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Acceptance of power plants in Hungary

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Introduction

Today's world is a world of rapid development. Newer products and services occur in every moment so quickly we do not have time to get used to them. Nowadays, there are no households without a computer, television, smartphones or tablets. But one thing is for sure: these products require energy, and this fact shows the importance of energetics, since it deals with power generation, transport, distribution. Furthermore, a considerable per cent of a country's GDP comes from energetics, so it is undeniable, that this topic is an essential part of the economy. That is the reason why I chose this topic. In this thesis I will compare several ways of energy production from an economic viewpoint, but first, we have to be familiar with some basic knowledge on the topic.

I. The basic knowledge of energy production

First and foremost, it is not possible to get energy out of nothing. What is more, we cannot use most of the raw energy sources we have, so we must convert them into usable energy (for example, we convert chemical energy into kinetic energy (cars)). We have to distinguish primary and secondary energy sources. The sources we consider primary are those that can be found in nature and which we have to convert to be able to use as energy. This includes: coal, oil, gas, uranium, wind, sun, water, geothermic- and biomass. After the conversion, these sources become secondary energy sources.

The primary energy has two groups: renewable and non-renewable energy. Wind, sun, water and biomass are renewable sources, whereas coal oil, nature gas and uranium are non-renewable. We could make electric energy from coal, gas, uranium, wind, sun, water and biomass. To convert energy we have to do several difficult processes. Nowadays there are some misbeliefs of this conversion.

Non-renewable sources except uranium are fossil energy sources, which means these give us energy as result of combustion process.

1.1 Features of energy sources

The coal is at the largest quantity of all available fossil energy sources. Most of it is in Russia, China, North-America and Europe. The certified supply of coal is 826 Gt, which will be enough for 122 years – assuming that today's average consumption of coal will not grow any further. A great benefit of coal is that it is shared out relatively evenly around the world, which makes it easily available. On the other hand, a main disadvantage of coal, compared to nature gas is that the coal's calorific value is lower (33.8GJ/t) and it's CO2 emission is twice as big as that of natural gas.

Nature gas is the noblest of all fossil energy sources. Its calorific value is higher (max. 49.5GJ/t) and the CO2 emission is lower than that of coal. The biggest drawback is its price, since it's shared out unevenly around the world. 52.4% of all natural gas can be found in only three countries; Russia, Iran and Qatar. The certified supply of natural gas is 185TNm3, which is enough for about 60 years.

The uranium is also a non-renewable energy source, but it is different from the previous energy sources. It stores energy in nuclear form. This has the largest benefit. From

uranium we can make the cheapest electric energy and it can be found almost all over the world. It has strict security requirements and its social acceptance leaves much to be desired.

The solar power can be found in the greatest quantities. It produces energy without carbon, but due to the small density of energy it does not produce energy effectively and it depends on the weather. Furthermore, making a solar panel is very polluting. Despite these, solar energy is more and more popular nowadays, but it cannot be a competitive energy source without the support of the government.

Wind power is similar to solar power, since these are both environmentally friendly. The efficiency of wind power is greater than that of solar energy, but it cannot be so widespread, since it is only worth to build it where the annual average wind speed is at least 5m/s (18km/h). Hungary's annual average of wind speed fluctuates between 2-4m/s.

Hydro energy's efficiency is high, it is a carbonless energy and it uses kinetic energy of – for example – a river to produce energy. It is only possible to build them on big rivers which have greater level drops in their beds. Its main disadvantage is that it is requires a big intervention into nature and its productivity depends on environmental factors.

The biomass contains organic fuels and wastes. It is renewable if the pace of use does not exceed the pace of producing. Calorific value of this is similar to coal, but the CO2 emission of biomass is a bit smaller. In spite of these, we consider it carbonless process, since we assume that the emissioned CO2 is balanced by the quantity of O2 the used organism could have produced. The main advantage of this method is that it is available everywhere, but it is very space consuming and it uses economically valuable areas.

The electric energy systems task is to always fulfil the consumers' needs. Of course, it doesn't mean that the whole world will be provided with energy 24/7 year round. What it means, is that there won't be a consumption limit if it can be avoided and it's affordable.

1.2 The change of the quantity of the produced energy

The task of electric energy systems is to always fulfil the consumer's needs. Of course, it does not mean that the whole world will be provided with energy 24/7 year round. What it means, is that there will not be a consumption limit if it can be avoided and it is affordable.

