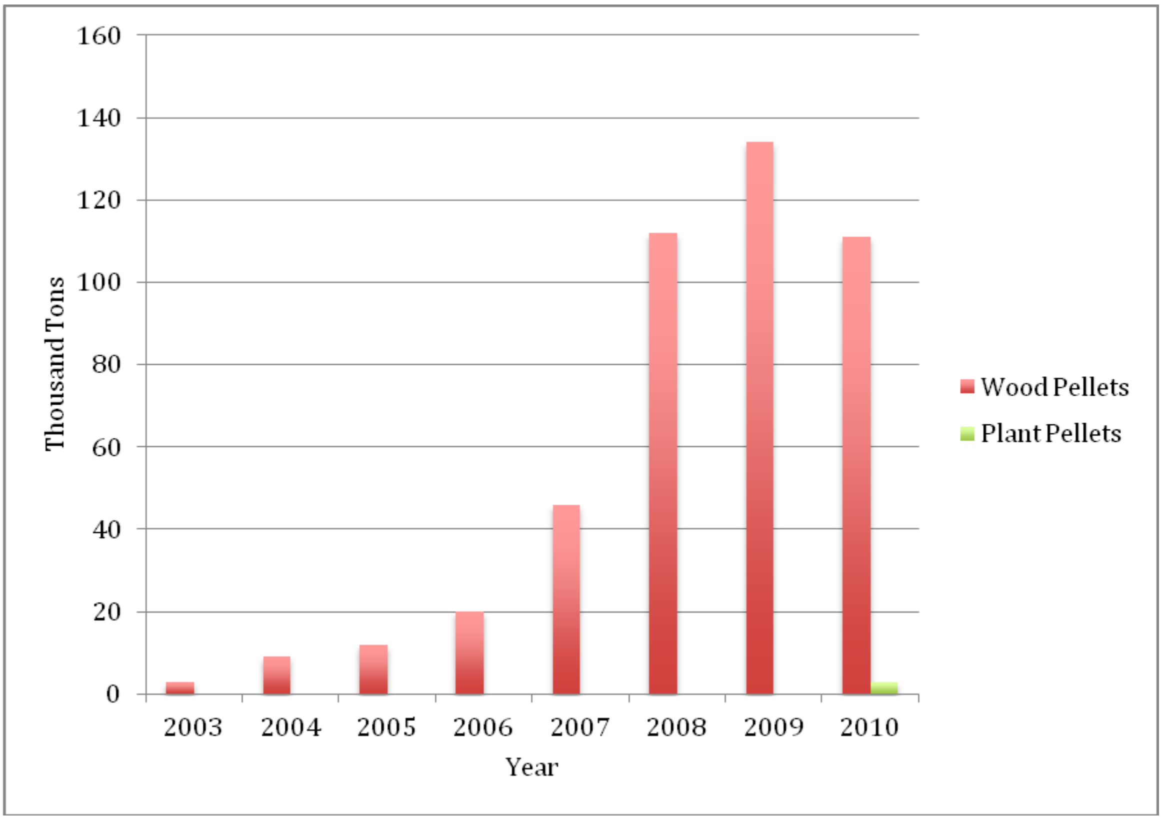
Source: Briquettes and Pellets in 2010, Ministry of Industry and Trade

The development of wood and plant pellets import is on the graph no.9. The import of plant pellets is recorded since 2007 when it was imported 2 000 tons, the same quantity was imported in 2008. In 2009 was the import sharply increased, to 10 000 tons but in 2010 was decreased to 7 000 tons.

The import of wood pellets was recorded in 2009 when the quantity was 4 000 tons. In 2010 the import sharply increased and the quantity was 13 000 tons. The import of wood pellets is 87% more than plant pellets.

4.3.3 Development of Pellets Export in the Czech Republic in the Czech Republic

Graph no. 10: Development of pellets export in the Czech Republic

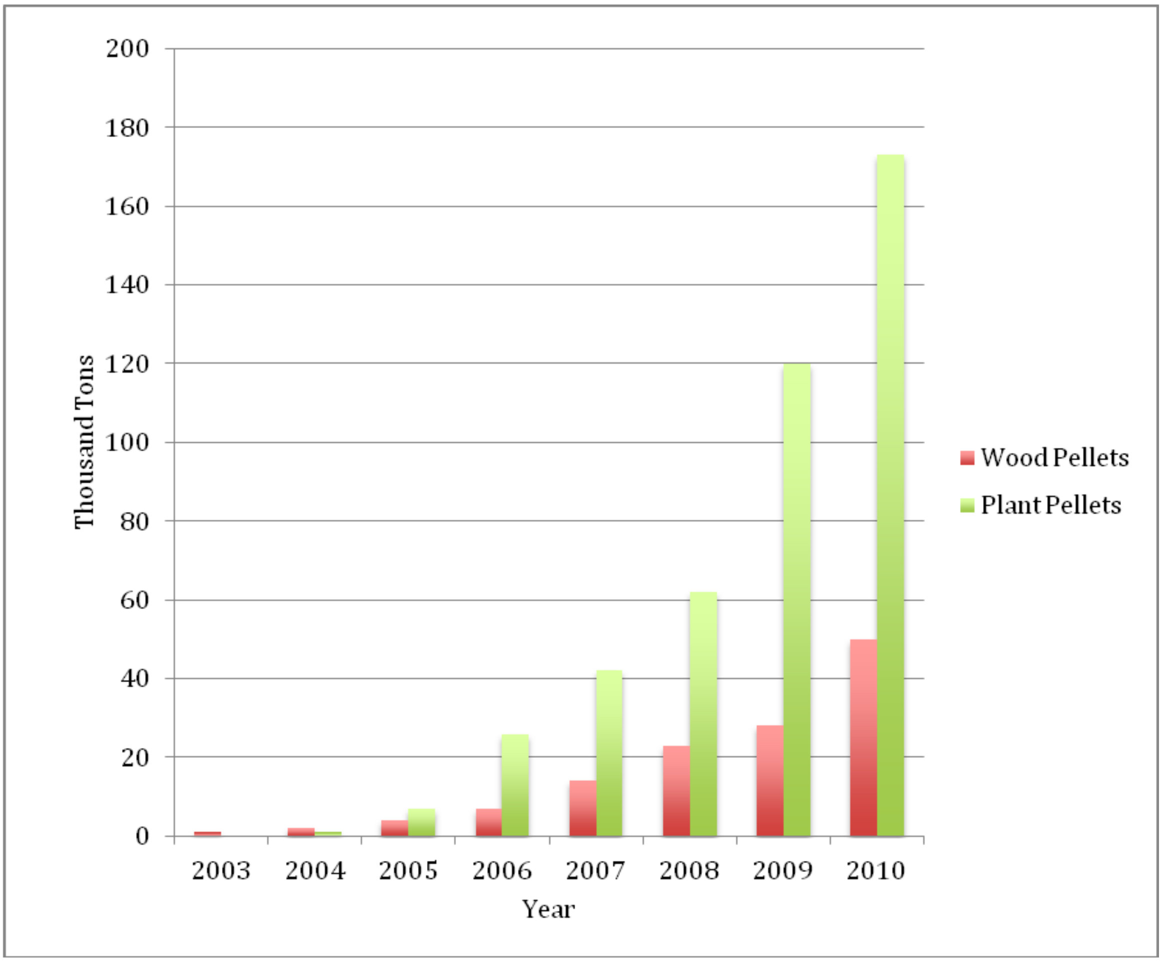


Source: Briquettes and Pellets in 2010, Ministry of Industry and Trade

Graph no. 10 shows the development of pellets export in the Czech Republic. The export of wood pellets is recorded from 2003 when it was 3 000 tons. Till 2009 the export was gradually increasing up to 134 000 tons. The decline was in 2010 up to 111 000 tons. Which is 17.2% less than in 2009. The export of plant pellets is recorded only in 2010 and the quantity was 3 000 tons.

