МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РФ

Национальный исследовательский Томский государственный университет
Томский государственный университет систем управления и радиоэлектроники
Болгарская Академия наук
Академия инженерных наук им. А.М. Прохорова
Международная научно-техническая организация «Лазерная ассоциация»

ИННОВАТИКА-2020

СБОРНИК МАТЕРИАЛОВ

XVI Международной школы-конференции студентов, аспирантов и молодых ученых
23–25 апреля 2020 г.
г. Томск, Россия

Под редакцией А.Н. Солдатова, С.Л. Минькова

Scientific & Technical Translations
STT
ИЗДАТЕЛЬСТВО
Томск – 2020

HOW TO CHANGE ENERGY SYSTEM

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The article discusses the reasons for the energy system changes, such as climate change and the development of technologies. The author also considers two main concepts and their components: the energy trilemma (Energy Security, Energy Equity, and Environmental Sustainability) and 3D (decarbonization, decentralization, digitalization). The final part of the paper discusses democratization as an additional element for forming the 4D concept.

Keywords: energy system, energy trilemma, concept of 3D, concept of 4D, GHG, governance, sustainable development, decarbonization, decentralization, digitalization.

Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time damaging the environment and human health. Recent figures indicate that fossil fuels provided 81% of the world's total energy demand and this level has remained stable for more than three decades.[1] The production and use of energy has multiple unwanted impacts. Climate change and air pollution are the reasons, why part of people think about changes of the energy system. Technologies are developing and digitalization has already affected the energy sector. Despite significant progress in recent years, the world is falling short of meeting the global energy targets set in the United Nations Sustainable Development Goals (SDG) for 2030. [2] So, it's clear, that the pace of change is not sufficient. There are many factors that inhibit changes, they are due to the complexity of the structure of the energy system. After all, the energy system is a system of systems. But global organizations and scientists at universities systematize, simplify, and analyze information from their own point of view. Some of the concepts will be discussed below.

Minimizing environmental externalities, along with security and affordability have often been at the front of decision-making and have tended to be described as an energy trilemma. The World Energy Council's definition of energy sustainability is based on three core dimensions: Energy Security, Energy Equity, and Environmental Sustainability of Energy Systems (Figure 1). Balancing these three goals constitutes a 'Trilemma' and balanced systems enable prosperity and competitiveness of individual countries. [3]

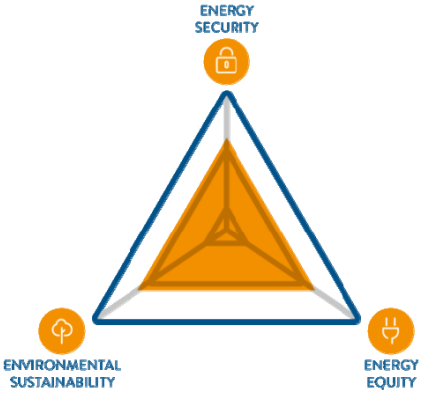

Figure 1. Balancing the 'Energy Trilemma'. © World Energy Council

The concept has been an acceptance that this implies trade-offs between the different dimensions. For example, energy security may be addressed partially by investing in more fossil fuel infrastructure, although that would affect sustainability objectives. The different elements of the trilemma can often be in tension and can carry different (and changing) political weight. As International Energy Agency writes in The World Energy Outlook, a fast-moving energy sector highlights the importance of a broad and dynamic approach to energy security. The attacks in Saudi Arabia in September 2019 underlined that traditional energy security risks have not gone away. Meanwhile, new hazards – from cybersecurity to extreme weather – require constant vigilance from governments [4]. This concept is a base for decision-making in energy system changes, but it does not cover all trends.

Most organizations consider the main trends in changing energy systems as 3D: decarbonization, decentralization, and digitalization [5, 6]. Firstly, the decarbonization of energy systems will be essential to avoid catastrophic climate change. Policies to support renewables have been in place for decades in many countries and have resulted in significant deployment and technology cost reductions (mainly within the electricity sector). If we look at global data on the deployment of renewable energy, there is a clear upward trend in the amount of installed capacity year by year. (Figure 2). The rapid deployment of technologies, combined with high learning rates (i.e. cost reductions as manufacturers/supply chains accumulate experience) are driving down costs for a range of technologies. This is expected to continue for many renewables,

making them increasingly competitive with fossil fuels in countries across the world and the least-cost option in a growing number of markets.

