CZECH UNIVERSITY OF LIFE SCIENCES
PRAGUE
FACULTY OF ECONOMICS

BACHELOR THESIS

Energy Economics – Solar Energy in the Czech Republic

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Affirmation

I declare that the bachelor thesis on topic: “Energy Economics – Solar Energy in the Czech Republic” was written individually by me, by the help of specific literature and other sources which are included in the review of used material, and by the help of consultations with supervisor Ing. Petr Procházka, MSc, Ph.D.

In Prague 29th April 2011

Signature

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Energy Economics – Solar Energy in the Czech Republic

Ekonomika energie – solární energie v České Republice

Summary

This bachelor thesis on topic “ Energy Economics – Solar Energy in the Czech Republic” analyses the Czech energy environment, its historical development and the Czech energy market with relation to the solar energy implication. This work also discusses the European Union’s objective of renewable resources share, its application and development within the Czech Republic.

Externalities of non-renewable resources with comparison to the photovoltaic technology and its effects on society (social costs) are also analysed. Both renewable and non-renewable resources have indirect impacts on the society.

The third part of the bachelor thesis deals with a relationship of the total amount of energy produced by renewable resources and its possible influence on the price of energy for consumers – households. This relationship is examined by simple regression method.

In the final section of this thesis, an optimisation and an explanation of the price of energy for households and firms is provided.

Keywords: Energy, economics, photovoltaic, solar, Czech Republic, European Union.

Souhrn

Tato bakalářská práce na téma Ekonomika Energie – Solární Energie v České Republice analyzuje prostředí České energetiky, její historický vývoj a Český energetický trh se zaměřením na solární energii a její implikaci. Tato práce také pojednává o plánu Evropské Unie ohledně podílu obnovitelných zdrojů na celkové produkci a aplikaci tohoto plánu a jeho vývoje v rámci České Republiky.

Dále tato práce analyzuje externality neobnovitelných zdrojů a porovnává je s externalitami fotovoltaiky a jejich dopadu na společnost (sociální náklady). Tyto dopady mají podobu interních nákladů, které jsou vytvořeny producenty energie avšak externalizovány na společnost.

Třetí část bakalářské práce jedná o korelaci celkově vyrobené elektřiny z obnovitelných zdrojů a jejími efekty na cenu energie pro zákazníky - domácnosti. Tento vztah je zkoumám pomocí regresní metody.

Na závěr práce poskytuje optimalizaci ceny energie pro domácnosti a firmy společně s výsledky a jejich objasněním.

Klíčová slova: Energie, ekonomika, fotovoltaika, solární, Česká Republika, Evropská Unie.

The Structure of the Bachelor Thesis

1. Introduction

Since the supply of fossil fuels is finite, the energy sustainability is becoming a well-discussed topic. The world's population is expected to grow for several decades and the demand and consumption for energy is likely going to rise even rapidly. The question is whether this growing tendency is sustainable and if it is not, how will be the possible shortage of energy produced? Future of fossil fuels may be in question, but there has to be a switch to other alternative sources of energy.

The European Union already acts towards this switch by setting target of 20% production share from renewable energies. Czech Republic's objective is to produce 13% of total energy production by renewable energies.

However, switching only to alternative sources is not the answer. Renewable resources such as wind or solar energy are unreliable and inappropriate for meeting the demand in the long run. Nuclear energy can be the solution but only if proper and detailed security conditions are guaranteed. The most reasonable solution to the energy sustainability problem is the right mix of all resources in the right ratio. Very important is the way of implication new technologies. The Czech Republic is an example of a market, which accepted the technology with external costs but did not take measures to internalize them, causing the price of energy to increase.

The energy sustainability is closely connected to environmental issues such as global warming and the energy dependency. Comparison of CO_2 pollution is provided within this thesis. With rising energy demand of emerging economies, the issue of energy dependency is becoming very clear and alerting. Energy efficiency along with renewable resources must be applied widely to stabilize energy sustainability, which has direct impact on the environment itself.

2. Objectives of Thesis and Methodology

The aim of this Bachelor thesis is to analyse Czech environment within the energy sector with focus on photovoltaics. This analysis examines the regression relationship between the price of electric energy for households and the amount of electric energy produced from renewable sources. The regression analysis sets the price of energy as an independent variable and the production of energy from renewable sources as the dependant variable on the opposite side of the equation. This analysis should provide necessary conclusion, which should be an answer to the hypothesis many times promoted by the media, that state uses current "solar boom" as an excuse for an increase of the price of energy.

The second part of the Bachelor thesis deals with the study of well-known phenomenon, which argues that the solar energy and photovoltaics are environmentally friendly. This phenomenon is consulted within the part "Life Cycle Assesment and its Application in

Photovoltaics”.

This paper presents my own point of view on externalities, caused by energy production from non-renewable sources of energy and photovoltaic technology. This certain study is provided because of increasing responses, that the “green wave” floating through the whole European Union is not that green as it is presented at all.

Last part of this paper focuses on the energy price optimisation. This optimisation process is performed for households and firms. Average consumption for each class is calculated and it is executed within three main distributers of energy in the Czech Republic (ČEZ, PRE, E. ON).

3. Literature Overview

3.1 Energy Economics

3.1.1 Supply and Demand

The basic factor that influences demand for all energy sources is obviously the economic development. With increase of an economy level, the consumption of energy sources increases too and if economy falls, the consumption falls too.
However, growing tendency of the World population also drives the demand for energy.
It is expected, that population might increase by 20% within next 20 years. High share on this growth is within emerging countries such as China, India, and Brazil. There has to be energy efficiency applied, because even if EU and other developed countries try to increase the share of renewable sources on the total demand for energy, the World will be still dependant on fossil fuels. It is than possible, that demand may overgrow the supply.

The price of electric energy consists of two variable compounds:

a) Regulated compounds / services
   1. Distribution fee
   2. System costs
   3. Support cost for renewable sources of energy
   4. Activity of the Operator of the Energy Market (fee)

b) Not Regulated compound
   1. Price for electric energy

Regulated services are set by price decision from the Czech Energetic Regulatory Office (ERU) within the 30th of November and are valid for the whole following year.
The price of electric energy is highly influenced by the price of energy on the Energy Stock

Market, which is influencing prices of electric energy within the European Union.

The Czech energy market is liberalized since the 1.1.2006 and therefore every consumer has the right to choose his distributer of electric energy. [11] [23]

However, even if the market is liberalized, the demand for energy stays inelastic within the short-term (Figure 1.1. D1). Demand within the long-term becomes more elastic (Figure 1.1. D2). It is obvious from the graph illustrated in Figure 1.1. that consumers are able to adapt more flexibly to the market price in the long-term.

The price of electric energy is established by the regulator (ERU) and the distributer over a certain timeframe (usually a year) and therefore, the consumer can't be sensitive (elastic) to the cost of production within the short-term period. The price flexibility is represented by ΔP.

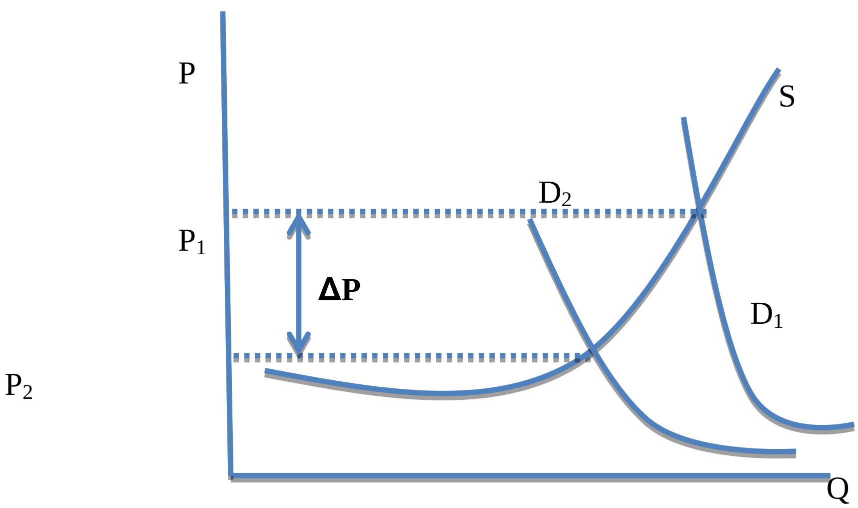


Figure 1.1. Inelastic Demand for energy, my own illustration

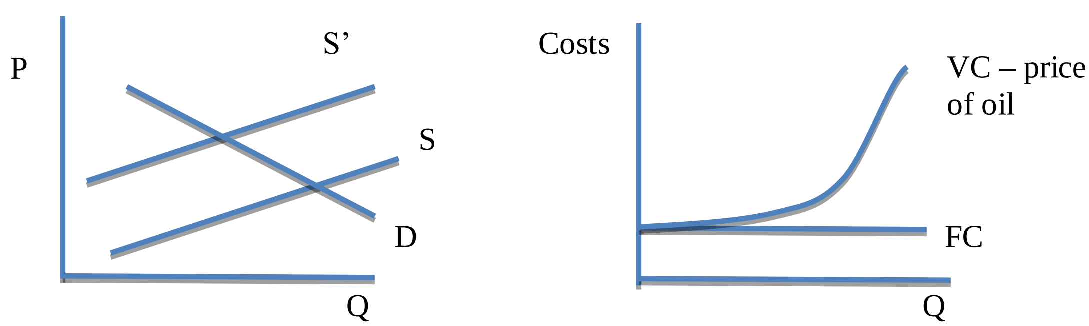


Figure 1.2. Shift due to production costs

Fixed Costs represent the regulated parts of the energy; distribution fee, support cost for renewable sources of energy, activity of the Operator of the Energy Market. The shift in demand can be caused due to production costs such as increase in the price of oil (Figure 1.2.)

3.1.2 The Czech Energy Market

The Czech Republic has advanced electricity supply infrastructure which stems from the industrial policies of the Austro – Hungarian era. With almost 3000km of high-voltage power lines (from which is about 1/6 doubled) and installed generation capacity of more than 15 thousand TW is Czech Republic imagined "bridge" between Eastern and Western Europe.