4.3.4 Development of Pellets of Supply on Domestic Market in the Czech Republic

Graph no. 11: Development of pellets of supply on domestic market in the Czech Republic

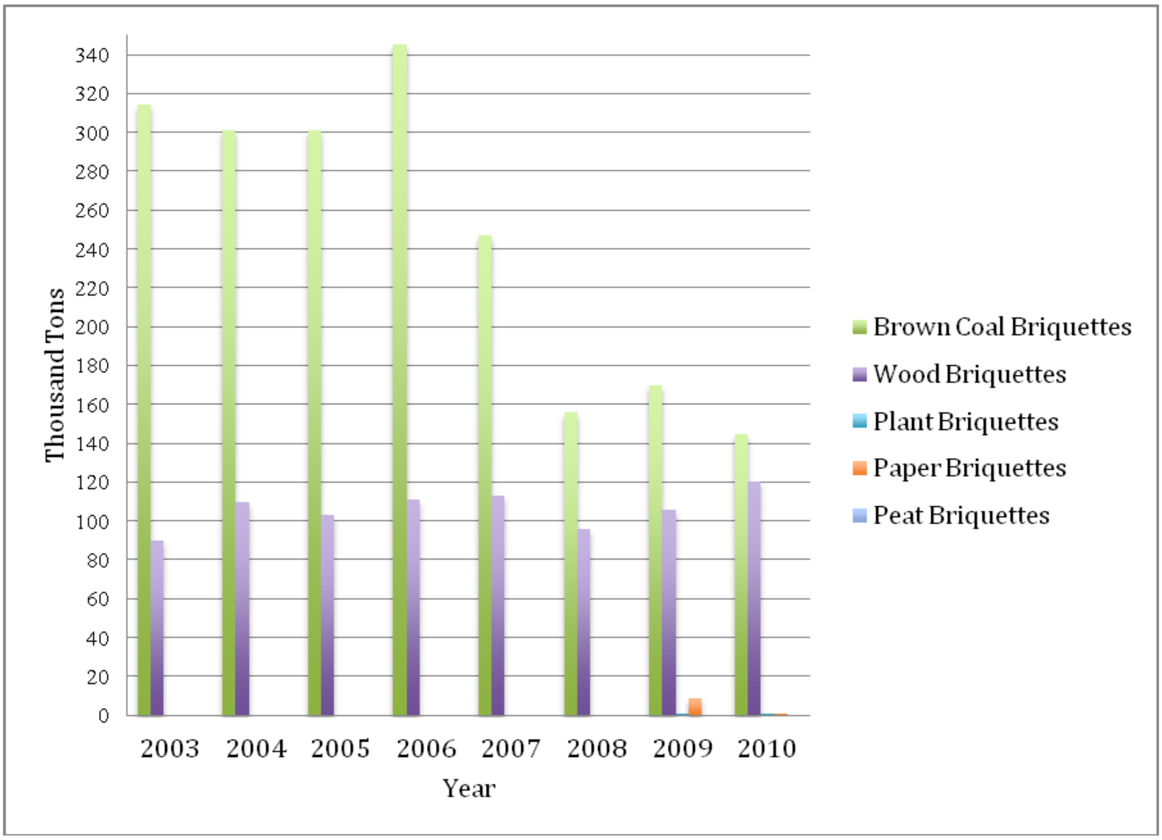


Source: Briquettes and Pellets in 2010, Ministry of Industry and Trade

The development of pellets of supply on domestic market in the Czech Republic is shown in Graph no. 11. In 2003 was the wood pellets supply on domestic market 1 000 tons. The increase was gradually till 2010 when the quantity was 50 000 tons. The plant pellets supply on domestic market is recorded since 2004 with the quantity of 1 000 tons. The increase came sharply and in 2010 the supply of plant pellets on domestic market is 173 000 tons.

