Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Energy supply only with renewables? Why does Hungary need to extend its nuclear power capacity?

To cite this article: Istvan Gärtner 2021 *J. Phys.: Conf. Ser.* **1929** 012078

Energy supply only with renewables? Why does Hungary need to extend its nuclear power capacity?

Istvan GÄRTNER

Óbudai Árpád Secondary Grammar School, 19 Nagyszombat utca, 1034 Budapest, Hungary MTA-ELTE Physics Research Group, Budapest, Hungary

Abstract. This presentation showed the results of my study which was connected to a survey in ELTE University in Budapest 8 years ago. The results of my research prompted me to prepare a compilation for high school students. In this work I tried to acquaint them from one side the energetics in general and from the other side the areas of use of the different energy sources, highlighting the natural conditions and the resulting opportunities for the energy production of Hungary. My aim was that the students could get a professionally authentic and understandable information in these topics. According to this I hope they could realize the importance of the energy supply in their future.

1. Introduction

As a physics teacher I often met with the fact that how little students know about energetics in general. This is surprising because nowadays you can hear a lot from various news items about energy production with renewable and nuclear energy sources, both domestically and internationally. Most often, there are arguments in favor of renewables and counter-arguments against the nuclear, but it is not certain, pros and cons, that all statements can be considered realistic.

It is true that in Hungary, energy production with renewable energy sources has really developed a lot in recent years. This was mostly manifested in the use of photovoltaic equipment, other types of renewables (hydro, wind) due to the natural conditions of the country, have little opportunity to participate in it. But unfortunately, it can also be seen that photovoltaic equipment can produce only a fraction of the amount of energy our country needs. Thus, if Hungary wants to reduce energy imports and energy production with fossil fuels, the issue of nuclear energy cannot be avoided either.

My experience shows that my students do not usually receive information related to the topic of energy production at school at first, so it is not surprising that their knowledge is usually inaccurate and very incomplete. One reason for this may be that this topic is given less emphasis in their science textbooks than would be needed today. The importance of energy production, the concepts of fossil, nuclear, and renewable energy sources first appear in the lower grades in the subject of geography, in physics they are introduced later. But then its task is already twofold, on one hand to present the physical background related to energy production, and on the other hand to strengthen the role of renewable energy sources in the field of education for energy saving and environmental protection. However, a deeper interpretation requires more serious physical and, in some cases, chemical knowledge, and these can only be found in the upper grades. Unfortunately, the knowledge in the Hungarian textbooks is rather incomplete, and it is also difficult for students of average ability, so this usually does not arouse serious interest. However, students are interested in both nuclear and renewable energy production, they also have their own opinions on these, but in my opinion, these views are not supported by adequate

professional knowledge. This can mean that external factors influencing their thoughts, such as the opinions of classmates or family, or even the role of the media, can be very significant.

I was confirmed of this in this year when I took a survey in my school. In this I used 10 questions of an older survey which had been taken in ELTE University eight years ago [1], and I completed them with five more questions. There were 53 students who participated in my study, all of them were from the 11th grade. In Hungary according to the curriculum the physics subject finishes in the 11th grade. In the 12th grade physics is optional, only those students choose, who want to learn it in the university too and want to graduate from it. The ratio of those students who wants to graduate from physics is low, even in our high school it is about only 10 % even though almost everyone continues their education after graduation.

2. Research

My survey was a test with 15 questions, students had to fill it without writing their names on the paper. They got only 15 minutes for the work, it was enough.

The first 10 questions required background knowledge from physics about general energetic problems, they did not need significant calculations and there were 6+1 answer solutions. The +1 solution was the so-called „escape route", which was: „I don't know the answer".

The other five questions connected to Hungary's current energy production and asked for estimates for the ratio of the renewable and nuclear energy sources in Hungary's energy production. These questions had only 4 answer solutions without „escape route".

In addition to the mentioned experiences my research was justified by the fact too, that in this year I got some questions from my students about the extension of the Nuclear Power Plant of Paks. They heard a lot and some of them read about it from media and they were very interested.

Here are two sample questions from part one /Questions 1-10 / and from part two /Questions 11-15 / of the test.

Sample questions

Part one:

The hydroelectric power plant produces electricity. Where does the electricity come from?