The electric power is a product. It cannot be stored in huge quantities (or at least, it does not worth it), therefore we have to produce it when it is needed. As we cannot control or limit the quantity of consumption, the producers have to adapt to the demands. Although each

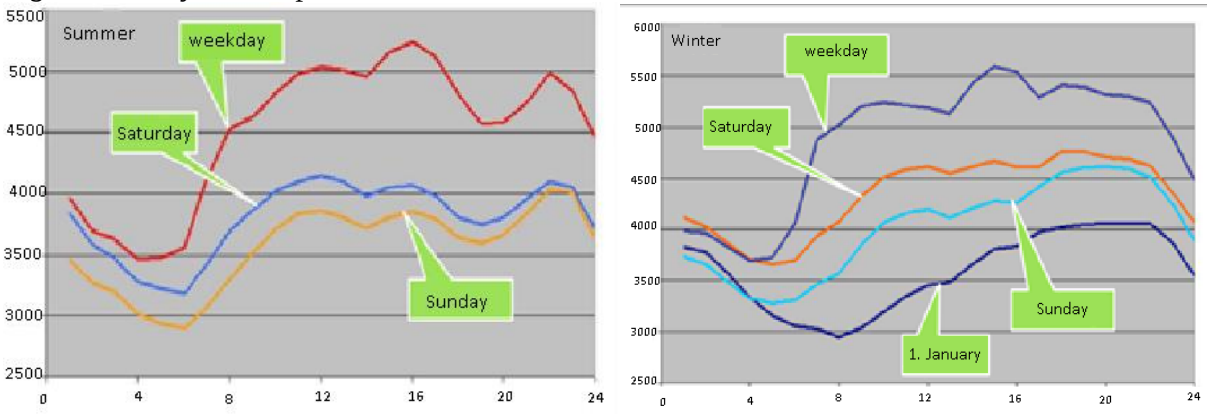
consumer's needs cannot be foreseen, their habits in regards to energy consumption are predictable.

Numerous consumer demands at the same time are called net consumer demand. To fulfil these demands we have to make available more power, because there are losses during the transport. These are called "network loss". The net consumer demand and the network loss together make the gross consumer demand. A Hungary-sized electric energy system exceeds the net consumer demand by 10%.

hort and long-term factors influence the power consumption. From an economic view we could explain long-term changes with constant economic growth, such as changes in industry structure and in consumer habits.

Beside the different economic development levels and industry construction of each country, the geographical and the climatic factors also influence the differences in the use of electric energy. In a shorter period of time the weather and the calendar (sunrise, sunset, weekdays, holidays) make the differences in the demand for electricity.

Figure 1: Daily consumption



Source: István Gács: Villamosenergia-termelés gazdasági értékelése

These line graphs show how consumption fluctuates in summer and in winter. We can see both seasons are similar and the lines reach the peak at late afternoon. In the morning starting work, work-related consumption and the traffic cause the increase. In the afternoon the consumption of households have a major function. The power stations have to follow these fluctuations. Therefore the regulation of power stations is important. The public utility power plants could be basic-, timetable holder and peak-load power plants.

The basic power stations have huge peak utilisation time span (over 5500 hours/year) and operate nearly permanently. These are usually modern, and work with high efficiency and use cheap fuel (e.g.: Hungary, Nuclear Power Plant "Paks").

Timetable power stations follow the changes of electricity demands. These can change their performance flexibly. We never build new power stations as timetable plants. The previous stations become timetable station (e.g.: next to the Tisza and the Danube).

Peak-load power plants work just in time of peak consumption (1500-2000h/years). For this aim we usually build stations which have cheap costs and the lower efficiency (generally gas turbine power stations).

1.3 What kind of basic power plant we should build?

Basic power plants add up to most of the produced energy. Characteristics of these different power plants show that not every power plant is suitable for the role of a basic power plant. Consumers provide a constant demand for energy and the producers must satisfy these demands regardless of the price of energy –, while on the other hand, price – after permanency – is one of the greatest viewpoint of consumers. Nowadays, the environment becomes more important, and the producers have to reduce the harmful emissions which adds additional costs. Their task is to find a method which produces power effectively and sustainably without harming the environment.

In the following, I will compare the basic power plants installation and maintenance costs (coal, nuclear, natural gas and biomass). The renewables are not mentioned in this paragraph.

