DOI 10.22394/1726-1139-2023-11-132-139

Improving the Energy Sector and Renewable Energy Resources in Egypt

(Challenges, Achievements, And Most Important Projects)

Oleg N. Misko, Alaa Sh. Darwish*

Russian Presidential Academy of National Economy and Public Administration (North-West Institute of Management of RANEPA), Saint Petersburg, Russian Federation; *misko-on@ranepa.ru

ABSTRACT

Egypt faces a challenge in providing sufficient resources for energy needs, especially, since Egypt relies mainly on oil and natural gas to meet its energy needs, on which the percentage of dependence has reached 95% of Egypt's total energy needs. All studies indicate that despite Egypt's possession of reserves from these sources, due to the growing use of these resources and the high cost of extracting them, Egypt will face a deficit in covering its needs from these resources. Although it is expected that the balance between oil and gas production will return with uses within few years after overcoming the economic difficulties that faced the oil and gas sector, according to Egypt's energy strategy for the year 2030 and its current update to reach it for the year 2035, it is expected that Egypt will become a permanent importer. Oil and gas within a period not exceeding several years from the beginning of the third decade of this century. This situation represents an additional challenge to the Egyptian economy, as it becomes exposed to price turmoil in the global energy markets, which cannot be expected or controlled. This is in addition to the drain on Egypt's foreign exchange resources, the impact on the balance of trade, and the reduction of the competitiveness of the national economy. Therefore, the diversification of energy sources must be reconsidered in order to achieve maximum benefit from local resources, which are characterized by sustainability and stability in prices, which are features that characterize electricity production projects from renewable sources, taking into account Egypt's richness in these resources.

Therefore, Egypt has already started implementing many projects that work to provide Egypt's energy needs, through the project of the nuclear power plant in "Al-Dabaa" in northern Egypt on the Mediterranean coast, as well as power generation projects from renewable energy sources available in Egypt, such as "wind energy" and "solar energy".

Keywords: Egypt, Economy, Energy, Resources, Renewable Energy, Electricity, Wind Energy, Solar Energy

For citing: Misko O. N., Darwish A. Sh. Improving the Energy Sector and Renewable Energy Resources in Egypt (challenges, achievements, and most important projects) // Administrative consulting. 2023. N 11. P. 132–139.

Совершенствование энергетического сектора и возобновляемых источников энергии в Египте (проблемы, достижения и наиболее важные проекты)

Мисько О. Н., Дарвиш А. Ш.*

Российская академия народного хозяйства и государственной службы при Президенте Российской Федерации (Северо-Западный институт управления РАНХиГС), Санкт-Петербург, Российская Федерация; *misko-on@ranepa.ru

РЕФЕРАТ

Египет сталкивается с проблемой обеспечения достаточных ресурсов для удовлетворения энергетических потребностей, особенно потому, что Египет в основном полагается на нефть и природный газ для удовлетворения своих энергетических потребностей, процент зависимости от которых достигает 95% от общих энергетических потребностей Египта. Все исследования показывают, что несмотря на наличие у Египта запасов из этих источников, из-за растущего использования этих ресурсов и высокой стоимости их добычи Египет столкнется с дефицитом покрытия своих потребностей. Хотя ожидается, что баланс добычи нефти и газа восстановится в течение нескольких лет после преодоления эконо-

мических трудностей, с которыми столкнулся нефтегазовый сектор, однако в соответствии с энергетической стратегией Египта на 2030 г. и ее текущим обновлением, чтобы достичь ее к 2035 г. ожидается, что Египет станет постоянным импортером. Эта ситуация представляет собой дополнительную проблему для египетской экономики, поскольку она подвергается воздействию ценовых потрясений на мировых энергетических рынках, которые невозможно предвидеть или контролировать. Это в дополнение к истощению валютных ресурсов Египта, влиянию на торговый баланс и снижению конкурентоспособности национальной экономики. Следовательно, необходимо пересмотреть диверсификацию источников энергии, чтобы получить максимальную выгоду от местных ресурсов, которые характеризуются устойчивостью и стабильностью цен, что является чертой, характеризующей проекты производства электроэнергии из возобновляемых источников, принимая во внимание богатство Египта этими ресурсами.

