

РОЗДІЛ 4

Наукові повідомлення

Investments in Renewable Energy for Smart Grid Technology Development*

*OLEKSANDRA V. KUBATKOⁱ, TETYANA S. TOLOKⁱⁱ,
HARRISON O. EDAFEJIMUEⁱⁱⁱ, ISMAIL Y. A. ALMASHAQBEH^{iv}*

The current state of economic development foreseen an increasing production processes efficiency and determines the demand for energy resources. At the same time, the global use of traditional energy sources is steadily growing and currently it is still dominant. Considering the empirical arguments regarding environmental degradation and problems related to climate change, the development and implementation of smart and safe energy technologies, such as the Smart Grid, is relevant. Smart and secure power grids today are seen as technologies that facilitate the transition of the energy system supply from traditional electrical networks to more sustainable and environmentally friendly operations. The article deals with theoretical and methodological approaches that reveal the essence of the Smart Grid concept, and analyzes the main areas of investment in such technologies. It is underlined that to ensure energy security and environmental sustainability of energy supply sector the generation of electric power should be based on the use of renewable energy sources. The long-run sustainability of energy sector in climate change conditions is guaranteed by forming deep links between renewable energy generation and Smart Grid technologies. The paper discusses the main factors which may influence the Smart Grid technology development. The investments in renewable energy are named to be the most important factor of Smart Grid technology development. The lack of investments is considered to be an important factor of poor energy efficiency in developing economies. In addition, the article focuses on European experience regarding the implementation of smart and safe energy systems based on renewable energy sources. It is underlined the best EU counties experience for Smart Grid technology development based on investments in renewable energy sector.

Keywords: Smart Grid, renewable energy, economic process, power network, energy supply, efficiency, investment.

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ⁱ *Oleksandra V. Kubatko*, C.Sc. (Economics), Associate Professor, Department of Economics, Entrepreneurship and Business Administration, Sumy State University;

ⁱⁱ *Tetyana S. Tolok*, Student, Oleg Balatskyi Academic and Research Institute of Finance, Economics and Management, Sumy State University;

ⁱⁱⁱ *Harrison O. Edafejimue*, Student, Oleg Balatskyi Academic and Research Institute of Finance, Economics and Management, Sumy State University;

^{iv} *Ismail Y. A. Almashakbeh*, PhD Student of Department of Economics, Entrepreneurship and Business Administration, Sumy State University.

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Introduction. The demand for energy and related services to ensure socio-economic development and population well-being is steadily growing. The society needs the energy to meet basic human needs (e.g., lighting, cooking, spatial comfort, movement, and communication) and to serve production processes. Considering that, the global use of traditional energy sources is steadily growing. The traditional energy sources are dominant in the electricity supply and often related to the deterioration of the environment. Therefore, it is relevant to consider smart and safe energy technologies such as the Smart Grid. Smart and secure power grids today are seen as technologies that facilitate the transition of the energy system from traditional electrical networks to more sustainable and environmentally friendly operations. However, there are contradictions in the scientific community regarding the introduction of such technologies and the possibilities of ensuring energy security and justice. This article analyses theoretical and methodological approaches to defining the concept of a Smart Grid, and also discusses the main areas of investment in such technologies. Additionally, the article focuses on European experience regarding the implementation of smart and safe energy systems.

Analysis of the recent publications. The practical measures to improve energy efficiency and changes in consumer behaviour patterns are the main factors contributing to renewable energy sources and Smart Grid over the past few decades. The other factors contributing to this improvement include: changes in the economic structure of the country, increasing activity in less energy intensive industries, constructive changes that stimulate technological advances of renewable energy products, migration of the population to warmer countries.

The peculiarities of the Smart Grid technology development, as well as best available technologies are analysed in works by many Ukrainian and foreign scientists. Thus, Farhangi H. [1], Hossaina M. et al. [2], Tuballaa M., Abundob M. [3] studied the role of smart grid in the renewable energy and analysed the Smart Grid offers as a sustainable technology (generation and microgrids) which can help to use energy resources more efficiently. At the same time Qian Sun et al. [4], Kappagantu R. et al [5] have estimated the current situation of Smart Grid implementation with an objective to implement smartness in the grid and to increase its reliability, efficiency, customer satisfaction and power quality. Despite deep research on this topic, the research of investments in renewable energy sector is still an important scientific problem for determining the long-run sustainability of energy supply sector through Smart grid technologies.

The purpose of article is research on theoretical and applied economic aspects of the Smart Grid technology development. The task of work: is research of investments influence in renewable energy on the efficiency of Smart Grid technology application in developed and developing economies.

