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THEORY MEETS REALITY: INVESTIGATING THE FINANCIAL, ECONOMIC AND ENVIRONMENTAL ASPECTS OF SUSTAINABILITY

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Abstract. In the last few decades, the topic of sustainability has become more and more widespread, which is logically explained by its relevance, given the environmental conditions and challenges posed by climate change. However, there are many contradictions and controversies regarding sustainable development. Therefore, the purpose of this study is to try to understand the true essence of sustainability as a concept. As a subject of research, no less relevant, one might say, even a "fashionable" industry today, the renewable energy was chosen. It is on the example of the latter that we try to explore the "reality" and the "possibility" of sustainable development.

Keywords: economic effect, environmental impact, financial aspects, technological change, renewable resources, sustainable development.

JEL Classification: O13, Q42, Q56.

Introduction

Throughout past several decades, scientists, politicians and other stakeholders worldwide had come to a conclusion, that achieving sustainability is the only rational choice not just to a Global development, but foremost to ensure its survival. It had come into being as a result of comprehending the further evolving inadequacy regarding fundamental economic problem of balancing the constantly growing needs and constantly reducing resources. The neo-industrial society is developing today against the background of deepening acute social, man-made, environmental and security risks, mediated partly by ruthlessness of development, partly by a relentless desire to maximize profits by various economic entities. Thus, provoking the active, sometimes thoughtless, use of available resources in terms of meeting the needs of industrial consumption today, regardless of the future.

In general, the active acceleration of economic processes due to the production infrastructure (technology, communications, transport, etc.) development orients economic agents to accelerate all operational processes and encourages to act quickly, aggressively, often without focusing on the future, especially given the already sufficient experience in generating synthetic alternatives to endangered resources. On the one hand, the trend certainly has a positive impact in terms of stimulating innovation, modernization, development, progress, etc. On the other hand, it identifies certain contradictions in the system that can lead to a deepening of the limited resources problem, creating and/or exacerbating existing threats to economic, social, and environmental security of mankind.

Here, sustainability kicks in. Aimed at comprehensive and integrated trifold (eco-, socio-, and economic) development, that will balance the optimal possible

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satisfaction of industrial and consumer needs with the rational non-predatory use of resources. And the World (at least it's developed part) seems to be meticulously implementing Sustainable Development Goals (SDGs) for some years now. Unfortunately, the question, whether the concept is indeed viable and implementable when theory meets reality, remains. As available data doesn't seem to confirm it without a doubt, leaving several aspects for a consideration.

Hence, the purpose of the research is to understand the various comprehensions of the "sustainability" as a concept in order to form a unified one, as well as to study the reality behind the implementation and achieving the sustainable development. As the subject of research, renewable energy was chosen because it is becoming increasingly associated and even equalized with sustainability.

1. The problem of interpretation

The impetus for the proliferation of contemporary scientific and journalistic heritage on sustainability was the "Earth Charter", presented during the UN Conference on Environment and Development in 1992, which outlines the directions for the development of global society in the 21st century, based on justice, sustainability and peace. The document identifies 4 main "pillars of building a new better society": respect and care for the community; 2) environmental dignity; 3) social and economic justice; 4) democracy, non-violence and peace (Earth Charter International, 2020).

At the same time, throughout its existence, the concept of sustainable development has been and continues to be criticized: both from the standpoint of its probability, as well as in terms of the question of what exactly should be sustained in this development. In particular, Turner (1988) denies the very possibility of sustainable use of non-renewable resources, "because any positive rate of exploitation will eventually lead to the depletion of planet's limited reserves"; Georgescu-Roegen (2013) emphasizes that this concept undermines the significance of the Industrial Revolution, as it "recognizes it as unsustainable"; O'Riordan (2013) argues that "the content of the concept is too broad and covers everything from environmental management to economic development and the Brundtland Report (Brundtland, 1987) promotes nothing more than a long-known global development strategy with an ambiguous and unfounded concept, added essentially as a slogan for public advertising".