Czech electricity export in 2000 and 2001 reached 12 TWh – for comparison that's almost twice higher than the entire power consumption of Macedonia. Czech Republic exports approximately 25% of its production. The additional quantity is partly due to the activation of the environmentally controversial plant near the Austrian border – Temelín.

" *The implementation of post-socialist energy sector reforms has resulted in the formal unbundling of the socialist-era electricity monopoly. The Czech Electricity Company (CEZ, České energetické závody) is now a 70% state owned joint-stock company, which operates 10TW of generation capacity, consisting of fossil-fuelled stations, thirteen hydro stations, two nuclear plants, three wind farms and one solar power station. The remaining 5TW of the electricity generation infrastructure is installed in 12 private fossil-fuel stations that sell the electricity to the high-voltage grid operator (ČEPS), a wholly owned subsidiary of ČEZ. The distribution network is divided between eight joint-stock regional electricity companies (AEA, 2006).* **"** [1, p.88]

Because of the industrial history during the Austro – Hungarian era and liberal attitude of government towards privatization and market reforms the energy industry is well developed in Czech Republic as mentioned above. Almost every lager town has its own district-heating network – sometimes it is oil or coal – fired heating, but there is an increasing effort to switch to the gas in the recent time. The only problem is that the gas is in 98% imported from Russia and Norway and that makes Czech Republic quite dependant. As it is known in the Czech Republic there is an effort to reduce this dependency on Russian Federation. This might be also the reason for building new gas and oil pipelines to Germany. Czech government in January 2002 signed a contract to sell Transgas – state owned company – to the RWE Gas of Germany. RWE is now very important player on the Czech energy market.

Energy efficiency policies – during the 90' there were many regulation reforms, which have resulted into fragmentation of policies into certain government departments.

For example: the core of the energy sector – Energy Policy Department that is within Ministry of Trade and Industry. Czech Energy Agency that controls very sticky theme of Renewable Energy Resources and Energy Saving.

State Environmental Fund that is operating within the Environmental Ministry and providing variety of small-sized grants and interest-free or loans guaranteed by state for demand side efficiency investment. Ministry of Regional Development, that controls the aspects of Energy Saving Programme and last – the Czech State Inspectorate of Energy, which undertakes audits in the public sector and in subsidized enterprises, and provides training for energy managers and technicians. [1]

3.1.3 History of the Czech Energy Market

The year of 1989 was a year of many opportunities also for an energy sector. Because of 40 years of central planning and especially Communism in Central Europe there wasn't quite a market for energy in this area. On the other hand, state intervention, state control and regulations of energy sector might be common in market economy too, while it did not have positive effects. In former Communist countries it was more devastating for economy.

What was common for all former Communist countries was government control of all investment decisions and other important operational factors. Problem was that during the 1989 there was a huge lack of managerial and accountability techniques in this region which had to lead to a enormous waste of resources in electricity supply. Nowadays situation is much more different, the politics of EU are riding on "green wave" and most people are thinking economically. That means they are looking for other efficient and more environmental friendly ways to get and also more importantly how to economically use energy without any pointless losses (energy saving light-bulls, thermal insulation etc.).

There was a will to keep all energy prices low before the 1989 and they had no relation to the costs. That has changed after 1989 – energy prices were increased but the real increases were more important because of the economic reform process in 1990. Later, because of unemployment declining real incomes for part of population and government anti-inflationary politics prevented an increase of electricity prices. That caused that energy sector was suffering from unpaid bills of other state-owned enterprises. [2]

"The generally liberal attitude of government towards a privatization and market reform is also reflected in its policy towards the electricity industry. In the Czech Republic production and transmission has been in the hands of the national monopoly CEZ (České Energetické Závody). Several of its production units have already been sold off and some of the new companies have brought in foreign shareholders. The company is also actively seeking finance in the international markets. Minority share in CEZ itself has been sold and more shares will be distributed in the government's final round of voucher privatisation, perhaps bringing the private share up to 49%. Some of the eight regional distribution companies will also be privatized, but also the state will remain the main shareholder. The goal of the Czech government is to privatize the competitive parts of the electricity sector, while retaining state ownership of the rest. Competition from foreign sources has gradually been allowed, since 1994. Opening up the CEZ national grid to third parties will also encourage competition. These steps taken so far indicate, that Czech industry may accomplish its modernization relatively fast and that the legacy of Communist system, as described above, can be overcome earlier than in the other Visegrad countries." [2, p.140]

The modernization described by Haugland, Bergesen and Roland 1998 [2] has already been successfully applied, especially during the years 2005-2010 when other competitors entered the market. Even though, as Buzar, 2001 stated, the CEZ monopoly is still apparent. However, the situation is developing well for consumers during last 5 years. The Czech energy market is progressively developing and the market competition is growing. The oligopoly of three main suppliers of energy (CEZ, PRE, EON) is slightly decreasing over last years. For comparison in 2006, CEZ controlled over 53% of the market, E. ON 20% and PRE (Prague energetics) approximately 17%, that is 90% of the market. Nowadays (2010) shares are following: CEZ 43%, E. ON 14%, PRE 12% and 27% is covered by new suppliers of energy. [9]

3.1.4 Participants of the Energy Market

1. **Manufacturer of the energy**

   - Electric power stations, solar power stations – power stations in general
   - Energy is an invisible and it fluctuates through semiconductors

2. **Distribution of the energy**

   - **State distribution** – ČEPS – has three functions:
     A) Operation of the distribution network – through very high voltage conduction
     B) Transfer of the energy
     C) Transit of the energy

   - **Private distribution** – also regional distribution companies
     A) Distribution of the energy through high voltage conduction

3. **Distributor of the energy**

   Distributors / Merchants
   The energy is an asset of the businessman.
   Trading on the energetic stock exchange.
   Valid license is an obligation.

4. **Customers**

   - End of line consumers use the energy for their own consumption
   - They can be divided into 2 groups:

A) Small-scale consumers – Households (flats, houses)
- Entrepreneurial subjects

B) Large-scale consumers – Very high voltage purchaser
- High voltage purchaser

5. Services

Regulation of the energetic market – ERU

- Specifies regulated prices
- Gives licences for entrepreneurial activity on the energetic market
- Provides rules for administration separated evidence of revenues
- Adjudicates law-suits and sets rules for functioning the energetic market
- Makes the "System" stationary

[11]

State Energetic Inspection (SEI)

- State authority that is entrusted to execute supervision
- Entrusted to set fines for not keeping law prescriptions within the energetic sector

OTE – Operator of the energy market

- Organising of the short-term energy (and gas) market with cooperation with the operator of distribution network
- Evaluating possible inclinations within the area of the Czech Republic and based on these inclinations providing accounting to appropriate subjects
- Measuring estimated supply and demand of energy and advising pertinent ways how to secure the balance between supply and demand of energy (and gas)
- Administration of the public registry of emission allowances

[10]