Research results. Global use of traditional non-renewable energy sources is dominant in electricity supply and can lead to environmental degradation. Recent data confirm that fossil fuel consumption accounts for the most of global greenhouse gas emissions of anthropogenic origin. Taking into account the consequences of the impact on the environment and the policy of ensuring energy efficiency in the field of communication technologies, the distribution of electricity systems have to become more environmentally friendly. According to the report [6], the Smart Grids platform is defined as an intelligent power system that integrates the actions of all consumers, generates energy and efficiently supplies sustainable, cost-effective and safe electricity. Similar definitions of Smart Grids as smart energy systems are also discussed in the report [7]. In this case, smart grids – Smart Grids are presented to energy consumers as smart grids capable of generating electricity.

H. Farhangi (2017) identified the smart grid as a new capacity that can provide electrical services with new opportunities, such as management, communication with energy consumers,

and the integration of renewable energy sources. According to this approach, the smart grid will allow energy enterprises to organize work on energy supply more efficiently and at the same time make capital expenditures at the expense of energy saving to increase the operating efficiency of using renewable energy sources [1].

In our opinion, the use of Smart Grid technology as a smart and safe energy network makes it possible to consider various types of energy into electricity at industrial facilities. But to ensure energy security and environmental sustainability, generation of power based on the use of renewable energy sources should be considered. Thus, according to the World Bank estimates and data from the Organization for Economic Cooperation and Development (OECD), countries that have high rates of production and consumption of renewable energy sources stand out (Table 1).

Table 1

Production and consumption of energy from renewable sources
by OECD member countries, 2014–2015

Country	2014			2015		
	Renewable energy consumption (% of total final energy consumption)	Renewable electricity output (% of total electricity output)	Electricity production from renewable sources, excluding hydro-electric (% of total)	Renewable energy consumption (% of total final energy consumption)	Renewable electricity output (% of total electricity output)	Electricity production from renewable sources, excluding hydro-electric (% of total)
Australia	9.28	14.9	7.50	9.18	13.64	8.34
Belgium	9.07	17.08	16.67	9.20	20.80	20.34
Canada	22.02	62.82	5.57	22.03	63.01	6.27
Chile	26.71	42.41	10.13	24.88	43.69	11.93
Finland	41.23	38.58	18.91	43.24	44.49	20.05
Germany	13.38	26.13	22.98	14.21	29.23	26.27
Hungary	15.67	10.68	9.66	15.56	10.58	9.81
Israel	3.68	1.51	1.49	3.71	1.89	1.85
Japan	5.63	14.06	6.30	6.29	15.98	7.76
Mexico	6.88	20.94	15.28	9.03	32.38	24.94
New Zealand	5.66	11.32	11.21	5.89	12.44	12.36
Norway	30.32	79.20	23.31	30.79	80.08	24.58
Poland	57.19	97.66	1.75	57.77	97.71	1.88
Portugal	11.57	12.52	11.14	11.91	13.80	12.69
South Korea	22.30	38.52	3.02	20.88	29.39	3.69
Sweden	49.69	55.84	14.31	53.25	63.26	16.75
UK	7.39	19.26	17.51	8.71	24.84	22.97
USA	8.75	12.95	6.90	8.72	13.22	7.39

Adapted from [8].

For many countries, such as the USA, China, Brazil, Canada, and Germany energy conversion based on renewable energy sources is an essential component of energy supply. Thus, the fraction of renewable energy in total energy production in Germany is 33.1 percent. In other words, in 2017, a third of electricity in Germany was produced from wind, biomass, the sun, and hydroelectric power plants. In 2016, this figure was 29 percent. Without doubt,

the attractiveness of renewable energy sources is its visibility, inexhaustibility, environmental friendliness, and independence from the price situation on world markets of traditional energy sources. Also, the UN Environment Program noted that alternative energy sources accounted for 60 % of the growth of energy potential in Europe and more than 50 % in the United States. Thus, global investment in renewable energy in 2017 reached \$ 279.8 billion, which is 2 % higher than in 2016, even though the cost of wind and solar power has decreased. Investments in renewable energy in developed countries in 2017 decreased by 19 %. Besides, investment has declined in two leading countries, the United States and Japan, as well as in leading European countries, Germany and the United Kingdom. According to the German Association of Energy and Water Management, Germany plans to build and commission 76 power plants with a total capacity of 38 thousand MW by 2020. Also, in September 2017, the governments of the coastal federal lands, business associations and trade unions appealed to the German government to allow the installation of wind generators with a total capacity of 20 gigawatts in the territorial waters of the country until 2030, with a subsequent increase in the limit by 2035 to 30 gigawatts. For comparison: the power of each of the seven German nuclear power plants still in operation is about 1.3–1.5 GW.

