New phenomena in the international localisation of investments in sustainable energy and digitalisation

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Abstract. The article analyzes new phenomena of international investments localization into the development of sustainable energy and related R&D technologies, digital solutions, and intersectoral projects. Paper identifies new trends in investment localization, and concerns, firstly, with shifting the focus of the investment process to industries characterized by intensive establishment of global value chains, primarily in the sectors of complex high-tech electronics and electrical equipment. Secondly, investors pay special attention to the latest digital solutions as an innovative metatechnology of production, regardless of industry specifics. Thirdly, paper notes strengthening of new players role among investors from developing countries, leading in the primary, extractive links of value chains in conditions of increasing demand for rare fossil elements and minerals from manufacturers of digital equipment and clean energy systems. Therefore, involvement of new global companies from developing countries in the processes of energy transition investing and creating sustainable energy, and active inclusion in international sustainable energy chains is a relevant issue. The paper considers controversial correlation of the decarbonization policy aimed at reducing greenhouse gas emissions into the atmosphere, growing need for additional energy consumption, and investment into design and development of «clean» industrial technologies. Hence, it makes most environmentally friendly industrial technologies commercially unavailable nowadays. We also agree with the United Nations Conference on Trade and Development (UNCTAD) proposal to develop a Global Compact for Action on Investments in Sustainable Energy.

Keywords: investments, sustainable energy, digitalization of the economy, global value chains, renewable energy sources, international investment projects.

JEL codes: F21, F64

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Introduction

Large-scale investments in sustainable energy and digitalization of the economy provide great opportunities for a global energy and digital technological transition. These investments are growing very rapidly worldwide in recent years, significantly surpassing investments into conventional industrial sector projects International investments in renewable energy and digital solutions have almost tripled since the adoption of the Paris Agreement in 2015. However, most of this expansion is concentrated in developed countries. More than 30 developing countries have not yet registered any international investment projects in the field of renewable energy sources (RES). These projects high capital intensity is a key barrier to energy investments in developing countries. Attracting international investors in partnership with the public sector and financial institutions significantly increases the effectiveness of project implementation.

Projects aimed at reducing the cost of capital and risk for energy transition investments in developing countries have been supported recently. International investment agreements provide additional technical assistance for investment planning and project preparation. They stimulated many countries to expand the economic space for combating climate change, and promoting and facilitating the investment. In 2023, in its annual Report on Global Investments, UNCTAD proposed a project of global agreement – «A global

Compact for Action on Investments in Sustainable Energy for All with Recommendations on National and International Investment Policies, Global and Regional Partnerships, Financing, and Capital Markets Participation» (World Investment Report, 2023).

Discussing this project, there is an issue of assessing the emerging trends and new phenomena of investment localisation for sustainable energy and digital development in recent years.

Main part

Trends in localization of investments in Global Value Chains (GVC) – intensive industries

The global shocks of recent years, including the COVID-19 pandemic, the Corona crisis, the disruption of traditional supply chains facilitating massive reshoring of industries, geopolitically engaged confrontations between key economic players in the energy, food, and high-tech markets resulted in the intensification of all types of economic and extra-economic risks in the world economy. The result has been an increase in international investment in industries with intensive use of global value chains (GVS). The number of announced new investment projects increased by 21.7% over the period 2020-2022, and their total cost – by 161.2% (see Table 1). Moreover, the cost and number of new investment projects increased most dynamically in the field of electronics and electrical equipment: by 31.4% (number of projects) and by 279.2% (cost of projects), respectively.

The global semiconductor deficit has prompted several investment megaprojects. The three largest projects announced for 2022 were precisely related to semiconductors: a Taiwanese semiconductor company announced a commitment to spend more than US $ 28 bn to develop advanced chips and build a new manufacturing plant in the US; Foxconn (also Taiwan) and Vedanta Resources (India) plan to invest US $ 19 bn to build one of India's first chip plants; and Intel (US) committed to invest a additional US $ 13 bn into its production in Ireland, the UK. As we can see, nowadays the specified production is not localized mainly in the labor-surplus region of Southeast Asia; the three largest projects are located across three main continents producing the final product: South Asia, North America, and Europe.