Scheme of the Energy Market

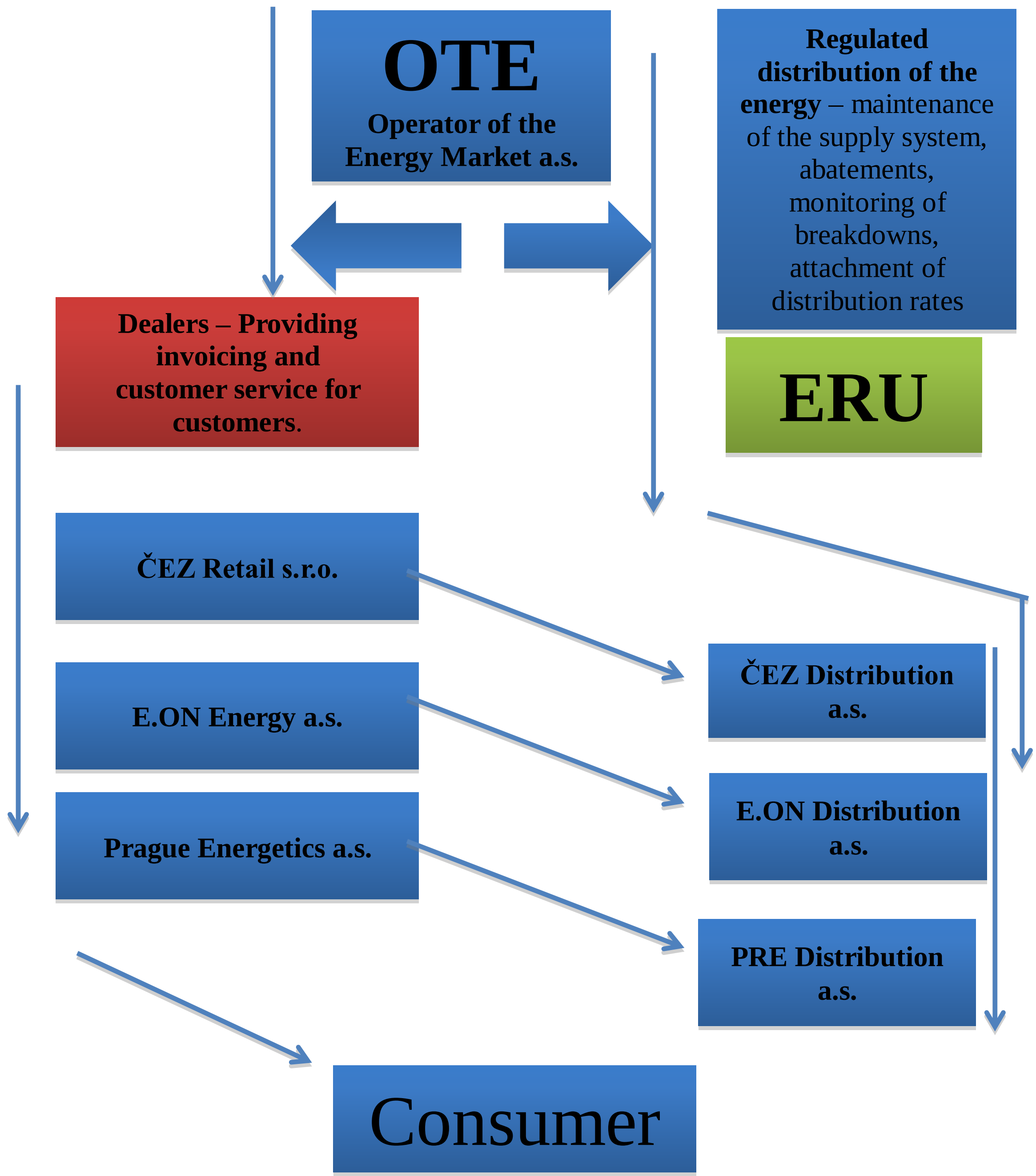


Figure 1.3. Energy Market, my own illustration

3.1.5 Structure of the Price of Electric Energy

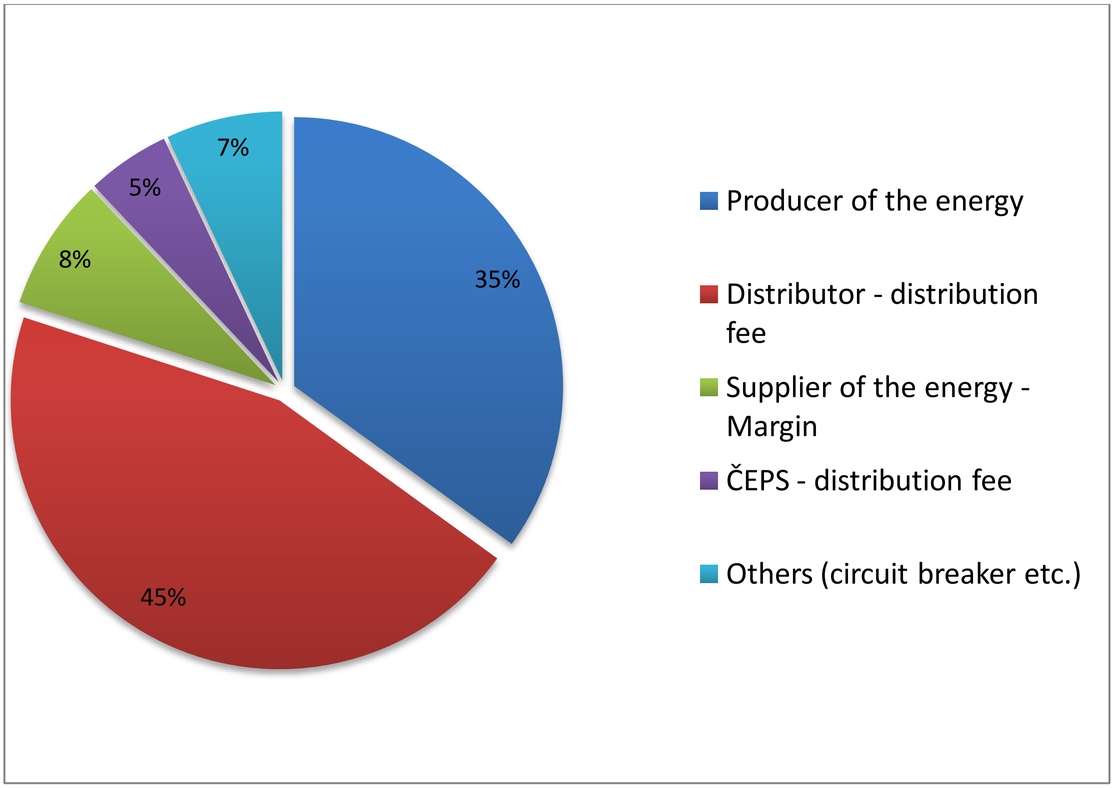


Figure 1.4. Energy price structure, my own illustration, [13]

Payment for the energy is fixed to the take off location (end-user).
Sometimes payment differs due to the change in the tariff – high tariff x low tariff. Usually dependent on the amount of MWh consumed.
Therefore payment is variable due to the consumption.

Related part of the price of the energy is the payment for the distribution of the energy. It can also differ due to the high / low tariff and it is dependent on the amount of energy consumed -> transferred (distributed).

Fixed part of the payment for energy is the payment for the size of the circuit breaker.
Important part of the energy price structure is a payment of system services. This payment includes necessary power station emergency, which operates as a back-up source of energy in case of any failure.

Last part of the structure is a payment for buyout support. This payment covers the support for renewable energy, which costs are much higher than in the case of ordinary, electric energy and that is the reason why these costs are covered from this payment. This bachelor thesis presents an regression model, which is concerned with this problematic. Due to the fact, that there was an extreme increase in the solar energy production within the

Czech Republic, this payment has risen up and influenced the price of the energy significantly. This paper is also occupied with this problematic and it tries to prove/disprove this hypothesis.

3.2 Energy Legislative

3.2.1 Czech Energy Legislative

Distributor is obliged to connect every customer to the distribution network and to assure that all participants of the energy market do not have disadvantaged conditions for connecting their devices to the distribution framework.
Distributor of the energy is obliged to offer the end users fair and not disadvantaged option of payment for the energy distributed.

For the purpose of registration, behaviour, laws and obligations all players on the market, there is an energetic law no. 458/2000 SB. A posteriori later novels, supplemented with promulgations of Energetic Regulation Office, ERU, Ministry of Trade and Industry, MPO and the State Energetic Inspection, SEI, Energetic Regulation Office publishes price measurements of regulated components, solves eventual law-suits within the players of the market and administrates licence agenda.
Ministry of Trade and Industry publishes mostly technical specifications.
State Energetic Inspection conducts investigation of adherence to the technical subordination of energetic subjects. All these organs are state organs and solve potential impulses due to the administration order.

Every customer must be connected to the distribution network, if it is technically and administratively possible.

Every energy distributor must allow the customer to receive quality energy within not discriminatory conditions.

Every customer has the right to freely choose and change the distributor of energy. [10]

3.2.2 <u>EU Renewable Energy Legislative</u>

"European leaders signed up to a binding EU-wide target to source 20% of their energy needs from renewables, including biomass, hydro, wind and solar power, by 2020. To meet this objective, they also agreed on a new directive to promote renewable energies, which set individual targets for each member state."[3]

Milestones:

- **Nov. 1997**: Commission publishes White Paper setting out a Community Strategy and Action Plan for renewable energy.
- **Sept. 2001**: EU adopts Directive on the Promotion of Electricity from Renewable Energy Sources.
- **May 2003**: EU adopts directive on the promotion of the use of biofuels or other renewable fuels for transport.
- **10 Jan. 2007**: Commission presents Renewable Energy Roadmap as part of its energy and climate change package.
- **March 2007**: EU summit endorses a binding target to source 20% of the bloc's energy needs from renewable sources by 2020.
- **23 Jan. 2008**: Commission presents a proposal for a new renewables directive.
- **9 Dec.2008**: Political agreement on the Renewables Directive (EurActiv 09/12/08).
- **11-12 Dec. 2008**: EU summit agrees final version of the Renewables Directive.
- **30 June 2009**: Commission issues template for National Renewable Energy Action Plans (NREAPs) (EurActiv 01/07/09).
- **30 June 2010**: Deadline for EU states to present National Renewable Energy Action Plans.
- **31 Jan**. **2011**: Commission progress report calls for doubling capital investments to achieve renewables target (EurActiv 31/01/11)
- **2020**: Target date for EU objective of sourcing 20% of energy from renewable sources. **[3]**

- *Renewable energies such as wind power, solar energy, hydropower and biomass can play a major role in tackling the twin challenge of energy security and global warming because they do not deplete and produce less greenhouse-gas emissions than fossil fuels.*

They are also expected to play a key role in creating new technology jobs and leading Europe out of the economic crisis.

Since the energy crises of the 1970s, several industrial nations have launched programmes to develop renewable energy solutions, but the return of low oil prices prevented renewable energies from picking up on a large commercial scale.

In 2007, renewable energies covered 13.1% of global primary energy supply and 17.9% of global electricity production (IEA, 2007). The IEA's 2006 World Energy Outlook foresees in its Alternative Policy Scenario that the share of renewables in global energy consumption will only slightly increase by 2030, at 14%. Renewables in electricity generation are expected to grow to around 25%, according to the IEA.

The European Commission published a White Paper in 1997 setting out a Community strategy for achieving a 12% share of renewables in the EU's energy mix. The decision was motivated by concerns about security of supply and environmental protection.

The 12% target was adopted in a 2001 directive on the promotion of electricity from renewable energy sources, which also included a 22.1% target for electricity for the EU-15. The legislation was an important part of the EU's measures to deliver on commitments made under the Kyoto Protocol.

Nevertheless, the targets were not binding and it became evident that they would not be met.

In January 2007, the Commission published a Renewable Energy Roadmap outlining a long-term strategy. It called for a mandatory target of a 20% share of renewable energies in the EU's energy mix by 2020. The target was endorsed by EU leaders in March 2007.

To achieve this objective, the EU adopted a new Renewables Directive in April 2009, which set individual targets for each member state.The 'Europe 2020' strategy, presented by the Commission in March 2010, incorporated the 2020 climate goals in its flagship initiative to promote a resource-efficient Europe. **[3]**

3.2.2.1 Member states' targets

A new EU directive on renewable energies, agreed in December 2008, requires each member state to increase its share of renewable energies – such as solar, wind or hydro – in the bloc's energy mix to raise the overall share from 8.5% today to 20% by 2020. A 10% share of 'green fuels' in transport is also included within the overall EU target.

To achieve the objective, every nation in the 27-member bloc is required to increase its share of renewables by 5.5% from 2005 levels, with the remaining increase calculated on the basis of per capita gross domestic product (GDP).

