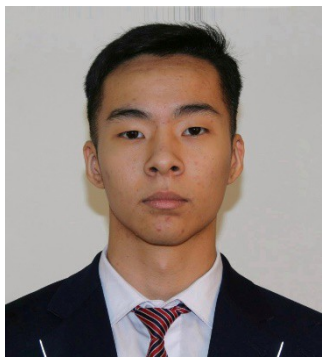


Renewable energy implementation in Kazakhstan.

How to develop renewable energy in Kazakhstan?

3207 words

Yerdaulet Zhumay

February 25, 2021

Authenticity Declaration

I declare that the work in this research project is my own and is authentic. All resources and sources are acknowledged and cited, where sources and resources of other people have been used.

Acknowledgement

The realization of this research work would not have been possible without the help of my GPPW teacher, Bauyrzhan Kaziyev. That is why, I would like to express my special thanks of gratitude to him, for support and oversight throughout the entire process. His baggage of knowledge, and constant feedback fulfilled strength and confidence in me. Moreover, I would like to express my sincere appreciations to my classmate at Nazarbayev Intellectual School, Kamila Zhaksylyk, who has assisted me in this project with advices and guidance when it was needed. In general, I would also like to thank my parents and friends who helped me a lot in finalizing this project within the limited time frame.

Abstract

Kazakhstan is well-known for natural resources such as oil, coal, uranium, and natural gas. The country currently depends on fossil fuels in electricity production. Although, the need for a new energy system based on renewable energy sources had risen, with regards to the concerns over greenhouse gas emissions, which yield negative environmental consequences. Despite the significant potential of renewables, some difficulties and obstacles might occur while switching from fossil fuels to renewable energy sources. The detailed analysis contained within this article represents the latest data on the development of renewables, potential barriers to adoption of renewables, the consumers' knowledge, and, first and foremost, the ways of implementation. The conducted research allows drawing several conclusions, which are presented at the end of the article as well as the recommendations for further research.

Қазақстан мұнай, көмір, уран және табиғи газ сияқты табиғи ресурстармен кенінен танымал. Қазіргі уақытта ел электр энергиясын өндіруде қазбалы отынға тәуелді. Бұған қарамастан, жаңартылатын энергия көздеріне негізделген, жаңа энергетикалық жүйеге деген қажеттілік күрт өсті. Ол парниктік газдардың экологияға деген теріс әсеріне қатысты алаңдаушылыққа байланысты туындап отыр. Жаңартылатын энергия көздерінің айтарлықтай әлеуетіне қарамастан, қазбалы отыннан жаңартылатын энергия көздеріне көшу кезінде кейбір қиындықтар мен кедергілер туындауы мүмкін. Осы мақалада келтірілген егжей-тегжейлі талдау жаңартылатын энергия көздерін дамыту, жаңартылатын энергия көздерін енгізуде пайда болуы мүмкін кедергілер, тұтынушылардың білімі, және де жаңартылатын энергия ресурстарын енгізу тәсілдері туралы соңғы деректер мен мәліметтер берілген. Бұл зерттеу жұмысы бірқатар қорытындылар мен одан әрі зерттеуге арналған ұсыныстарды жасауға мүмкіндік берді.

Казахстан хорошо известен такими природными ресурсами, как нефть, уголь, уран и природный газ. В настоящее время страна зависит от ископаемого топлива в производстве электроэнергии. Несмотря на это, потребность в новой энергетической системе, основанной на возобновляемых источниках энергии, возросла в связи с опасениями по поводу выбросов парниковых газов, которые приводят к негативным экологическим последствиям. Несмотря на значительный потенциал возобновляемых источников энергии, при переходе от ископаемого топлива к возобновляемым источникам энергии могут возникнуть некоторые трудности и препятствия. Подробный анализ, содержащийся в данной статье, представляет собой последние данные о развитии возобновляемых источников энергии, потенциальных барьерах на пути внедрения возобновляемых источников энергии, знаниях потребителей и прежде всего, способах их внедрения. Проведенное исследование позволяет сделать ряд выводов, которые представлены в конце статьи, а также рекомендации для дальнейших исследований.

***Keywords**: Fossil fuels; renewable energy; hydro; wind; solar; Kazakhstan; Energy transition; Sustainable development; Consumer knowledge.*

Introduction

Energy had a profound impact on our lives. The energy sources are used everywhere, from merely charging phones to running whole factories. Although United Nations Development Programme (n. d.) found that the current energy system is causing global warming. It is producing greenhouse gases which might result hunger, droughts, weather extremes, etc. Apart from that, according to the International Energy Agency (2019), Global energy consumption has increased at nearly twice the average rate of growth since 2010, as demand for all fuels has increased.

Passage of time will not solve the energy problem. Indeed, it becomes even more difficult as the processes of creating new energy applications are neither properly researched nor weighted (Woodcock, 1982). After looking at these issues, it is logical to infer that there is a critical need for change and innovation of alternatives for traditional energy sources, such as fossil fuels. In recent decades, the world has met new and green energy sources, and many countries are trying to embed them into their infrastructure.