Поэтому Египет уже приступил к реализации многих проектов, которые работают на обеспечение энергетических потребностей страны, посредством проекта атомной электростанции в «Ал-Дабаа» на севере Египта на побережье Средиземного моря, а также проектов по выработке электроэнергии из доступных возобновляемых источников энергии, таких как энергия ветра и солнечная энергия.

Ключевые слова: Египет, экономика, энергия, ресурсы, возобновляемая энергия, электричество, энергия ветра, солнечная энергия

Для цитирования: *Мисько О. Н., Дарвиш А. Ш.* Совершенствование энергетического сектора и возобновляемых источников энергии в Египте (проблемы, достижения и наиболее важные проекты) // Управленческое консультирование. 2023. № 11. С. 132–139.

1. Introduction

Egypt has a significant role in the international energy market due to many reasons, particularly due to its location [15]. Egypt is located in North Africa and the Arab region with approximately 3000 km of coastlines on the Mediterranean, Red Sea, and the Gulf of Suez and Aqaba, and also at the crossroads between Europe, Middle East, Asia, and Africa [20]. Additionally, Egypt is home to one of the key transportation routes of the world 'the Suez Canal' and the Suez-Mediterranean Pipeline (SUMED). These help Egypt to be in a strategic position in the international energy market.

Egypt is Africa's greatest oil exporter, despite not being an associate with the Organization of Petroleum Exporting Countries (OPEC) [1]. It is also the continent's second largest supplier of natural gas. The country is, nevertheless, Africa's largest user of oil and natural gas, with a growth rate in energy utilization greater than 6% per annum [4]. Global power requirements are primarily fulfilled by oil and natural gas, which are the most extensively used fuels, with natural gas accounting for 95% of total world energy consumption [19]. Provided that the Egyptian government still meets its growing energy demand using the conventional power generation techniques, CO2 emissions are expected to increase from around 800 Mmt in 2012 to above 1800 Mmt in 2035, marking a massive 125% increment [8].

Egypt witnessed violent political, economic and social unrest after the revolution of January 25, 2011, and this state of instability continued for more than three years, until the revolution of June 30, 2013, and President Abdel Fattah El-Sisi took over the reins of power in Egypt in the middle of the year. In 2014, the return to stability gradually began. Since then, the Egyptian government has begun to develop a new strategy in order to improve the conditions of the Egyptian citizen economically, socially, and environmentally which is the strategy of "Egypt's Vision 2030" [10].

Egypt's Vision 2030 strategy relies on three main dimensions to achieve its goals, which are summarized in achieving sustainable development and improving the quality

of life of the Egyptian citizen. The strategy also aims for Egypt to be among the best thirty countries in the world in terms of economic development indicators, combating corruption and human development, market competitiveness and quality of life [10].

The energy pillar is considered one of the most important pillars on which the economic dimension of the strategy depends in achieving its desired goals, which required a lot of work, effort and attention from the government, especially after the difficult period of revolutions that Egypt went through, which led to a significant deterioration of the economic situation due to the great shortage of energy sources needed to meet the needs of the various economic sectors, as well as the family sector. That period witnessed power outages for very long periods during the day, in daily manner, in addition to the severe shortage of Petroleum derivatives and fuels such as (gasoline and diesel), which had a significant negative impact on the economic activity and the social aspect in Egypt during that period. Indeed, the government has begun to implement the part of the energy file stipulated in the strategy (Egypt's Vision 2030) quickly and effectively.

Egypt, like most countries in the world, at present relies more heavily on non-renewable resources than renewables; more than 90 percent of its power supply is generated from fossil fuels (Petroleum Oil, Coal, Natural gas) [11].

But it is expected that the country's reserves of crude oil, which is natural gas from non-renewable energy sources, will be depleted within 15 years or so [3], and accordingly the government moved to reconsider diversifying energy sources to make the most of local resources that are characterized by sustainability and stability in Prices, which are characteristics of electricity production projects, whether through renewable energy sources and nuclear energy.