According to the report by IEEFA (Institute of Energy Economics and Financial Analysis), China is on its way to becoming the leading international investor in renewable energy, because in recent years, it has increasingly invested in green projects in other countries.

It should be noted that the countries of the European Union, the USA and Ukraine have certain contradictions and problems of primary energy reduction and implementation of energy efficient measures. However, at the legislative level, all countries are trying to formulate goals for increasing energy efficiency and disseminating energy efficiency experience at the international level.

The China has spent almost \$ 45 billion on clean energy. China has exported solar panels for \$ 8 billion, which is significantly higher than Germany and the United States. [9]. China also plans to invest 361 billion US dollars in renewable energy sources by 2020. Besides, as part of this plan, it is planned to create 13 million jobs in the energy sector and increase the fraction of renewable sources in total electricity generation to 15 percent, which is equivalent to 580 million tons of coal.

Also, a significant increase in investment was provided by developing countries: Mexico, Egypt, the United Arab Emirates, and Argentina [10]. It is assumed that renewable energy in the UAE is a real opportunity to ensure the long-run energy independence of the state. Thus, in 2015, the construction of a solar power plant began in Dubai. The presence of such a large project, according to experts, will attract the attention of investors from around the world to the national alternative energy in the UAE. Also, by 2030, 5 % of all energy in the United Arab Emirates will come from solar panels. Today, the state finances large-scale projects from alternative energy sources around the world, actively lending to the construction of renewable energy facilities in Iran, Mauritania, Argentina, Cuba, and St. Vincent Islands [9].

Thus, according to the results of 2017, global investments in the production of renewable energy, not including hydroelectric power plants, amounted to \$ 279.8 billion. The fraction of total investment in the development of solar energy was 57 %, which is about \$ 160.8 billion, and increased by 18 % compared with 2016. This figure exceeds the volume of investments in gas and coal-fired capacity by about 103 billion US dollars. More than half of all solar power plants are in China. Also, participating countries using solar cells are Australia, Mexico, and Sweden [11] (Fig. 1).

According to experts, investments in renewable energy in the US in 2016 accounted for \$ 56.9 billion, becoming the second largest investor in “clean” energy. However, in 2017, the United States spent \$ 40.5 billion, while demonstrating a slight decrease in investment.

Besides, in 2017, significant investments in renewable energy sources were made by Australia (increased by 150 % to 8.5 billion dollars) and Mexico (increased by 516 % to 6 billion dollars) [12].

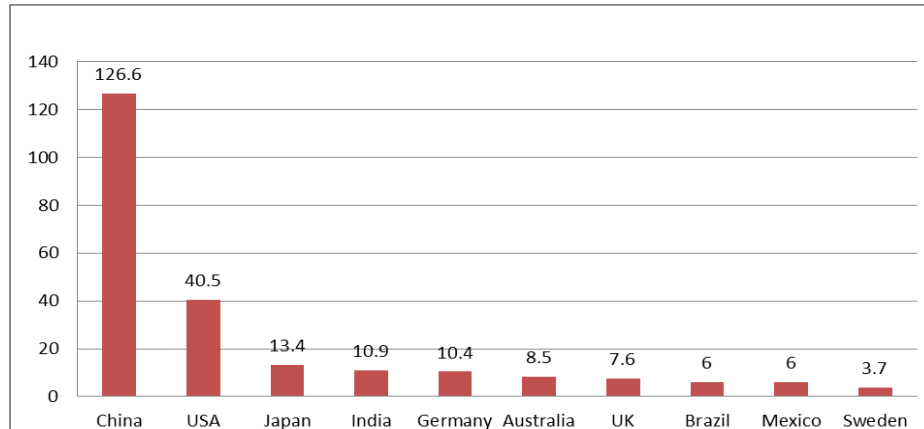


Figure 1. Renewable energy investments in 2017, billion \$ [build by authors using data 10]

At the same time, global solar energy showed an extraordinary result – 161 billion US dollars were invested in the sector (48 % of the total investment). Thus, China, in which investments in solar energy grew by 58 %, according to BNEF, put into operation 53 GW of solar power plants (against 30 GW in 2016) [13].