Table 1 – Sectors with intensive use of GVC: announced new investment projects in 2020-2022, number and cost (USD, mln)

Industry	2020	2021	2022	Industry share in project cost (2022), %	2022 / 2020, %
Investment projects in the industry with intensive use of GVC					
- value (total)	101,373	197,388	264, 813	100	261.2
- number (total)	2 ,796	3, 232	3, 402		121.7
including:					
Electronics and electrical equipment					
- value	47, 714	137,928	180,928	68.3	379.2
- number	888	1, 100	1, 167		131.4
Automotive industry					
- value	35, 096	38, 567	58, 949	22.3	168.0
- number	578	718	694		120.1
Machinery					
- value	7, 238	8, 061	12, 224	4.6	168.9
- number	670	650	727		108.5

Industry	2020	2021	2022	Industry share in project cost (2022), %	2022 / 2020, %
Other industries					
- value	11, 326	12, 883	12 ,712	4.8	112.2
- number	660	764	814		123.3

Source: composed by the authors according to FDi Markets[1]

Furthermore, GVC-intensive investments dominant in projects on electronics an electrical equipment. In the total value of all new investment projects of this type their share accounts for almost 70% (180.9 out of US $ 264.8 bn). The automotive industry, ranked 2nd, has only 22.3% of all newly announced projects value. The other branches of GVC-integrated production account for less than 10% of new investment projects total value.

Investment localisation trends in digital industries

Indeed, digital TNCs, as a rule, are less involved into new projects investment. Firstly, they have no requirement to invest in large tangible assets. Secondly, in digital business it is more common to merge or acquire competing companies or start-ups. E-commerce companies are exceptional ones; they need to establish logistics networks including warehouses, terminals, transshipment, and distribution facilities. The pandemic-induced boom in e-commerce investment activity continued in 2022. Indeed, it has lower rate, as boom declines as the global economy recovers from the pandemic. The number of projects decreased, but remained high compared to previous years (see Table 2). However, most of the decline concerns with the e-commerce giant Amazon (USA). It announced twice less projects in 2022 as in 2021. Overall, its total cost of US $18 bn was slightly lower than in 2021. The largest projects announced in 2022 included the launch of a new service infrastructure in Europe with headquarters in Switzerland. Their total cost is about US $ 5.9 bn, and a cloud infrastructure cost in Thailand is about US $ 5 bn.

Internet platforms also actively invested in new projects in 2022: the number of projects, as well as their cost, increased almost 1.5 times compared to 2020 and reached a record US $ 6.3 bn. Most of them were on the 2 largest platforms: Alphabet and Meta. Alphabet is actively investing. Over the past three years the company invests an average of US $ 3 bn annually in new projects. Meta's foreign investments in new projects increased significantly: from US $103 mln in 2021 to US $ 2.7 bn in 2022. The key geographical directions of this investment flow are as follows: investments of US $1.5 bn in a new R&D project in Canada, and US $1 bn to built a Data center in Spain. Apparently, the company aims to maintain equal parity between the North American and European destinations (World Investment Report, 2023).

Table 2 – Digital industries: announced new investment projects in 2020-2022, number and value (USD, mln)

Digital industry	2020	2021	2022	Industry share in project cost (2022), %	2022 / 2020, %
Investment projects in digital industries					
- value (total)	21, 211	31, 172	32, 057	100	151.1
- number (total)	306	376	338		110.5
including:					

[1] *FDi Markets. The crossborder investment monitor. Available at: https://www.fdimarkets.com / (accessed: 06.11.2023).*

Digital industry	2020	2021	2022	Industry share in project cost (2022), %	2022 / 2020, %
Digital content					
- value	506	1, 804	506	1.6	100
- number	30	43	37		123.3
Digital solutions					
- value	1, 206	2, 962	2, 929	9.1	242.9
- number	38	48	59		155.3
Electronic commerce					
- value	15, 214	23, 837	22, 368	69.8	147.0
- number	199	231	185		93.0
Internet platforms					
- value	4, 285	2, 569	6, 254	19.5	146.0
- number	39	54	57		146.2

Source: composed by the authors according to FDi Markets [2]

Challenges of decarbonisation and new demand for sustainable energy

The world is decarbonizing. Plans to reduce carbon dioxide emissions meet the commitments of the Paris Agreement on Climate Change and the plans adopted at the 26th United Nations Climate Change Conference (COP26) caused many international, national, and corporate initiatives aimed at eliminating net greenhouse gas emissions by the middle of the century. The plans of the major economies and manufacturers are very ambitious. The European Union predicts zero emissions by 2050 and aims to halve emissions over the next decade. China declared net zero by 2060; India aims to reach zero emissions by 2070. Simultaneously, customers and end-users have new demands on all sectors to gain assurances the products and services they supply do not exacerbate the problem.