One of the major contributors for the development in Egypt is the energy sector. It generates more than 20% of the total GDP and more than 300,000 people are employed in such sector in year 2017 [26]. So, If Renewable Energy projects will rise and increase, then this will create more job opportunities that will definitely reduce the unemployment. The usage of Renewable Energy will encourage businesses and firms to put into consideration opening businesses with the aim of providing Renewable Energy. This will increase the domestic competition, and the competition among different countries will increase since the high-tech inputs needed for energy can accelerate exports. In addition, substituting energy to the usage of more Renewable Energy will have a direct positive effect on subsidies. Giving more support for investments of Renewable Energy to switch the usage of diesel generators to solar pumping especially in agriculture, this will give the chance for many small domestic firms to compete in such field and this will replace the subsidy for diesel.

The problem here is that since year 2007, the country faced many obstacles in such sector especially in the electricity due to the tremendous increase in electricity consumption. Regarding the renewable energy, from the beginning of year 2008, the awareness concerning the crucial importance of RE has increased. This was obvious by adopting new national RE strategy by Egyptian solar plan and by announcing the feed-in tariff for wind and solar photovoltaic (PV) projects. There was tax reduction applied for the renewable equipment in 2014 and offering tax incentives for Renewable Energy in 2015 [16].

Egypt's Vision 2030 anticipates that the energy sector will be able to meet all the requirements of sustainable development using renewable energy resources and maximize the utilization of its both non-renewable and renewable resources. The aim is to contribute effectively to promoting economic growth, competitiveness and social justice, as well as preserving the environment and achieving leadership in the development of renewable energy sources while keeping pace with the international goals of sustainable development [9].

2. The renewable energy resources in Egypt

In Egypt, there are many kinds of renewable energy resources.

2.1. Hydroelectricity

Hydropower is an integral part of the electricity generation of many countries. Some countries such as India, Russia, Canada, the United States, Brazil, China and Norway generate at least 50% of their electricity from hydro; where the estimated global hydropower capacity has increased from 35 GW in 2014 to about 1055 GW as of July 2018. It has been predicted that hydropower will account for around 15% of the world's electrical energy needs by 2040. Hydropower is the highest utilized renewable energy source worldwide, and its growth is expected to continue due to its effectiveness and given the future availability of water sources [3].

The River Nile is Egypt's most important hydroelectric resource, with the greatest potential at Aswan, where a series of hydropower stations are located, with a combined capacity of 2,800 MW and a corresponding annual electric generation capacity of 13,545 GWh [2]. Egypt's hydroelectric power capacity accounted for approximately half of the country's total energy generation capacity between 1960 and 1970. However, as a result of the escalation in the segment of thermal power plants, the energy share generated from hydroelectric power stations has decreased dramatically denoting 7.2% of the overall electricity generated in the years 2015 and 2016. By 2011/2012 to 2015/2016, Egypt's hydropower industry has grown at the fastest pace of any of the country's renewable energy technologies, with a mean growth rate of 1.2% per annum in power generated from hydroelectric facilities [5]. Unfortunately, due to the governmental focus on solar, wind, and conventional power stations utilizing gas turbines, the development in hydropower station has ceased since 2016.

2.2. Solar Energy

Egypt has the highest daily typical irradiance values in Northern Africa, averaging from 2000 to 3200 kWh/m2/y with average sunshine of 9–11 h/d. In 2020, solar energy in Egypt accounted only for 1.9% of the produced electricity, making it the country's second-highest renewable energy source. Egypt is the second-highest solar energy generator in Africa after South Africa, whilst it is the thirty-first worldwide [21].

Egypt possesses extraordinary solar resources that can be applied to a vast variety of solar energy systems and industries, including photovoltaic (PV) or concentrated solar power (CSP) plant establishments [6]. Egypt has a solar energy potential of 74 billion MWh per year, according to the Global Solar Atlas [14].