4.3.5 Development of Briquettes Production in the Czech Republic

Graph no. 12: Development of Briquettes production in the Czech Republic

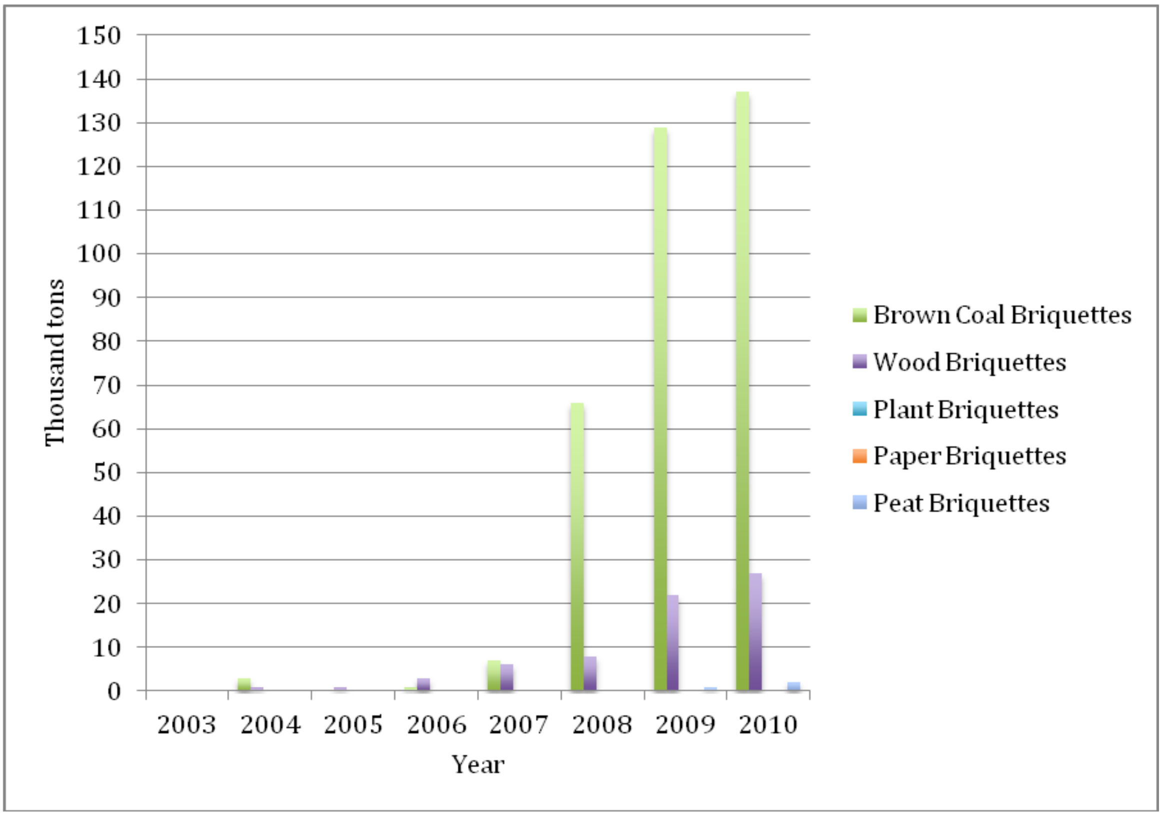


Source: Briquettes and Pellets in 2010, Ministry of Industry and Trade

Development of briquettes production is shown on the graph no.12. The brown coal briquettes were produced in very high quantity in 2003, 314 000 tons. The quantity was decreasing till 2006 when it increased up to 345 000 tons, which is 8.98% more than in 2003. Then there was a sharp decrease and in 2010 the quantity of brown coal briquettes production was 145 000 tons. Wood briquettes production is slowly growing. The quantity in 2003 was 90 000 tons. During the period between 2003-2010 was decline and also increase. In 2010 the quantity of production of wood briquettes is 120 000 tons. The plant and peat briquettes are produced in very low quantity, just paper briquettes in 2009 were produced in quantity of 9 000 tons.

4.3.6 Development of Briquettes Import in the Czech Republic

Graph no. 13: Development of briquettes import in the Czech Republic

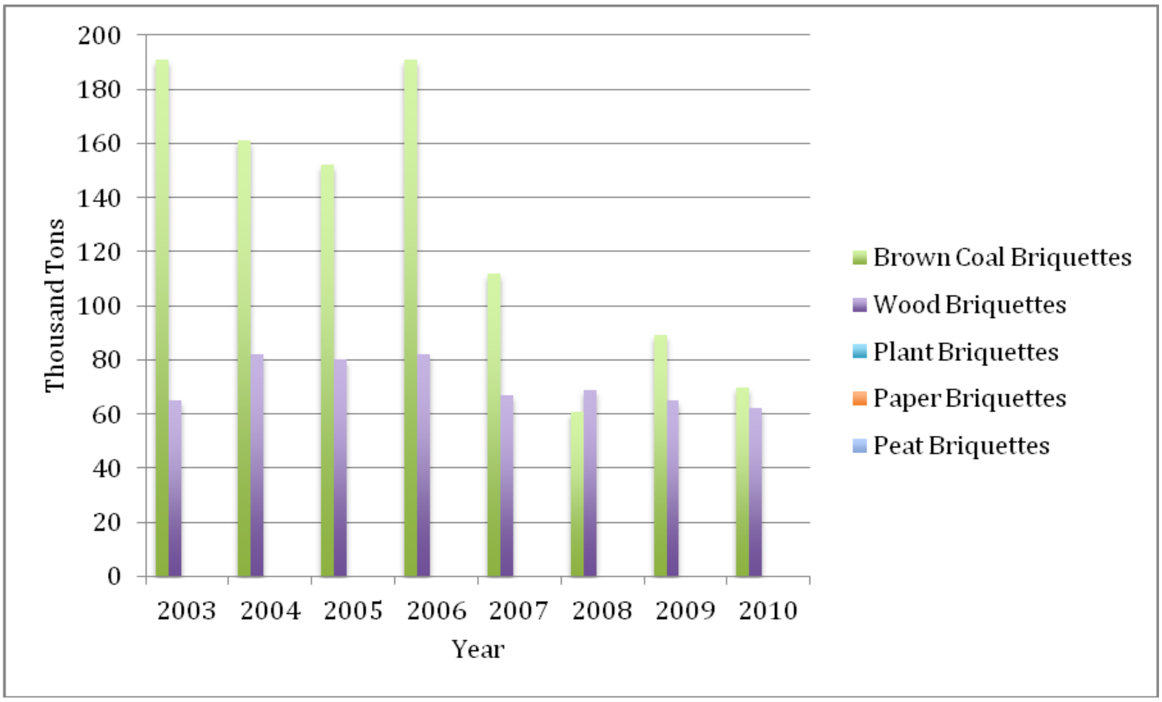


Source: Briquettes and Pellets in 2010, Ministry of Industry and Trade

Development of briquettes import is in Graph no. 13. The brown coal briquettes import is recorded since 2004 when the quantity was 3 000 tons, in 2005 was not any amount of brown coal briquettes was not imported. Since 2008 the sharp increase is up to 66 000 tons and the increase is still pending. In 2010 the quantity is 137 000 tons. The wood briquettes import is recorded also since 2004 when the quantity was 1 000 tons. The slowly growing was up to 2010 when the quantity of the wood briquettes import was 27 000 tons. The plant and paper briquettes are not imported. The peat briquettes are imported in 2010 in quantity of 2 000 tons.