Kazakhstan's high energy consumption has negatively affected the competitiveness, cost of goods, and the economy, in general. Improving energy efficiency is one of the crucial tasks for sustainable development. That is why Kazakhstan, in November 2011, proposed to contain a discussion of the international energy-ecological strategy for sustainable development in the agenda of the United Nations Conference on Sustainable Development. The main goal is to achieve an optimal level of energy needs of all republics, using renewable energy sources, by the middle of the 21st century. According to the Government of Kazakhstan, the strategy of balanced and efficient energy consumption substantially decreases the negative environmental impact and confines consumption progress (Babazhanova et al., 2017, p. 164).

Renewable energy sources are tools that will give an ultimate solution for energy problems and other tremendous issues been caused, such as global warming. As most of Kazakhstan's population are still using the traditional energy sources, it gives the sense of being part of the immense problem. I believe that significant changes start with small ones. I think that everyone should contribute themselves, to tackle the energy problem in our country. That is why I am willing to find out what we can do to develop affordable and clean energy in Kazakhstan. Renewable sources have great potential to change our world for the better.

The purpose of this research is to find the possible ways of development and implementation of renewable energy sources into Kazakhstan's energy system, taking into consideration the potential challenges and difficulties. The following questions are taken into account:

1. How knowledgeable people are, regarding renewable energy trends?
2. What are the ways for the development of renewable energy in Kazakhstan?
3. Are there any challenges in the development of renewable energy sources?
4. What will be the potential consequences of renewable energy implementations?

These questions will help to focus on key areas of the research and provide full information on the research topic, covering all the main perspectives.

Literature review

Renewable energy

The United Nations General Assembly (UNGA) in 2015 created the list of Sustainable Development Goals (SDGs), the aim of which is to offer a powerful basis for international collaboration in order to have a sustainable condition for better living. The 17 SDGs driven by "Agenda 2030", have laid the path to end inequality, injustice, extreme poverty and to protect the environment of the Earth. As United Nations (2016) laid it out Renewable Energy Source (RES) is the main energy that comes from extraction of Renewable Energy Products (such as sun, wind, etc.) RES is also equal of the terms "accumulation" or "deposit" used for solid mineral resources and petroleum (p. 4). Renewable energy is the base component of future success for Agenda 2030. SDG 7 - includes three crucial targets: ensure reliable, affordable and universal access to modern energy services; increase significantly the share of renewable energy in the global energy mix; and foster the improvement of energy efficiency. The different targets of the SDG 7 not only correspond with the development in energy sector, but also contribute invaluable resources to the achievement of other SDG goals (Gielen et al., 2019, p. 38).

Kazakhstan's current energy system

According to Karataev & Clarke (2014), Kazakhstan's current economy profits from its natural resources (such as oil, uranium and gas), agricultural sectors and heavy industry (non-ferrous and ferrous metals). These are the main factors which has built the majority of Kazakhstan's economy as Kazakhstan's land is full of natural resources. For instance, the coal production is equal to 120 Mt, 80% of which is majorly consumed for heat production in thermal power plants and electricity, with export of remaining portion. (p. 98-99).

Issues of current energy system

However, as in many developing countries, rapid economic growth in the past decade has yielded a dramatic jump in electricity consumption. Also, the power lacks in the winter demanded restrictions on consumption of electric loads, which as the result had a contrary influence on regional economic growth. Apart from issues on electricity consumption, Kazakhstan's energy sector was also responsible for carbon dioxide productions of 275 MtCO2 in 2011. 80% of it, resulted from the energy consumption from heat as well as from power generation due to the aging generating, low efficiency and network assets (Karataev & Clarke, 2014, p. 99).

Types of RES

These are the main reasons why Kazakhstan need change in energy sector as new alternative energy technologies have expanded priority for development (Mukhamediev et al., 2019, p. 122276). Previous studies have shown us that the most common types of renewable energy are biomass, solar, wind, hydro, biofuels and geothermal energy (Banshwar et al., 2017).

Advantages

Many experts came to the agreement that the projects in the RES field can potentially bring economic benefits for numerous regions, since most of the projects are remote from main urban area and suburbs of the capital cities (Shakeel et al., 2017).

Another major benefit from usage of RES is that they never run out, as less maintenance costs needed in comparison to the traditional energy sources. Renewable energy has also been known as a production with minimal impact on the environment, as it practically does not emit carbon dioxide (Babazhanova et al., 2017, p. 165).

Drawbacks

One of the drawbacks of using renewable energy is their low capacity, which does not allow them to produce energy in great amounts in contrast with conventional energy sources. To solve this issue energy consumption must either be reduced, or simply build more RES facilities. Many experts note that to tackle energy problems, it is important to perceive the balance of many energy sources (Babazhanova et al., 2017, p. 165-165).