Solar energy projects have long been noted to be economically viable. Numerous solar energy collection and generation projects have been built or are in the process of being built to collect solar energy and produce electrical power using a variety of solar energy technologies [28].

The most three major solar power projects in Egypt, which are the "Beneban Solar Park", "Siwa Solar Plant", and "Kuraymat Concentrated Solar Power (CSP) plant". Benban Solar Park is expected to grow to be the world's largest solar photovoltaic facility when completed forecasting an average contribution to the total electricity generation in Egypt of approximately 18% [18]. Moreover, the Siwa Solar Plant is an off-grid station that is not connected with the national electricity grid, providing power to around 6,000 houses, accounting for 30% of the entire electrical demand in Siwa City and its environs. Furthermore, the Kuraymat power plant is an integrated solar combined cycle, where the supremacy of solar energy and the advantages of a combined cycle are blended into a single system accounting for 3% of the total energy production in Egypt [1].

2.3. Wind Energy

Egypt is endowed with a plethora of inexhaustible wind energy supply, specifically in the region of the Sinai Peninsula and areas surrounding the Gulf of Suez. Egypt is one of the foremost places on Earth for harvesting wind energy [28] because of its high consistent wind velocities, which vary between 8 and 10 meters per second at a height of 100 m, and the presence of large uninhabited deserted regions. Egypt enjoys excellent wind along the Gulf of Suez with an average wind speed of 10.5 m/sec. It is just one of 38 countries in the world with a published National Wind Atlas. Egypt's wind-generated power capacity is expected to reach 7 GW by 2023, making it an important contributor to the renewable energy mix.

Since 2001, a series of large-scale wind farms with a total capacity of 1.2 GW were established in cooperation with Germany (KFW), Denmark (DANIDA), Spain (Siemens Gamesa), and Japan (JICA).

In the Gulf of Suez, a 540 MW project is under construction, with another 580 MW project in financing. In addition, a feasibility study is underway for a 200 MW project in the West Nile. More projects are under preparation in cooperation with Germany, AFD, EIB and the EU (200 MW), MASDAR (200 MW), Germany and AFD (200 MW), and Japan (200 MW).

The Egyptian government recently allocated around 7,845 square kilometers in the Gulf of Suez region and the Nile Banks for NREA to implement additional wind energy projects. The 262.5 MW Ras Ghareb wind farm project near the Gulf of Suez was inaugurated in December 2019. Executed by a consortium led by the French company Engie (Engie 40%, Toyota Tsusho 40%, and Orascom 20%), the farm will supply power to approximately 500,000 households. It is the first project in wind energy to follow the BOO (Build-Own-Operate) model. Additionally, Lekela's West Bakr Wind Farm located Gulf of Suez will generate 250 MW of clean energy. This project is a BOO (Build, Own, and Operate).

The government is working on refurbishing and repowering NREA's wind farms in Zaafarana and Gabal El Zeit with additional pipeline capacity. Preliminary estimates indicated that Zaafarana projects can yield a significantly higher energy and have improved efficiency at a much lower cost with the refurbishment of some turbines according to the Minister of Electricity and Renewable Energy. This farm includes around 700 turbines [18].

2.4. Bioenergy

Egypt has multiple unused energy sources, whilst the extensively used resources for power generation are limited to petroleum and natural gases. The nation generates vast quantities of solid waste which were recorded to be 89 Mt in 2012. If used optimally, through solid waste recycling processes rather than dumping into landfills or incinerating, these wastes could be a hidden treasure for centuries, generating enough electricity to supply millions of houses. This would significantly reduce the need to obtain energy from other conventional resources. [3].

Egypt has excellent potential for bioenergy resources for applications such as heat and combined power plants. Egypt produces a substantial quantity of biomass of approximately 40 Mt/y. The agricultural sector constitutes around 14.5% of the gross domestic products in the national economy as of 2014 [22]. The largest volume of residues is generated from the agricultural sector every year, followed by municipal and animal wastes. Open burning is the most frequently used technique for waste disposal in Egypt. Around 52% of agricultural residues have been directly burned in fields or in effective burners. Egypt is one of the eleven fastest-growing countries emitting greenhouse gases globally and the main contributors to these emissions are wastes from the agriculture, energy, and industry sectors [12]. To overcome this problem, residues from agriculture should be used as feedstock to generate energy. These residues are divided mainly into two types: livestock and crop residues.