However, UNEP experts in the Global Energy Investment Trends Report, prepared by the United Nations Environment Program, report a reduction in investments in renewable energy, for example, investments in the United States decreased by six percent to \$ 40.5 billion. At the same time, there was a decline in investment in VEI in European markets. In Europe, the volume of such investments fell by 36 % to \$ 40.9 billion. For example, in the UK they fell by almost half (by 65 % to \$ 7.6 billion) and in Germany (by 35 % to \$ 10.4 billion). In general, in the European market, investments in clean energy declined by 26 % – to 57.4 billion dollars, in the USA they have kept it at about the same level for the last three years. Investments in renewable energy in Japan decreased by 28 % to \$ 13.4 billion [12, 13]. But, despite these arguments, UNEP experts point to a positive future trend in the growth of investment in VEI. In the period from 2007 to 2017, the RES projects received an investment of \$ 2.7 trillion. Thus, the world has seen an increase from 5.2 % to 12.1 % of the fraction of electricity produced using wind energy, solar panels, waste, geothermal sources, sea waves, and small hydro objects.

Conclusions. Renewable energy sources and their integration into the existing system remain a main challenge for energy policy promotion both at developed and developing economies. Therefore, the expansion of electricity grids and the development of appropriate storage facilities are the basis for the successful integration of renewable energy sources into the Smart grids. Thus, for 2017 in Europe, 73.4 % of investments in the electric power industry accounted for renewable energy sources. It is also predicted that renewable energy will attract \$ 7.8 trillion of investments by 2040. In Europe, renewable energy will cover 70 % of needs by 2040, in the USA – 44 %. Also, according to the long-term forecasts of Bloomberg New Energy Finance (2017), the share of wind and solar power generation in the global energy basket is expected to increase sixfold by 2040 and exceed all other forms of

energy [14, 15]. The use and distribution of renewable energy sources in the smart grid system provided about 6 % of new connections to electricity throughout the world from 2012 to 2016. In some countries, smart grids play a crucial role in meeting the energy needs and livelihoods of millions of people living in rural and remote areas of the world.

Definitely the attractiveness of renewable energy sources is guaranteed by its inexhaustibility, environmental friendliness, independence from volatilities on global economic markets and independence from traditional energy sources markets.

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**Инвестиции в развитие возобновляемой энергетики
для технологий Smart Grid**

АЛЕКСАНДРА ВИКТОРОВНА КУБАТКО^{*},
ТАТЬЯНА СЕРГЕЕВНА ТОЛОК^{},**
ХАРРИСОН ОМУВИ ЭДАФЕДЖИМУЕ^{*},**
ИСМАИЛ ЮСЕФ АЛИ АЛЬМАШАКБЕХ^{**}**

^{} кандидат экономических наук, доцент, старший преподаватель кафедры экономики, предпринимательства и бизнес-администрирования Сумского государственного университета, ул. Р.-Корсакова, 2, г. Сумы, 40007, Украина, тел.: 00-380-542-332223, e-mail: o.kubatko@econ.sumdu.edu.ua*

*^{**} студентка Учебно-научного института финансов, экономики и менеджмента имени Олега Балацкого Сумского государственного университета, ул. Р.-Корсакова, 2, г. Сумы, 40007, Украина, тел.: 00-380-542-332223, e-mail: tolok@i.ua*

*^{***} студент Учебно-научного института финансов, экономики и менеджмента имени Олега Балацкого Сумского государственного университета, ул. Р.-Корсакова, 2, г. Сумы, 40007, Украина, тел.: 00-380-542-332223, e-mail: harrisonomovie@ymail.com*

*^{****} аспирант кафедры экономики, предпринимательства и бизнес-администрирования Сумского государственного университета, ул. Р.-Корсакова, 2, г. Сумы, 40007, Украина, тел.: 00-380-542-332223*