4.3.7 Development of Briquettes Export in the Czech Republic

Graph no. 14: Development of briquettes export on the Czech Republic

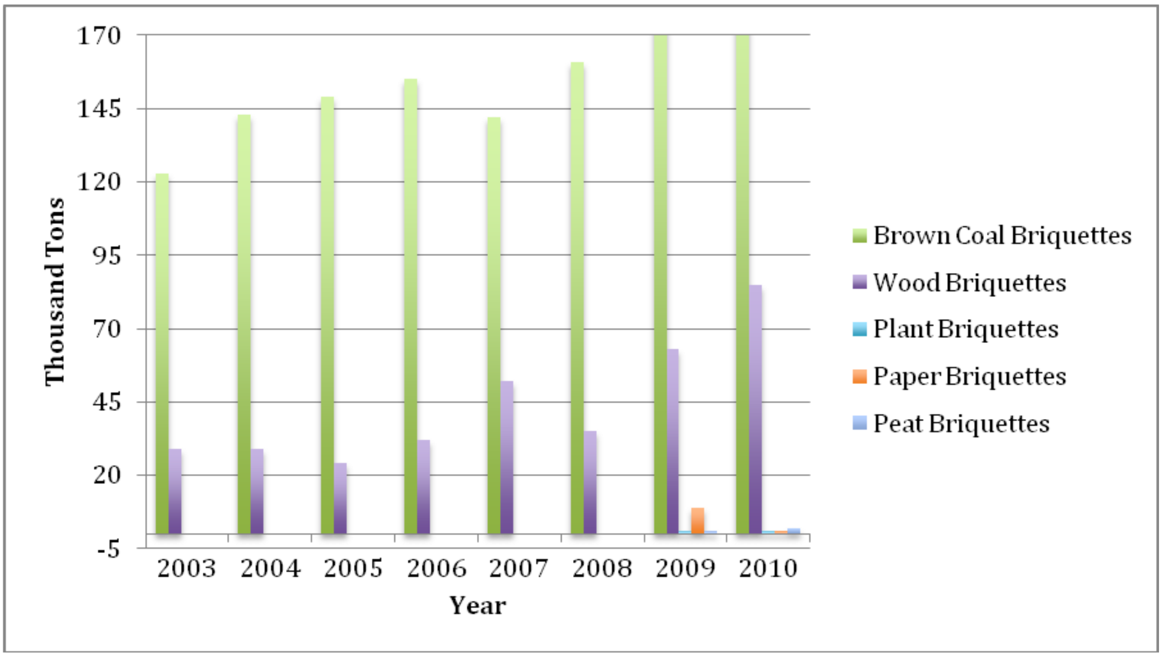


Source: Briquettes and Pellets in 2010, Ministry of Industry and Trade

The development of briquettes export in the Czech Republic is shown in the graph no. 14. The brown coal briquettes were export in quantity of 191 000 tons in 2003. The decline was till 2005. In 2006 the increase was up to 191 000 tons as in 2003. The sharp decline was in 2007 where the quantity of export brown coal briquettes was 112 000 tons and in 2008 just 61 000 tons. In the 2010 was the quantity 70 000 tons. The export of brown coal briquettes is decreasing. The export of wood briquettes was 65 000 tons in 2003. During the period 2003-2010 the quantity of export was increasing and then decreasing. In 2010 the quantity of tons exported wood briquettes was 85 000. The plant, paper and peat briquettes were not exported in any quantity.

4.3.8 Development of Briquettes Supply on domestic market in the Czech Republic

Graph no. 15: Development of briquettes supply on domestic market in the Czech Republic



Source: Briquettes and Pellets in 2010, Ministry of Industry and Trade

The development of Supply of Briquettes on domestic market in the Czech Republic is shown in Graph no. 15. The brown coal briquettes were in quantity of 123 000 tons. The increase was up to 2006 when the quantity was 155 000 tons. In 2007 was decreased up to 142 000 tons. From 2008 till 2010 the supply of brown coal briquettes was increasing to 212 000 tons in 2010. Supply on domestic market of wood briquettes was 29 000 tons in 2003. During the period 2003-2010 was slow decrease and sharply increase in 2010 up to 85 000 tons. Paper briquettes are recorded since 2009 in quantity of 9 000 tons and in 2010 only 1 000 tons. Supply of plant and peat briquettes is very low just 1 000 tons each.

5 CASE STUDY

5.1 Introduction

The case study focuses on particular company that is Benko spol. s.r.o.("Benko") in Kopidlno. Benko mainly produces parquets and other wood products. Produced waste is further processed in order to produce wood briquettes. Benko Company has a long tradition, which is over 90 years and in 2012 has 80 employees.

Benko handles the timber only from hard deciduous trees (beech, oak and ash) for the use in furniture, carpentry, joinery, and construction companies.
The company satisfies the demand in the Czech Republic and also deals with foreign partners. The main part of the process is the production of wood floors, all-solid floors – parquets, suitable for different types of residential, cultural, historical, sport and industrial interiors. Briquettes are produced from the produced waste.

The company is a regular supplier with domestic wood raw material in the required quantity and providing intensive production. Its manufacturing tradition guarantees high quality of its products.

Benko disposes of a machine for cutting, equipment for woodworking, equipment and technology for the parquet production, furniture blanks, wood briquettes, and dryers.

5.2 Briquettes machines in Benko

5.2.1 Machine BRISUR 200

Machine BRISUR 200 consists of rolled up auger for scooping loose material from the pile of belt and screw conveyors for the transport of wood chips, sawdust screens, tumble dryers, including BUS boiler for its heating and one piece of briquetting presses BrikStar. [23]

Table no. 2: Technical data of BUS drum dryer

Total consumption of raw materials with humidity of 45%	355 kg/h
Fuel consumption	35 kg/h
The amount of evaporated water	120 kg/h
The amount of the output material of humidity 12%	200 kg/h
Electric power	21 kW
Weight of drum	2 100 kg
Dimensions of the dryer BUS	7 x 1,7 x 2,3 m

[23]

Table no. 3: Technical data of briquettes machine BRISUR 200

Power of the machine	200 kg/h
Total electric power without crusher	37 kW

[23]

The scroll is able to dump material from the sawdust conveyors. Wet chips are sorted by vibrating sieve that is placed over the tray of wet material. Coarse pieces fall into the container and can be manually attached to the boiler. Combustion gases from the boiler to automatic burning wood waste heat the sawdust dryer. Dosage of sawdust into the dryer is regulated so that the output of steam from the dryer temperature is maintained at a constant value. The control system also controls the fuel stoking to the boiler. Flue gases are mixed with cold air to the temperature of 300 to 500 ℃ and the dryer fan aspirated. The fan is located behind the dryer and the cyclone for dust separation. Dry sawdust is screwed up to conveyor from the dryer, which is as a turnstile. It is also transported by screw conveyor into the hopper briquetting press.

Briquettes can be burned in all types of stoves, boilers and incinerators for burning solid fuels. The gasification boilers better use of large heating value of 15 to 18 MJ/kg. The line includes BrikStar briquetting press with cylindrical shape and diameter of 50 mm.

[23]

5.3 Benko briquettes

Benko briquettes are an ecological product made entirely from solid hardwood with no additives and binders. They are pressed under high pressure and therefore stands a reasonable calorific value.

They are produced in two forms:

- Cylinder - packed in a plastic bag of 25 kg
- Brick – packed in a plastic bag of 16 kg

A few examples are shown for the comparison of calorific values:

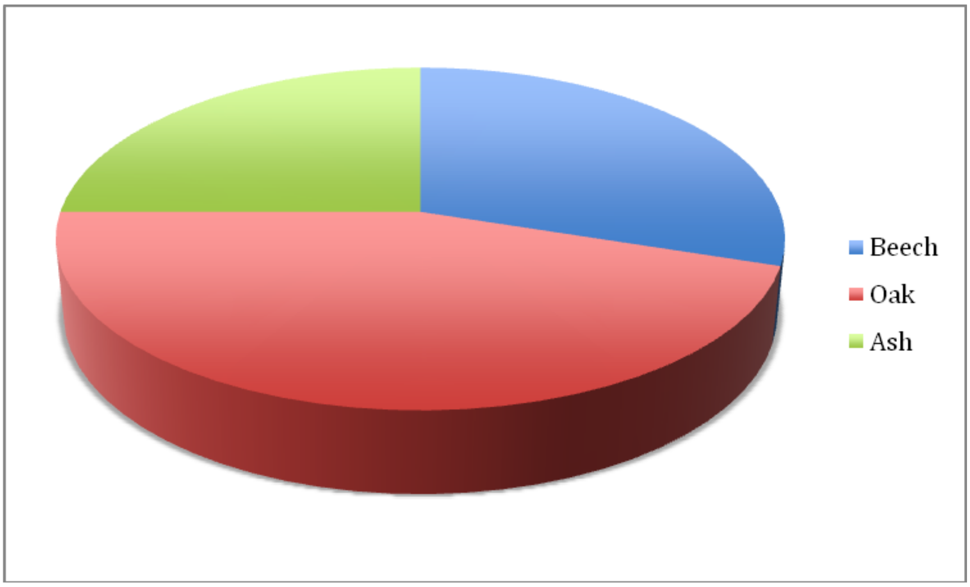
- 10 kg of Benko briquettes
- 14.8 kg of brown coal
- 15.4 kg of wood
- 14.7 kg of wood chips
- 5.6 m3 of natural gas
- 40.5 kWh of electricity – heaters