3. The renewable energy sector's challenges in Egypt

There are many challenges facing the renewable energy sector in Egypt, which the government had to overcome in order to be able to carry out a comprehensive development process for this sector, which are technical, manufacturing, political and economic challenges.

The manufacturing of Renewable Energy technologies is challenged by the following factors:

1. Lack of competencies [7]: this includes a lack of qualifications for operation and maintenance. Egyptian technology is still under development in the solar energy field and investments, are still at the experimental stage and have not reached the level of massive production [24].
2. Low command of technologies: this includes lack of technical knowledge about the design and manufacturing of solar energy components and the design of wind energy components.
3. Lack of extensive use of geothermal energy resources: there is a considerable lack of suitable equipment for direct geothermal applications, and the available equipment is operating with low efficiencies and poor durability. This means the country has not reached the international level in terms of technological development.
4. Absence of specialized training centers for skills development.
5. The shortage of individuals skilled in RE technology is one of the main barriers that can hinder the rise in the RE generation [23].
6. Technical challenges due to the absence of adequate storage technologies [7].
7. The low production rates are due to the absence of investments and governmental initiatives.

As for the legislative challenges, which are among the reasons for slowing the development of the renewable energy sector in Egypt, which are:

1. The missing of the standards and norms: the lack of the establishment of a coherent regional regulatory framework (including conditions for electricity trade, regulation, etc.).
2. Non-harmonized regulations between the government sectors.
3. Limited grid access for third parties and limited capacity of the electrical grids [7].
4. Lack of guidelines and regulations or decrees governing geothermal energy. The government is still lagging behind in terms of investment opportunities and support for the industrialization of geothermal energy.
5. The lack of governmental control on the investment scale in the renewable energy sector and the adaptation of industrial investment direction.
6. Non-governmental organizations are not participating in the publication of RE [13].

The development of Renewable Energy industries encounters some economic challenges that include:

1. Fossil fuel subsidies: the low energy prices (mostly for conventional non-renewable energies) resulted in over-dependency on the conventional energy resources and limited the attraction towards the slightly high-priced Renewable Energy technologies.
2. Some rural communities are below the poverty line, not supported by government subsidies, and cannot afford to consume costly Renewable Energy [27].

Additionally, one of the most important challenging factors that impede the implementation and the financing of renewable energy technologies in Egypt is the infrastructure, especially in transmitting energy from wind farms which requires transmitting electricity to special substations and high voltage cables.

4. The nuclear energy

On November 19, 2015, Egypt signed an IGA with Russia for the construction and operation of NPP [17]. The nuclear power plant will be set up at El Dabaa, located in the province of Marsa Matruh on the Mediterranean coast.The plan will be implemented by a Russian state-owned company (Rosatom). The reactor will consist of four nuclear power units, each of which will be able to produce 1,200 megawatts of power (4,800 megawatts). Work on the El Dabaa station, west of Alexandria, began in December 2017 and the company will maintain the station's four reactors for 60 years [25].

The first 1200 MW reactor is expected to enter commercial operation in 2026. The remaining three reactors should be up and running by 2028, Rosatom has announced.