Современный этап развития экономических отношений предусматривает повышение эффективности производственных процессов и обуславливает потребности в энергообеспечении. При этом глобальное использование традиционных источников энергии неуклонно растет и является, по сути, доминирующим. Учитывая доводы ученых относительно ухудшения качества окружающей среды и проблем, связанных с изменением климата, актуальным является рассмотрение и внедрение умных и безопасных энергетических технологий, таких как Smart Grid. Умные и безопасные электросети на сегодняшний день рассматриваются как технологии, способствующие переходу системы от традиционных электрических сетей к более устойчивым и экологически безопасным системам. В статье рассмотрены теоретико-методические подходы, которые раскрывают сущность концепции Smart Grid, а также проанализированы основные направления инвестирования в подобные технологии. Подчеркивается, что для обеспечения энергетической безопасности и экологической устойчивости сектора энергоснабжения производство электроэнергии должно основываться на использовании возобновляемых источников энергии. Долгосрочная устойчивость энергетического сектора в условиях изменения климата гарантируется путем формирования глубоких связей между производством возобновляемой энергии и технологиями Smart Grid. В статье рассматриваются основные факторы, которые могут повлиять на развитие технологии Smart Grid. Инвестиции в возобновляемую энергию названы наиболее важным фактором развития технологии Smart Grid. Отсутствие инвестиций считается важным фактором низкой энергоэффективности в развивающихся странах. Кроме того, статья посвящена европейскому опыту внедрения интеллектуальных и безопасных энергетических систем на основе возобновляемых источников энергии. Подчеркивается лучший опыт стран ЕС по развитию технологий Smart Grid на основе инвестиций в сектор возобновляемых источников энергии.

Ключевые слова: Smart Grid, внутренняя энергетика, экономический процесс, энергосбережение, экономическая помощь, эффективность, инвестиция.

Інвестиції в розвиток відновлюваної енергетики для технологій Smart Grid

ОЛЕКСАНДРА ВІКТОРОВНА КУБАТКО^{*},
ТЕТЯНА СЕРГІЇВНА ТОЛОК^{},**
ХАРРИСОН ОМУВІ ЕДАФЕДЖІМУЄ^{*},**
ІСМАІЛ ЮСЕФ АЛІ АЛЬМАШАКБЕХ^{**}**

** кандидат економічних наук, доцент, старший викладач кафедри економіки, підприємництва та бізнес-адміністрування Сумського державного університету, вул. Р.-Корсакова, 2, м. Суми, 40007, Україна, тел.: 00-380-542-332223, e-mail: o.kubatko@econ.sumdu.edu.ua*

*** студентка Навчально-наукового інституту фінансів, економіки та менеджменту імені Олега Балацького Сумського державного університету, вул. Р.-Корсакова, 2, м. Суми, 40007, Україна, тел.: 00-380-542-332223, e-mail: tolok@i.ua*

**** студент Навчально-наукового інституту фінансів, економіки та менеджменту імені Олега Балацького Сумського державного університету, вул. Р.-Корсакова, 2, м. Суми, 40007, Україна, тел.: 00-380-542-332223, e-mail: harrisonotomie@yemail.com*

***** аспірант кафедри економіки, підприємництва та бізнес-адміністрування Сумського державного університету, вул. Р.-Корсакова, 2, м. Суми, 40007, Україна, тел.: 00-380-542-332223*

Сучасний етап розвитку економічних відносин передбачає підвищення ефективності виробничих процесів і обумовлює потреби в енергозабезпеченні. При цьому глобальне використання традиційних джерел енергії неухильно зростає і є, по суті, домінуючим. З огляду на доводи вчених щодо погіршення якості навколишнього середовища і проблем, пов'язаних зі зміною клімату, актуальним є розгляд і впровадження розумних і безпечних енергетичних технологій, таких як Smart Grid. Розумні і безпечні електромережі на сьогоднішній день розглядаються як технології, що сприяють переходу енергетичної системи від традиційних електричних мереж до більш стійких і екологічно безпечних. У статті розглянуті теоретично-методичні підходи, які розкривають сутність концепції Smart Grid, а також проаналізовані основні напрямки інвестування в подібні технології. Підкреслюється, що для забезпечення енергетичної безпеки та екологічної стійкості енергопостачання виробництво електроенергії має базуватися на використанні відновлюваних джерел енергії. Довгострокова стійкість енергетичного сектору в умовах зміни клімату гарантується формуванням глибоких зв'язків між виробництвом відновлюваної енергії та технологіями Smart Grid. У статті обговорюються основні фактори, які можуть вплинути на розвиток технологій Smart Grid. Інвестиції у відновлювану енергетику названі найважливішим фактором розвитку технологій Smart Grid. Відсутність інвестицій вважається важливим фактором низької енергоефективності в країнах, що розвиваються. Крім того, в статті розглядається європейський досвід впровадження інтелектуальних та безпечних енергетичних систем на основі відновлюваних джерел енергії. Підкреслюється найкращий досвід країн ЄС для розробки технологій Smart Grid на основі інвестицій у сектор відновлюваної енергетики.

Ключові слова: Smart Grid, відновлювальна енергетика, економічний процес, енергомережа, енергопостачання, ефективність, інвестиція.

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