All greenhouse gas (GHG) emissions are conditionally divided into three categories (Scope 1, Scope 2, Scope 3). Both greenhouse gas emissions from production itself and emissions from the purchase of electricity and heat (steam) are taken into account. According to experts, carbon emissions account for 81% of total greenhouse gas emissions.This is largely due to the production. The remaining GHG emissions include methane (10%), nitrous oxide (7%), and fluorinated gases (3%) (see Figure 1).

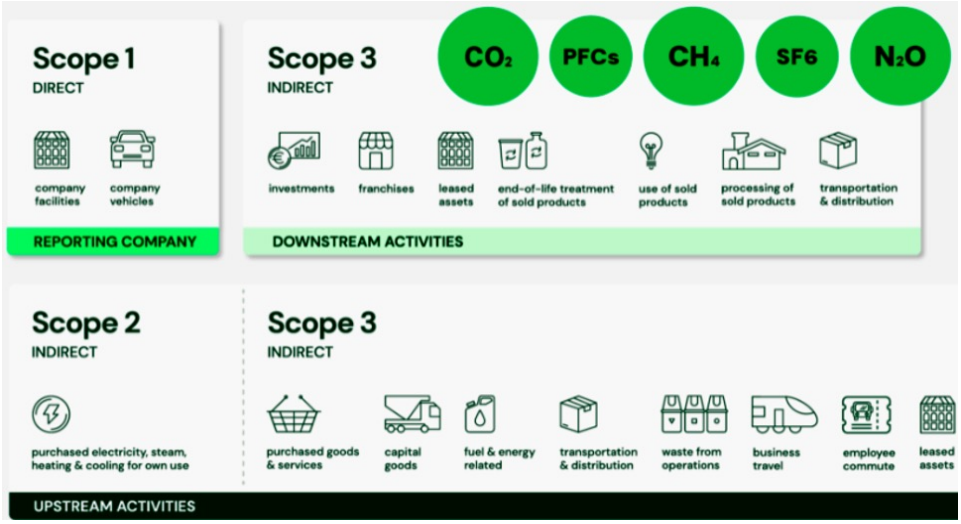

Figure 1. Three categories of greenhouse gas emissions

Source: Ranganathan et al., 2004

[2] *FDi Markets. The crossborder investment monitor. Available at: https://www.fdimarkets.com / (accessed: 06.11.2023).*

Category 1: direct emissions

Category 1 emissions are direct emissions from resources owned and controlled by the company. They are divided into four types. The first is stationary combustion (for example, heating, boiler room, etc.). The second is mobile combustion – emissions from all vehicles owned or controlled by the company (e.g. cars, buses, vans, lorries, etc.). The growing use of electric vehicles and electric buses and the associated growth in purchased power supply implies some activities of organisations' fleets may be classified as Category 2 emission generating activities. The third is volatile emissions – are greenhouse gas leakages (e.g. vapours from refrigeration, air conditioning, etc.). The fourth is technological emissions. They occur during industrial processes directly at the production site (for example, the release of CO2 during cement production, factory smoke emissions, chemical emissions as a side effect of petrochemical industries, etc.).

Category 2: indirect emissions

Category 2 emissions are indirect emissions from the production of purchased energy from a utility provider. There are all GHG emissions released into the atmosphere from the consumption of purchased electricity, steam, lighting, heat, and cooling. For most organizations, electricity is the only source of category 2 emissions.

Category 3: indirect emissions outside the company's control

Category 3 emissions are indirect emissions, not included in Category 2. They occur in the company's value chain, including both upstream and downstream emissions along the production chain of operations. In other words, emissions related to the company's activities. In accordance with the protocol on greenhouse gases, category 3 emissions are divided into 15 types. Activities generating Category 3 emissions include, for example, business travel (e.g., air travel, rail travel, metro and light rail, taxis, buses, and business travel using personal vehicles). Also, Category 3 also includes use of personal cars by employees for commuting to and from work, as they also generate GHG emissions. These emissions can be reduced by increasing the use of public transport, or by remote work from home. Emissions generated during operation refer to waste sent to landfills and treatment plants. Waste disposal releases methane (CH4) and nitrous oxide (N2O), which cause more damage than CO2 emissions.