Today we can find several interpretations of sustainability: starting from socially hypertrophied general equality up to its denial altogether. The authors find them to be aberrations inherent in the concept of sustainability, as any other multifaceted system. And these deviations are making it impossible to formulate a unified common understanding of a given concept and its implementation. We believe them to be as follows:

- Politicization. Boehmer-Christiansen (2002) states that "sustainability is a very attractive concept for politicians… <this> idea offers the opportunity to expand their sphere of influence and make new alliances with stakeholders interested in protecting the environment … however, this interest has led to the politicization of sustainable development, the reduction of this concept to an occasion to intervene in the expanded range of activities… rather than giving clear guidance to public policy-making, it instead empowers bureaucracies to increase their influence and assert themselves in their old roles";
- Hypertrophy. The controversy over "sustainable development" is explained not only by ambiguous interpretations of the concept, but also but also by endowing this system with non-specific essential characteristics. The above-mentioned economic and social equality can be an example of such hypertrophy. Undoubtedly, the social component of sustainable development is not only important, but, without exaggeration, a key one. At the same time, the interpretation of the social component of sustainability from the standpoint of "equalization", in our opinion, is debatable, since, on the one hand, absolute equality cannot be realized, and on the other hand, it levels the development component in the "sustainable development" system;
- Hyperbolization in the context of this study seems to us in connection with politicization. Thus, exaggerating, on the one hand, the role of gender and national equality, on the other – exaggerating the extent of discrimination, can cause not only disruption of sustainability: economic, social and environmental altogether, but also the destruction of the entire system, provoking conflicts from local to international;
- Imitation. In addition to politicization and controversy, "sustainable development" today has received another characteristic – it became a brand. Thus, after the Brundtland Report (Brundtland, 1987), the concept of sustainable development was not only institutionalized in various organizations but also acted as a catalyst for the establishment of many socially and environmentally friendly enterprises. The active proliferation of the sustainable development ideas gave rise to many scientific and journalistic works, which, in turn, turned sustainability into "social consciousness", "environmental friendliness", "dignity", that is, they formulated the public idea of the need to take measures to protect the future and future generations. Of course, this had a positive impact: a significant layer of consumers is increasingly choosing products from the position of socio-environmental awareness, encouraging manufacturers to create a "sustainable environmental product". Environmental friendliness is in vogue today, but fierce competition is the reason for imitating this "environmental friendliness" more and more brands and companies are declaring the transition to a sus-

tainable development model; however, analysis shows that these declarations are not always true (Hicks, 2020; Kostetska et al., 2021; Truth in Advertising, 2021). Unfortunately, greenwashing today becomes as much a trend as the real sustainability.

- Reducibility. Governments and businesses "continue to choose between economic, social and environmental pillars, convinced that they are substitutes for each other rather than complementary components" (O'Connor, 2006). Such reduction provokes exacerbation of "development traps". The basis for development in general, and even more so, sustainable development in particular, is the complex transformation of the system as whole, which is being achieved by all its components development in integrity. In particular, institutionalists were the first to prove that development as a whole is not equal to the development of only the economic subsystem. That is, economic development in itself is impossible, it is achieved along with the development of culture and the entire system of values, the entire set of economic and social institutions and relations (Godo, 2005).
- Reverse (or inverse) efficiency. This type of aberration is characterized by the inverse effectiveness of an innovation/action/process aimed at achieving sustainable development, a vivid illustration of which is the "plastic bag paradox". The "plastic crisis" widely discussed today, which, according to some estimates (Encyclopedia Britannica, inc., n.d.), led to the largest environmental catastrophe in the history of mankind, arose as a result of the Swedish engineer S.G. Tulin efforts on "saving the planet". Basically, engineer's invention was a response to ideas of conserving forests in Europe and the Amazon, widely spread in 50s (Independent Digital News and Media, 2019). Created by Thulin in 1959, plastic bags were developed as an alternative to paper bags, which were considered harmful to the environment as their production resulted in deforestation. They were significantly more durable than their paper counterpart, as the engineer planned to reuse them for a long time. Unfortunately, initially "green" innovation became a global scale man-made disaster.

2. Sustainability energy wise

Throughout its existence, humanity is in a recursive process of meeting the inherent needs of society: consumer needs, the basic of which are identified by A. Maslow, and economic ones. And both those classes of needs are, in essence, reduced to finding the energy necessary to satisfy them. Moreover, there is a logical causal relationship: in the process of searching for energy to meet needs, humanity introduces innovations, the implementation and development of which require more powerful energy and/or more of it. At the same time, the dominant source of energy determines the direction of research and the development of innovations.