Another disadvantage of RES is high dependence on weather conditions and unreliability (Banshwar et al., 2017). So, for instance, wind generators require wind to spin the blades, hydro generators require rain to fill the dams to provide running water, solar panels need sun and cloudless sky to generate heat and electricity (Babazhanova et al., 2017, p. 166).

Kazakhstan's Potential

According UNDP Kazakhstan (n.d.) in 2014 was published the first Wind Atlas for Kazakhstan. This atlas contains wind power data for 14 Kazakhstan regions. Generally, the entire potential of wind power in Kazakhstan is valued at about 929 billion kWh per annum. This is over 18 times as much as capacity coming from electricity generating plants, which are now installed in Kazakhstan. However, this potential is frequently under-utilized. For example, in 2013 wind capacity in Kazakhstan was only 5.6 MW. In 2015, there was only one working wind farm in the South Kazakhstani region.

Kazakhstan undoubtedly has a great potential for development of renewable energy, since the available resources for energy generation are an order of magnitude higher than most of the Organisation for Economic Co-operation and Development (OECD) nations and other transitional economies. Although the current contribution of renewable energy into country's energy system is less than 1%. Renewable energy potential has enough capacity to achieve clear renewable electricity and to meet the rising electricity demand. (Karatayev et al., 2016, p. 125-126).

Methods

A mixed-method has been conducted to collect relevant data, connected to the topic of this research. This method involves both qualitative and quantitative approaches, which aims to collect not only numerical data but also precise data that can be used in research work. The mixed-method allows to exploit strengths and compensate for weaknesses (Johnson & Onwuegbuzie, 2004). For quantitative data, it was decided to create a survey, whereas the interview was taken as the qualitative approach. Both of the methods represent their own benefits and drawbacks. Firstly, the survey was chosen with aim of collecting numerical data from the average population, hence the questions of the survey were general and did not dig deep into the topic. That is why statistic findings are usually easier to accumulate through the survey. However, there are human factors that negatively affect the final results, such as the irresponsibility of participants. Careless attention and lack of time of participants are the worth enemies in proceeding survey. Secondly, the interview was taken from reliable individuals to acquire qualitative data. In this case, the previously mentioned disadvantages of the survey did not occur. In fact, the response was rate was much better and invaluable information was collected as the result. Nevertheless, there were few drawbacks needed to be considered, such as time-consuming trend and complexity.

The survey was used to gather information about different perspectives of society about renewable energy and to understand the consumers' knowledge. Aside from the drawbacks mentioned in the previous paragraph, there was also difficulty in setting up research questions. As the solution to these issues, the questions have been constructed in different ways to fully

understand the picture. The survey consisted of carefully organized 9 questions, and several types of questions were taken, including rating scales, multiple-choice, ratio data, and open-ended questions. This diversity in question types allowed to archive the goals which were put behind conducting the survey. The questionnaire was taken from the NIS community in general (students, teachers, etc.), as all of them use energy and there is a significant difference between ages which assisted to cover different generations and their perspectives. Initially, it was planned to surpass the total number of participants above 100, however, 86 answers were completed. The questionnaire was sent via different platforms like Outlook and WhatsApp. In the end, since the questionnaire is easier to classify and count the features of the topic being studied, the collected information was quantified and subjected to statistical treatment.

Using interviews to acquire information is very common in today's world, as people live in an "interview society" (Fontana & Frey, 2005). For this reason, the project work also included the interviews as a qualitative method. The interviews assisted to precisely understand other people's views and to get a detailed analysis of the concerning topic. The interview was a compound of 7 open-ended questions related to renewable energy. Initially, it was planned to take interviews from 5 information-laden individuals, however, 4 of them agreed to take part in the research. They had a direct connection to the topic being studied: the teachers in the physics field, a 12th-grade student, and the graduate of NIS who has worked on the projects related to this topic. All of them gave full answers and some invaluable insights. The conversations were recorded by interviewees' approvement. However, during the process, there were some difficulties, particularly with the consent form. With regards to current conditions the world is living in, all interviews were done online, and consent forms too. Many participants did not have the opportunity to sign the document. Another interesting point to keep in mind is that some initially planned participants did not answer the emails. Indeed, they were experts in this area. Moreover, writing the transcripts of recorded materials was time-consuming, although it was part of the process.

Results

In total, 86 individuals took part in the survey from wide range of age categories (35 men and 51 women). The most common age category was people who are older 36 years (Appendix-1). To set a clear picture whether the participants could differentiate renewable from non-renewable energy sources was crucial. Most (62.8%) of them knew the difference whereas others were unaware of such tendency (Appendix-3). In general, half the audience (47.7%) found the issue as serious one in Kazakhstan (Appendix-4), and more than half the contestants had a positive view regarding renewable energy (Appendix-5).