References

1. Abdelrahman Tarek, Mohamed Gaber, Nour A. Moharram, Seif Bayoumi. Brief review on Egypt's renewable energy current status and future vision // Energy Reports. 2022. Vol. 8. Suppl. 9. P. 165–172. DOI: 10.1016/j.egyr.2022.06.103.
2. Abdel-Shafy H.I., Kamel A.H. Groundwater in Egypt issue: Resources, location, amount, contamination, protection, renewal, future overview // Egypt J Chem. 2016. Vol. 59. P. 321–62.
3. Abeykoon C., Mahmoud Eltaweel, Salah, Salma I. Towards a sustainable energy future for Egypt: A systematic review of renewable energy sources, technologies, challenges, and recommendations // Cleaner Engineering and Technology. 2022. Vol. 8. P. 100–497. DOI: 10.1016/j.clet.2022.100497.
4. Al-Riffai P., Breisinger C., Eldidi H., Mondal Mah et al. Long-term optimization of Egypt's power sector: Policy implications // Energy. 2019. Vol. 166. P. 1063–1073. DOI: 10.1016/j.energy.2018.10.158.
5. Aliyu A.K., Modu B., Tan C.W. A review of renewable energy development in Africa: A focus in South Africa, Egypt and Nigeria // Renew Sustain Energy Rev. 2018. Vol. 81. P. 2502–2518. DOI: 10.1016/j.rser.2017.06.055.
6. Bayoumi S., El-Maghlany W.M., Hanafy A.A., Moharram N.A. Techno-economic analysis of a combined concentrated solar power and water desalination plant // Energy Convers Manag. 2021. Vol. 228. P. 113–629. DOI: 10.1016/j.enconman.2020.113629.
7. Berrada A., Loudiyi K., Mentesidi K., Svendsen H.G. Grid code status for wind farms interconnection in Northern Africa and Spain: descriptions and recommendations for Northern Africa // Renew. Sustain. Energy Rev. Vol. 81. P. 2584–2598. DOI: 10.1016/j.rser.2017.06.065.
8. Bottoms I. Egypt's Future Electricity Pathways [Electrpnic source]. URL: https://ecesr.org/wp-content/uploads/2016/03/80-Gigawatts-of-Change-En-Pages.pdf (accessed: 12.10.2023).
9. Central Agency for Public Mobilization and Statistics (CAPMAS). Egypt Vision 2030: Sustainable Development [Electrpnic source]. URL: http://sdsegypt2030.com/wp-content/uploads/2016/05/الاستراتيجية-التنمية-المستدامة-رؤية-مصر-2030.pdf (accessed: 12.10.2023) (in Arabic)
10. Egypt vision 2030 [Electrpnic source]. URL: https://andp.unescwa.org/sites/default/files/2020-09/Sustainable%20Development%20Strategy%20%28SDS%29%20-%20Egypt%20Vision%202030.pdf (accessed: 12.10.2023).
11. Egypt's voluntary review 2018 [Electrpnic source]. URL: https://sustainabledevelopment.un.org/content/documents/20269EGY_VNR_2018_final_with_Hyperlink_9720185b45d.pdf (accessed: 12.10.2023).
12. El Haggar S., Hassan M.G., Nakhla D.A. Impact of Biomass in Egypt on Climate Change. 2013. DOI: 10.4236/ns.2013.56083.
13. Elnokaly A., Elseragy A. et al. What Impedes the Development of Renewable Energy Technology in Egypt. 2007 [Electrpnic source]. URL: https://www.researchgate.net/publication/311351636_What_impedes_the_development_of_renewable_energy_technology_in_Egypt (accessed: 12.10.2023).
14. Global solar atlas. 2022 [Electrpnic source]. URL: https://globalsolaratlas.info/map?c=11.523088,8.173828,3 (accessed: 12.10.2023).
15. Hegazy K. Egypt's Energy Sector: Regional Cooperation Outlook and Prospects of Furthering Engagement with the Energy Charter. 2015 [Electrpnic source]. URL: https://www.energycharter.org/what-we-do/knowledge-centre/occasional-papers/egypts-energy-sector-regional-cooperation-outlook-and-prospects-of-furthering-engagement-with-the-energy-charter/ (accessed: 12.10.2023).