For example, technological systems within the pre-industrial society, which lasted the vast majority of human history, were based on the physical energy of first people, later people and animals, and therefore, the relevant innovations were those that improved the productivity of the latter: the wheel; levers; reducer; bellows; heavy plough, etc. Prior to the first Industrial Revolution, innovative use of water and wind energy was aimed primarily at facilitating the physical labour of millers and artisans. The Industrial Revolution caused not only another shift in the technological paradigm as a whole, but also a further reorientation of innovative developments. As spinning machines needed water and steam energy, mankind accordingly learned about the possibility of using fossil energy sources to support and ensure the industrial process (Nitsenko et al., 2018).

The Steam Age – the second industrial technological order prompted engineers and researchers to rationalize the use of limited, as they turned out to be, non-renewable resources and the subsequent transition to oil and electricity (Zhen et al., 2018). This eventually caused subsequent technological progress and became the precondition for the next technological advance bringing forward the third Industrial Revolution. It was the proliferation of electricity that contributed to the emergence and development of new sectors of the economy: heavy engineering; electrical and radio engineering and, subsequently, provided the basis for the fourth industrial revolution – the information one. And, if the fourth technical and technological paradigm proceeded from the possibilities of using hydrocarbons and internal combustion engine (as opposed to reciprocating steam), the next one is based on further active use of electrical engineering, microelectronics, nuclear energy, etc., which provide adequate energy to the main cost-forming industries: telecommunication; bio- and genetic engineering; chemical industry, etc.

Interestingly, today, during the formation of the sixth technological order, humanity finds itself in need for a "regression" in a sense – in a need to return to basics, using the renewables: water, wind and solar power. As the current level of society's productive forces is threatened on the one hand, with ever closer depletion of fossil energy resources, and on the other – with the cartel and/or administrative monopolization of mining and processing industries. At the same time, this "regression" is purely historical, as in the conditions of proper development innovativeness, the productivity of the energy sector is doomed to an incremental progress (International Renewable Energy Agency, 2020).

3. Leading charge on renewables

Nowadays carbon-free future remains in a scope of development strategies for economies around the World. As global warming from being a potential distant problem for upcoming generations becomes a real, snowballing trend of today, more and more countries embrace

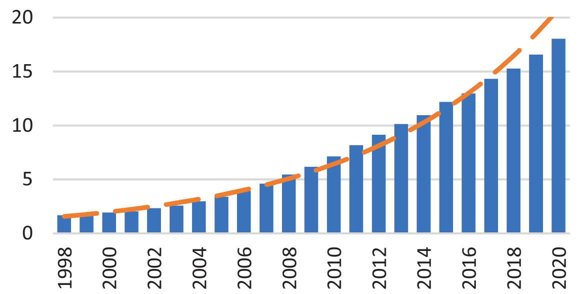

Figure 1. Consumption of renewable energy in OECD countries from 1998 to 2020* (in exajoules) (source: adapted from Jaganmohan, 2021a)

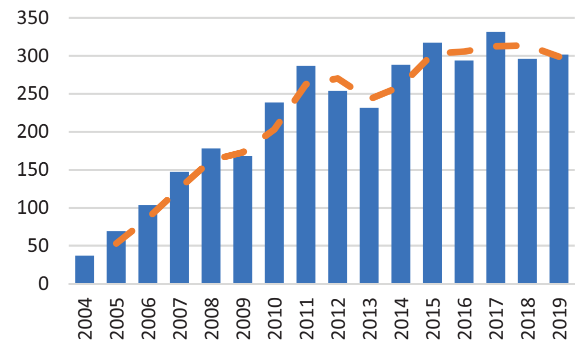

Figure 2. New investment in clean energy worldwide from 2004 to 2019 (in $ billion) (source: adapted from Jaganmohan, 2021b)

the transition to water, solar, geothermal power, as well as other renewables (Figure 1):

Notably, new investment in renewables over the last 15 years shows an almost constant increase (Figure 2) as well as the Global renewable energy market currently valuing at $ 613,77 billion: and according to some data, it is expected to triple (with current trend remaining) by the end of 2027 (Jaganmohan, 2021c).