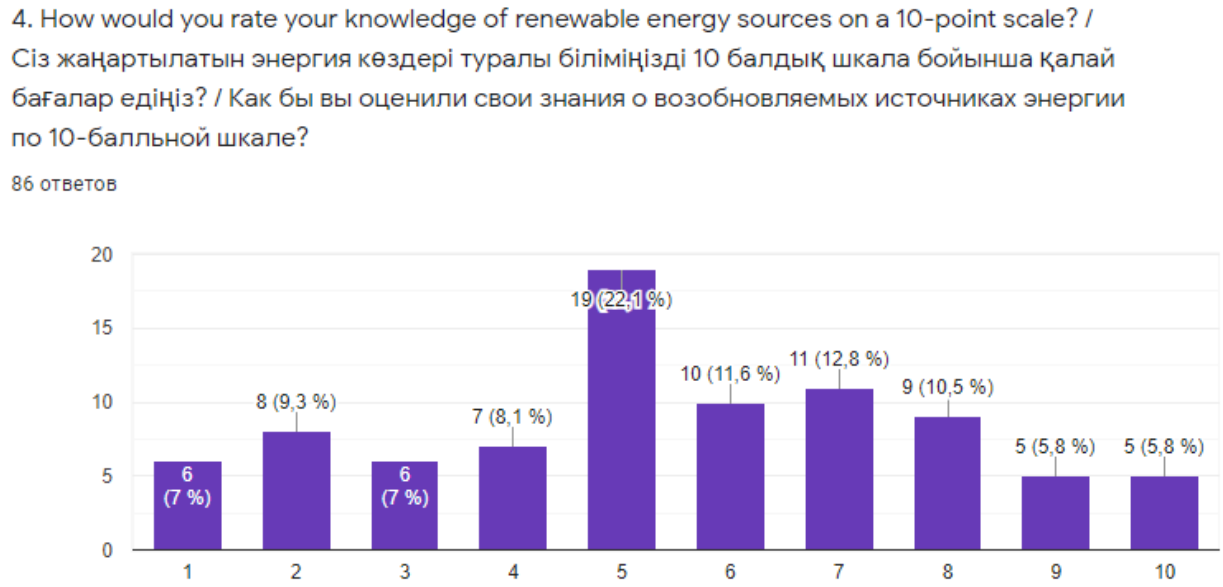


Figure-4. *Knowledge of renewable energy sources*

The next question was meant to gather a perspective about the participants' knowledge. The given illustration precisely shows how people rated their knowledge on a 10-point scale concerning the renewable energy sources. Most of the audience choose between 5-8 points. Only 7% rated their knowledge with 1 point, though even less people were well informed about the topic (5.8%).