- **The potential energy of the water swollen by the dam.**
- The thermal energy of the swollen water.
- The internal friction of water flowing to the turbines at high speed.
- The chemical energy of the Sun.
- The chemical energy from the water.
- The kinetic energy from the speed of the water.
- I don't know the answer.

Based on which law does the hydroelectric power plant generate electricity?

- Newton's law of gravity.
- Pascal's law.
- Coulomb's law.
- **Faraday's law of induction.**
- Boyle's law.
- Planck's law.
- I don't know the answer.

Part two:
What is the ratio of production of the solar powered equipment now in Hungary in the total energy production?

- **1-2 %**
- 3-5 %
- 8-10 %
- over 10 %

What is the ratio of production of the Nuclear Power Plant of Paks now in Hungary in the electricity production?

- less than 10 %
- 15-20 %
- 35-40 %
- **45-50 %**

3. Results

In part one only nine of the 53 students answered the first question well, this was about 17 %. and the number of the correct answers for the second question was twenty, it was little more than 37 %. In part two there were 16 correct answers for the first and 25 correct answers for the second question, so the percentages were about 30 % and 47 %. (Table 1)

The results of the survey was very thoughtful. The correct answers of the whole test were 325 from 795 answers, and it was only 40,88 %. After 5 years of studying physics only this result can be achieved from this topic?

The difference between the first and second part was even more surprising. There were 244 correct answers from 530 answers in the first 10 questions, it was 46,04 %, and 81 correct answers from 265 answers from the second part which was 30,57 %. (Table 2)

Table 1. Results of the sample questions

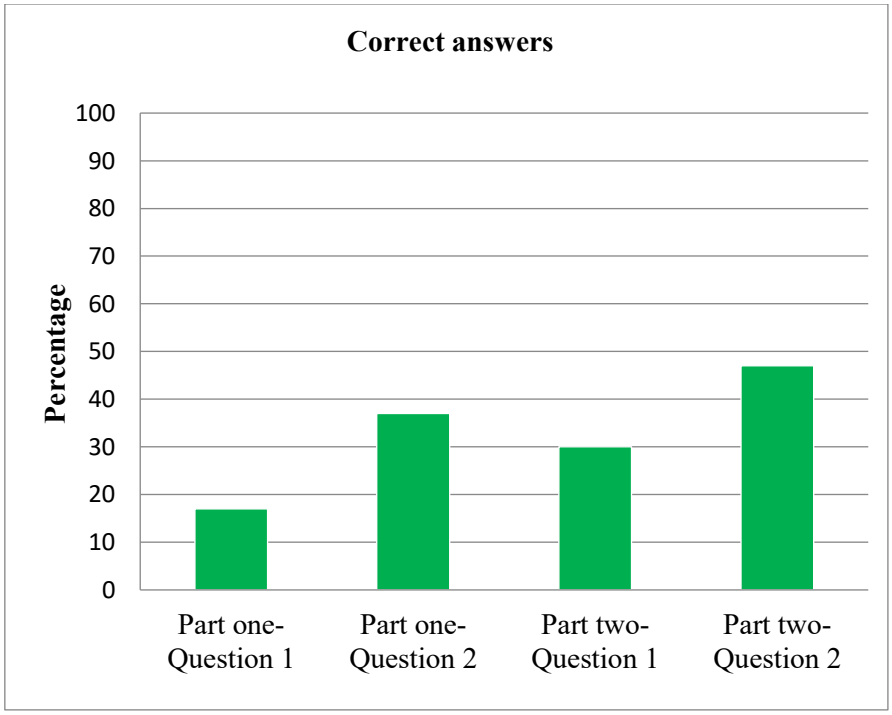
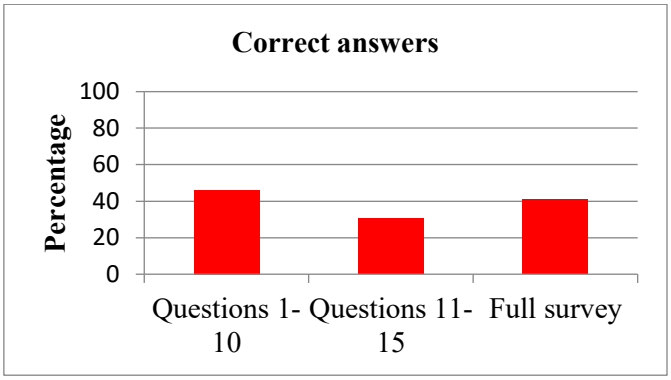


Table 2. Results of the survey



I found that students had too little knowledge in this topic and even little of it has been put into practise. They could estimate very inaccurately the ratio of the renewable and ratio of the nuclear energy in the total energy production. They thought that the percentages of the renewables were higher (generally 3-5 %) and the percentages of the nuclear were more lower (only 15-20%).