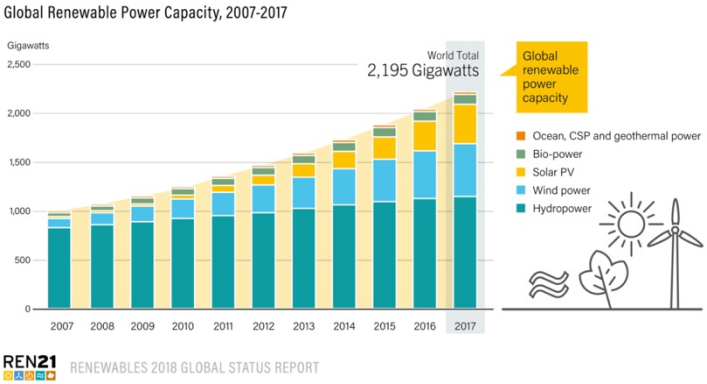

Figure 2. Renewables 2018 global status report

Figures from Bloomberg New Energy Finance forecast note that by 2050, wind and solar technologies will provide almost 50% of total electricity globally – with hydro, nuclear and other renewables taking total zero-carbon electricity up to 71% [7].

Secondly, energy systems are decentralizing. Clean energy technologies such as onshore wind and solar PV are decentralized by their nature. Renewable energy technologies (including storage, smart appliances, and electric vehicles) are often connected to the distribution network (rather than the transmission network), and many are deployed on buildings. Collectively, energy technologies connected at the distribution grid level are referred to as distributed energy resources – or DER.

Thirdly, digitalization has the potential to both support more efficient use of existing energy infrastructure and its operation, and to create new services and business models. In terms of existing infrastructure, greater use of sensors and controls, together with automated collection and analysis of data from geographically-dispersed parts of the gas and electricity networks can help network companies to optimize grid capacity, isolate faults more quickly, or to pre-empt and repair damaged infrastructure. Digital innovation also creates opportunities for the development of entirely new products, services, and business models. Increased numbers of smart appliances could facilitate the development of home automation services enabling households to shift energy-

intensive processes to times of the day when energy is cheaper both benefiting the consumer and relieving grid constraints. Artificial intelligence, machine learning, data collection sensors, and blockchain are the main technologies being developed and implemented. But issues such as the market design for storage, the interface between electric vehicles and the grid, and data privacy all have the potential to expose consumers to new risks.

Professors from the University of Exeter (UK) consider another element in this concept – democratization [8]. Whilst there is already significant momentum evident in the decarbonization and decentralization of energy systems, and digitalization is currently experiencing rapid innovation and growth, there is more uncertainty in relation to how democratic or equitable energy system transformation will be. On the one hand, customers are set to become far more central to the energy system with the ability to generate, store, and sell energy. On the other hand, there are significant uncertainties regarding how the benefits of transformation will be balanced between those able and willing to be engaged and those who are not. Those who are not able or willing to invest in generation and storage technologies or participate in new business models could, therefore, miss out on many of the benefits of energy system transformation. Figure 3 shows the relationship between changes and elements of the 4D concept.

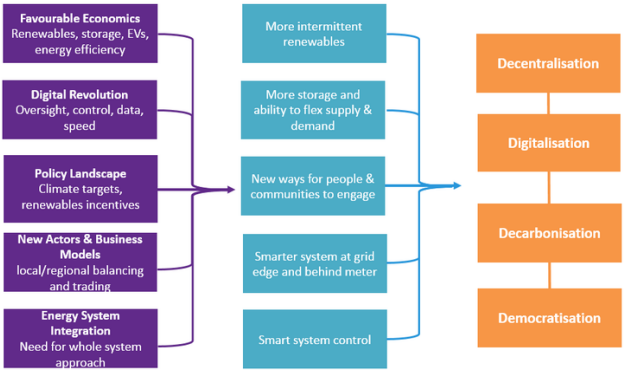

Figure 3. © Adapted from Forum for Future by IGov

The 4Ds of decarbonization, decentralization, digitalization, and democratization are all interrelated. For example, cost reductions in decentralized storage are increasing the viability of solar PV. Moreover, advances in data and analytics further reveal the value of the generation and

shifted demand to the system at different times and in different places. These changes are happening at a decentralized level and are engaging some consumers in transformative new ways with the energy system.

The transformation is already taking place before our eyes and it will continue to happen. The measures taken depend on local and political conditions. Some countries already have green tariffs and ordinary residents can enter the energy market. Some countries, like Australia, face limitations in technology (energy storage) on their way to sustainable energy. These concepts will help in the path of global change.

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