With the highest share of renewables and low-emission power sources in total energy consumption, several countries top the list of nations highly devoted to implementing the SDGs, and each economy had chosen its own path (Longley, 2022):

Norway's rational choice is hydropower (45% of total energy supply) reasonably taking into account its specific geography, steep landscape and number of rivers, as well as climate. Remarkable, that hydroelectricity remains a preferable energy source since 1892.

Leading in turning waste in to power are Brazil and Finland: biofuel and waste account for 32.1% and 32% of total energy supply respectively. The former is considered to be the largest sugarcane-based ethanol producer and second-largest ethanol fuel producer in the world.

One more geographically rational choice, looking back on the strong and harsh winds of the "Roaring Forties", is New Zealand's wind and solar powerplants which account in total for the quarter of its energy supply.

France, as the ninth largest energy consumer in the world, is heavily dependent on its 56 operational nuclear reactors producing 103,966 kilotonnes of oil equivalent (Ktoe), as the country has the highest part of nuclear power in its total energy supply reaching up to 42%.

Charging towards a net-zero today are Sweden, UK, Germany and the Netherlands. It is worth noting that if two formers are shown to be quite successful in this regard, the latter are facing major and minor difficulties, respectively. However, in terms of the different results and possibly different prerequisites, all these countries had made a common choice, namely: the wind power as their main renewable energy source. And a decision seems to be quite clear when it comes to decarbonisation, as wind and solar energy remain preferable sources among a wide number of nations worldwide. According to available statistics at the very least. Only in 2020, about 93.000 MW of wind energy capacity was added worldwide (onshore and offshore combined) (Bundesverband WindEnergie, 2021) (Figure 3).

At the same time, Europe alone installed 14.7 GW (10.5 GW in the EU-27) of new wind capacity, showing a slight decrease of 6% from a previous year, which, according to the Bundesverband WindEnergie, is explained by the impact of the COVID-19 pandemic on the wind sector. 65% of all wind power installations in Europe are spread across five countries: Germany (63 GW), Spain (27 GW), the UK (24 GW), France (18 GW), and Italy (11 GW). This is followed by Sweden, Turkey and the Netherlands with 10 GW, 9 GW and 7 GW respectively (Bundesverband WindEnergie, 2021).

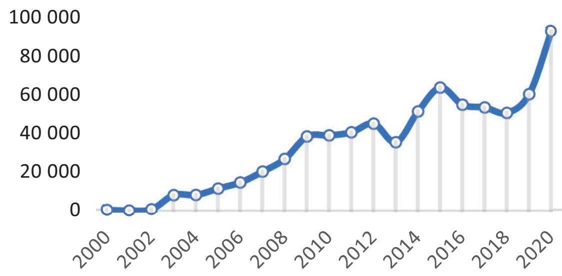

Figure 3. Annual new construction worldwide in MW (source: built by the authors using the data from Bundesverband WindEnergie, 2021)

And, given the stability (more or less) of a trend, other things being equal, we can expect further growth of the industry. But the question remains whether these popular choices are indeed effective ones. Looking back at the forementioned France, Brazil, and Finland, it is worth mentioning the importance of the country's geography, general economic structure and recourse base, as well as climate. Because, overlooking those aspects could potentially be costly enough, not to forget conclusively harmful to economic and otherwise general security.

To better understand probable concerns regarding the matter and to consider future possible outcome, it is necessary to analyse several different scenarios, comparing the experience of abovementioned economies in a practical light.

Ambitious Ørsted's Hornsea Project One had not only revived stagnating Danish state-owned company, formerly known as Dansk Naturgas A/S, but changed the wind power industry as we know it (Power Technology, 2020). Hornsea Project One (2020) is known today as the World's largest offshore windfarm located in the southern North Sea, covering the area of 407 sq. km with 174 turbines and is powering (at least as it is declared by Ørsted) almost 1 million UK's homes with the total capacity of 1,2 GW (Power Technology, 2020). This project is largely responsible for UK's success in the industry, resulting in levering the fossil energy use for the renewables, which currently add up to 20% of country's total energy supply (33% electricity is being generated from renewable sources) as well as lowering greenhouse gas emissions by over 50% below the 1990 levels (Deloitte UK, n.d.). Its staggering success prompted further development of the Yorkshire coastline, and Hornsea Project Two with declared potential to generate more than 4 GW of renewable energy is currently under construction, and Hornsea Project Three is currently being finalized (Power Technology, 2020). However, the cost-effectiveness of the project remains to be determined, especially given its estimated value of at least £ 4.2 billion.