Seeing these results I found useful and necessary to create and present as a supplement of the physics subject a short summary of energetics at the end of 11th grade. In my opinion not enough relevant and authentic information could reach high school students I taught.

4. Parts of the summary

The document included the compressed knowledge to understand the energy production from the fossil, from the nuclear and from the renewable energy sources, the current data of the total energy consumption of the world and a brief presentation on Hungary's energy production potential. Most of them were missing in the high school curriculum although they would be very important for understanding and accepting energy saving. With this data and information it would be more realistic to compare and judge the role and validity of power generation and energy consuming equipment. Main arts:

- The total energy consumption of the world and the energy consumption per capita.
- The share of the energy sources in the energy production.
- The data of the energy production and the energy consumption of Hungary.
- The opportunities of Hungary in the energy production.

What were the values of the energy consumption in the last almost forty years and what was the rate of the growth? As you can see on the graph (Figure 1) the energy consumption is monotonically increased and during this period it doubled.

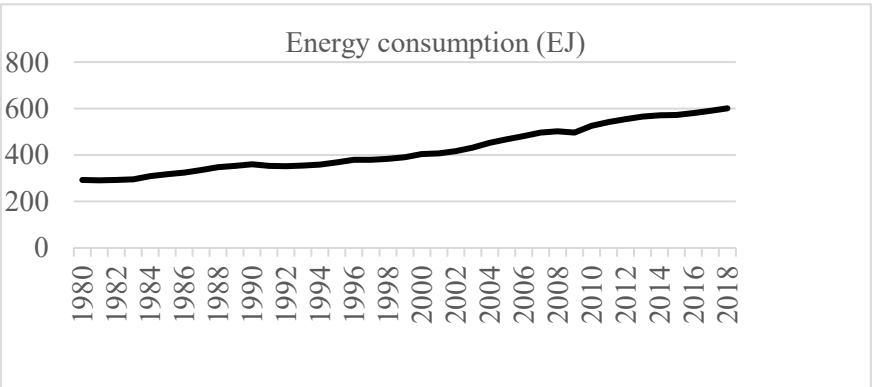


Figure 1. Energy consumption of the world

The total energy consumption of the world in 2018 was 601 EJ [2], the population of the Earth was 7674 million [2], so it was 78 GJ energy per capita. This value was an average there were big differences in the world. Three example [2][3]: USA 282 GJ, China 94 GJ and India 30 GJ, but in some developing countries it did not reach even 10 GJ per capita value.
On the next graph (Figure 2) could be seen the changing of the energy consumption per capita. It also increased but much less than the other, the growth was about 20 %. Thinking that in 1980 there were only about 4500 million people on the Earth, the growth of the population is about 70%. So based on these it could be concluded that the energy consumption correlated primarly with the growth of the population.
/It can also be stated that in the future futher growth is expected as the Earth population grows by about 80 million per year. /

