The Global Energy Association and the perspectives of future development of the energy sector within the Fourth Industrial Revolution

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Abstract. The Global Energy Association is the organizer of the Global Energy Prize Summit. The Association also performs a number of programmes for young scientists around the world. The activities of the Association are aimed at ensuring the effective development of energy in the future. New technologies are important as much as the old ones, but the most important thing is to find the way of balancing them. Renewable energy sources are playing a crucial role in the energy sector right now and new methods of using them are emerging. The world is going through the Fourth Industrial Revolution. Ongoing discussions on the topic of the Fourth Industrial Revolution and especially digitalisation of the energy sector showed that the latter is developing in two directions. First, modern technologies allow calculating the necessary amounts of energy to be obtained from renewable energy sources, taking into account the inconsistency of electricity supply to the network. Second, digital systems can predict consumer demand for energy, which is extremely difficult to accurately calculate given the development of the private energy sector.

1 Introduction

The Global Energy Association is engaged in the development of international research and projects in the field of energy with the support of PJSC Gazprom, PJSC Surgutneftegaz and PJSC FGC UES. The Association manages the international Global Energy Prize, annually organises the Global Energy Summit, and performs a number of programmes for the young scientists from all over the globe. The Global Energy Prize is an international award for outstanding research and development in the field of energy. Since 2003, it has been awarded to 39 scientists from 13 countries: Australia, Canada, Denmark, France, Germany, Iceland, Japan, Russia, Sweden, Switzerland, Ukraine, the UK, and the USA. The award is among the TOP 99 most prestigious and significant international awards according to the IREG International Observatory. Moreover, the Global Energy Prize is included in the official list of the International Congress of Distinguished Awards (ICDA). In ICDA

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prestige rating the Global Energy Prize is in the category of Mega Awards for its laudable goals, exemplary practices, and the overall prize fund. The activities of the Association are also in line with the work to ensure the effective development of world’s future energy mix. Humanity depends on energy. New technologies, as well as the old ones and the possibilities of their balance are all of utter importance. Now renewable energy sources are in vogue while new methods and materials are emerging. It is said, that the world is now undergoing the Fourth Industrial Revolution. Its inevitable consequence is the strong development of alternative energy sources. Expensive “oil times” were the times of profitable investment in green energy, new technologies in production, storage, and energy transfer systems. As a result, alternative energy has received a strong impetus and is now harmoniously integrated with the landscape of new circumstances.

2 Methods

The Global Energy Association is constantly in contact with the Global Energy Prize laureates (Fig. 1). In cooperation with the scientists, it develops common scenarios for the future development of the energy sector. The International Renewable Energy Agency (IRENA), it is an intergovernmental organization acting as the platform for cooperation. It is a center of excellence, repository of political and technological resources and financial knowledge. It drives action on the ground to advance the transformation of the global energy system. IRENA contributes to widespread adoption and sustainable use of all forms of renewable energy sources, including bioenergy, geothermal energy, hydropower, solar and wind energy, in pursuit of sustainable development, access to energy, energy security and low-carbon economic growth and prosperity.

Many energy experts participated in the global discussion. They are Alexey Texler (Governor of Chelyabinsk Region, the Russian Federation), Pavel Livinsky (General Director, PJSC ROSSETI), Christoph Frei (World Energy Council’s Secretary General). It was noted that a large amount of information has always existed in the energy sector, and now there is a unique opportunity to use digitalization to improve business processes.

Experts agreed that over the time the role of renewable energy would increase. The role of active consumer, demand management, and the fast development of the storage systems and increasing number of electric vehicles should be also taken into consideration. The basis for the future transformational process in the electric power industry will be the digitalization of networks. Digitalization plays an essential role for sustainable development economy, energy security, and environmental problems. The development of digitalization is not a goal in itself, but a means of increasing the efficiency of energy companies and business processes in energy management. It was determined that Russia has difficulties with the implementation of distributed generation and renewable energy projects in the country. Taking into consideration that we have a relatively low cost of electricity production it is difficult to develop the hydrocarbon economy, [2-3].