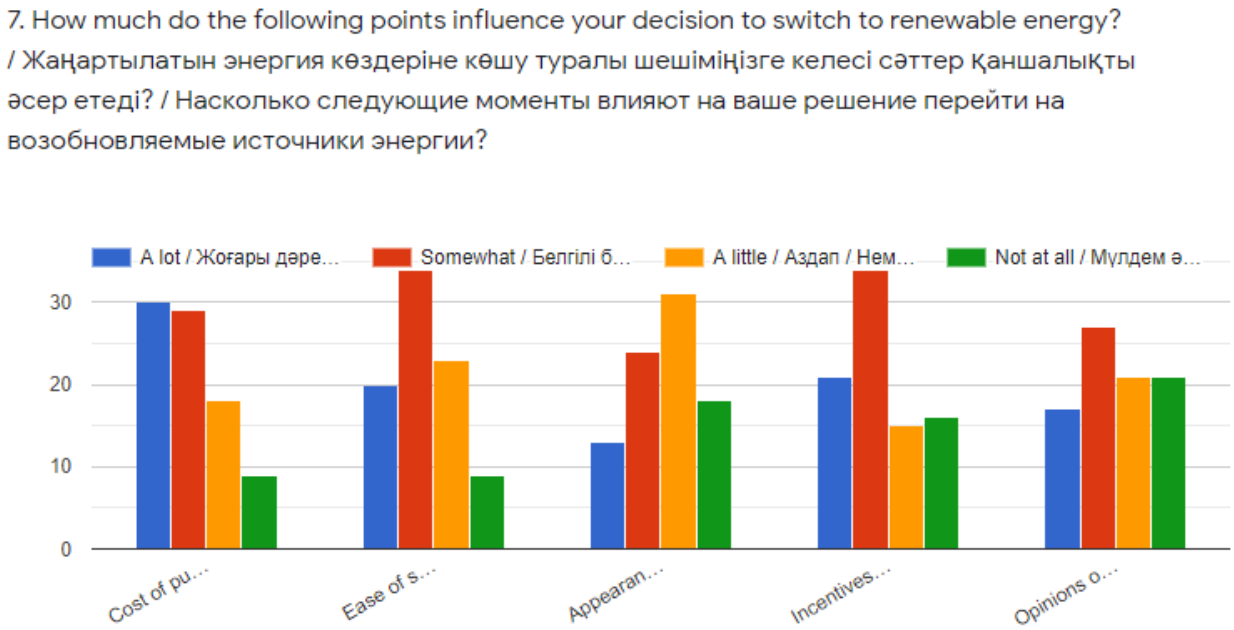


Figure-7. *Factors influencing the decision to switch to renewable energy.*

In order to implement renewable energy to current energy system, the key factors regarding consumer's decision should be evaluated. With this in mind, 7th question was constructed to find out how much the following factors would affect them (Figure-7). The level of influence was assessed by 4 categories. They are "*a lot*", "*somewhat*", "*a little*" and "*not at all*". First factor was "cost of purchasing" where most of participants assumed it would influence *a lot* or

somewhat degree. The next factor was the "ease of switching" where a dramatic difference occurred; 34 people opted for *somewhat* degree of influence, while those who chose options "*a lot*" and "*a little*" were roughly the same (20 and 23 respectively). Then the "appearance of device" was put into evaluation. This factor would affect most people's decision just *a little* (31 votes). For what comes to "incentives for switching", 34 contestants anticipated a certain degree of influence. The last but not least factor happens to be the "opinions of family/friends". Astonishingly the most popular answer was "*somewhat*" (27).

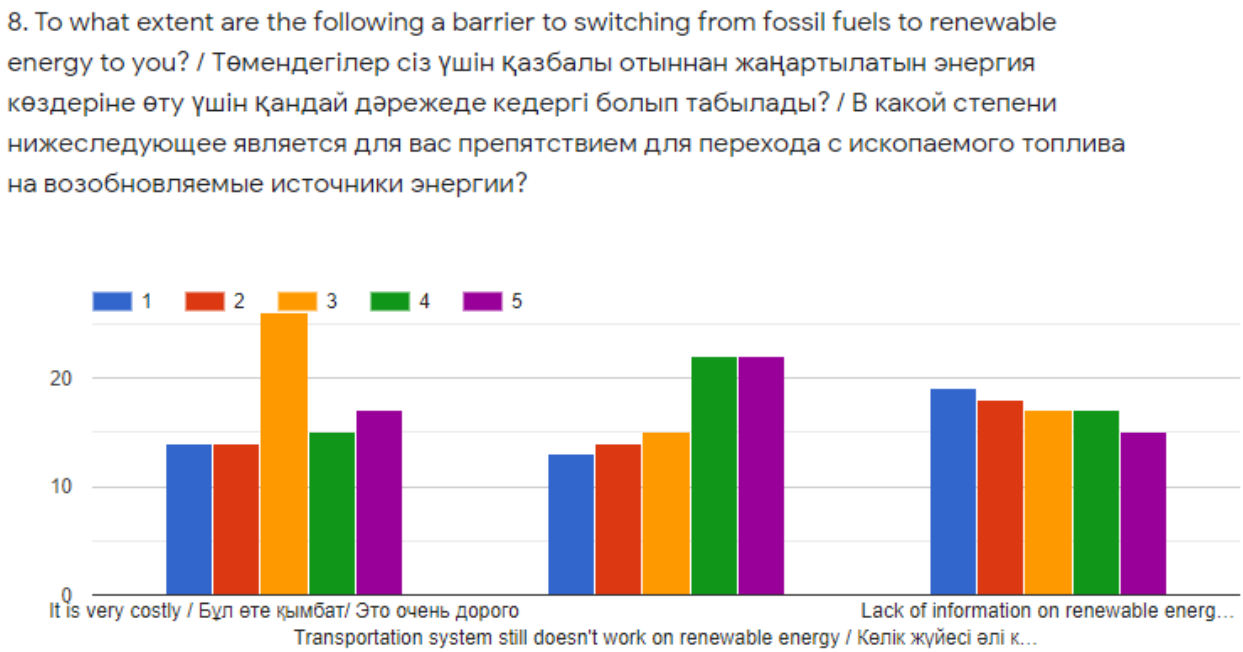


Figure-8. *Barriers to switching to renewable energy.*

With the aim to eliminate some possible barriers, participants' views were asked in the next question. The Figure-8 shows how 3 aspects can inhibit the process of switching to renewable energy. The evaluation was done in 5-point scale. The first aspect was the fact that "renewable energy costs a lot". 26 people gave *3 points*, 17 gave *5 points*, 14-15 assessed with *about 3 points.* The next aspect was concerning the "transportation system". *4* and *5 points* were the most common choices (22 each). *1, 2, 3 points* had approximately 14 answers. Then the "lack of information about renewable energy" was assessed, where a significant difference did not occur; Although, most people (19 contestants) choose to give *1 point*.