Member State	**Share of Renew. In 2005**	**Share required in 2020**
Austria	23,30%	34%
Belgium	2,20%	13%
Bulgaria	9,40%	16%
Cyprus	2,90%	13%
Czech Republic	6,10%	13%
Dennmark	17%	30%
Estonia	18%	25%
Finland	28,50%	38%
France	10,30%	23%
Germany	5,80%	18%
Hungary	4,30%	13%
Ireland	3,10%	16%
Italy	5,20%	17%
Latvia	32,60%	40%
Lithuania	15%	23%
Luxembroug	0,90%	11%
Malta	0%	10%
The Netherlands	2,40%	14%
Poland	7,20%	15%
Portugal	20,50%	31%
Romania	17,80%	24%
Slovak Republic	6,70%	14%
Slovenia	16%	25%
Spain	8,70%	20%
Sweden	39,80%	49%
United Kingdom	1,30%	15%

Figure 1.5. EU Targets, my own illustration, ***[3]***

Czech Republic's target and current development

Due to the EU directions, the Czech Republic should keep up with its target of 13% (based on the share of renewable energies from 2006) as following:
2012 – 7,5%, 2014 – 8,2%, 2016 – 9,2% and 2018 – 10,6%. These targets are auxiliary and they might be specified during the process of implementing renewable energies.
The EU directive also offers an option for states, which do not fulfil their share. States that will produce an excess of their share can transfer their excess to states who will suffer from lack of renewable energies.
[4]
The indicative target for the year 2010 in the Czech Republic was later set to 8%. The energy production from renewable resources for the year 2010 is estimated to be 8,5GWh [11], which represents slightly over 8,3% of total gross consumption of the Czech Republic. It can be already stated, that the Czech Republic has fulfilled its commitment to its target for the year 2010. On the other hand, this rapid growth might be slowed down, because of the negative influence, that media are creating in case of photovoltaics.

Interim targets

The directive set a series of interim targets, known as 'indicative trajectories', in order to ensure steady progress towards the 2020 targets.

- *20% average between 2011 and 2012;*
- *30% average between 2013 and 2014;*
- *45% average between 2015 and 2016, and;*
- *65% average between 2017 and 2018.*

EU countries are free to decide their own preferred 'mix' of renewables, allowing them to take account of their different potentials. They must present national action plans (NAPs) based on the indicative trajectories to the European Commission by 30 June 2010, followed by progress reports submitted every two years. The plans will need to be defined across three sectors: electricity, heating and cooling, and transport.

The compromise agreement eventually rejected a regime whereby member states would have faced financial penalties for failing to reach interim targets towards the 2020 goal. Member states are, however, required to submit amended NAPs, setting out measures for rejoining the indicative trajectories.

Brussels reserves the right to enact infringement proceedings if states do not take 'appropriate measures' towards their targets, meaning the decision to take legal action will be at the Commission's discretion rather than based on strict criteria. [3]

3.3 Photovoltaics

Photovoltaics mean ecologically clean creation of energy from the Sun. Sun itself is an enormous energetic potential – since it is thermonuclear reactor, which provides heat and energy to the Earth, it is possible to employ this source for creation of ecologically clean and cheap electric energy (or heat).

Photovoltaics work on a principle of converting solar radiation into a current (direct) electricity. This process is applied by arrays of cells, that contain material able to convert solar radiation into a DC electricity.

Materials used today include amorphous silicon, polycrystalline silicon, microcrystalline silicon, cadmium telluride, and copper indium selenide/sulfide. A material is doped to increase the number of positive (p-type) or negative (n-type) charge carriers. The resulting p- and n-type semiconductors are then joined to form a p-n junction that allows the generation of electricity when illuminated. PV performance decreases when the cell temperature exceeds a threshold of 45°C. [13]

3.3.1 History of Pohotovoltaics

French physicist Alexandr Edmond Becquelere firstly discovered the photoelectric effect in the year 1839. In the year 1876 same effect for selene crystals was discovered by William G. Adams and Richard E. Day. However the first explanation for this effect did not occur till they year 1905, when Alber Einstein firstly enlightened this effect for which he received the Nobel Prize for Physics. The first pile, which was able to overcome the effectiveness of 4% was invented in the year of 1954 by Dryl Chapin, Calvin Fuller and Gerald Pearson.[16]

Photovoltaic piles were firstly used for powering satellites during the sixties. First satellite that took advantage of this technology was Vanguard I. This satellite was released to the orbit in 13th of March 1958. Thanks to this success, the demand for photovoltaic technology increased a lot. This demand, mainly from aircraft industry, caused rapid advance in the development of the photovoltaic technology.[16]

Thanks to the energetic crisis in the seventies, increased demand for satellites and especially to the change of perception of sustainable environment, alternative sources of energy, such as photovoltaics, became economically and also politically very attractive. These sources of energy caused many changes in policies and laws. There are even many programs for supporting photovoltaic technology. Biggest leaders in this sphere are Germany, USA and Japan. However, many other states are catching up very quickly, mainly developing countries such as Brazil and India, where is a huge potential, also due to their suitable geographic location. [17]

3.3.2 Current Development

Manufacturing the energy from the sun radiation almost doubles every year since 2002 that makes the fastest growing technology in the field of energy sector. In the year 2007, 2,826 GWp (gigue watt peak) was installed worldwide and in the year 2008, 5,95 GWp was installed – that means 110% increase. [14]
However, with comparison to the non-alternative sources of energy, these capacity numbers are insignificant. The portion of alternative (renewable) sources of energy (solar, wind and geothermal) was only 0,7% in the year 2006. [15] This rising trend is certainly good sign for the environment, but there must be will to keep up with this tendency for a long run. In the year 2012, the Kyoto protocol will run out and the world will have to set new guidance in the sense of emission pollution. All time discussed issue of global warming; air pollution and green house effect is helping to the development progress of renewable energies, such as photovoltaics. We might expect constant growth of portion of energy produced by renewables. One of the slowdowns of photovoltaics is quite high purchase price.
On the other hand, as we can see, acquisition costs associated with photovoltaics are rapidly decreasing. Due to an increasing number of entrepreneurs interested in this business sector, demand is rising and the economy of scale is applied causing significant decrease of costs. This decrease is evident in the Czech Republic, where in the year 2010 extremely convenient surrender prices were set, causing solar boom in the Czech Republic.

3.3.3 Principle of the Photovoltaic Process

The process of photovoltaics itself is made by the help of photovoltaic piles, which are made of materials that enable the transfer of the solar radiant into a direct current. When fotons from the Sun fall on the surface of silicon solar piles they bolt out electrons from the crystal chancel screen which than become free and part of the electric current.

Solar pile is usually a plate around the size of 12x12 cm or bigger. For the action of photovoltaics itself, it makes the use of the fact that on the edge of 2 two materials on which the sunlight is dropped, a voltage is created and by the help of closing the electrical circuit the electricity can be gained.[6]

Solar piles are usually made from silicon (amorfed silicon, polycrystalline silicon, microcrystal silicon, telluride kadmia and CIGS allied substances) because silicon is a crystal matter with structure similar to a diamond. In contrast to a diamond, silicon has the ability to absorb part of the solar radiant and has properties of the semiconductor. That means that when it is illuminated, its conductibility highly increases. The performance unit of solar panels is Watt peak – WP. Effectiveness of solar panel is stated to be 14-20% and the operating life is expected to be circa 30 years.
Each solar pile can create at max the voltage of 0,5 V and electric current to 3 A.

Very good attribute of solar piles is the ability of creating larger units and its ease linking. These larger units are called solar or photovoltaic modules and are basic building

units of photovoltaic systems.
Effectiveness of solar panel is stated to be 14-20% and the operating life is expected to be circa 30 years. [6]

3.3.4 Components of Solar Power Stations

1. **Solar/Photovoltaic panels**
   Silicon is the main material used for solar panels. Based on the type of manufacturing, panels can be monocrystal, polycrystalline and uncrystalline photovoltaic piles. Practically, polycrystalic are the most common in use. Pohotovoltaic panels are able to create electric power even without direct solar radiant – it is called the diffusional radiance [6]
2. **Chopper (current inverter)**
   The electric current made in photovoltaic panels is direct current. Chopper it converts into the indirect current. Chopper also controls, regulates and monitors the power supply of the current and in case of breakdown or any other disturbance it disconnects the solar generator from the current. Chopper can be also equipped with a monitor that shows information about the system, its performance, voltage and the amount of the energy produced.[6]
3. **Electrometer**
   Electrometer simply shows the amount of the energy, that the solar power station distributed into the local power grid.
4. **Cabling, batteries** (if exist) and electronic equipment (battery controller etc.)

3.3.5 Environmental Effect of the El. Energy Production Process

"Energy systems are known as a major source of environmental pollution. Therefore, the selection of a particular energy system can influence the pollution output by reducing or increasing the extent of emissions dispersed into the environment. Criteria developed to choose from various energy technologies need to take into consideration not only technical but also socio-political aspects to ensure that the social and environmental costs and benefits of a chosen energy technology have been taken into account.
Emissions generated during the life-cycle of a given energy system are dispersed into the environment and impose a burden on living systems and items of value to human society, such as historic buildings. These burdens have an impact on the physical and biological environment as well as on human health, and thus these impacts impose significant costs on society. Costs imposed by pollution have in the past been treated as external to the energy economy and have not been incorporated into the total costs of energy production and distribution." [8]

Quantified marginal external costs of electricity production in Germany[2] (in € cent per kWh)

	Coal	Lignite	Gas	Nuclear	PV	Wind	Hydro
Damage costs							
Noise	0	0	0	0	0	0.005	0
Health	0.73	0.99	0.34	0.17	0.45	0.072	0.051
Material	0.015	0.020	0.007	0.002	0.012	0.002	0.001
Crops	0	0	0	0.0008	0	0.0007	0.0002
Total	0.75	1.01	0.35	0.17	0.46	0.08	0.05
Avoidance costs							
Ecosystems	0.20	0.78	0.04	0.05	0.04	0.04	0.03
Global Warming	1.60	2.00	0.73	0.03	0.33	0.04	0.03

Figure 1.6. External costs of el. energy production in Germany, [8]

It is obvious from the table, that non-renewable energies represent much larger portion of marginal social costs than renewable energies. As Miquel A. Aguado-Monsonet [8] stated, costs arising from pollution are external to the economy and energy production, these costs are considered to be social costs. In case of pollution, these costs result into a negative externality.
My own illustration and analysis of non-renewable energy externalities in comparison with renewable energy externalities can be found in the chapter 4.2.