In this table we see values per power plant:

Figure 2: Cost of energy

Type of power plant	Coal	Coal+CCS (Carbon capture and storage)	Nuclear	CCGT (Combined cycle gas turbine)	Biomass
USD/kWh	**0,075**	**0,129**	**0,1135**	**0,113**	**0,154**
HUF/kWh	**20,775**	**35,733**	**31,43**	**31,30**	**42,658**
EUR/kWH	**0,6825**	**0,117**	**0,103**	**0,103**	**0,14**

where the exchange rate in 26.03.2015 is:

1USD= 277HUF 1EUR=305HUF 1USD=0,91EUR

(based on exchange rate of the Hungarian National Bank)

As we can see, the cheapest way to produce energy is to use coal power stations. However, this method is the most polluting solution to make electric energy. The most expensive way is the biomass power plant.

II. Analysis of the energy production methods based on customer reviews

In the followings I would like to introduce my researching data and my conclusions. With this questionnaire I wanted to know more about the people's knowledge about the energy production methods and I also was curious about are they willing to pay more money to help saving the environment or they aren't.

2.1 Hypotheses

According to the earlier studies plus my experiences I made 3 hypotheses.

1. In recent years there have been a lot of talk about environmental pollution and protection, maintaining or improving our environment, so I assume that younger people pay more attention about these questions.
2. I consider the public acceptance of the nuclear power plants are low, people judge this method so they would prefer to choose different ways to produce the necessary amount of energy.
3. I assume people don't have the valuable knowledge about how they can create energy and they are not aware of the costs of the methods.