“The development of such areas as renewable energy and distributed generation is complicated because it is hard to compete with current energy mix”, - Pavel Livinsky, General Director, PJSC ROSSETI. A very important challenge is the need to decentralize energy, which is one of key global trends.

Predictions and scenarios differ by the share of renewables in electricity production by 2050.
Uncontested, however, is the claim that the bulk of energy demand in the future will not come from OECD countries, but will move towards China, India and other developing countries. (IEA 2018, IRENA 2019, BP 2019). Consequently, the largest steps towards decarbonization will have to happen in these countries as well, although all scenarios expect a stagnant or even falling energy demand for the industrialized countries (IEA 2018). As a side effect, the shift towards renewables might reduce import dependence of fossil fuels countries. For instance, today Morocco creates 52% of its energy supply from renewable energy sources, while formally it was fully on import dependent.

3 Discussion

Technological innovations in the energy sector affect issues of energy production and consumption.
Concerning energy production, one has to further distinguish mitigation technologies that use fossil fuels but emit considerably less CO2, such as oxygen separation technologies or micro – coal. On the other hand, technologies such as solar energy or petrothermal energy will be most cost efficient ones in the long run. Also, wind turbines and their energy production potential has increased enormously during the last years (IRENA 2019).

Fig. 2. Professor Michael Graetzel – the 2017 Global Energy Prize laureate.

Further, the innovations in ICT technologies will transform the energy sector, such as smart grids or smart meters. It will enable the decentralization of energy production. As pointed out by Mr. Amin, Member of the Global Energy Prize International Award Committee, Director General of the International Renewable Energy Agency (IRENA), a good example is Germany, where already 6 million people consume and produce energy through the fixed feed-in tariffs. Moreover, by transforming other sectors of the economy, ICT technologies affect the energy demand of these activities. Usage of computers, sensors and AI requires electricity, which is why in the future it will become the main energy carrier. Moreover, innovations in the ICT field could accelerate the pace of innovation in the energy - producing sector.

In this sense, photovoltaics is a promising renewable energy source. In this particular area, technological progress also includes disruptive innovation. Uli Lemmer, head of the Department of optoelectronics, Director of the Institute of lighting engineering of the Karlsruhe Institute of technology, presents a case made about perovskite semiconductors, that increase the efficiency of solar cells up to 27%. Moreover, during in recent years, energy production through photovoltaics has been growing strongly. For example, the 2017 Global Energy Prize laureate Michael Gratzel, the inventor of the Graetzel cells, made a revolution in photovoltaics by developing cost-effective and efficient photovoltaic cells that are capable of operating at different frequency ranges of the light flux, up to infrared. Elements can be made flexible and produced in various colors, which expands the possibilities of their use in civil and industrial construction. In 2009, new class of devices was invented based on these cells - perovskite solar cells, the efficiency of them exceeding 22% as of today. Perovskite technologies use 1000 times less expensive light-absorbing materials than silicon batteries and do not require any energy-intensive processes in production. It reduces their cost several – fold and develops a new growing segment in the global market. Currently, Graetzel solar panels (Fig.2) are produced in tens of thousands of square meters, but the experts say that in the next several years this figure will go up to
millions of square meters. This will generate gigawatts of electric power. According to forecasts, at least 20 GW of electricity will be generated annually by 2030.

The 2018 Global Energy Prize laureate Martin Green, who has been making his revolutionary contribution into silicon photovoltaics achieved other tremendous results. Mr. Green invented the PERC solar cell (a solar cell with passivated emitter and rear surfaces). At present, their sales are second – highest in the world, exceeding USD 4 billion. Total sales of solar cells using his technology will exceed USD 1 trillion by 2040. PERC solar cells are becoming the commercial standard all over world. As forecasted, these elements will save an additional USD 750 million in energy generation in Australia alone in the next decade. Also, other technologies such as TEG (Thermo-Electric Generator), innovative batteries, water splitting and fuel cells are under development and could contribute to transforming the energy sector.