3.3.6 Life Cycle Assessment

“*Environmental costs arise from emissions at various stages in the construction, operation and decommissioning of power sources. In order to identify and quantify these environmental externalities, a full life-cycle assessment of energy systems has to be undertaken. The identification of the “upstream” and “downstream” activities of energy systems allows a comparative evaluation of their environmental burdens, impacts and costs.*
There are also ranges of costs imposed on society which are associated with energy supply but which flow from decisions taken by governments for reasons, which may not always be related directly to energy supply. These non- environmental external costs include national security considerations (including security of supply and safety issues), natural resource management, liability limitations, employment and politico-economic instruments such as subsidies or tax concessions. It is extremely difficult in most cases to quantify these non-environmental costs and even more difficult to allocate these costs to specific technologies in terms of costs per unit output. Attempts have been made to quantify R&D expenditures, subsidies and tax concessions to specific energy technologies. However, although consensus of the appropriate treatment of these issues has not been reached yet, these costs do not appear to be negligible and are quite likely to increase over the years.
The emissions of pollutants can, at least in principle, be measured and a quite accurate technical assessment can be made by emissions from given power sources, and the means and costs of controlling them. These emissions disperse into the environment, and although this can be modelled quite well on a large scale, microclimatic effects can change the burden imposed on natural systems on smaller geographical scales.

Life cycle assessment generally is a tool used to compare two competitive activities or products. In the comparison of energy technologies the following impacts should be considered: a) Exhaustion of raw material, b) Energy needed, c) Global warming, d) Acidification and e) Waste “
[8]

3.3.7 <u>Application of LCA to the Photovoltaic Technology</u>

The application of the LCA methodology to the photovoltaic technology should consider all steps necessary for the production of the components of a photovoltaic system as well as the decommissioning of the system.
For this reason, the first step to follow is to evaluate in each stage of the process a detailed inventory of the inputs and outputs of energy, materials and required capital equipment. In a second step, the evaluation of the potential hazards associated with each step of the process should be also evaluated for each component of the photovoltaic system. The following figure shows the life steps for a photovoltaic module.

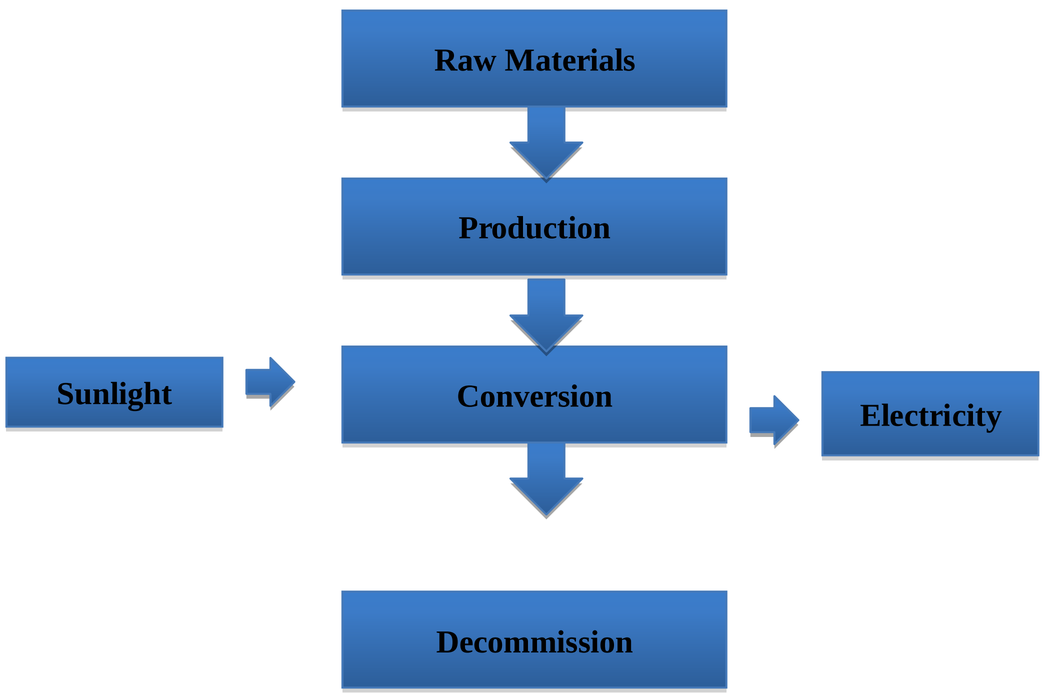


Figure 1.7. Life cycle of the photovoltaic panel [8]

"Of course the evaluation of the inventory and the analysis of the hazards of each step should be made for each component of a photovoltaic system. Each step of the process has inputs of energy and materials and requires capital equipment, and each also has potential hazards associated with it.
A photovoltaic system consists of the following set of components: photovoltaic panels, batteries (if they exist) and electric and electronic equipment (battery regulator, cabling, controller and inverter (if it exists)).
Because the environmental performance of PV-systems is greatly improved by increased efficiency and longer lifetimes, both should be stimulated for the modules as well as the total system.

For roof-integrated PV-systems, module production and production of the support structure are the largest contributors to the environmental issues and are almost equally important from an environmental point of view. If batteries are used, their recycling should be considered.
Environmental interventions in the module production process can be reduced by about 30% through increasing production scale and optimizing the production process, simultaneously resulting in material and energy requirement reduction. Little supplemental energy conservation policy may be necessary to achieve this outcome."
[8]

3.4 Summary of the Literature Overview

The situation within the Czech energy market has developed during last ten years and it is becoming very competitive. The oligopoly, which was noticeable during the 90's, is falling apart as new suppliers enter the market.

The demand for energy is highly increasing, especially because of rising demand in emerging countries. The GDP of emerging countries is rising and the growth of these economies needs higher supply of energy. With this rising demand and finite amount of non-renewable sources, the share of renewable sources and alternative sources such as nuclear energy must be evolved. To keep up with rising tendency of demand for energy, energy efficiency must be applied. To remain energy sustainable; right mix of renewable, non-renewable and alternative sources is needed. On the basis of this need, analysis of externalities is provided in the next section "Analysis".

The fact, that energy from renewable sources of energy is more expensive to produce can cause negative influence upon the price of energy in case, that there is a relationship between the price of energy and the amount of energy produced from renewable sources. To examine this relationship, further analysis has to be done. This analysis is provided by the simple regression analysis. Solar energy; photovoltaic technology is examined, because within the Czech energy market, it belongs between one of the most costly energy produced from renewable sources.

4. Analysis

4.1 Externalities

Definition of an Externality

"Externalities are defined as benefits or costs generated as an unintended by-product of an economic activity that do not accrue to the parties involved in the activity and where no compensation takes place. Environmental externalities are benefits or costs that manifest themselves through changes in the physical-biological environment."
Pollution emitted by road vehicles and by fossil fuel fired power plants during power generation is known to result in harm to both people and the environment. In addition upstream and downstream externalities, associated with securing fuel and waste disposal respectively, are generally not included in power or fuel costs. To the extent that the ultimate consumer of these products does not pay these environmental costs, nor compensates people for harm done to them, they do not face the full cost of the services they purchase (i.e., implicitly their energy use is being subsidised) and thus energy resources will not be allocated efficiently.
The origin of an externality is typically the absence of fully defined and enforceable property rights. However, rectifying this situation through establishing such rights is not always an easy task. In such circumstances, at least in theory, the appropriate corrective device is a Pigouvian tax equal to marginal social damage levied on the generator of the externality. If the tax is subsequently used to compensate the sufferer(s), then the externality is said to have been "internalised."

"Externalities of energy production/consumption (whether based upon fossil fuel combustion, nuclear power or renewable technologies) can be divided into two broad (net) cost categories that distinguish emissions of pollutants with local and/or regional impacts from those with global impacts:

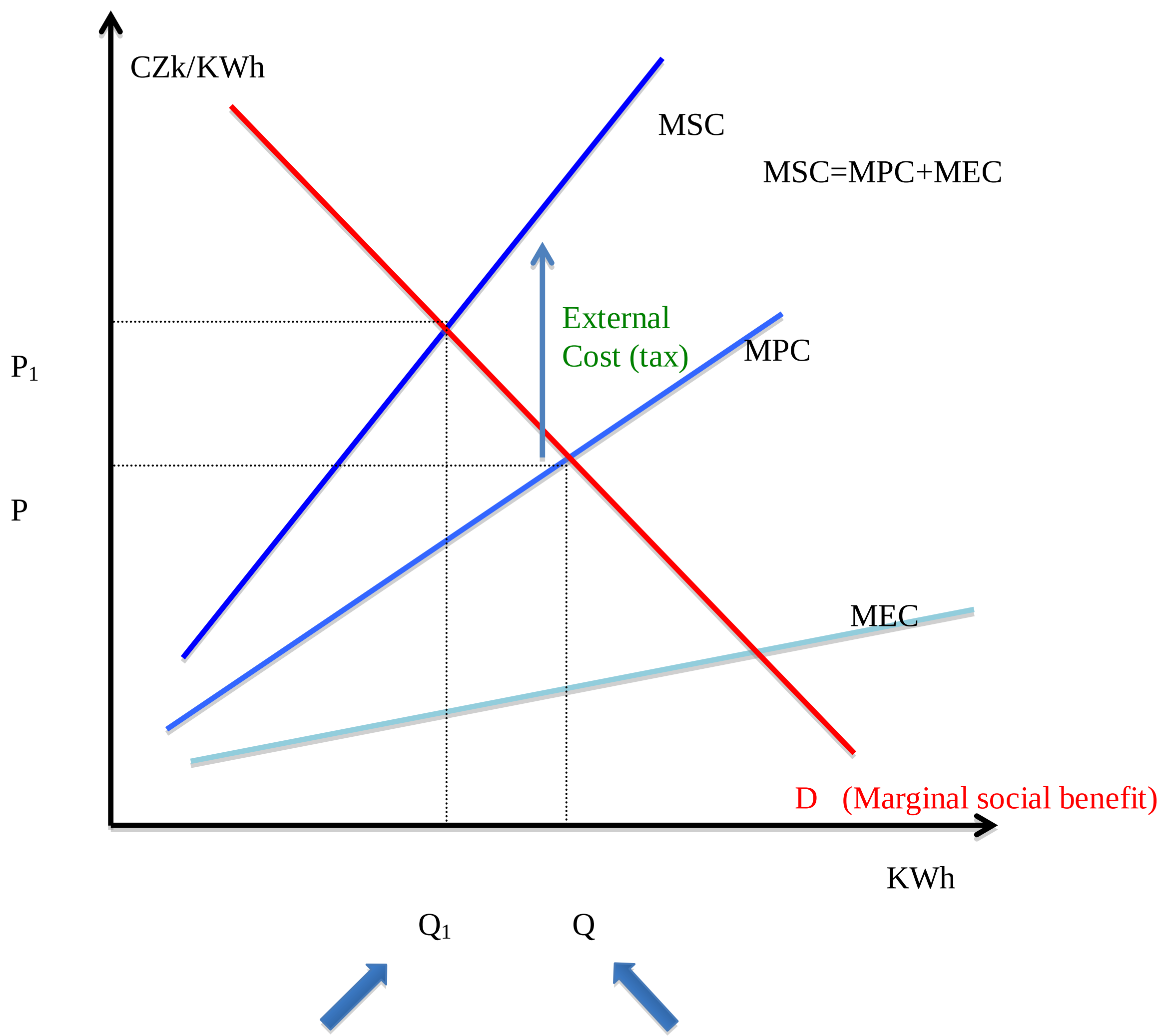
** costs of the damage caused to health and the environment by emissions of pollutants other than those associated with climate change; and*

