Impact of the Pandemic and War on Energy

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The COVID-19 pandemic and Russia's war on Ukraine have impacted the global economy, including the energy sector. The pandemic caused drastic fluctuations in energy demand, oil price shocks, disruptions in energy supply chains, and hampered energy investments, while the war left the world with energy price hikes and energy security challenges. The long-term impacts of these crises on low-carbon energy transitions and mitigation of climate change are still uncertain but are slowly emerging. Both crises initially appeared as opportunities for low-carbon energy transitions: the pandemic by showing the extent of lifestyle and behavioral change in a short period and the role of science-based policy advice, and the war by highlighting the need for greater energy diversification and reliance on local, renewable energy sources. However, the early evidence suggests that policymaking worldwide is focused on short-term, seemingly quicker solutions, such as supporting the incumbent energy industry in the post-pandemic era to save the economy and looking for new fossil fuel supply routes for enhancing energy security following the war. As such, the fossil fuel industry may emerge even stronger after these energy crises creating new lock-ins. This implies that the public sentiment against dependency on fossil fuels may end as a lost opportunity to translate into actions toward climate-friendly energy transitions, without ambitious plans for phasing out such fuels altogether.

Keywords: global warming ; energy policy ; energy trade ; renewable energy system models

1. Introduction

The COVID-19 pandemic affected many countries and economic sectors worldwide. Different measures were put in place to contain the outbreak of the virus, including complete or partial lockdowns, travel bans, and confinement measures, such as social (physical) distancing and remote working. These measures caused disruptions in the mobility of people, goods, and materials, which resulted in a reduced output of industrial and economic activities. Consequently, the economy shrunk in different countries, raising significant debate over health and economic recovery pathways and their climate impacts [1].

The energy sector was challenged by the pandemic too. The short-term developments marked a drastic fall in energy demand due to reductions in mobility and economic activities. The demand for transportation fell by 50% in countries under lockdown, compared to the same period in a normal year [2]. The reduced demand for transportation fuels directly translated into an unprecedented drop in global crude oil prices, raising concerns over the risks and resilience of energy systems being dependent on such volatile international energy markets [3]. Moreover, disruptions in industrial activities and the introduction of online and digitalized solutions for doing businesses reduced electricity demand in different countries [4]. These supply-side impacts were compounded by lifestyle changes that emerged following the pandemic and containment measures, such as remote working and homeschooling, which caused new patterns of occupancy and energy consumption in buildings at different times of the day [5]. The outcome of these changes multiplied by the lower capacity of consumers for paying energy bills left energy utilities in a difficult situation: reduced sales and decreased collection of revenues.

The COVID-19-induced disruptions were not limited to supply and demand for energy commodities. The supply chain of energy technologies, such as batteries and solar PV panels, was affected too, especially via inter-continental trade routes from China to other countries. The uncertainty in the supply chain, lack of mobility of the workforce, project shutdowns due to lockdowns, and declined revenues from energy sales reduced the capacity of firms and governments for investment in energy projects [6]. Moreover, unlike metals and agricultural goods, the energy sector will face the return shocks being broadcasted the most [7]. This raised concerns about green energy investments and efforts for reducing the climate impact of the energy sector [8]. COVID-19 exacerbated the progress toward meeting SDG7 (clean, modern, and affordable energy for all) since the economic slowdown in many developing countries reduced their capacity for development

projects. Job losses and longer stays at home left many families in challenging conditions in terms of access to modern energy services and digitalized solutions for remote working and homeschooling [9].

Once lockdown measures were lifted at the beginning of 2021, and the industry resumed its day-to-day activity in many regions of the world, demand for energy carriers produced a surge in energy prices. Natural gas prices increased worldwide following an increased demand in Asia, followed by Europe, resulting in electricity and natural gas price hikes in 2021 [10]. The situation became so critical that some EU Member States introduced support mechanisms such as tax exemptions to protect low-income consumers already hit by the economic consequences of the pandemic [11], and the European Commission introduced a “toolkit” [12] to tackle the crisis. The energy price shocks raised debates as to what extent European energy and climate policy has been successful in increasing the security of energy supply, by increasing the role of natural gas as a “bridge fuel” in the renewable energy transition [13][14].

While many economies were still struggling to recover from the impact of the pandemic, and in some cases dealing with the post-pandemic energy price hikes, the invasion of Ukraine by the Russian Federation (hereafter “Russia”) and the following war deepened the energy crisis furthermore. The physical blockade and sanctions imposed on Russia have disrupted the energy trade and increased energy prices. According to the World Bank, energy prices are expected to increase by more than 50% in 2022 [15], which together with other impacts of the conflict may push the global economy to a stagflation not observed in decades [16]. As the EU has significant energy imports from Russia (around 40% of natural gas, 25% of oil, and 50% of coal imported to the EU came from Russia in 2019), the geopolitical conflict has worsened the energy price crisis in the region, resulting in serious debates between the Member States on effective energy policies that could increase energy security, while maintaining a relatively ambitious climate target for the Union.