Thus, one of the points discussed during the first panel was the role of renewable energy in comparison to fossil fuels in the future energy sector. Scientists presented the prospect of turning electricity into the main source of energy by 2050. However, according to various scenarios, fossil fuels will still be used in future in considerably less amounts compared to the modern ones. The point is some countries cannot make such swift changes towards renewable sources. The reasons for that are lack of access to such energy sources or unstable prices.

The Fourth Industrial Revolution is underway. It will surely bring massive technological transformation to various spheres of modern society. The hope is that the present Revolution will continue the process of developing our society. In that regard, the First Industrial Revolution of the 18-19th centuries will find it logical extension in our time. The question remains whether such transformation will benefit people’s lives around the world. Energy sector should react to changes the 4th Industrial Revolution brings and move towards better efficiency and ecofriendly character. Alongside with that, possible threats and drawbacks should be studied and prepared for considerably. The danger of cyberattacks being one of the most visible and realistic of them should be treated especially carefully. Only by addressing all the possible threats in a well-timed manner we can make the 4th Industrial Revolution spearhead the further development of society. Are we already experiencing this revolution or expecting it? Will it be beneficial or detrimental? And what are the challenges and changes of these developments for the energy sector? At first, a closer look at the notion of the 4th industrial revolution is necessary. Sauro Pasini, the Global Energy Prize expert, President of the International Flame Research Foundation, sums up the idea in a nice way, as it describes the situation where machines, people and physical assets are connected to build one large digital ecosystem. The innovations in ICT technology like the internet of things and the internet of services affect all sectors of the economy and everyday life. This development will lead to changes not only in the production of energy, but also in its consumption. The industry maturity index 4.0 describes the difference between digitalization and industry 4.0. Digitalization includes the first two steps of computerization and connectivity. Industry 4.0. (fig.3) starts with visibility of processes that generate data via sensors [15-18].This kind of data is then analyzed and processed in order to be able to make predictions about what would happen to then react in a flexible way. Looking at these steps of development also sheds light on the social and economic impact of this technological development. Industry Maturity Index; Stage in the industry 4.0. development path (Acatech 2017, courtesy of FIR eV at RWTH Aachen University).

Apart from these technological advances, the social and economic impact of this revolution is estimated to be larger than that of digitalization of the 1990s, because it will also have its effects on business models, and producers and consumers alike. For example, does the industry 4.0 also require a “worker 4.0” as Mr. Pasini points out?
The technological development brings forward two developments in the energy sector. The new ICT technologies enable new forms of energy distribution, e.g. through smart grids or smart metering. The future growth potential of renewable energy sources will emerge not from single technologies but from intelligent integration of existing technological solutions (IRENA 2019). For this, smart devices and smart processes are needed for this. On the other hand, all the new ICT solutions will need electricity, leading to the shift in energy demand towards electricity (IRENA 2018).