** costs resulting from the impact of climate change attributable to emissions of greenhouse gases."* [18]

The case of pollution within the sector of non-renewable energy resources is illustrated in the next section

4.1.1 Non-renewable Resources

Pollution as a negative externality caused by non-renewable energy – my own illustration



The “socially efficient” solution

The market equilibrium
At point where MPC=MSB but if MEC is added, it shifts to Q_1

Figure 1.8. Non-renewable externalities, my own illustration

MSC = Marginal Social Cost

Represents negative externality which occurs in this case by many activities, such as manufacturing processes in many industries – in case of non-renewable energy resources it represents the process of burning fossil fuels, where smelting and other processes that emit CO2 into the air. Important notice is also that the higher the amount of pollution is, the higher the damage caused to environment and human health is. Pollution emitted by cars (transportation) does also harm the environment and people. Therefore major air pollutants are fossil fuels. (Figure 1.9.).

MPC = Marginal Private Cost

Marginal private cost is less than the marginal social cost by the value of the external cost. MPC is the cost by private company, institution or the subject that is running the fossil fuel fired power plant. It represents costs associated with this subject

In case that marginal private cost is higher than MSC, there is a positive externality and vice versa.

MEC = Marginal External Cost

Marginal external cost is often associated with disposal of waste products of energy. Nuclear energy, as an example, has to cost its own waste management and disposal (equivalent to about 5% of generation cost, with a further similar sum for decommissioning). [19]

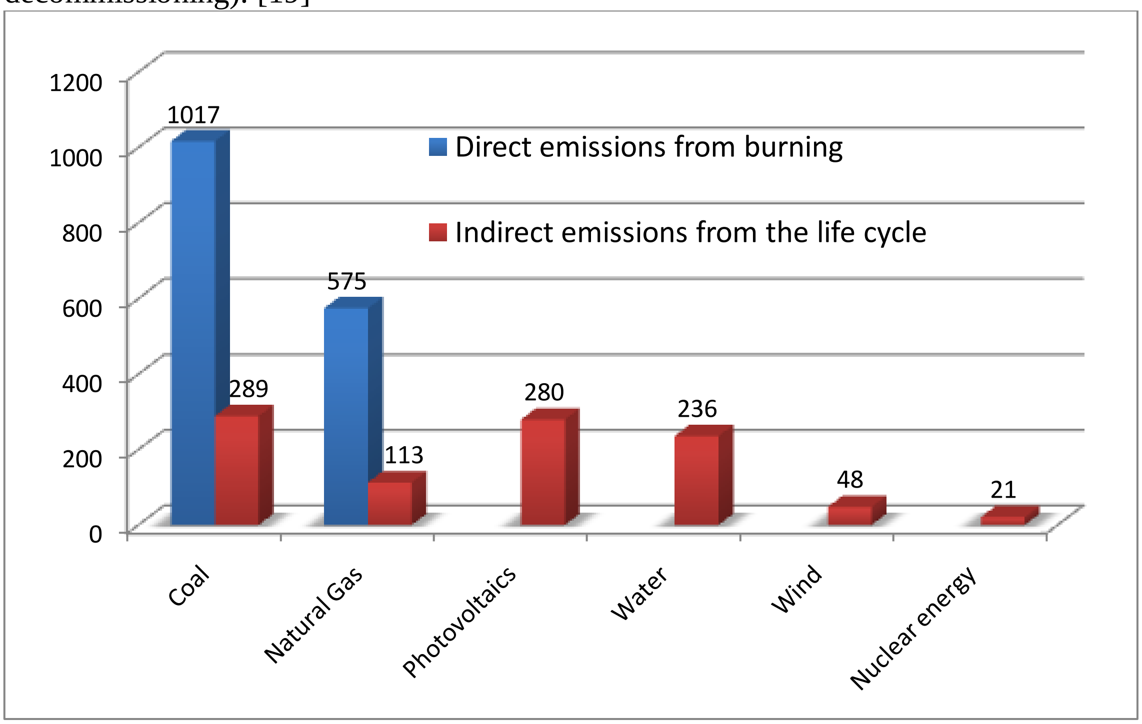


Figure 1.9. CO_2 emissions, my own illustration, [25]

4.1.2 Photovoltaic Technology

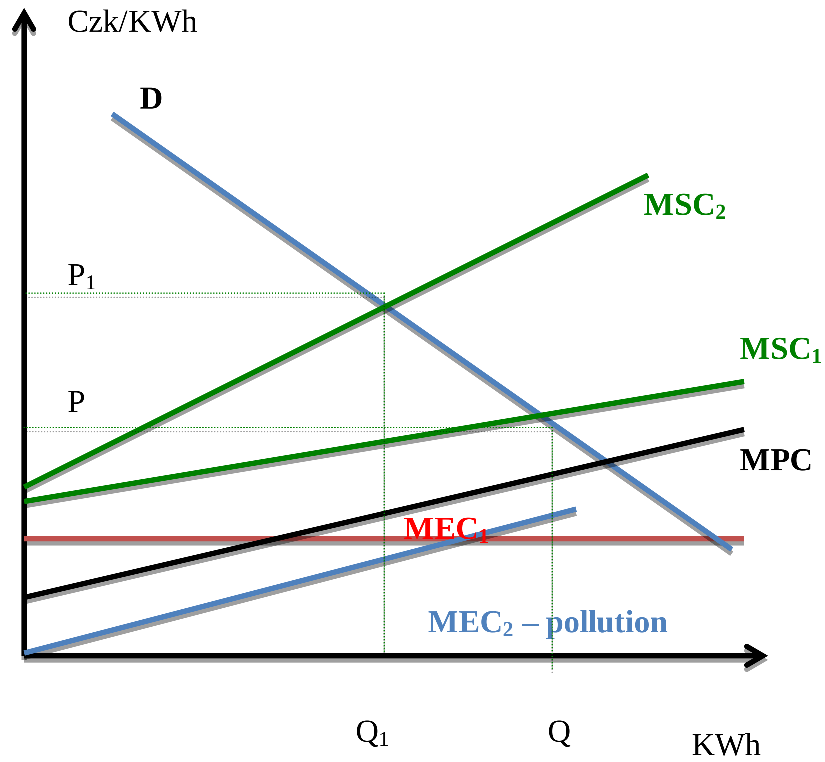


Figure 2.1. Photovoltaic externalities, my own illustration

MEC_1 – exploitation of land in preventing an alternative use of the land
MEC_2 – pollution (manufacturing processes, transportation etc.)
MPC – private costs of firm running the PV power plant
MSC_1 – marginal social cost with a constant externality
MSC_2 – MPC + MEC_1 + MEC_2
Externalized costs switch the quantity from Q to Q_1 and the price increases from P to P_1.

Marginal external costs - Photovoltaics

Companies or entrepreneurs running PV power plants created costs which are imposed on a third party. In other words, these costs are externalised onto a society and therefore, society is negatively affected. To internalise these costs, governmental intervention is needed.

As **Owen, 2006** [20] stated: due to the technological progress within the renewable technologies that causes significant cost reduction and the principle of economies of scale, the unit-generating costs are very likely going to be significantly reduced. If externalities of power production were “internalised”, renewable technologies might have significant social cost advantage.

a) Pollution

Photovoltaic process is much less CO2 pollutant, during its functioning, but the process of creating (and disposal) PV equipment is pollutant itself.
Nevertheless since the pollution by PV is in the long run much lower in comparison with other fossil fuelled technologies (Figure 1.2), it may able the world economy to reduce significantly the socially desirable level of pollution.
On the other hand, we must take into consideration the costs of scrapping ordinary power plants, waste disposal, manufacturing costs (production causes pollution) of demanded PV plants and **social cost** of the fact, that people working in fossil fuelled energy sector might loose job, due to this “energy switch”. My recommendation would be to continuously decrease the production of energy from fossil fuels such as hard coal, crude oil etc. and substituting this market gap in supply by increasing the energy produced by renewable energy resources or by nuclear power plants, which are risky to operate (current development in Japan) but have great potential with the comparison of pollution / amount of energy generated.

b) Exploitation of the agricultural land

Another external cost resulting from the photovoltaic technology is the exploitation of agricultural land in preventing alternative use of the land. Instead of using the land for agriculture, growing crops and remaining the land sustainable it is used for generating energy or heat causing the land damage, that is hard to fix afterwards.