The main principles of manipulating with Benko briquettes:

- Store in dry place, do not expose on direct sunlight
- Burn with chips or solid firelighters
- Furnace packed in half - burning briquettes are gaining on volume
- The remaining ash, which is about 1%, can be used as a garden fertilizer

5.4 Share of Briquettes Material in Benko

Graph no. 16: Share of briquettes material in Benko



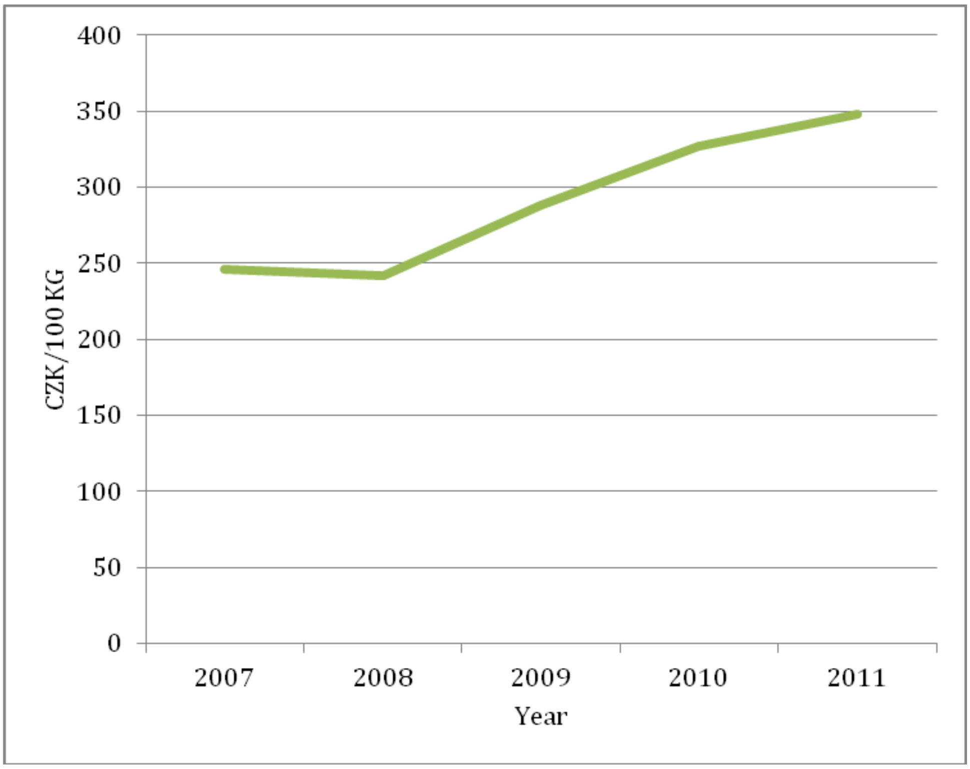
Source: Internal data

Graph no. 16 shows the share of briquettes material in Benko Company. Benko is producing the products only from deciduous trees – beech, oak, and ash. The hard wood has the highest quality and the products have longer service life than the products from soft wood such as pine, spruce, birch, etc.

Briquettes are made from the produced waste. The main share of the briquettes material has an oak, which has 45%. Beech is produced on 30% of the total share of material and ash is 25% of the total share but it also depends on demands of specific products.

5.5 Development of Briquettes Price in Benko

Graph no. 17: Development of briquettes price in Benko

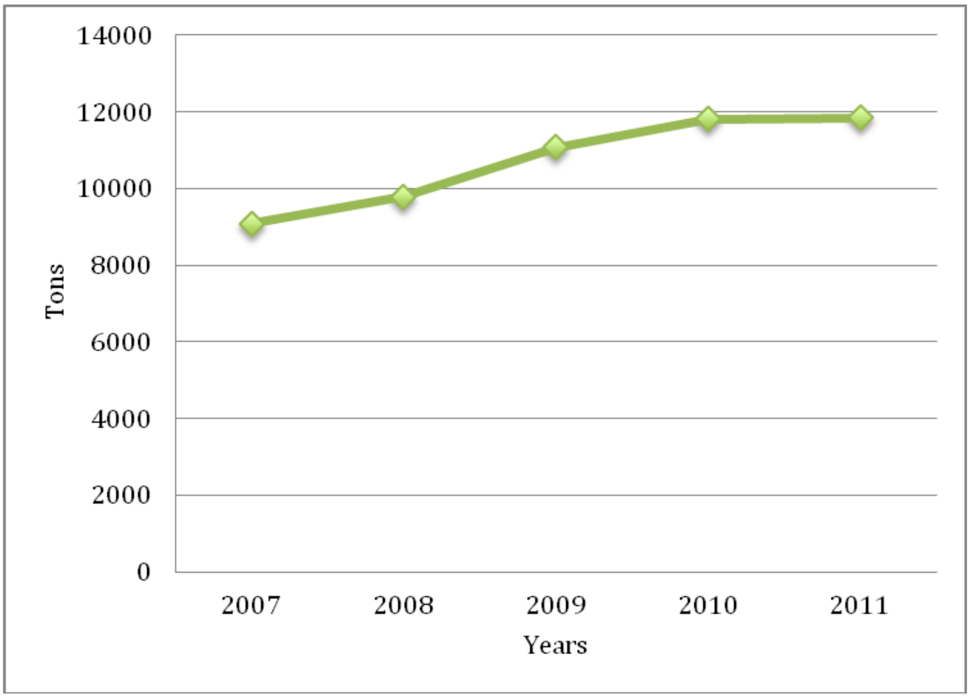


Source: Internal data

Graph no. 17 shows the development of briquettes prices in Benko Company. The price starts on 245.82 CZK in 2007. In 2008 the price slowly decreased to 241.65 CZK. From 2009 the price starts to increase and it is 288.61 CZK. In 2010 is the price increasing to 327.29 CZK and in 2011 is the price about 101.99 CZK higher than the price in 2007. In 2011 is the price of briquettes 347.81 CZK. The prices are per 100 kg of briquettes. In 2012 the price of briquettes is up to 350 CZK.