The decarbonization trend imposes strict requirements on energy, since it accounts for a significant part of global emissions. Moreover, energy sector is one of the most energy-intensive industries; hydrocarbons still being the main raw material. And more than half of its total emissions belong to the first and second categories, i.e. they are the results of the organization activities. Reducing these emissions will require huge investments. According to the International Energy Agency, technologies which can achieve 75% of the required emission reductions by 2050 are currently commercially unavailable. The task challenging is evident in three scenarios developed by the German Chemical Industry Association. They show the possible change in greenhouse gas emissions over time. The roadmap developed by German experts describes the upcoming path to carbon neutrality from 2020 to 2050 in three possible directions, which can be understood as different levels of ambition (see Figure 2).

The basic path. The companies continue to manufacture products on the same technological basis. Their investments also remain at the current level and serve to maintain and improve system efficiency. Companies will pay more attention to recycling. Germany's energy supply will permanently reduce emissions due to the expected cessation of coal-fired power generation in 2038.

The technological path. Companies will invest into new «clean» technologies reducing CO2 emissions, which will be implemented as soon as they become economically profitable. The role of renewable energy sources in energy supply and increased processing of carbon-containing products will grow.

The path of carbon neutrality. All restrictions are removed on this pathway; carbon neutrality scheduled to be achieved by the middle of the 21st century. However, all traditional processes must be completely replaced by alternative ones (Geres et al., 2019).

The basic path will provide the German economy with a 27% reduction in GHG emissions by 2050 compared to the level in 2020 due to the gradual abandonment of coal and increased energy efficiency. The technological pathway will ensure a 61% reduction in GHG emissions by 2050 compared to the level

in 2020 due to increased investments in new processes. Although, the demand for electricity will increase approximately fourfold by 2050. The path of carbon neutrality will ensure by 2050 an almost 100 % reduction in GHG emissions due to maximum investments in alternative processes. Indeed, it increases the electricity demand by 11 times.

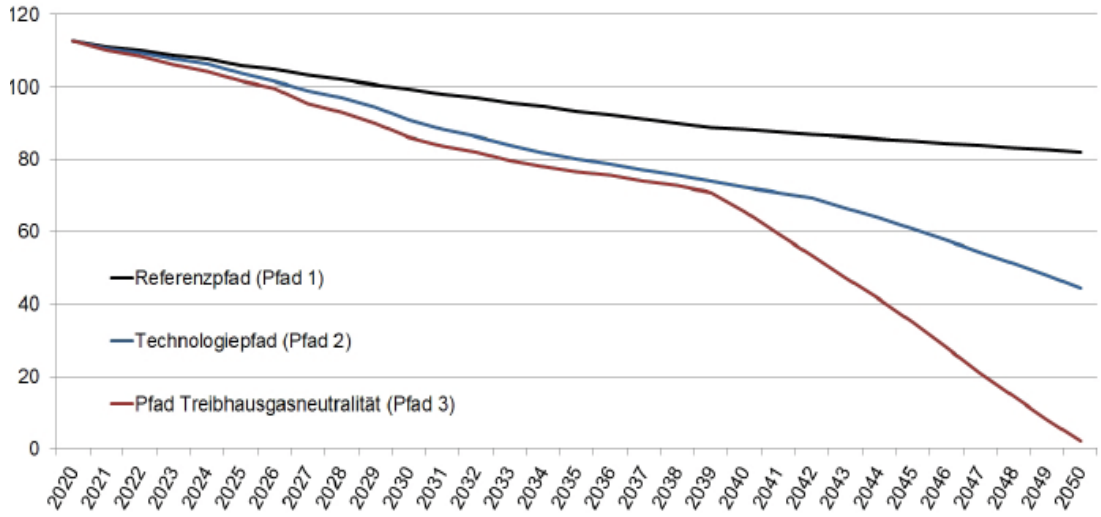

Figure 2. Dynamics of greenhouse gas emissions (in million tons with CO2-equivalent) from 2020 to 2050 according to three scenarios by the German Chemical Industry Association

Source: Geres et al., 2019

The more companies and countries strive for carbon neutrality, the more the associated costs increase. Therefore, decarbonization and the transition to sustainable energy are becoming a key task, without which the solution of the issues of achieving carbon neutrality can be delayed far beyond 2050.

Projects related to sustainable energy in developing countries

More than 80% of investments in digitalization and renewable energy are private ones. Today leaders are China and several developed countries. They are implementing the world largest investment projects in renewable energy technology. However, in recent years there has been a sharp increase and a shift in attracting investment in high-tech projects to developing countries. It is because production is becoming increasingly diversified and developing countries are actively occupying new niches in high-tech sectors, apply public funding, and actively co-operating with world-leading companies.