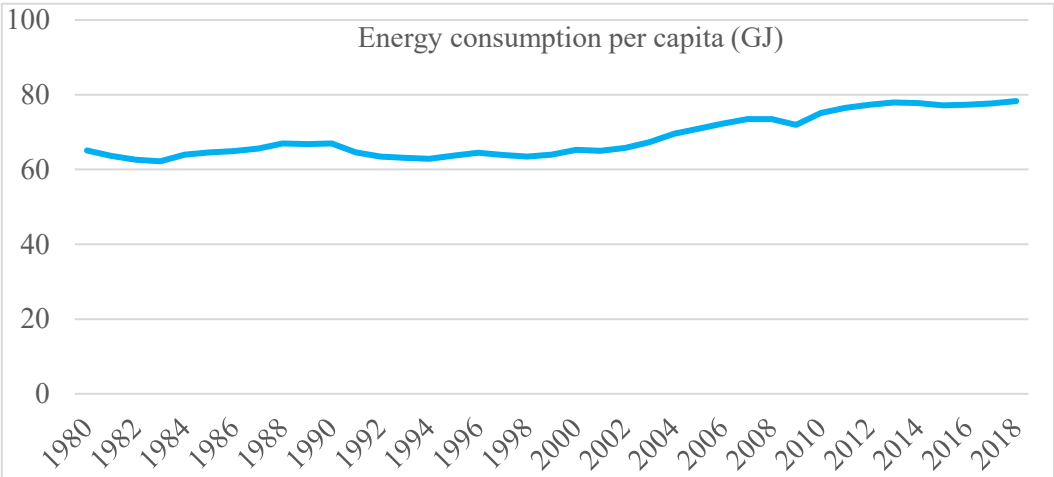


Figure 2. Energy consumption per capita

Even today about 85 % of the total energy production comes from fossil energy sources and this rate has been practically constant for decades. The share of the nuclear energy is about 5 %, the share of the renewables is higher, about 10 %, two-thirds of it is produced by hydroelectric power plants. The potential for renewable energy production on Earth is different and strongly depends on the natural conditions of each country. Most countries, unfortunately Hungary is one of them, are limited in such conditions.

What were the data of the energy consumption in Hungary last year? The total energy consumption in 2018 was ≈1,13 EJ [4], the population was 9,773 million [3], these resulted ≈ 116 GJ/capita, which was almost 50 % more than the world average but less than the EU's 150 GJ/capita consumption. Hungary has only a small amount of energy source, the country need to import it. The proportion of the import is about two-thirds of the total primary energy and it has been constant for several years.

Based on my survey I was convinced that my students thought the ratio of the renewables in the total energy production more significant than reality. In 2018 this value was 13,3 %, but the main part of it came from biomass, the sun energy, the hydropower and wind energy together did not reach 4 %. What were the reasons of it?

The main reason was Hungary's geographic position, it was a determining factor for energy production from renewables. This state is permanent so it sets the opportunities in energy production from this kind of energy sources. Let's have a look at the position of wind energy, hydropower and solar energy one by one!

Hungary is inside the continent, far from the seas, so there are no areas where availabilty time is close to 50 %, in Hungary this value is less than 25 %. There is only one and not too wide and long wind channel in the northwest part of the country in addition there are only a few smaller areas can be

considered as a constant wind movement in Hungary. Wind turbines can be found in these areas but all of their energy production is just over 1 % of the total energy production.
The possibility of the hydropower is worse! We have two bigger river Danube and Tisza but each river has a small drop. The water supply of Danube is more or less constant, but in case of Tisza it is fluctuating. At the end of the 20th century owing to the political and social decisions based on primarly environmental considerations, now in Hungary there is no hydro power plant on river Danube. On river Tisza there are two smaller ones (28 MW and 12 MW) and there are some very little plants (1-2 MW) on other rivers but the whole energy production from them does not reach 1 % (0,7%) of total energy production.

Hungary has made efforts in recent times to develop the energy production by sun energy. Therefore the state supports those private and public investments which choose the implementation of the energy supply by solar energy. The process has started although now it is still in an initial state. We also need to know the limits and must not forget that in Hungary the number of sunny hours is satisfactory for this purpose only between May and October and only in flat areas. Currently the share of solar energy production in Hungary is 1-2% of total energy production, which is expected to increase in the future, but will not solve all problems of the missing energy. In conclusion, as I mentioned it earlier, the combined share of these three types of renewable sources in total energy production is less than 4 % and no significant progress can be predicted in the coming decades.

What about other renewable energy sources? The share of the biomass in energy production now is almost 10 % this ratio can no longer be greatly increased. The potential for utilizing geothermal energy would be very good in Hungary, as the temperature gradient (60 °C/km) is about twice the European average, but this type of energy production is still in its initial state. It is currently used mainly in agriculture and in thermal spas.

The circle seems to be closed, but Hungary would need its own-produced energy, its constant dependence on imports can cause problems. Where will our energy come from, what could be the solution? The only possible option is nuclear energy, which can have serious risks in power generation. This is obvious, but Hungary has no other option! If the country wants to solve its energy production problem, then it has to face this fact!