5.6 Development of Briquettes Production in Benko

Graph no. 18: Development of briquettes production in Benko

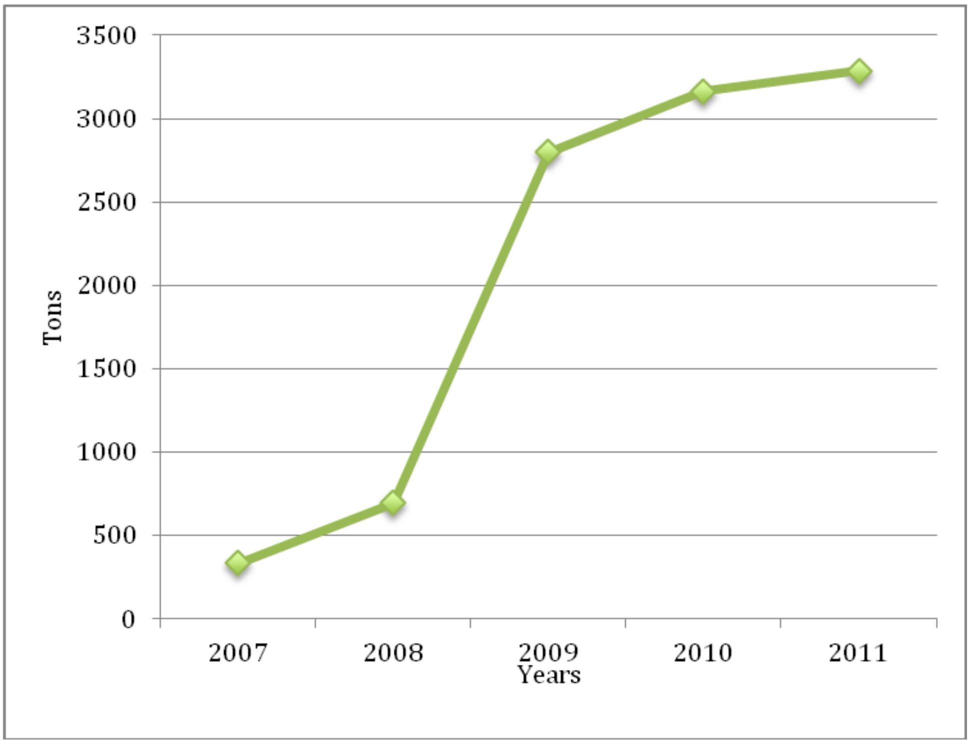


Source: Internal data

Graph no. 18 shows the development of briquettes production in Benko Company. In 2007 the production of briquettes was 9 078.27 tons. The production is gradually increasing. In 2009 was the production 11 084.12 tons of briquettes. In years 2010 and 2011 the increase is not too sharp. In 2010 was the production 11 809.62 tons and 2011 was production of the briquettes 11 854.45 tons.

5.7 Development of Briquettes Export in Benko

Graph no. 19: development of briquettes export in Benko

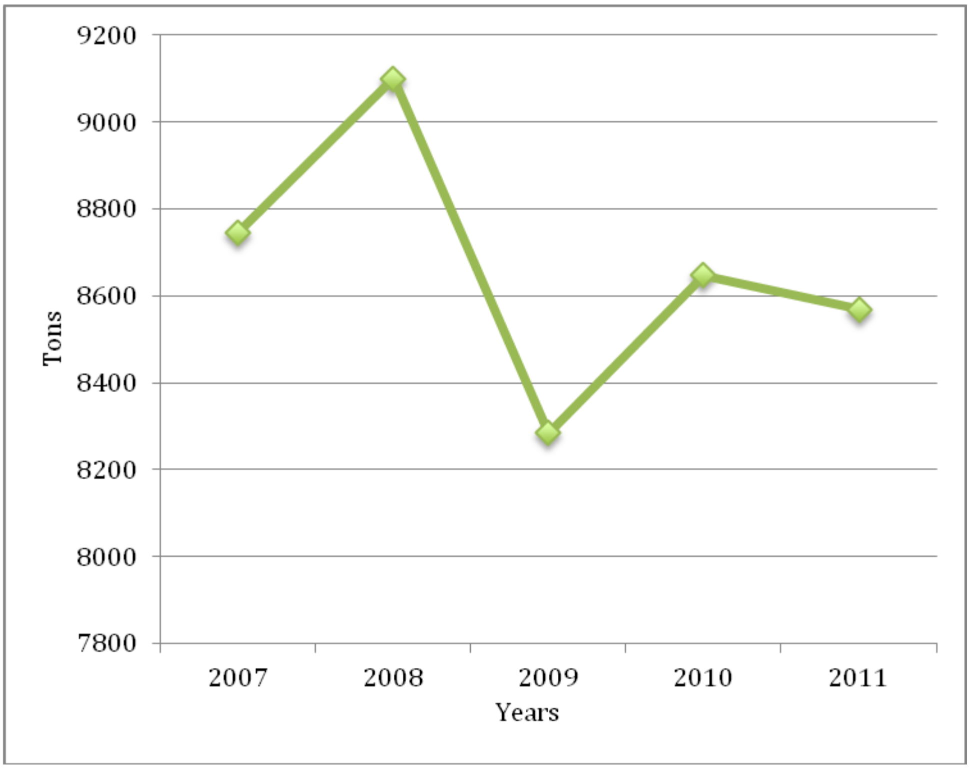


Source: Internal data

On the graph no.19 is shown the development of briquette export in Benko Company. In 2007 the export was 332.75 tons and in 2008 was the export 695 tons. In 2009 was sharp increase from 695 tons to 2 800.20 tons. In 2010 was the export 3 161.75 tons and in 2011 was the export quantity 3 286 tons. The export is slowly increasing.

5.8 Development of Briquettes Domestic Sales in Benko

Graph no. 20: Development of briquettes domestic sales in Benko

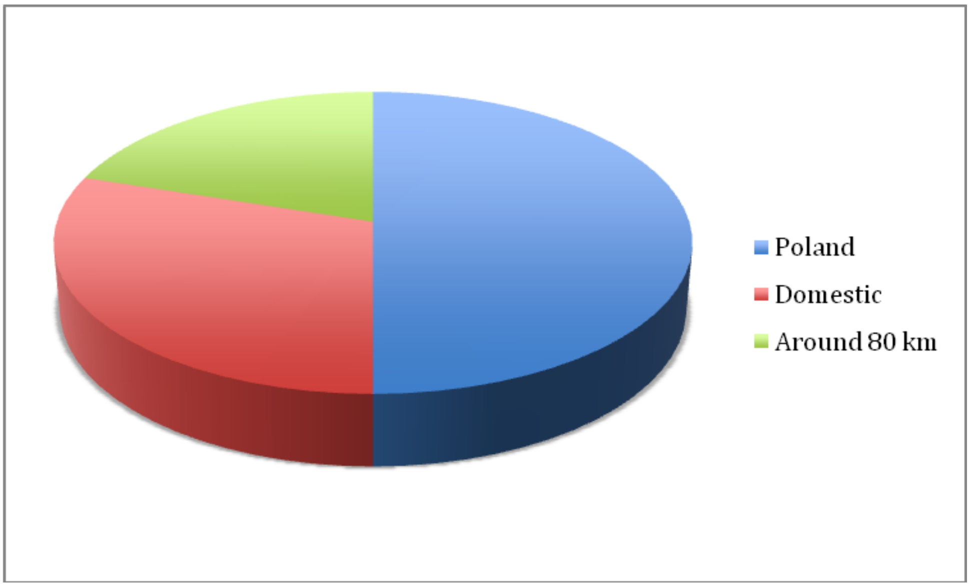


Source: Internal data

Graph no. 20 shows the development of domestic briquettes sales in Benko. In 2007 the domestic sales were 8 745.52 tons. The increase in 2008 was to the quantity of 9 099.50 tons. Sharp decrease was in 2009 because of the high export and the quantity of domestic sales was 8 283.93 tons. In the 2010 increased the domestic sales to 8 647.87 tons and in 2011 decreased the domestic sales to 8 568.45 tons. The domestic sales are slowly decreasing because of slowly increasing export.