The vulnerability of global energy trade and volatility in fossil fuel prices in international markets have raised concerns related to the resilience of the energy system to shocks such as the pandemic and geopolitical conflicts. Hence, it is important to understand the impact of such disruptions on the transition to low-carbon energy systems and to formulate policy recommendations to tackle such impacts.

In this respect, different studies have researched the impact of COVID-19 on specific subsectors or certain stakeholders of the energy sector. Jiang et al. [5] investigate the impact of the pandemic on energy demand and report different developments observed during the pandemic and recovery, offering solutions for increasing energy efficiency and promoting energy savings. In Ref. [17], the impact of COVID-19 is analyzed on energy use in buildings, discussing the impetus for progress toward green housing. In another study [18], the impact of COVID-19 lockdowns on mobility trends is analyzed in selected cities, noting reductions in GHGs from the transportation sector. Hoang et al. [8] analyze the impact of the pandemic on renewable energy strategies, by research different measures and summarizing short-term policy priorities and mid- to long-term action plans. The researchers emphasize the smaller risk of offshoring for renewable energy investments and energy efficiency improvements compared to traditional fiscal stimulus methods as solutions for reducing the dependency on fossil fuels. Moreover, there is research indicating COVID-19 has revealed the sensitivity of oil prices to global crises, which in some cases has shifted investments from fossil fuels to other commodity markets [19]. Kuzemko et al. [3] investigate the politics and governance of energy in a COVID-19-affected world, highlighting the difficulty of regaining momentum for sustainable energy transitions in a constrained economy. Last but not the least, the financial implications of economic recovery packages are discussed in a number of studies, e.g., with regard to implications on climate change mitigation efforts in [20] and societal responses to climate urgency in green recovery packages in [21].

2. Supply of Energy

Unexpected disruptions affected the supply of energy, both in terms of commodities and technologies during the pandemic period and, especially, in the first 6 months, through the decrease and restructuring in energy demand. These developments were due to reduced demand for mobility and energy, as well as disruptions in the supply chains of energy technologies and related materials [22].

The war in Ukraine directly affected the upstream energy supply in many countries. The imposed sanctions on Russia have impeded the supply of energy, not only to importing regions such as Europe but also to the rest of the world, as importing regions seek to substitute the loss of supply from Russia by importing from other regions [23]. This has increased energy prices worldwide in the short term, with consequences for many countries with varying levels of development.

2.1. Upstream Fossil Fuel Industry

Decreased industrial activities and reduced energy demand, together with fuel price volatility at the beginning of the pandemic, impacted the international energy markets. Oil prices went down to their lowest level in 20 years [24], which reduced the investment capacity of some oil and gas companies, resulting in job cuts and damaging the economies of some oil-export-dependent countries [25]. For example, the oil field services companies in the USA alone have shed more than 99,000 jobs in the first months of the pandemic [26]. In the UK, the oil and gas industry observed 30,000 potential job losses [27]. Decreased electricity demand and lower-than-usual prices for natural gas caused a large reduction in the use of coal for electricity production and related GHG emissions [28].

However, this dynamic has been highly volatile—the Russian invasion of Ukraine and the concurrent pressure on fossil fuel supply chains led to hikes in fossil fuel prices and appear to have induced new investments into gas and oil drilling and infrastructure. Some fossil-fuel-exporting countries, e.g., in Africa and the Middle East, gauge opportunities to increase their supply of fossil fuels, especially natural gas and liquified natural gas (LNG), to Europe. This may accelerate the fossil-fuel-exploration plans in such regions, e.g., natural gas extraction from the Mediterranean Sea and possible pipeline infrastructure to Europe [29]. The Russian fossil fuel industry, on the other hand, will suffer in the long term not only because of the loss of exports but also because of the lack of access to Western capital markets and high investment risks in oil and gas exploration and technology transfer [30]. It is expected that the Russian stock market loses between USD 137 and 353 billion, equivalent to 7–20% of its annual GDP, due to war costs and lower energy exports. Importing countries will experience between a 2–3% loss in their stock markets [31].

The COVID-19 and war-related shocks in the energy sector are mainly received by consumers in oil-importing countries [32][33]. This includes an increase in oil prices in the post-pandemic recovery period in 2021 and the consequences of the war in Ukraine in 2022. An increase in oil prices will impact different sectors and industries, including the power sector in developing regions, e.g., in West Africa, where diesel generators are still a major source of electricity. The affected countries may, thus, encounter difficulties in meeting their low-carbon energy policy targets and implementing the fiscal stimuli necessary to support the transition to a more sustainable energy system.