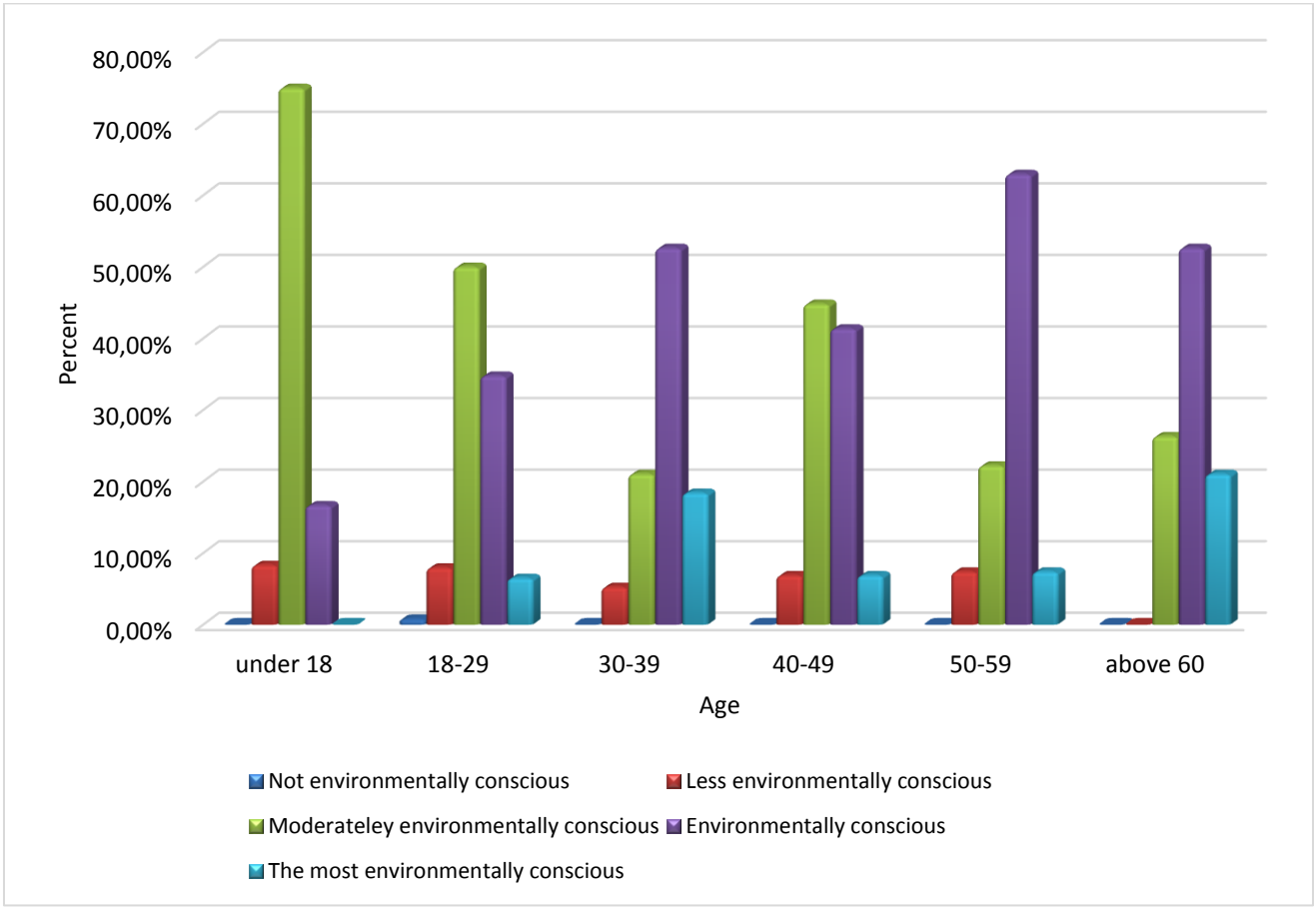
2.2. Results of my research

The questionnaire was answered by 262 people, 153 female (58,4%) and 109 male (41,6%). The majority of the respondents were between at the age of 18 and 29 (53%). I hardly get answers from below 18 years old and above 60 years old. I assume the higher the education someone got the higher knowledge they have. The majority of the responders who have university or college degree (44.7%, 37.8%) have more interest about these questions than those who only have primary school leaving exams (17,5%).

2.3 Analysis of the responses to the questions

The questions were related about energy production and environmental protection. First, I wanted to know how much people pay attention to their surroundings. I believe that the protection of our environment is of one of the most important issues nowadays however we don't do a lot about it. In my experiences, the most people tend to have so much waste unnecessary. On the other hand just only one respondent thought of himself that he does not pay attention about his environment. The moderate majority consider themselves environmentally conscious, while only 24 respondents feel that (9.2%), they are doing their best in order to protect their environment.
If we want to see the perfect diagram about the percentages of ages, I noticed this conclusion:

Figure 3: Being environmentally conscious according to the ages



Source: The diagram was based on my own research

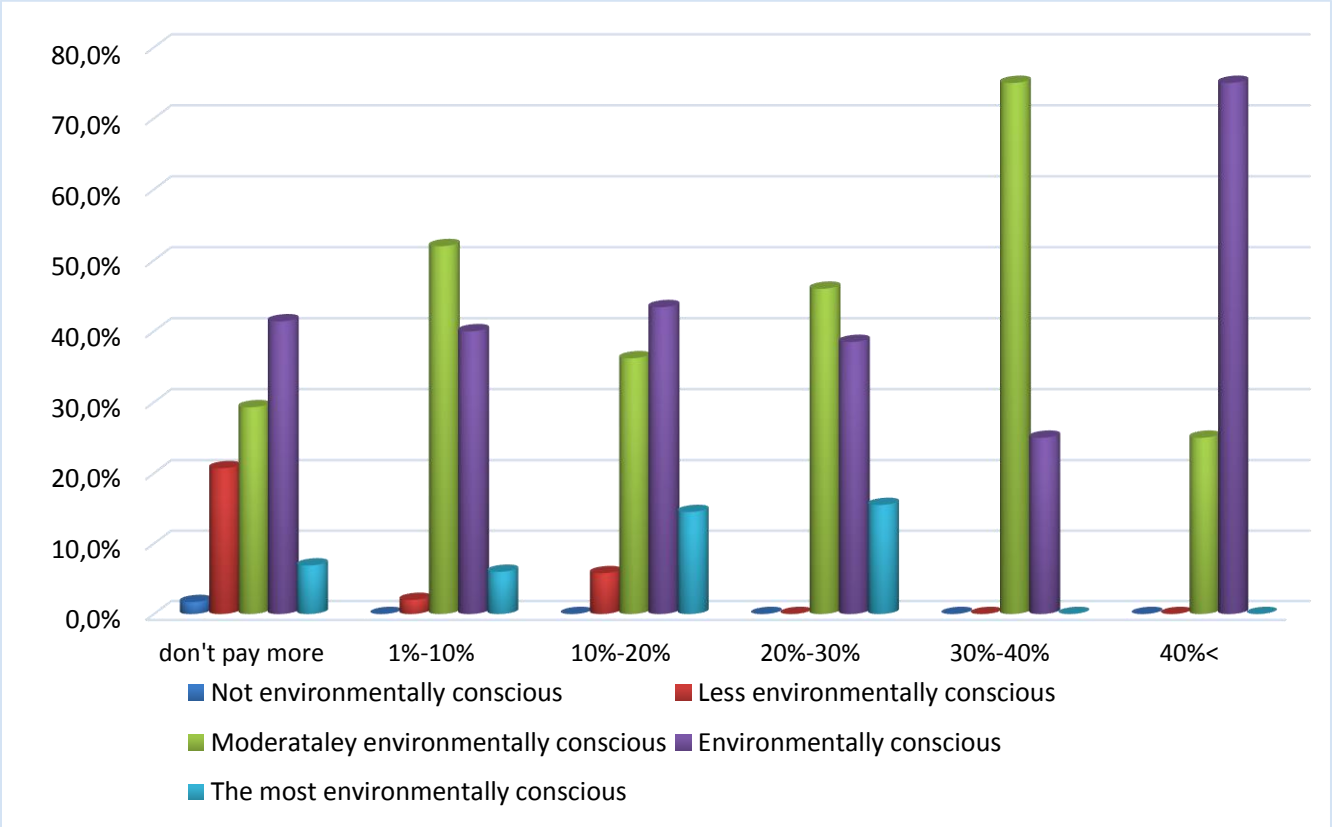
At the age below 18 people are not environmentally conscious at all. Around this age I found the highest rate about they think about themselves they are moderately environmentally