5.9 Share of Benko's Purchasers

Graph no. 21: Share of Benko purchasers



Source: Internal data

Graph no. 21 shows the share of Benko's purchasers. The main purchaser of the Benko's briquettes is Poland that has share of 50%. The domestic purchasers have 30% of the total share and purchasers that are around 80 km from the Company have 20% of total share.

5.10 Investment Analysis of machine BrikStar MAGNUM 300

5.10.1 Machine BrikStar MAGNUM 300

Machine BrikStar MAGNUM 300 features a compact design, modern operation, reliable hydraulic compression mechanism, which allows maximum compaction of the material. For continuous operation the machine is with an oil cooler as standard. An automatic regulation of the quality of briquettes and feeding auger minimizes power variations for stamping materials ranging from very mild to coarse material. Sensor controls turn on an automatic startup and shutdown and prevents unnecessary operations from the machine press. The press is designed to make the rectangular briquettes of dimension of weight more than 1000 kg/m3 and meet the DIN 51731 norms. [24]

Table no. 4: Technical data of briquettes machine BrikStar MAGNUM 300

Output (± 10%)	250 – 500 kg/h
Humidity of input material	8-15 hm%
Maximum operating pressure	240 bar (24MPa)
Maximum operating temperature	60 °C
Power supply equipment	400 V
Control Voltage	24 V
Device noise	77 dB

[24]

Table no. 5: Data of machine MAGNUM 300

Power of machine	400 kg/h
A year production of briquettes	2400 t
A year consumption of sawdust	4200 t
Electric power	40 kW
Consumption of electric energy	30 kW
Consumption of sawdust	75 kg/h
Number of operating person	1
Performance of briquetting press	250 – 500 kg/h
Electric power of the press	28 kW

[24]

Total investments

- Cost of the machine, other equipment 9 400 000 CZK

5.10.2 Calculation of the BrikStar MAGNUM 300 utilization

Load = the volume of production of sawdust per year x coefficient / output devices

L = (4 030 000 x 2400/4200) / 400 = 5757 hours

Produced briquettes (year)

5757.5 x 400 = 2 303 000 kg

Capacity = effective working time (minus time for the necessary operational maintenance)

C = calendar working time x 0.87

C = 1754 hours in one shift

Machine use = L/C

Use of the machine is 3.28 shifts

The capacity calculation shows that the production line will be operate in 3-shift operation with a partial increase of overtime to produce wood briquettes from whole volume of produced chips.

5.10.3 Personal costs

One worker per shift	
Average personal costs	127.6 CZK
Production	400 kg/h

The personal costs on briquettes production are calculated as 127.6/400

- 0.319 CZK/kg of personal costs on briquettes production

5.10.4 Costs of maintenance

Costs of maintenance	193 000 CZK

The costs of maintenance are calculated as 193 000/ 2 303 000(produced briquettes/year)

- 0.083 CZK/kg produced briquettes

Costs on electric power 0.264 CZK/kg produced briquettes

5.10.5 Overhead costs associated with manipulation

- It is possible to straighten 36 packages of briquettes on euro pallet, i.e. 576 kg
- Transport of the pallets to the warehouse takes 6 minutes, 1/10 hour.
- 1 hour with forklift is calculated on 214 CZK/h
- Costs on manipulation are 0.037 CZK/kg of produced briquettes

5.10.6 Packaging Costs

Price of one bag for briquettes packaging is 3.78 CZK
In one bag are 16 kg of briquettes. The costs of packing are calculated: 3.78/16 = 0.236

- 0.236 CZK/kg of produced briquettes

Packaging Costs are 0.236 CZK/kg

5.10.7 Feedstock price

From 1.75 kg of sawdust is produced 1kg of briquettes

- Market price of sawdust waste as raw material 0.44 CZK/kg
- Cost on material 0.77 CZK/kg of produced briquettes

5.10.8 Depreciation

Total investments	9 400 000 CZK
Depreciation period	5 years
Depreciation	0.878 CZK/kg of produced briquettes

5.10.9 Structure of production costs and profit calculation

Table no. 6: Structure of production costs and profit calculation

Personal costs	0.319 CZK
Costs of maintenance	0.083 CZK
Electric power	0.264 CZK
Overhead costs associated with manipulation	0.037 CZK
Packaging	0.236 CZK
Material	0.770 CZK
Depreciation	0.878 CZK
Total Costs	**2.587 CZK**
Sale price	**3.500 CZK**
Cover post	**1.791 CZK**
Profit	**0.913 CZK**

Source: Internal data, own calculation

5.10.10 Pay back period - PB

Pay Back period is the needed length of time that is required for recovering the costs of the investments. [25]

The time of recovering the costs is 3 years.

5.10.11 Cash Flow - CF

CF = Revenues – Costs

Revenues	8 060 503 CZK
2 303 000 x 3.5	

Costs

Total Costs (without depreciation) x A year briquettes production

1.709 x 2 303 000	3 935 827 CZK

CF = 8 060 503 – 3 935 827

CF = 4 124 676 CZK

5.10.12 Net Present Value - NPV

Net present value is included in the whole life of the project, and also the possibility to invest to project. It takes the time value of money and also depends on the anticipated cash flows and opportunity cost of capital. [25]

Investments	9 400 000 CZK
Cash Flow	4 124 676 CZK
Period	5 years
Rate	5 %

It is calculated from values of Cash flow of each period and it is used the excel function for calculation of NPV.

NPV = 8 054 941 CZK

5.10.13 Profitability

The calculation express what ration has a profit from sales (from the total turnovers). [25]

Annual profit	2 102 639 CZK
Total Investments	9 400 000 CZK
Profitability	22.36 %

The profitability is 22.36 %.

5.10.14 Internal Rate of Return - IRR

The method of Internal rate of return method, usually as IRR, indicates the relative profitability that the project during its life cycle provides. [25]

It is calculated from values of Cash flow of each period and it is used the excel function for calculation of IRR.

IRR = 34 %

Internal rate of return is 34%.

Table no. 7: Calculation

Machine BrikStar MAGNUM 300						
	CF	PB	Discounted CF 5%	DPB	NPV	IRR
0	-9400000	-9400000		-9400000	-9400000	
1	4124676	-5275324	3928263	-5471737	3928263	
2	4124676	-1150648	3741203	-1730534	3741203	
3	4124676	2974028	3563050	1832516	3563050	
4	4124676	7098704	3393381	5225897	3393381	
5	4124676	11223380	3231792	8457689		
					Kč8 054 941	34%

Source: Own calculation

6 CONCLUSION

The fossil fuels are limited and their stocks are declining. The efforts to find alternatives besides non-renewable resources are going to be the question not only economic but also security. Inventories of renewable resources for electricity and heat production, their economic use and potential coverage the energy needs of the domestic economy has become in recent twenty years often a political issue and the object of many academic and corporate researches.