16. Hosny N. A., Salman D. The nexus between Egyptian renewable energy resources and economic growth for achieving sustainable development goals // Futur Bus J. 2021. Vol. 7. N 47. DOI: 10.1186/s43093-021-00091-8.
17. IGA, Agreement between the Government of the Russian Federation and the Government of the Arab Republic of Egypt on Cooperation in Construction and Operation of the Nuclear Power Plant on the Territory of the Arab Republic of Egypt. Cairo, 2015 [Electrpnic source]. URL: https://faolex.fao.org/docs/pdf/bi-172786.pdf (accessed: 12.10.2023).
18. International Trade Administration. 2022 [Electrpnic source]. URL: https://www.trade.gov/country-commercial-guides/egypt-electricity-and-renewable-energy:~:text=Egypt%20is%20working%20on%20increasing,conventional%20energy%20sources%2057.33%20percent (accessed: 12.10.2023).
19. International — U. S. energy information administration (EIA). 2020 [Electrpnic source]. URL: https://www.eia.gov/international/analysis/country/EGY (accessed: 12.10.2023).
20. IRENA, R. E. S., 2018b. Renewable Energy Outlook: Egypt. International Renewable Energy Agency, Abu Dhabi. Technical Report. IRENA, 2021. Renewable Capacity Statistics 2021 // Technical Report. Abu Dhabi [Electrpnic source]. URL: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En.pdf (accessed: 12.10.2023).
21. IRENA, 2021. Renewable Capacity Statistics 2021 // Technical Report, Abu Dhabi [Electrpnic source]. URL: https://www.irena.org/publications/2021/March/Renewable-Capacity-Statistics-2021 (accessed: 12.10.2023).
22. Jia J., Li X., Long H., Wang H. Biomass resources and their bioenergy potential estimation: a review // Renew. Sustain. Energy Rev. 2013. Vol. 26. P. 344–352. DOI: 10.1016/j.rser.2013.05.035.
23. Njoh A. J. A systematic review of environmental determinants of renewable energy performance in Ethiopia: a PESTECH analysis // Renew. Sustain. Energy Rev. 2021. Vol. 147. P. 111–243. DOI: 10.1016/j.rser.2021.111243.
24. Patlitzianas K. D. Solar energy in Egypt: significant business opportunities // Renew. Energy. 2013. Vol. 36. P. 2305–2311 [Electrpnic source]. URL: https://www.researchgate.net/publication/251627461_Solar_energy_in_Egypt_Significant_business_opportunities (accessed: 12.10.2023).
25. Shaul Shay. Russia and Egypt signed a “comprehensive cooperation and strategic partnership agreement” // Institute for policy and strategy publications. 2018 [Electrpnic source]. URL: https://www.runi.ac.il/media/fusgznha/shaulshayrussiaegypt28-10-18a.pdf (accessed: 12.10.2023).
26. Springborg R. Egypt’s economic transition: challenges and prospects // Combining economic and political development. 2018. P. 184–210 [Electrpnic source]. URL: https://www.researchgate.net/publication/345211546_Egypt’s_Economic_Transition_Challenges_and_Prospects (accessed: 12.10.2023).
27. Suman A. Role of renewable energy technologies in climate change adaptation and mitigation: a brief review from Nepal // Renew. Sustain. Energy Rev. 2021. Vol. 151. P. 111524. DOI: 10.1016/j.rser.2021.111524.
28. The ministry of electricity and renewable energy. 2022 [Electrpnic source]. URL: http://www.moee.gov.eg/english_new/home.aspx 30 (accessed: 12.10.2023).

About the authors:

Oleg N. Misko, Head of the Department of Economics of North-West Institute of Management, Branch of RANEPA (St. Petersburg, Russian Federation), Doctor of Science (Economics); misko-on@ranepa.ru

Alaa Sh. Darwish, PHD student of North-West Institute of Management, Branch of RANEPA (St. Petersburg, Russian Federation); amokhameddarvi-20@edu.ranepa.ru

Об авторах:

Мисько Олег Николаевич, заведующий кафедрой экономики Северо-Западного института управления РАНХиГС (Санкт-Петербург, Российская Федерация), доктор экономических наук, доцент; misko-on@ranepa.ru

Дарвиш Алаа Шавки, аспирант Северо-Западного института управления РАНХиГС (Санкт-Петербург, Российская Федерация); amokhameddarvi-20@edu.ranepa.ru