conscious and I got the lowest rate from this age group who said they are fully tend to save their environment, 16.6%.

Those who tend to protect their environment are in their thirties, especially between at the age of 30 and 39. The responders disprove the 1. hypothesis which said the younger generation protects their environment more.

In my next question I wanted to know about how much more money they are willing to pay to be more environmentally conscious. The current price is 37.8HUF/kwh. Among the answers I gave them the opportunity to choose about percentages. 22.1% of the responders said they are not willing to pay more. I found this answer interesting because they said they are take care of their environment.

Figure 4: Being environmentally conscious and willing to pay more money



Source: The diagram was based on my own research

The 12th graph shows those who are willing to pay more just to have environmentally friendly solutions and they were not the responders who said they are environmentally conscious. Those who wants to pay more 40% and they are moderately environmentally

conscious and those who doesn't want to pay more are not even close to being called environmentally conscious.

In fact being environmentally conscious not just only means how we produce energy. We can do a lot about the environment by using recycled products, papers for example.

I also was curious about what kind of energy sources would be supported. 10.7% of the responders voted to the fossil flower plants, however 67.5% wouldn't support the coal based methods. There are a lot of talk about environmentally friendly solutions and that might be reason for these results on the other hand I still think people don't have enough knowledge about producing energy, how much these methods cost or how they can affect our everyday life.

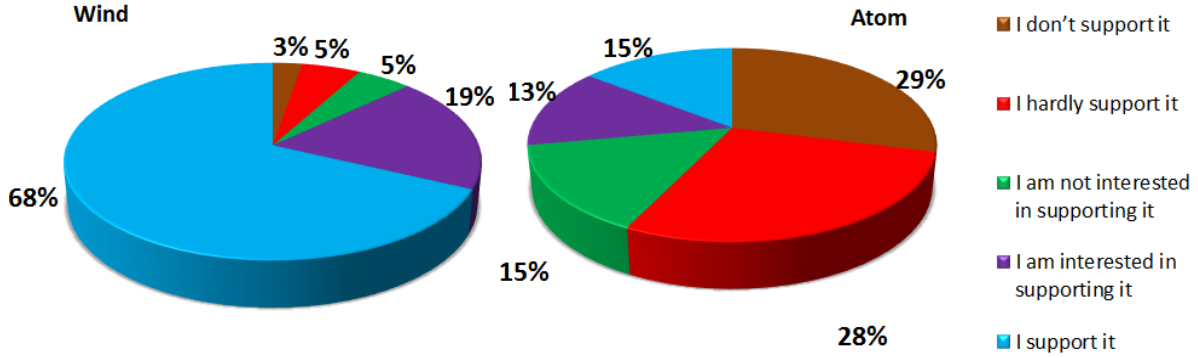
How about the solar energy? The solar energy would be popular according to my research. People think using solar panels would be an environmentally friendly solution however the prices of the panels are too expensive, they won't willing to buy them without having financial support from the government.

Let's see the energy that wind can produce. In my research I got the same results as with the solar energy. 8% of the responders said we don't need more wind turbines. In my opinion the idea of using wind as an energy source is great, however Hungary is not the perfect place for it. The weather is often windy but it is not as strong as the wind turbines need to be able to work beneficially.

Using water as an energy source can be efficient and people are supporting this idea. They have a huge benefit which is: they are able to give constant power. In Hungary they started to build a system for it but they had to stop because of some political reasons.

Let's talk about the nuclear power. According to my research 57.2% thinks it is not really good to use as an energy source. However in Hungary we have a nuclear power station and it gives almost 50% of energy. 14,9% of the responders said they don't mind if we use nuclear power and 27.9% supports the idea. According to my opinion, using uranium as an energy source can be beneficial and it causes less damage in the environment than the fossil power plants.