At the end of 2021, the total capacity of wind power in the Netherlands generated by 2827 turbines (19% of which are based offshore) was estimated to be 7,88 GW (Windstats, 2022). The Netherlands installed the most wind power capacity in 2020 (1.98 GW). 75% of that was offshore wind and it had covered 12% of country's demand in electricity (Bundesverband WindEnergie, 2021). The widely known continuous historically supported preference of the Dutch for windmills had provided the nation with the prospect of leading the EU race to net zero. On the other hand, that relationship comes with an issue, as today country is met with a need to optimize a large number of smaller and not so efficient older windfarms and to either replace or modernize already deployed turbines. Reinventing of the wind power actively began in 2015 with Windpark Noordoostpolder and subsequent projects (two onshore and one nearshore), which generate around 1.4 billion kWh utilizing 84 turbines (Windpark Noordoostpolder, n.d.), as well as offshore Gemini Wind Park (2021), commissioned in 2017 with 600 MW production capacity ensured by 450 turbine blades.

At the same time, despite last year's record for new capacity among Europe's neighbours, the country still remains heavily dependent on fossil fuels. Especially natural gas, which is responsible for 45% of the total energy supply of the economy (Longley, 2022).

4. Environmental issues

As the available data accumulate and scientists are able to asses modern "energy revolution" outcomes in a broader sense, they often conclude, that apropos renewable energy, sustainability is not entirely obvious. There is no doubt in climate change and the catastrophic prospect of planet overheating, as well as there is no doubt in the positive influence of replacing fossil energy sources with renewables when it comes to reducing carbon emissions, responsible for the considered overheating. However, the modern level of technological development in this field currently does not allow us to consider it as one fully satisfying the conditions of sustainable development. Arguments and subsequently areas to improve are as follows:

CO_2 debt and footprint. Rather interestingly, that renewables are widely considered to be of minimum (if any) emissions and are therefore intensively developed to minimize planets carbon footprint and at the same time hydro and bioenergy almost reach coal and gas CCS with CO_2 levels of 97gCO_2e/kWh and 98 gCO_2e/kWh versus 109 gCO_2e/kWh and 78 gCO_2e/kWh respectively. The study finds that among available energy sources the lowest carbon footprint is left by nuclear (4gCO_2e/kWh), wind (4gCO_2e/kWh), and solar (6gCO_2e/kWh) energy. It also argues about presumably large hidden carbon debt of the latter, related to their initial manufacturing and deployment (Pehl et al., 2017). In other words, renewable energy does not automatically mean "net-zero" and "to guarantee 100 percent emissions reductions from renewable energy, power consumption needs to be matched with renewable generation on an hourly basis" (de Chalendar & Benson, 2019).

Toxicity and recycling. The average utility span of a wind turbine is estimated to be in a range of 20 to 25 years. The main reason behind relatively short period is dictated by the structure itself (as the massive blades are fixed to the ground basically by a single fulcrum) and is usually worsened by harsh environmental conditions (turbulence, high speed wind, humidity, erosion, high force waves, etc.) in which aggregate is usually deployed. Relative caducity conditions recycling problem. And if most parts of turbine construction could potentially be recycled or otherwise reused, the blades, made of fibre-reinforced plastic, pose the hardest challenge.

Solar power poses an even greater challenge. The problem lies not only in dealing with ever-growing solar panel waste, but also in the toxic compounds used for its production (Desai & Nelson, 2017).

Land footprint. Another major issue associated with renewables is their impact on landscape and topography. As the global demand for energy constantly rising and transition to renewable energy accelerates, the footprint of the industry's land expands rapidly. Taking into account, that it competes in a way, with agricultural footprint, there is a possibility in diminishing a cost incentive for the renewables with according to aggravation of farming goods scarcity. The problem deepens further as both solar plants and wind turbines require a specific land that meets their initial efficiency needs.