Another used method was an interview that served as a qualitative approach. The interviews were taken from 4 individuals who had a connection to this topic. They were asked 7 open-ended questions and some similarities occurred under scrutiny. The first interviewee was the aboard physics teacher. He was chosen for an interview because his field had a strong connection to the discussed topic. Despite giving detailed and laid-out answers, he also provided few examples of how his home country, Portugal, uses renewable energy. The next person interviewed was a physics teacher too. His answers slightly differed from first-interviewee's. He chose a specific area of renewable energy to talk through and brought some valuable insights about energy extracted from the waste. Indeed, there was some resemblance with the answers of the next interviewee. He is a graduate of NIS in Aktobe who has won several competitions defending projects on renewable energy. This interviewee gave explicit answers and both third and second

interviewee pointed out the possible rivalry between companies producing electricity from fossil fuels and renewable energy. The last interviewee was a 12th-grade student in NIS Aktobe. She has also worked on projects connected to renewable energy. By and large, her well-rounded answers greatly impacted the overall data collection procedure.

Conclusion

Taking into consideration the aforementioned points, the following conclusions were made, referring back to the outlined questions at the beginning.

The conducted research revealed that various gender and age categories have an adequate comprehension regarding renewable energy trends. In the course of the study, it became clear that people can differentiate renewable energy from non-renewable and accordingly assess its potential for the years to come. Indeed, most citizens had a positive attitude towards renewables. Furthermore, many perceive the energy problem as a severe issue in Kazakhstan, which requires urgent execution.

A broad scope of renewable energy source implementations has been discovered during rigorous scrutiny. The most common suggestions included an electricity usage reduction, investing and promoting renewable energy sources, creating more efficient shaped turbines, and using carbon fibers. There was a particularly unique suggestion among other suggestions; to provide energy supply to each building separately than using a large scale of power plants. Moreover, using other countries' past themes in behalf of Kazakhstan's energy condition was extensively mentioned. Many interviewees concur that Sweden, Japan, and Portugal are paradigms of successful renewable energy usage. Another thought-provoking perspective came into the spotlight: investing money in education, i.e., providing grants and scholarships to soar the number of qualified experts in this field.

Regarding the interviewees' answers, developing renewable energy in Kazakhstan still needs a long way to go due to challenges that inhibit the process. Some of them require a rapid corresponding response, while others are hard to control. For instance, the materials' shortage can either be reduced by investing in environmentally friendly materials or making current ones affordable. As for the possible counter-productive rivalry between companies producing electricity from fossil fuels and renewables, the arduous control over the issue will create an additional burden to authorities. In addition to this, the complexity of maintaining transportation systems with renewables has been thrown into sharp relief. It correlates with the high dependence on weather conditions, which indeed, present a major problem to the development of renewables.

As the renewable energy trend will start progressing by leaps and bounds, economic, political, and ecological consequences will arise. A whole set of new jobs, alleviating the unemployment rate, and the electricity costs reduction will contribute to economic growth. Be that is it may, the political forces would witness some changes, opening the door for new collaborations with other countries. Furthermore, as an inevitable consequence of renewable energy implementation, the global amount of greenhouse gas emissions will plummet, thus will result in a remarkable improvement of people's living standards.

For further research, the scope of the study should be enlarged as covering all the population of Kazakhstan. It will aid to get a more concise picture of consumers' knowledge. Moreover, the experts in this field should have been chosen as interviewees, since they are more knowledgeable and experienced about the merit and demerits of such phenomenon. Similarly, the experience of other countries using renewables should be taken into consideration. Summarizing all above, renewable energy is highly required these days, almost obligatory in order to create a better place

for the younger generation to live in. However, one should ponder the previously mentioned points to create a successful procedure of renewable energy implementation.

Appendix

Appendix 1

Questions for survey:

1. How old are you?

   Under 18

   Over 18

2. What is your gender?

   Male

   Female

   Other

3. Do you know the difference between renewable and non-renewable energy?

   Yes

   No

4. How would you describe your knowledge on renewable energy?

   I do not know anything about it

   I am partly familiar

   I am fully aware

5. What view do you have about the potential of renewable energy in the future?

   Positive

   Negative

6. Is energy problem in our country a serious problem?

   Yes

   No

   Partly

7. How much do the following points influence your decision to switch to green energy?

   A lot, somewhat, a little, not at all

   - Cost of purchasing
   - Ease of switching

- Appearance of the devices
- Incentives for switching
- Opinion of family/friends

8. To what extent are the following a barrier to switch from fossil fuels to renewable energy to you?

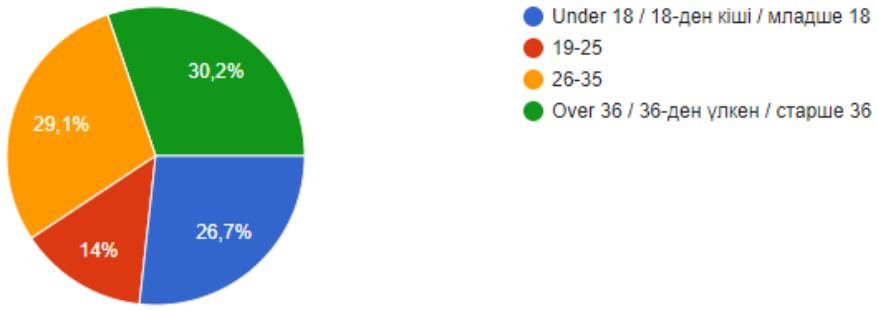
   From 1 to 5

   - It is very costly
   - Transportation system still doesn't work on renewable energy
   - Lack of information on renewable energy