Figure 5: Supporting wind turbines and the atom



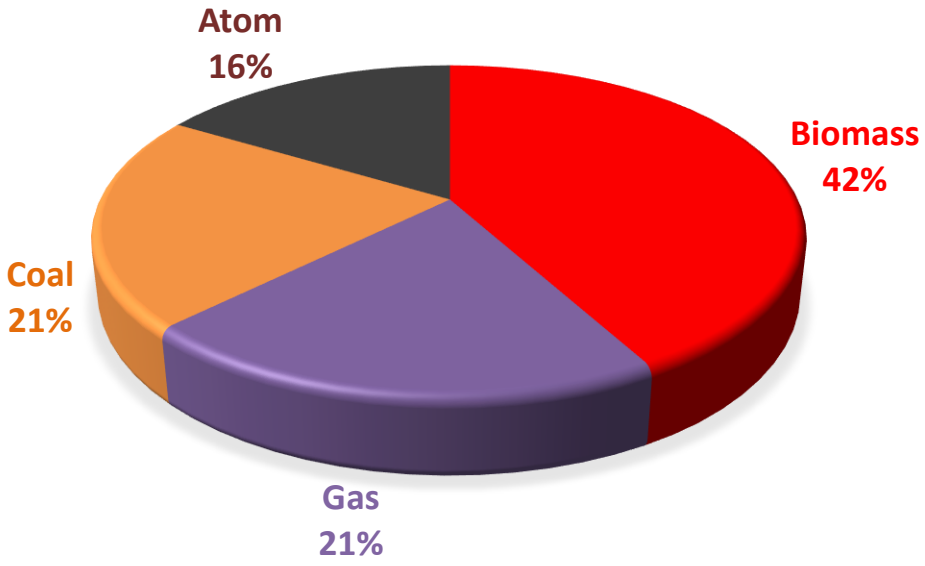
Source: The diagram was based on my own research

According to the answers right now the responders don't agree with the situation of using the energy sources. They support renewable energy sources however in Hungary we are using mostly uranium, coal and gas. The first illustration shows the support of the wind turbines and the second shows the support of the nuclear power plants. 10% of the representers don't interested in having wind turbines and 57% don't want another nuclear power plants.

Selecting the most harmful energy sources are not so easy, even the responders couldn't agree. What does it really mean harmful for the environment? Radiation or carbon issues? I didn't want to influence the representers so 121 representers said the most harmful is the coal which is 46%. The second most harmful energy source is the atom and the third one is the gas. As you can see on the graph it has way less pollutant emission than the coal. In my opinion, all these 3 energy sources can be harmful for the environment. The atom is because of the radioactivity but if they strictly use all the rules as the atom needs it can be used safely however there were lot of cathastrophes because of the atom.

6,1% of the responders think the biomass based power plants are the most harmful sources. Using coal or gas produce the highest co2 in the air. They are trying to lower the amount of co2 but it costs so much extra money.

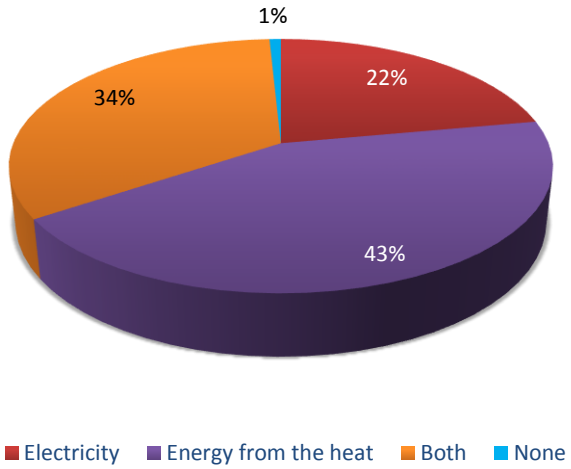
Figure 6: The least expensive methods according to the responder's answers



Source: The diagram was based on my own research

I was also interested in to find out what they are think about which source can be the cheapest to produce energy. 42% of the responders said the biomass power plants, on the other hand it is the most expensive, followed by the coal, atom and the cheapest is the gas. So here is the question: are we willing to pay more money for having environmentally friendly solutions? The responders said not really, which means even though the biomass power plants have great opportunities, we still use other sources because of financially it can be cheaper.