Most of the technology projects needed for the energy transition also enjoy government support in developing countries, large investments are made within countries, and the most ambitious projects are within the framework of joint projects with foreign private investors (see Table 3).

Table 3 – Top 10 largest internationally funded projects announced in 2022 in developing countries in the field of sustainable energy, USD mln

Country	Sector	Project name	Value
Vietnam	Renewables	Marine wind farm project with AES (USA) in Bin Tuan Province with a capacity of 4 GW[3]	13, 000
South Africa	Energy industry	Project «Green Hydrogen» with the output capacity of 500 thousand tons per year of green hydrogen by 2030[4]	10, 000

[3] *AES Corporation unveils a 4 GW offshore wind project in Vietnam. Available at: https://www.enerdata.net/publications/daily-energy-news/aes-corporation-unveils-4-gw-offshore-wind-project-vietnam.html (accessed: 06.11.2023).*

[4] *Green hydrogen vision. GH2 Country Portal – South Africa. Available at: https://gh2.org/countries/south-africa (accessed: 06.11.2023).*

Country	Sector	Project name	Value
Brazil	Renewables	Ceara marine wind farm project on the north-east coast of Brazil with a capacity of 3840 MW[5]	9, 462
China	Renewables	Joint project with Canadian Solar Inc. (Canada) to create a cross-industry new energy chain in Haidong. High-purity polysilicone plant with a capacity of 500 thousand per year for solar energy production[6]	8, 874
Egypt	Energy industry	Joint project with ReNewPower (India) to produce green hydrogen in the Suez Canal Special Economic Zone with a capacity of 220 thousand tons of green hydrogen per year[7]	8, 000
Thailand	Energy industry	Green hydrogen and ammonia plant project	7, 000
Mexico	Water, sanitation and hygiene	Desalination and pipeline project with IDE Technologies	5, 000
Sudan	Transport infrastructure	Abu Amama port construction	4, 000
Malaysia	Telecommunications	Project of construction of Technopark «Green Data Center» in Johor, with a capacity of 500 MW, working with solar energy[8]	3, 497
Ghana	Transport infrastructure	Western Railway Project in Ghana	3, 200

Source: composed by the authors

An additional phenomenon in the localisation of sustainable energy investments has been the dramatic increase in the presence of companies from developing countries in the pool of the world's largest investors. It increased the bias towards investing in the developing economies themselves (see Table 4). By table 4, the 10 largest global investors in the period 2015-2022 are 10 companies from EU countries and one company from Canada. They have implemented many different projects during this period: from 361 (Enel) to 95 (Impala). The global giants BP and Shell did not rank the top 10, although they placed 12th and 16th, respectively. The US investors mainly invested in domestic projects. The largest American sustainable energy companies NextEra Energy, AES, and Duke Energy implemented 59, 45 and 44 projects in the American market, respectively.

Against this background, there is an increase in the activity of investors from top 10 developing countries: China, Saudi Arabia, Singapore, the United Arab Emirates. Hence, the largest investors implemented 60-100 investment projects in sustainable energy and related digitalization during the study period: two Saudi companies – 103 projects; three Chinese companies – 84 projects; two companies from the UAE – 71 projects;

[5] *Geradora Eolica Brigadeiro – Costa Nordeste Offshore Wind Complex 3840 MW – Ceara. Available at: https://www.globaldata.com/store/report/geradora-eolica-brigadeiro-costa-nordeste-offshore-wind-complex-3840-mw-ceara-profile-snapshot/ (accessed: 06.11.2023)*

[6] *Qinghai Haidong New Energy Whole Industry Chain Project Signed. Available at: https://www.seetao.com/details/175632.html (accessed: 06.11.2023).*

[7] *ReNew Power to set green hydrogen plant in Egypt with $8 bn investment. Available at: https://www.business-standard.com/article/companies/renew-power-to-set-green-hydrogen-plant-in-egypt-with-8-bn-investment-122111502025_1.html (accessed: 06.11.2023).*

[8] *YTL Green Data Center Park launches in Johor, the First Integrated Data Center Park Powered by Renewable Solar Energy in Malaysia. Available at: https://www.ytl.com/shownews.asp?newsID=4892&category=pressreleases (accessed: 06.11.2023).*

2 Singaporean companies – 63 projects (World Investment Report, 2023).

Table 4 – The largest investors in sustainable energy (leaders by the number of projects in 2015-2022)