Appendix 2

1. Age category / Жас санаты / Возрастная категория

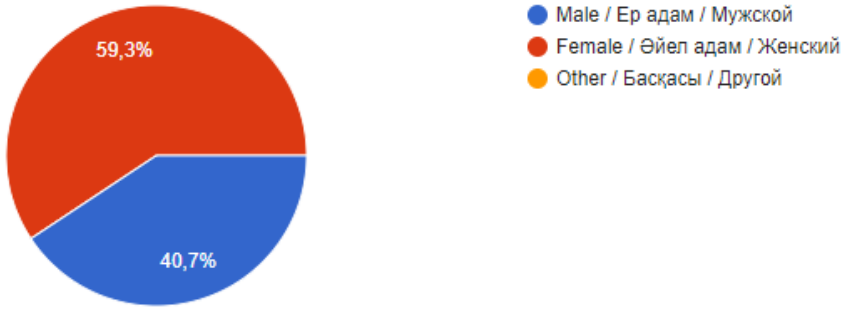
86 ответов



Appendix-1. Age category

2. Gender / Жынысы / Пол

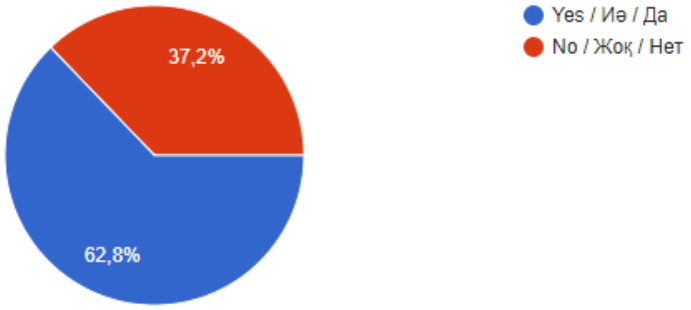
86 ответов



Appendix-2. Gender

3. Do you know the difference between renewable and non-renewable energy? / Жаңартылатын және жаңартылмайтын энергия түрлерінің арасындағы айырмашылықты білесіз бе? / Знаете ли вы разницу между возобновляемой и невозобновляемой энергией?

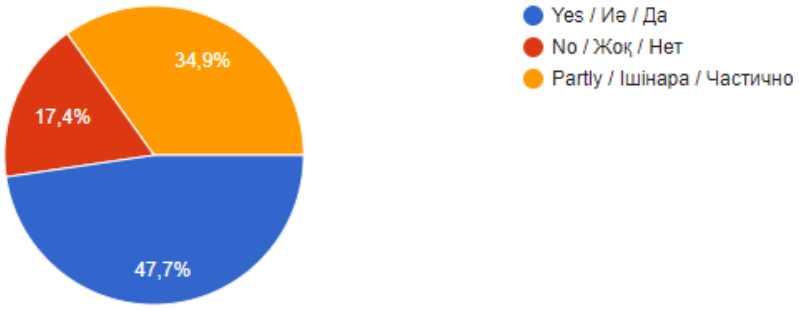
86 ответов



Appendix-3. Renewable and non-renewable energy sources

5. Is the energy problem in our country a serious problem? / Біздің еліміздегі энергетика мәселесі күрделі мәселе ме? / Проблема энергетики в нашей стране является ли серьезной проблемой?

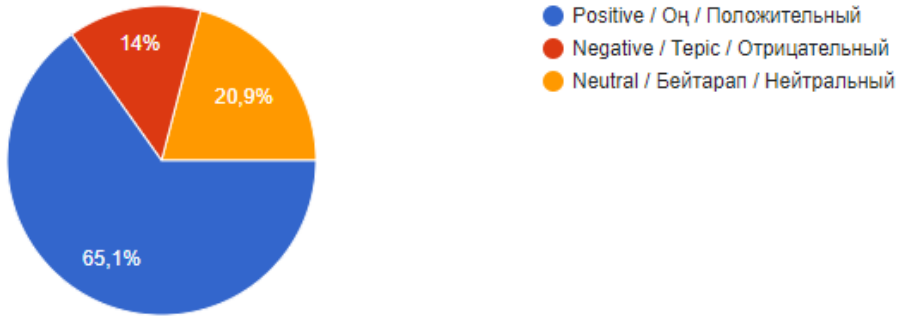
86 ответов



Appendix-4. Energy problem in Kazakhstan

6. What view do you have about the potential of renewable energy in the future? / Болашақта жаңартылатын энергия көздерінің потенциалы туралы көзқарасыңыз қандай? / Какой у вас взгляд на счет потенциала возобновляемых источников энергии в будущем?