"Onshore wind farms are meeting increasing opposition from local residents, and available land in good wind locations is getting scarcer". Meaning, that they reasonably would require even more land to operate. If advertised utilization of a modern windfarm peaks only to about 40–45%, and typical capacity reaches not more, than 32%, less windy areas would promise to be even less cost efficient. At the same time, increasing land scarcity means, that the more windfarms there would be, the less capacity they would generate per unit of land. With the calculated by The National Renewable Energy Laboratory average land use for a windfarm of 34.5–57 hectares (ha) per Megawatt (MW), the energy density comes to about 0.56 Watts per square meter (W/m^2) (Antweiler, 2020). Surely, offshore windfarms, such as forementioned Hornsea Project One and Gemini Wind Park (2021) with peaking capacity of 1,2 GW and 600 MW respectively could in theory lever mentioned land footprint, but in respect to economic sense, it would take as much as 9000 turbines to fulfil current Europe's power demand.

Solar energy has even higher density than a wind power estimated as 35–146 kwh/m^2a or to 4–17 Watts per square meter (Denholm & Margolis, 2008). In fact, it is projected, that by the 2030, nuclear power would remain the least land-use intensive (Figure 4):

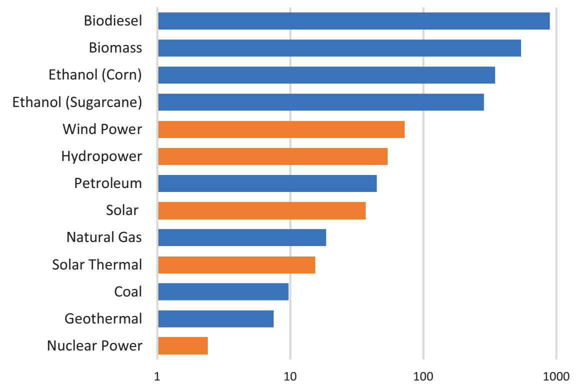

Figure 4. Projected land-use intensity in 2030 (sq. km / TW per hour) (source: adapted from McDonald et al., 2009)

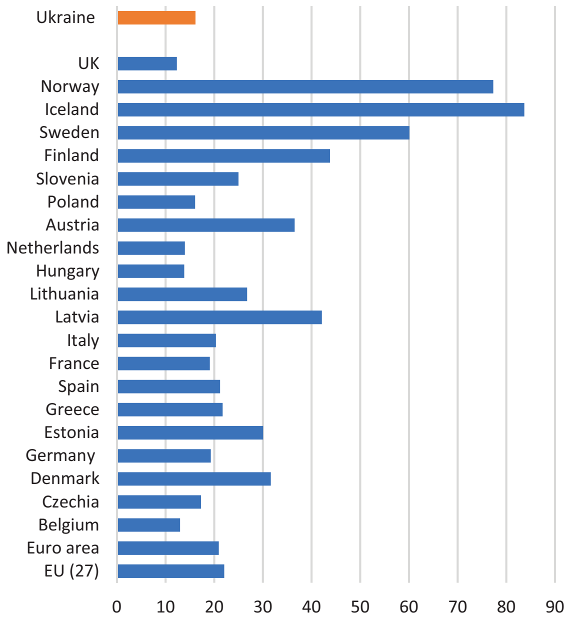

Figure 5. Share of energy from renewable sources in gross electricity consumption (2020) (source: built by the authors using data from Eurostat, 2021)

Wildlife. According to recent studies, published by Johns Hopkins University Press and The Wildlife Society, renewables could potentially be harmful to a wildlife, as requiring on average more land, they affect its habitat resulting in species migration, decline and behavioural changes (Moore, 2019).

5. Environmental issues

According to Eurostat, the overall share of renewables doubled in EU member states in last 15 years: in gross final energy consumption stood at 22.1% in the EU in 2020, compared with 9.6% in 2004 (Figure 5).