Developed countries			Developing countries		
Company	Industry	Country	Company	Industry	Country
Enel	Energy services	Italy	ACWA Power	Renewable energy	Saudi Arabia
Engie	Energy services	France	Abdul Latif Jameel	Multi industry	Saudi Arabia
Électricité de France	Energy services	France	Masdar Clean Energy	Renewable energy	UAE
Iberdrola	Energy services	Spain	Vena Energy	Infrastructure	Singapore
Energias de Portugal	Energy services	Portugal	China General Nuclear Power Corp	Energy industry	China
Canadian Solar	Renewable energy	Canada	Ayala Group	Multi industry	Philippines
RWE	Energy services	Germany	Power Construction Corporation of China	Energy industry	China
Total Energies	Oil and gas	France	AMEA Power	Renewable energy	UAE
Orsted (Dong Energy)	Renewable energy	Denmark	ReneSola	Renewable energy	China
Impala	Multi industry	France	Sembcorp Industries	Infrastructure	Singapore

Source: World Investment Report, 2023

Localisation of renewable energy value chains

Clean energy strategies are increasingly shaping industrial policy. There are new players emerging among developing countries in addition to traditional developed economies, aiming to establish themselves as production centres for clean energy technologies. The upstream and midstream links of renewable energy value chains – for now – remain concentrated in developed countries. But the middle and downstream links are strengthening in Asia, Latin America, Africa:

– firstly, the energy transition has increased the demand for metals and minerals. Copper, nickel, cobalt, aluminum, chromium, lithium, manganese, and molybdenum are required for a number of low-carbon technologies, in particular for wind turbines, solar photovoltaic panels and electric vehicle batteries. Moreover, solar energy production, transmission lines, and distribution cables also require large amounts of copper. These important minerals are traditionally mined in developing countries: the Democratic Republic of the Congo (cobalt), Indonesia (nickel), and Latin American countries (copper). Australia is one of the major extractor of minerals. However, currently the key location is China, which provides processing of 88% of rare earth metals, 65% cobalt, 58% lithium, 40% copper, and 35% nickel. But the situation is gradually changing. Over the past two years, the growth of announced investments in essential minerals has doubled, and further growth is expected. According to forecasts, the demand for copper in 2050 will double the supply in 2020, and the demand for nickel will triple. Lithium is expected to show the highest growth in demand, with a forecast value of 5 to 10 times. The shift of investments in the middle links of the GVC will occur towards the geographical location of the deposits (World Energy Transitions Outlook, 2022);

– secondly, the local concentration of international investment projects in the production of solar energy components is decreasing. In 2022, The top five destinations included the USA, Brazil, India, Vietnam, and China, which accounted for 42% of all projects. But other developing countries have also attracted large projects for the production of solar components: Malaysia, Turkey, Mexico, and South Africa (World Energy Outlook, 2022);

– thirdly, the main locations for the production of components for wind energy are increasingly being captured not only by developed, but also by developing countries. The UK, the USA, Turkey, India, and China have almost half of the total number of projects in 2016-2022;

– fourthly, the geography of the location of the key link in the electric vehicle production chain – the manufacture of batteries – has expanded. Before 2020, the world leaders in terms of investment inflows in the sector were companies from the EU, the USA, and China. Recently, investments have also actively gone to Brazil, India, Malaysia, and Mexico, which are the leading countries in the production of batteries (World Investment Report, 2023).

Conclusions

The research conducted allows us to draw the following conclusions.

The growing investments in the digitalization of the economy and sustainable energy reflect the processes of technological transformation of production. It is also primarily related to the formation of a global digital environment and ensuring a «green» economic course. These investments are significantly outpacing investments in conventional industrial projects.

In industries with intensive formation and use of global value chains, there is a faster growth in investments in the sectors of electronics, electrical equipment, and the automotive industry, mainly related to the production of electric vehicles and buses.

The Digital Solutions segment is the absolute leader in the group of digital industries in terms of the growth rate of attracted investments. It is significantly outperforming both e-commerce and the development of Internet platforms.

The transition to sustainable energy has attracted new players to the global market of «clean industrial technologies»; technology giants and large investors from developing countries are among them: China, India, Saudi Arabia, the United Arab Emirates, Singapore.

The sustainable energy and digitalisation investment gap will gradually shrink for developing countries due to an increase in the number and total value of projects localised. They also include the technology upgrades and supply chain restructuring in electronics, renewable energy, and electric vehicle manufacturing.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR'S CONTRIBUTION

Elena V. Sapir – Conceptualization, Project administrat
Igor A. Karachev – Writing – review, Editing

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