There are benefits from the new technologies, such as the improvement in reliability and services, the joint system of producers and consumers and the optimization of working processes. But with new technologies, new problems arise. One problem is the intermittent energy supply from solar and wind power plants. As Veit Hagemeyer, Director of the Institute for Automation and Applied Informatics (IAI) of the Karlsruhe Institute of Technology, pointed out, these imbalances need to be buffered by conventional power plants. However, the integration of the renewable energies, the grids, consumer and mobility solutions with the help of ICT might solve this problem in the long run. And not all technologies are already available. There are fields where more innovation is still needed in order to complete future sustainable energy supply. One of them is energy storage as pointed out by Dominique Fache, Member of the Global Energy Prize International Award Committee, Member of the Board of Directors of Sophia Antipolis Technology Park; Chairman of the Board of Directors of RTF; an independent director. If energy cannot be stored in large volumes, this may lead to energy shortages, when renewable energy sources are not available (no wind, little sun, etc.). This problem can be especially serious on a seasonal basis. However, panelists agree that numerous technologies already exist that are part of this 4th industrial revolution, for example the digital twin, the development of smart machines and systems and the connection of formerly disjointed activities via remote control, automation and artificial intelligence. Moreover, there is more technological progress going on, also in conventional energy technologies. For example, small-scale liquid natural gas (LNG) is pointed out by Stanislav Roginsky, the Global Energy Association expert, associate professor of National Research University, as well as hydraulic fracturing, the subsea production of oil and gas and solar technology. Nikolai Voropai, Member of the Global Energy Prize International Award Committee, Director of Melentiev Energy Systems Institute, Siberian Branch of the Russian Academy of Sciences; Member of the Technical Committee of IFAC, Member of the International Council on Large Electric Systems of CIGRE, gave an example where the new technological development plays out for producers. He showed how a gas company uses ICT for remote operation and the control of gas fields. Moreover, he showed how heating could be digitalized using smart grids and integrated smart energy systems. Benefits of digitalization are the improvement in reliability and services, the optimization of work processes and joint systems of producers and consumers. However, he also described challenges such as cyber risks alongside disruptive innovation through new technologies that is already happening. And as the connection of energy production, consumption and transport contains larger potential it also creates new risks. Highly integrated systems are needed to provide, for example, the flexibility for including renewables into energy supply. However, they may also increase vulnerability for cyberattacks if security is not paid sufficient attention. These risks for energy production are related to information security, e.g. the risk of data losses for machines or maintenance, the theft of sensitive data through cyberattacks or a low number of qualified workers. (Jiri Tupa et al. 2017).
Fig. 3. Industry-Maturity-Index: Stage in the Industry 4.0. development path (Acatech 2017 with courtesy from FIR e.V. at RWTH Aachen University).

This was also the opinion of the panelists. When they were asked about the most important risks of the new technology, they mentioned cyber attacks against energy providers, producers, grids and technology developers. Thus, the 4th Industrial Revolution will bring universal computerization and an overall digital ecosystem[18-19]. This fact will increase the global need in electricity alongside shifting towards renewable energy. Many spheres are ready for such changes. However, some areas, such as energy storage, cannot correspond to that and needs to be further reformed. Also, the threat of cyberattacks will increase tremendously due to the Industrial Revolution. It is one of the main dangers the new era may bring, which brings the necessity of introducing changes to cybersecurity systems and improving their efficiency.

4 Conclusions

First, fossil fuels are and will be part of the future energy mix. In order to get a hand on climate change, however, their share in the future mix has to decrease considerably as the various sustainable scenarios are showing (IRENA 2018). Another lever to limit CO2 emissions would be carbon capture from the air or already during the process of burning fossil fuels, as in the Allam Cycle (a technology allowing to generate inexpensive and clean energy from hydrocarbon fuels without harmful emissions) (Allam et al 2014). Second, time to influence climate change is running low, given the long operational life of fossil-fueled power plants, which is about 15 years. One way to shift energy production from fossil fuels to solar energy and finance the shift was presented by David Faiman, the Global Energy Prize International Award Committee member, Professor Emeritus of Ben-Gurion University of the Negev. However, this will only be possible if requirements concerning the transportation grid for electricity are met. Several panelists brought up the technology of UHVDC/super grid as the solution to this problem. In connection to this idea, the following decoupling of energy production and energy consumption would open possibilities for developing countries to become energy producers for themselves but also energy exporters for the industrialized countries. This in turn, would spur development in these countries, contributing to SDGs of the UN that were subject to the second panel of the summit. Third, the technologies for a Fourth Industrial Revolution in the energy sector are there already. Starting with innovations that further develop the traditional technologies, such as e.g. smart metering or the Allam cycle, new technologies also push forward renewables, an example being the perovskite solar cell. The innovations in ICT, however, also impact the energy sector in two ways. They have the potential to revolutionize energy production, e.g. through intelligent construction of power plants, smart grids and decentralizing production. On the other hand, all those intelligent solutions will likely lead to a higher energy demand, in particular they will increase demand for electricity (IRENA 2019). However, when
combined with the capabilities of these new, more integrated energy systems, the threats of cyberattacks are increasing and must be taken into account.

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