Biomass has in the Czech Republic a significant potential for further development, which is influenced by many factors. A major factor is the increasing demand for renewables, which is caused by long-term growth rates and instability of supply of substitute fuels, mainly oil and natural gas. On the supply side there is a significant shift in technology and equipment enabling the development of efficient biomass combustion as well as surplus production factor - agricultural land for its use in terms of long-term intensive agricultural overproduction looking for a new economic recovery. Agriculture will become a significant producer of biomass energy, which will cover an increasing proportion of the total consumption of primary energy sources in the Czech Republic.

In the gross production of electricity in the Czech Republic, the biggest share of the renewable resources had a hydroelectric in 2009, with the share of 2.95% and in 2010 the share increased up to 3.25%. In the production of thermal energy in the Czech Republic, the biggest share of the renewable resources has a biomass; in 2009 the share was 88.09% (43 007 154.1 GJ) and in 2010 the share decreased to 87.8% but the total production in GJ is higher (46 736 280 GJ).

In the analysis of biomass utilization in the Czech Republic is apparent that energy use of biomass is increasing every year. The national indicative target share of gross electricity consumption in the Czech Republic was set on 8% (in 2010) by ministry of industry and trade, the indicative target share has been met and was higher, 8.3%.

The wood pellets production was increasing from 2003 to 2009. The plant pellets production started in 2005 and in 2010 was the production higher than wood pellets. Plant pellets are currently taken as a standard additional fuel in power and heating plants.

The brown coal briquettes have been discontinued in production at the end of 2010 in the Czech Republic. The wood briquettes production is recorded since 2003 and the production is alternately growing.

The case study is on particular company, Benko spol. s.r.o. (“Benko”). Benko is mainly producing parquets and other wood products. Produced waste is further processed to producing wood briquettes. Benko Company has a long tradition, which is over 90 years and in 2012 has 80 employees. Benko handles the timber only from hard deciduous trees (beech, oak and ash) for use in furniture, carpentry, joinery, and construction companies. The company satisfies the demand in the Czech Republic and also deals with foreign partners. The briquettes production is still increasing and the potential of this production is very high.

In the investment analysis of the Machine BrikStar MAGNUM 300 is calculated internal rate of return it is 34%. It indicates the relative profitability that the project during its life cycle provides. The net present value is included in the whole life of the project, and also the possibility to invest to project, in this case the value is 8 054 941 CZK. The calculation of profitability expresses what ration has a profit from sales. The profitability of the investment is 22.36% and the time for recovering the costs of the investments; pay back period which is 3 years. In the investment analysis is possible to see the high potential of the investment of the Machine BrikStar MAGNUM 300, so the company should accept this deal.

Due to geographical, climatological, technical and economic conditions, biomass is currently the most used renewable resource in our county and has the greatest potential especially for heat production.

7 REFERENCES

[1] Nonrenewable energy sources [online]: [cit. 29.8.2011]. Available at WWW: http://www.eia.gov/energyexplained/index.cfm?page=nonrenewable_home

[2] Renewable energy sources [online]: [cit. 28.8.2011]. Available at WWW: http://nationalatlas.gov/articles/people/a_energy.html#six

[3] CURRIE, Stephen. Hydropower. Reference Point Press, 2010. ISBN 1601521227.

[4] Hydropower [online]: [cit. 30.8.2011]. Available at WWW: http://www.vodni-tepelne-elektrarny.cz/vodni-elektrarny-cr.htm

[5] Hydropower [online]: [cit. 30.8.2011]. Available at WWW: http://nationalatlas.gov/articles/people/a_energy.html#one

[6] Pros and Cons of hydropower [online]: [cit. 31.8.2011]. Available at WWW: http://www.energeticky.cz/64-vodni-energie.html

[7] Geothermal power [online]: [cit.14.10.2011]. Available at WWW: http://myecoproject.org/get-involved/energy-conservation/renewable-energy-sources/geothermal-energy/

[8] Geothermal Energy in the CR [online]: [cit.13.11.2011]. Available at WWW: http://www.nazeleno.cz/energie/energetika/prvni-geotermalni-elektrarna-v-cr-liberec-nebo-litomerice.aspx

[9] MANWELL, James F., MCGOWAN G. Jon, ROGERS L. Anthony. Wind Energy Explained: Theory, Design and Application. 2. Edition. United Kingdom: John Wiley & Sons Ltd., 2009. ISBN 978-0-470-01500-1

[10] Wind Energy in the CR [online]: [cit.19.11.2011]. Available at WWW: http://www.cez.cz/cs/vyroba-elektriny/obnovitelne-zdroje/vitr/informace-o-vetrne-energetice.html

[11] KALOGIROU, Soteris. Solar energy engineering: processes and systems. 1.Edition. USA, 2009. ISBN 978-0-12-374501-9

[12] KLAS DONALD, L. Biomass For Renewable Energy, Fuels, and Chemicals. 1. Edition. ISBN 01-2410-950-0

[13] MALAŤÁK, Jan, VACULÍK, Petr. Biomasa pro výrobu energie. 1. Vyd. Praha: Powerprint s.r.o., 2008. ISBN 978-80-213-1810-6

[14] ROSILLO-CALLE, Frank and Coll. The Biomass assessment handbook. 1.Editon. UK and USA: Eartscan, 2007. ISBN-10: 1-84407-285-1, ISBN-13: 978-1-84407-285-9

[15] VERTES, A., ALLAIN and Coll. Biomass to Biofuels. 1. Edition. UK: John Wiley & Sons Ltd., 2010. ISBN 978-0-470-51312-5

[16] MURTINGER, K., BERANOVSKÝ, J. Energie z biomasy. 1. Vyd. Praha: EkoWATT, ERA group s.r.o., 2006. ISBN 80-7366-071-7

[17] DRAPCHO, M., Caye and Coll. Biofuels Engineering, Process Technology. 1. Edition. USA: The McGraw-Hill Companies, Inc., 2008. ISBN 0-07-148749-2

[18] Ministry of Industry and Trade, [online] Available at WWW: http://www.mpo.cz/cz/energetika-a-suroviny/

[19] Ministry of Industry and Trade, Report on the Implementation of the indicative target of electricity from renewable sources in 2009

[20] Ministry of Industry and Trade, Report on the Implementation of the indicative target of electricity from renewable sources in 2010

[21] Ministry of Industry and Trade, Renewable sources in 2009

[22] Ministry of Industry and Trade, Renewable sources in 2010

[23] Machine BRISUR 200 [online] [cit.: 2.3.2012] Available at WWW: http://www.briklis.cz/briketovaci-linky/#product-tabs=content-details

[24] Machine BrikStar MAGNUM 300 [online] [cit.: 2.3.2012] Available at WWW: http://www.briklis.cz/briketovaci-lis/magnum/300/#product-tabs=content-details

[25] BRIGHAM, F., Eugene, HOUSTON, F., Joel. Fundamentals of financial management. 7. Edition. USA, 2012. ISBN 978-0-538-47711-3.