4.1.3 Energy Dependency

We live in a world, which is crucially dependant on electricity. Almost everything runs on electricity. A huge exception is the transportation sector, which however is not dependant on electricity, but everything is dependant on the transportation – partially even the production of electricity itself. The issue is, that transportation consumes even more than the half of petroleum consumption. There must be made a conversion – *Energy resilience* from the transportation to the energy sector if we want to make energy resilient. To be able to make this substitution, we have to make conversion to electric-fuelled cars. [22]

Most significant part of the pollution comes from the CO_2 emissions. The Intergovernmental Panel on Climate Change (IPCC) stated, that that CO_2 emission should peak in the year 2015. If we want to limit the average temperature increase to 2°C, we have to sharply decrease this rising trend.

Currently, World's emissions are around 24billion tonnes per day (increase by 500 million tonnes a year) – due to IPCC statements and calculations, there is a need of reduction by 1 billion tonnes per year (with comparison to current development).[21]
As I stated in the previous chapter, the problem can be solved by combination of more energy efficiency. Combination of the right amount of renewable, nuclear and fossil fuels with carbon capture and sequestration can be answer to this issue.

<u>The security of supply</u>

After the end of Word War II global economies became to rebuild their economies. As the production and distribution of energy increased, demand curve for energy increased rapidly, while the supply curve started to downtrend. This process was hastened in 1970s, after the OPEC (Organisation of Petroleum Exporting Countries) was created and consequently when it started the first Oil shock. Later during 1990s when some of the Asian development countries started to grow at very rapid rate, the demand for energy increased according to this growth (Figure 2.2.).

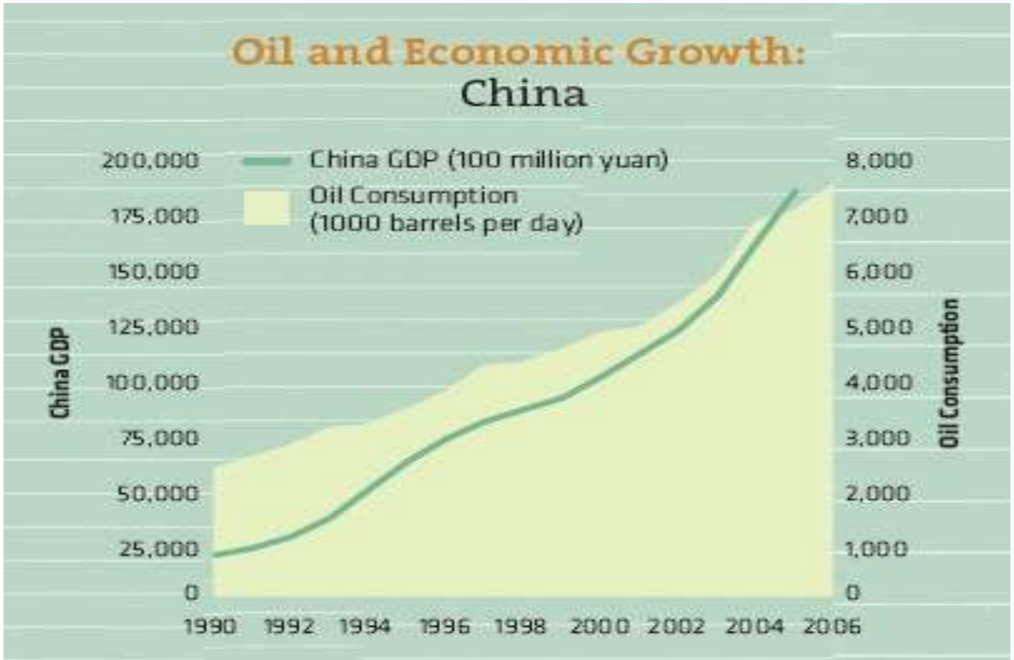


Figure 2.2. China's GDP vs. Oil consumption, [22]

The problem is the decreasing number of Earths non-renewable energy sources reserves (Figure 2.3.), but mainly the enormous rising demand and consumption of energy. To be able to satisfy energy needs for all customers, major investments are needed (Non-renewable power plants, exploration and research, pipelines, research in renewable energy sources, renewable power plants etc.)

The International Energy Agency states, that investments in amount of over 20 trillion dollars are needed, to meet the rising demand for energy for the year 2030.
The concern is that, we are not on the way to meet these investments. Due to financial crisis, political uncertainty the market environment is not well disposed to any big investments. This uncertainty within the energy sector is also caused because of the Kyoto Protocol regulations, which are valid only to the year 2012. Which investor is willing to take the risk of investing enormous amount of money into a power plant, that might be highly regulated due to the CO_2 restrictions, which are very likely going to be even more stringent than they are now. Important role within the concern of global energy supply plays the energy nationalism. There are a number of countries, which permit investments only to their national investors. The problem is that energy nationalism is often applied in countries with largest oil and gas reserves. [21]

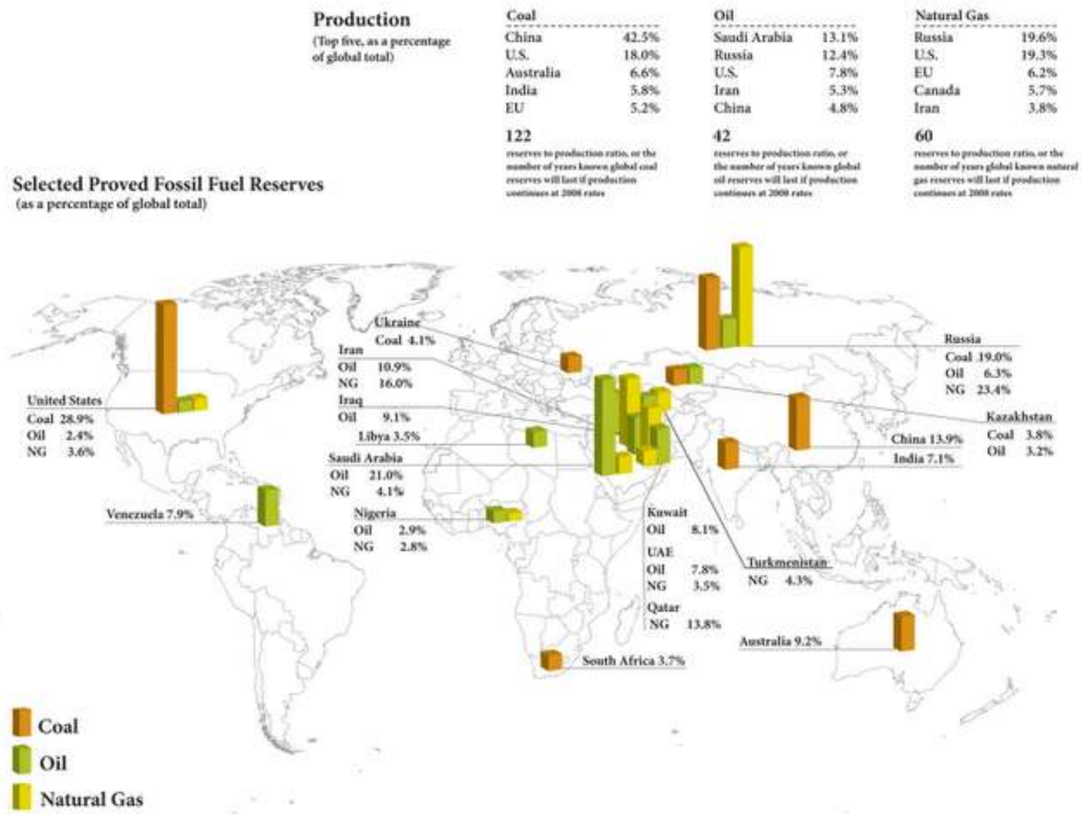


Figure 2.3. Non-renewable reserves, [26]

Future development

As a consequence of current situation and reasons I have stated above, the price of energy is expected to grow. The demand curve exceeds the supply, because remaining oil fields are located in fewer countries (The Middle East, former Soviet Union) and the lowering of CO_2 emissions will cause another external costs.

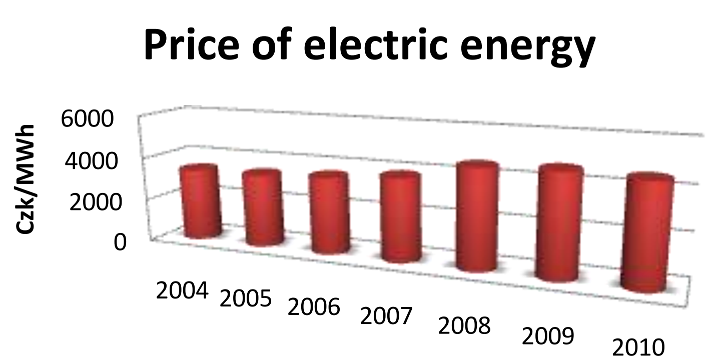
The key is energy efficiency strategy. It reduces emissions, partially provides energy security of supply and is cost effective. The transportation sector needs to be transferred to biofuels and electric fuels. Regrettably, additional development and research are needed within this sector.

4.2 *Simple Regression Analysis*

This part of the bachelor thesis deals with the hypothesis about casual effect of the amount of produced energy from renewable resources in the Czech Republic upon the price of energy for domestic households.
To execute this analysis I chose the simple regression analysis.
The input data have nature of time series and therefore proper inferences must be tested. This verification can be provided either by unit route test or by co-integration.

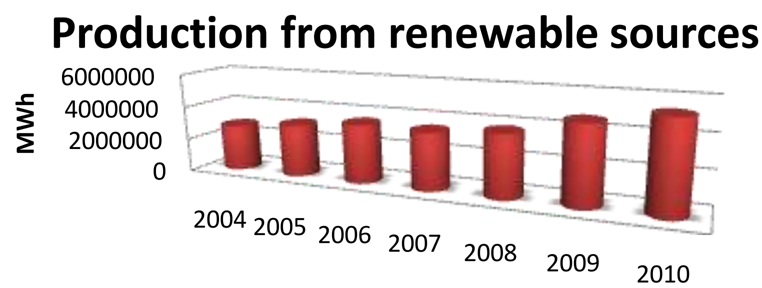
The result I obtained is confirmative as it is explained in the conclusion, but due to the fact that to present significant and reliable result, detailed scientific approach is needed, which is not taught on the bachelors level. Therefore I was forced to omit variables and the result is not scientifically reliable. The structure of the electric energy price is simply too complex, that needs more variables and conditions included.
More detailed and scientific approach will be provided within my Diploma Thesis.