5. The extension of Nuclear Power Plant

Hungary has only one Nuclear Plant (Figure 3) which generates electricity, it has 4 blocks, which produce about the half of the electricity what the country needs. A few words about its history:

Figure 3. Nuclear Power Plant – Paks, Hungary

It began in the 60-s, in 1966 when the decision was made to build a nuclear power plant in Hungary. The construction started in 1974, the first block began to produce in December 1982 and the last block in August 1987. All blocks got the operating licence for 30 years. From 2012 to 2017 all blocks got operating time extension for further 20 years, so the Nuclear Power Plant with all the four blocks (500 MW per blocks) can produce energy till 2032 and the shutdown will take place in an ascending system until 2037. Based on the Hungarian-Russian agreement in 2014 the Nuclear Power Plant will be extended with two more blocks, their power will be 1200 MW per blocks and their energy production is expected to start in the late 2020s.

High school students are very interested in nuclear fission and the operation of nuclear reactors. These are taught at the very end of the physics curriculum, so anyone who wants to know and understand it can easily do so. As a physics teacher in addition to teaching the physics of this topic you should talk about the advantages and disadvantages too of the Paks expansion. Let's see a few of them!

5.1. Advantages

- Environmentally friendly operation: no dust and greenhouse gases, no carbon-dioxide
- Easy transporting and stockpiling of fuel: Currently it requires only 42 tonnes of uranium per year
- Cheap energy production process: The nuclear power plant has been the least expensive domestic electricity producing facility. [5]
- Due to its high level of reliability it is able to provide power continuously: The availability time is constantly around 95%

5.2. Disadvantages

- Long and costly construction
- The management of radioactive waste: The disposal of low and medium activity waste is solved, but the issue of the final disposal of high activity waste is still open.
- There are not enough reactor engineers in the country
- Possible nuclear accident

During the evaluation of the survey, in addition to the correct answers, the students were introduced to a small part of the curriculum related to energetics in order to obtain an accurate interpretation. However, due to the end of the school year, it was no longer possible to transfer all the knowledge because most of the grade had been completed in high school physics. Thus, in connection with this topic, I have only reached a partial solution. In the coming years, I plan to conduct this survey in each of the 11th grades I teach, and I will also provide time for my students to learn the full knowledge with a minor rearrangement of the compulsory curriculum.

What have been the reactions of my students right now?

The data on energy production and use, which related to Hungary and the whole Earth, were received with great surprise. The situation was similar when I outlined the future possibilities of Hungary for them. They had to face reality, and this often did not match the information that came from their immediate environment or other sources prior to the survey.

6. Conclusion

This project had a dual purpose. One of the goals is to provide students with knowledge that they hardly get from their high school books. The other purpose would be to raise awareness. They need to understand the importance of energetics in their present and future lives. For this, however, it is essential to be aware of the meaning of physical concepts related to energetics and at least at basic level understand the relationships. It is also important to have a realistic view of the potential of Hungarian energy production and the role of renewable energy sources in this. They must receive this information from that source who is accepted and who is presumably professional. I think as a high school physics teacher it is my duty, because students, unless they have an intention to study physics, will not get it from anyone else.

Unfortunately I could not measure the effectiveness of my work because a significant majority of them finished learning physics at the end of the 11th school year. Nevertheless, this transfer of knowledge was not unnecessary!

It is very conceivable that a student who is still in high school, as an adult may find himself or herself in a life situation where he or she has to express an opinion or even make a decision on an energy-related issue! This knowledge can help them to have a real judgment of this topic. That is my ultimate goal!

Acknowledgements
I want to express my special thanks to Professor Adam Kiss who supported me with his remarks, ideas and suggestions. This study was funded by the Content Pedagogy Research Program of the Hungarian Academy of Sciences.

7. References

[1] A. Juhász - P. Nagy What do secondary school students know about energy? Teaching science in a modern and attractive way – Conf. Proc. (Budapest 2011) p. 354-363 (in Hungarian)
[2] https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html
[3] https://www.worldometers.info/world-population/world-population-by-year
[4] http://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_qe001.html
[5] http://www.atomeromu.hu/en/AboutUs/Lapok/1default.aspx