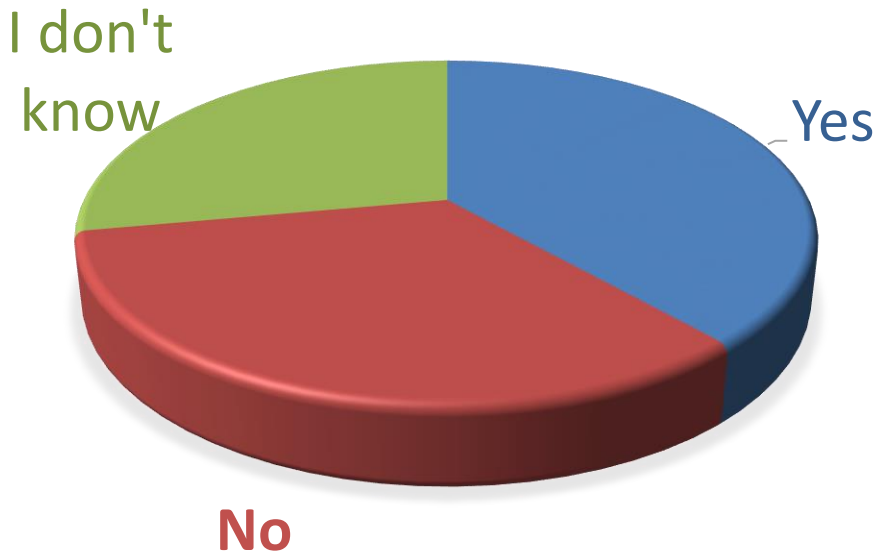
Figure 7: This diagram shows the responder's anwer for this question: What can a solar panel produce?



Source: The diagram was based on my own research

In recent years there have been a lot of talk about the renewable energy sources so I was curious about the people's knowledge about this topic. I wanted to know what is the benefit of using solar panels. Only 43,5% gave the right answer. The solar panel generates heat which can generate hot water or we can use it as a heater at nights. I think the most environmentally friendly solution is the solar panel system but we haven't got enough knowledge about it. My second hypothesis is confirmed which said people have no valuable knowledge about the costs or how even these systems are working.

Figure 8: Can we only use renewable energy sources?



Source: The diagram was based on my own research

My next question was about what they think: is it possible just to use renewable energy sources? I gave them the answer which says: I can't decide because I don't have enough knowledge about this subject. From the 262 responders 101 agreed on we can replace the fossil power plants with renewable sources. I think they are those people who really care about their environment.

73 people said they are not able to answer for this question. I did some research and I found an interesting thing: In Costa Rica they tried only using renewable energy sources and it worked perfectly for 75 days. They used the power of the water and they were lucky because the weather on that time was extremely wet. Costa Rica has a great geographical location which means they could use the power of the wind, the sun and they also used biomass. Actually it was a special case and it shows it can be done with

renewable power sources but it can’t really be done in Hungary because of the natural conditions are not the best for it.

I also wanted to know what they think about the imported products in Hungary. I gave them answers and 34.7% chose the right answer. The imported electricity comes from Austria, Slovakia and Ukraine and we export it to Croatia, Serbia and to Romania.

Last but not least I wanted to know about are they agree or disagree with building bigger nuclear power station at Paks. 58.8% of the responders said they disagree with it. My personal opinion is, it was necessary to make bigger, stronger power station because our desire to energy keeps growing and we will be able to become indepent one day from other countries financially and it can be less harmful if it comes to environmental pollution and protection in Hungary.

Summary

The reason why I chose this topic it's because nowadays there have been a lot of talk about how can we produce the electricity more efficient. This is that subject that we can't avoid, it affects our lives, it doesn't matter how much money we pay for it, not to mention the effects that we create in our environment. My research shows that financially the best choice of the energy sources is the gas and for safety the uranium.

However isn't it interesting that the responders thinks the best methods are using renewable energy sources? My first hypothese was where I tried to find out which generation cares about their environment the most. My guess was the younger people but the answers disproved it and now I know the older people do more to take care of their environment than the younger generation.

My second hypothese was about using atom to make energy and socially it's acceptance is low. The answers were confirmed this hypothese. The opinions were agreed, it pollutes the environment too much and they don't support this method to produce energy at all.

My third hypothese was people doesn't have enough knowledge about the methods and how much they cost. My hypothese was right because they voted for the most expensive method and they weren't really sure how solar panels and solar cells work exactly. My personal opinion is we need to teach more about these, using the media for example.

The responders support the renewable energy sources and I agree with their decision. It it is a difficult question because of the lack of information people have about solar energy for example and they are so pricey, an average household can't afford to buy solar panels without getting financial help from the government.