Dependent variable: Price of electric energy for households (MWh / Czk)
Independent variable: Production of energy from renewable sources (MWh)
Time series are within years 2003 and 2010.



	2004	2005	2006	2007	2008	2009	2010
Price of elelctric energy	3381,66	3396,66	3554,96	3826,9	4542,48	4653,71	4547,48

Figure 2.4. Price of electric energy for households, my own illustration, [11]



	2004	2005	2006	2007	2008	2009	2010
Production from renewable sources	2770877	3133463	3518830	3421097	3731013	4654969	5301000

Figure 2.5. Production from renewable sources, own illustration [11]

The equation:

P = **α + β.Q + ε**

Where:

P = price of electric energy for households (average price for MWh, 2004-2010, [11], Figure 2.4)
α = constant amount
β = the effect in Czk of an one additional unit of energy from renewables production
ε = aggregation of omitted factors

Production of energy from renewable sources = production from all renewable sources in the Czech Republic, 2004-2010*, [11], Figure 2.5

The resulted "effect" value is 0,000545 and it implies that if we add one unit of energy produced from renewable sources, the price of electricity for household will be affected by the positive value of 0,000545 Czk.

In practice, if we suppose that the increase of production from renewable sources for the year 2012 will be same as for the years 2009 -2010 (13,8%), the expected production would be 6 032 538 MWh. That would represent an increase in price of electric energy for households by 398,68 Czk.
This assumption is not probable; it is just for the purpose of illustration the result.

* The production of energy from renewable sources for the year 2010 is only an estimate by the ERU. Definite production is not yet calculated.

If this regression is applied on the difference between the price of electric energy for years 2009 and 2010 we get estimated increase of 350Czk. In fact, the price of energy decreased by 106Czk. On the other hand, the price of electric energy on the energy stock market decreased by 25-30% [23]. Therefore, there was enough space for the price regulation from the side of the Czech Energetic Regulatory office.

For the year 2012, estimated increase of energy prices on the energy stock market by 10% is expected. [24] Due to almost 14% increase in the production of energy from renewable sources, significant increase in the price of energy can be expected too. Czech Energetic Regulatory office already set the fee for buyout energy from renewable energy sources in the value of 370Czk per MWh (first preliminary fee decision was 578Czk per MWh).

4.3 Optimization of the Price of Energy for Households and Firms

Case study

This case study is focused on average household and it provides comparison between three main energy distributers within the Czech energy market.

Tariff D02d and consumption

The average energy consumption of a household is approximately 2 200KW/year. Most common tariff rate is D02d. This tariff is single-tariff rate that means the price of energy is constant over all the time that it is consumed. This tariff is focused on low and middle-consumption households.

It is specified for households, which do not use energy for heating or warming up water.

Tariff D02d is than used in households, where common appliances are used, such as freezer, dishwasher or washing machine.

Tariff D02d is used approximately by 2/3 of all Czech households. It is the most used tariff on the market. The reason for choosing this tariff is simple - households do not have to fulfil any specific criteria to be able to use this tariff. In case of double-tariff rate, certain criteria have to be fulfilled (f.e. having a boiler etc.)

This case study counts with circuit breaker value of 3 x 25A.

Tariff itself is consisted of three parts: a) Price for energy itself (KW/hour)
b) Fixed payment tariff (lump sum)
c) Fixed payment for circuit breaker

All prices stated are with VAT and consist all compounds due to the price decision and due to the law of stabilisation public budgets (see chapter Czech Energy Legislation):

- Provision of the energy (E.ON, ČEZ, see Czech Energy Market Scheme)
- Distribution of energy
- Protection of additional costs resulting from renewable energy resources and combined production of energy, heat and secondary resources.
- System costs
- OTE a.s. Accounting action
- Energy VAT (20%)

All prices are valid from 1.1.2011

4.3.1 Households

Main distributers

ČEZ

D02d tariff ČEZ		
Average consumption	2200	KW/year
Price for KW/hour	4,331	Czk
Price for yearly consumption	9582,2	Czk
Monthly fixed payment (lump sum)	129,6	Czk
Fixed payment for year	1555,2	Czk
Total yearly costs	**11083,4**	**Czk**

Figure 2.6. ČEZ price for households, my own computation, [23]

PRE

D02d tariff PRE		
Average consumption	2200	KW/year
Price for KW/hour	4,307	Czk
Price for yearly consumption	9475,4	Czk
Monthly fixed payment (lump sum)	176,4	Czk
Fixed payment for year	2116,8	Czk
Total yearly costs	**11592,2**	**Czk**

Figure 2.7. PRE price for households, my own computation, [23]

E. ON

D02d tariff E. ON		
Average consumption	2200	KW/year
Price for KW/hour	4,383	Czk
Price for yearly consumption	9642,6	Czk
Monthly fixed payment (lump sum)	139,2	Czk
Fixed payment for year	1670,4	Czk
Total yearly costs	**11313**	**Czk**

Figure 2.8. E. ON price for households, my own computation, [23]

Since the energy distributed has the same quality, it can be stated that the optimal distributer for average household (in case of all conditions stated above – consumption of 2 200 KW/year, D02d tariff etc.) is ČEZ because for the year 2011 it provides the best price. It cannot be stated that the ČEZ is the cheapest distributer, based on this short case study because all these three distributers provide very wide portfolio of their tariffs and services and each of them focuses on different type of potential customers.

4.3.2 Firms

Tariff D02d

This tariff is focused on small and middle-sized firms. The electric energy distributed within the D02d tariff has constant value during the whole year. It is most efficient for offices, outlet shops or for business premises. It is not recommended for places where electric heating is used.

Main distributers

ČEZ

D02d tariff ČEZ		
Average consumption	2500	KW/year
Price for KW/hour	5,167	Czk
Price for yearly consumption	12917,5	Czk
Monthly fixed payment (lump sum)	171,6	Czk
Fixed payment for year	2059,2	Czk
Total yearly costs	**14976,7**	**Czk**

Figure 2.9. ČEZ price for firms, my own computation, [23]

PRE

C02d tariff PRE		
Average consumption	2500	KW/year
Price for KW/hour	5,138	Czk
Price for yearly consumption	12845,7	Czk
Monthly fixed payment (lump sum)	236,4	Czk
Fixed payment for year	2836,8	Czk
Total yearly costs	**15682,5**	**Czk**

Figure 3.1.PRE price for firms, my own computation, [24]

E.ON

D02d tariff E. ON		
Average consumption	2500	KW/year
Price for KW/hour	5,143	Czk
Price for yearly consumption	12857,5	Czk
Monthly fixed payment (lump sum)	175,2	Czk
Fixed payment for year	2102,4	Czk
Total yearly costs	**14959,9**	**Czk**

Figure 3.2. E. ON price for firms, my own computation, [23]

The cheapest distributer for firms with low or middle-consumption of electric energy is the E. ON. On the basis of basic distribution without any services is the cheapest distributer. However, companies are often willing to pay more for above standard services such as non-stop customer support or virtual business office for comfortable bills accounting.

The difference between all three top energy distributers is not significant and it expresses the competition on the Czech Energy market. Especially during last two years many smaller distributers have pulled significant portion of customers from the three main distributers, who practically turned the Czech Energy market into an oligopoly market.

In the year 2010, ČEZ has 43%, E. ON 14%, PRE 12% and 27% covers alternative distributers of energy. In comparison in the year 2006 ČEZ controlled over 53% of the market, E. ON 20% and PRE approximately 17%, that is 90% of the market. [9]

5. Conclusions

The aim of the thesis is to analyse Czech energy environment and whether there is a relationship between the price of electric energy (for households) and the amount of energy produced from renewable sources has any correlations. To obtain any result, data series for both price of energy and the amount of renewables production had to be gained. The data available on the web of Czech Energetic Regulatory Office were not hard to get, but since this thesis is done on the turn of the year 2010 and 2011, value of energy produce by renewables for the year 2010 are not still computed. Therefore it was necessary to personally contact Ing. Jaroslav Lukáš to get preliminary data for the year 2010. At the time all data needed were prepare, the simple regression was ready to be executed with help of the MS Office component – MS Excel and its function "regression".
The significance of the result is very high, but regrettably due to omitted variables and spurious regression, the result is not scientifically reliable although its interpretation is confirmatory. If the result is applied within the Czech environment and we assume that the production of renewables will increase by 13,8% (as it did in year 2010), the increase in the price for the following year should be 398,68 Czk. This result is not probable but also not implausible. In fact, due to the current energy development – Japanese nuclear crisis and Germany provisionally closing down their nuclear facilities – the price of energy is expected to increase significantly. Additionally, the Czech Energetic Regulatory Office set the support cost for buying energy from renewables to 370 Czk (from 166,34 Czk) per MWh, creating an increase of more that 100%.

Important result is, that the regression confirmed that in the Czech Republic there is a significant dependency between the price of energy and the production from renewable energies.

Furthermore, due to the research provided it is obvious that photovoltaics are notably friendlier to the environment than ordinary non-renewable resources. On the other hand, non-renewables generate social costs that are already being internalized by the governmental interventions but photovoltaics generate negative externalities, such as exploitation of possible agricultural land or pollution, which should be internalized to responsible subjects, but they are transferred onto society instead. Even though, photovoltaics are in the long run contributing to the environmental and more importantly the energy sustainability.

Last part of the paper deals with the optimisation of the price of energy for households and firms. The research calculated with an average consumption per year for every sector (households – 2200KW, firms 2500KW). Tariffs chosen were the most occurring within the sector.
The cheapest distributer of the electric energy for households and firms for the year 2011 is ČEZ. Differences between single distributers are not eminent. This fact confirms that the Czech energy market is becoming very competitive.

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7. Table of Figures