Wind and water power remain preferable energy sources throughout Europe as they provide most clean electricity (36 and 33%, respectively). The remaining one-third of electricity generated was from solar power (14%), solid biofuels (8%) and other renewable sources (8%). But if put to a perspective, those quite reassuring numbers do not seem to be convincing enough, as, for example, the wind turbines alone (although producing 458 TWh of electricity covering 16.4% of the electricity demand) do not seem to be sufficient in covering the power demand (Figure 6). At the same time, according to a report, the fastest growing energy source in a region appears to be solar: in 2008, it accounted for 1% (7.4 TWh) opposite to 14% (144.2 TWh) in 2020 (Eurostat, 2021).

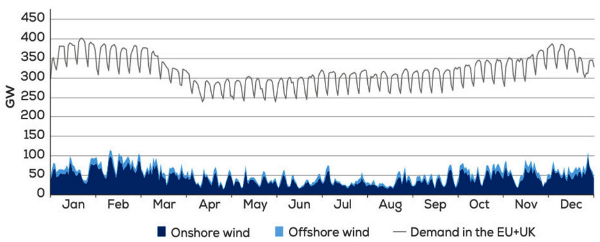

Figure 6. Power demand and wind energy generation in the EU-27 and the UK (GW) (source: WindEurope Business Intelligence, 2021)

But this "revolution", as well as EU's fossil fuels decommissioning plans, is heavily dependent on a sufficient renovation of deployed electric grid and storage facilities, which potentially could lever abovementioned cost incentive.

The production of solar and wind power, unlike other energy sources, is rather difficult to predict. Capacity differs seasonally and even hour by hour, depending on weather fluctuations. And, even with the possibility to predict those particular fluctuations, there is not much to be done. As solar energy is produced only when the sun shines directly on the solar panel, which on average lasts a small part of the day, and turbines generate energy from wind only when the latter blows and given its strength, generation capacities can fluctuate significantly. This poses a problem not only in satisfying the power demand but also a problem of storing that generated energy for timely use. Again, both come with a challenge to the renewables cost incentive.

To understand the problem behind the reality of moving compared to theory, we need to explore the troublesome experience of Germany. The country is currently in a transition from nuclear, coal, and gas energy to renewables. The choice to stop using fossil fuels seems reasonable enough. But the government's decision to cut nuclear power (that produces relatively similar CO2 emissions using considerably less land) along the way had led to the large dependence of the economy on natural gas, which is today responsible for 50% of the total energy supply (Longley, 2022). To date, despite being focused on the transition to renewables, the country is heavily dependent on natural gas imports (93%), the vast majority of which come from the Russian Federation. This somewhat controversial strategy eventually resulted in economic and political threats circling the scandalous Nord Stream 2. And "without the inexpensive power source, the entire wind power sector is in jeopardy" (Deutsche Welle, 2020).

Abovementioned need in grid expansion and infrastructure renovations and ever shrinking land suitable for the windfarms appear to be the main prerequisites to Germany's net-zero transition struggle. Due to the outdated regulation, offshore wind power is stagnating in its development and several companies have already left the offshore wind industry or relocated from Germany to other countries. And still, the economy resiliently continues to phase out not only coal, but also nuclear and generation, in conditions of the struggling wind industry, which provokes even heavier reliance on gas in electricity generation. And, in turn, it will eventually increasingly tie electricity security to gas security (International Energy Agency, 2020).

Conclusions

Sustainability as a concept constantly deals with the problem of interpretation. It is either criticized on initial possibility or being deemed altogether as denying the Industrial Revolution or levelling its results. Often sustainability is being utilised by the politicians, stakeholders and even scientists in regards of fulfilling their specific needs, promoting their own interests. As the result, we came to a notitia of aberrations that negate the its true meaning, resulting in "sustainability" being "unsustainable".

To confirm this conclusion, misconceptions in the "sustainability" interpretation on the example of the renewable energy industry were investigated, that allowed us to describe the deviations of sustainable development in this context. Renewables sustainability's flipside investigation had as well shown a number of issues, as well as prospects for future studies, that accompany world's transition to a net-zero, namely: controversial government policy; disregard for geographical features and resource base; assumptions on renewables being emissionless and altogether environmentally friendly; disregarding nuclear power etc.

It is worth noting, that sustainability is a complex multifaceted system and its misinterpretation, politization, imitation, hypertrophy or exaggeration potentially would result only in a disruption of sustainability: economic, social and environmental altogether.

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