Maybe we should think about creating more methods, using the wind and building more and more solar panels so we would be able to produce the energy that we need more efficiently and continuously.

Annex 1

Symbols

To calculate this we have to use some marks:

r: interest

n: operating time

$\alpha_{l:}$ establishment costs compare operating time

i: internal costs

$\alpha_{TMK:}$ planned scheduled maintenance

α_e: other costs

α: combined cost factor

a: specific investment costs

ε: self-consumption

$r_{TMK:}$ maintenance reserve factor

$r_{ÜT}$: operational safety reserve factor

v_{vh}: variable deficit

τ_{cs}: peak utilization time

$k_{áll}$: fix costs

p_q: fuel price (heat)

ṅ: efficiency/ year (%)

k_v: fuel price (material)

k: full costs

Annex 2

The calculating

In the following calculations I used a coal power plants data.

The expenses of the establishment could be calculated with the help of the interest and the operating time.

$$\alpha_l = \frac{r}{1-(1+r)^{-n}}$$

The coal power plant's value substituting into this formula:

$$\alpha_l = \frac{6}{1-(1+6)^{-35}} = 0{,}069$$

From we could calculate the combined cost factor:

$$\alpha = \alpha_l * \mathrm{i} + \alpha_{TMK} + \alpha_e$$

Substituting into this:

$$\alpha = 0{,}069 * 1{,}2 + 0{,}025 + 0{,}01 = 0{,}118$$

From these data we could calculate the constant costs of 1 kWh energy.

$$\mathrm{k_{áll}} = \frac{\alpha * \mathrm{a} * \mathrm{r_{TMK}} * \mathrm{r_{ÜT}}}{\tau_{\mathrm{cs}} * (1-\varepsilon) * \mathrm{v_{vh}}}$$

After the substituting:

$$\mathrm{k_{áll}} = \frac{0{,}118 * 2000 * 1{,}06 * 1{,}04}{7000 * (1-0{,}09) * 0{,}97} = 0{,}042$$

After that we have to count with a changing factor. We get this from:

$$k_v = \frac{\mathrm{p_q}}{\acute{\eta}}$$

After substituting:

$$k_v = \frac{\frac{3,6}{1000} * 3,6}{0,39} = 0,33$$

Finally from these we get the all of costs of 1kWh energy.

$$k = k_v + \mathrm{k_{áll}}$$

$$k = 0,33 + 0,042 = 0,075$$

This is how we can calculate the costs of coal+CCS, nuclear, CCGT and biomass power plants.

Annex 3

The results

Type of power plant		Coal	Coal+CCS (Carbon capture and storage)	Nuclear	CCGT (Combined cycle gas turbine)	Biomass
r	%/year	6	6	6	6	6
n	year	35	35	60	25	25
α_l	1/year	0,069	0,069	0,062	0,078	0,078
i	-	1,2	1,2	1,25	1,1	1,15
α_{TMK}	1/year	0,025	0,025	0,03	0,035	0,045
α_e	1/year	0,01	0,01	0,012	0,008	0,01
α	1/year	0,118	0,118	0,1195	0,1255	0,1413
a	USD/kWh	2000	4000	5500	1200	4000
ε	%	9	11	6	5	10
r_{TMK}	-	1,06	1,06	1,06	1,04	1,08
$r_{ÜT}$	-	1,04	1,04	1,04	1,04	1,05
v_{vh}	-	0,97	0,97	0,96	0,98	0,97
τ_{cs}	h/year	7000	7000	7500	7000	7500
$k_{áll}$	USD/kWh	0,042	0,086	0,107	0,025	0,1
$k_{áll}$	HUF/kWh	11,634	23,822	29,639	6,925	27,7
$k_{áll}$	EUR/kWh	0,0382	0,0782	0,097	0,023	0,091
p_q	USD/GJ	3,6	3,6	0,6	14	4,2
$\dot{\eta}$	%	39	30	33	57	28
k_v	USD/kWh	0,033	0,043	0,0065	0,088	0,054
k_v	HUF/kWh	9,141	11,911	1,8	24,376	14,958
k_v	EUR/kWh	0,03	0,039	0,0059	0,08	0,049
k	USD/kWh	**0,075**	**0,129**	**0,1135**	**0,113**	**0,154**
k	HUF/kWh	**20,775**	**35,733**	**31,43**	**31,30**	**42,658**
k	EUR/kWH	**0,6825**	**0,117**	**0,103**	**0,103**	**0,14**

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