86 ответов



Appendix-5. Views on renewable energy.

Appendix 3

Interview questions:

1. Are you familiar with the term "renewable energy"?
2. Do you think that it has the potential for a successful future?
3. "Renewable energy can solve major global problems such as global warming". To what extent do you agree or disagree with this statement?
4. How can we change our energy system towards more efficient and clean energy?
5. What would be the potential consequences of transformation to a renewable energy system?
6. What kind of challenges are holding our country from fully using renewable energy sources?
7. How can we solve them?

References

Babazhanova, Z., Khambar, B., Yessenbekova, A., Sartanova, N., & Jandossova, F. (2017). New Energy System in the Republic of Kazakhstan: Exploring the Possibility of Creating and Mechanisms of Implementing. *International Journal of Energy Economics and Policy, 7*(6), 164-170. Retrieved November 25, 2020, from https://www.econjournals.com/index.php/ijeep/article/view/5871/3450

Banshwar, A., Sharma, N., Sood, Y., & Shrivastava, R. (2017, September 22). Renewable energy sources as a new participant in ancillary service markets. *Energy Strategy*

Reviews 18, 106-120. Retrieved November 25, 2020, from https://www.sciencedirect.com/science/article/pii/S2211467X17300512

Fontana, A., & Frey, J.H. (2005). The Interview: From Structured Questions to Negotiated Text. *The Sage handbook of qualitative research 3, 695-727.* Retrieved January 26, 2021, from http://www.iot.ntnu.no/innovation/norsi-common-courses/Lincoln/Fontana%20&%20Frey%20(2000)%20Interview.pdf

Gielen, D., Boshell, F., Saygin, D., Bazilian, M., Wagner, N., & Gorini, R. (2019, January 31). The role of renewable energy in the global energy transformation. *Energy Strategy Reviews, 24*, 38-50. Retrieved November 25, 2020, from https://www.sciencedirect.com/science/article/pii/S2211467X19300082

International Energy Agency (2019). Global Energy & CO2 Status Report 2019: The latest trends in energy and emissions in 2018. *Flagship report 2019*. Retrieved November 25, 2020 from https://www.iea.org/reports/global-energy-co2-status-report-2019

Johnson, R.B., & Onwuegbuzie, A.J. (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come. *Educational Researcher, 33, 14-26.* Retrieved January 27, 2021, from https://journals.sagepub.com/doi/10.3102/0013189X033007014

Karatayev, M., & Clarke, M. L. (2014, December 04). Current Energy Resources in Kazakhstan and the Future Potential of Renewables: A Review. *Energy Procedia, 59,* 97-104. Retrieved November 25, 2020, from https://www.sciencedirect.com/science/article/pii/S1876610214017214

Karatayev, M., Hall S., Kalyuzhnova Y., & Clarke, M. L. (2016, December). Renewable energy technology uptake in Kazakhstan: Policy drivers and barriers in a transitional economy. *Renewable and Sustainable Energy Reviews, 66*, 120-136. Retrieved November 25, 2020, from https://www.sciencedirect.com/science/article/abs/pii/S1364032116303847?via%3Dihub

Mukhamediev R. I., Mustakayev R., Yakunin K., Kiseleva S., & Gopejenko V. (2019, July 6). Multi-Criteria Spatial Decision Making Supportsystem for Renewable Energy Development in Kazakhstan. *IEEE Access, 7,* 122275-122288. Retrieved November 24, 2020, from https://ieeexplore.ieee.org/abstract/document/8813086

Shakeel, S., Takala, J., & Zhu, L. (2017, May 10). Commercialization of renewable energy technologies: A ladder building approach. *Renewable and Sustainable Energy Reviews, 78,* 855-867. Retrieved November 24, 2020, from https://www.sciencedirect.com/science/article/abs/pii/S1364032117306299

United Nations Development Programme (n. d.). Goal 7: Affordable and Clean energy. *Sustainable Development Goals.* Retrieved December 1, 2020 from https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-7-affordable-and-clean-energy.html#:~:text=Investing%20in%20solar%2C%20wind%20and,achieve%20SDG%207%20by%202030

United Nations. (2016, July 16). Specifications for the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 to Renewable Energy Resources. *Twenty-fifth session Geneva, 28–30*. Retrieved November 25, 2020, from https://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/UNFC-Bioenergy-Specifications/Specification_Bioenergy.pdf

Woodcock, L. (1982). International cooperation for effective utilization of energy, resources and environment. *Energy, Resources and Environment, 7–12*, 3-8. Retrieved December 1, 2020, from

https://www.sciencedirect.com/science/article/pii/B9780080293967500082?via%3Dihub