2.2. Renewable Energy Transitions

Renewable energy scored a record in global electricity generation of 25% in 2019 before the pandemic, with remarkable growth in the Global South, in countries such as China, India, and Vietnam [34]. The pandemic had some short-term impacts on the renewable energy sector, mainly due to decreased manufacturing or disruptions to the supply chains of low-carbon technologies, e.g., solar photovoltaic (PV) or batteries, especially from major manufacturing countries such as China to the rest of the world. On the other hand, renewable-based electricity showed an increasing share in electricity generation in some regions, for example, in Europe, mainly due to lower electricity demand during the COVID-19 outbreak and lower generation of baseload fossil fuel power plants [4]. However, these disruptions were temporary, as there was not a long-lasting change in the environmental quality or a more sustained effort for investment in green technology [35]. The reduced investment capacity of energy companies and delayed construction projects due to the confinement measures, combined with disrupted international trade and reduced availability of workforce, resulted in a 10–15% drop in new investments in clean energy projects in Europe, compared to pre-pandemic figures [36]. Considering this financial difficulty and the vulnerability observed in the resilience of centrally planned energy systems, there was a growth in the investment in onsite energy technologies post COVID-19, e.g., making solar-based applications in buildings and the development of mini-grid systems a priority in some developing countries [37].

The renewable energy sector showed relatively significant resilience to the crisis on a global scale. According to [38], “overall investment in new renewable power capacity (excluding large hydro-electric dams of more than 50 MW) was $281 billion in 2020 (cf. investments in fossil fuel power capacity reached $111 billion)”. Despite recent developments in renewable energy investments, the relationship between financial markets and green bonds could be volatile in the future. Hence, risk management measures should be put in place for such investments [39].

The invasion of Ukraine by Russia was another impetus for some nations to accelerate their clean energy transitions based on renewable energy. Germany as one of the countries with a high dependency on fossil fuel imports has accelerated its transition to renewable energy to cope with the possible cut of energy imports from Russia [40]. However, the evidence as of July 2022 suggests that investors’ assessments of renewable energy projects have not changed significantly after the conflict between Russia and Ukraine [41]. Renewable energy comprised 28% of the electricity generation globally in 2021, with wind and solar reaching a record high of 10% of the total electricity mix [42]. However, the 4% surge in energy demand after the pandemic was met mainly by fossil fuels. The share of renewables in total energy consumption shows a slight growth from 8.7% in 2009 to 12.6% in 2020, leaving fossil fuels as the main source of energy

needs globally (78.5% in 2020) [43]. The early evidence indicates that the global energy crises have not accelerated the transition to renewable energy, as anticipated, at least in the short term.

2.3. Global Energy Crises and Sustainability Goals

The 8.4% drop in manufacturing production in 2020 due to the pandemic [44], which was equally severe as during the Financial Crisis of 2007 [45], was exacerbated by the war and the related economic slowdown [16]. This long-term economic recession imposes significant risks on the availability of public expenditure on climate-related and green energy investments. The decline in the international cooperation and access to multi-national development funds needed to support low-income countries in their effort to have access to capital, innovation, technology, and skills will hinder sustainable energy transitions. Based on reports published on the tracking of Sustainable Development Goal (SDG) 7 [46], "significant progress had been made on various aspects of SDG 7 prior to the start of the COVID-19 crisis". This included a significant reduction in the number of people without access to electricity, an increase in the penetration of renewable energy, and improved energy efficiency.

The progress in the developing world, e.g., in sub-Saharan Africa, is, however, not on track with the ambitions of SDG 7, which have been further delayed by the consequences of the pandemic and the war. Recent analyses suggest that a continued slow economic recovery from the pandemic will have a significant impact on making modern energy access unaffordable for a significant share of the population, particularly in regions with the largest access gaps [47]. The tracking of international financial flows to developing regions for improving the share of renewable and clean energy shows that only 12% of such economic support reached the least-developed countries in 2020 [46], a worsened situation due to the pandemic [48]. The Russian–Ukrainian conflict has exacerbated the situation in different world regions. The conflict has increased global energy prices, reducing the capacity of governments in developing regions for investment in development plans, including the transition to cleaner energy. The sanctions against Russia will distort the relationship between some African countries partnering with Russia in low-carbon energy technology transfer—as of 2020, seven African countries had nuclear power agreements with Russia [29].

3. Lifestyle, Behavior, and Demand for Energy Services

Demand for energy services was affected by the pandemic in many ways, mainly as a consequence of the related confinement measures. People's activities were restricted to the local level through work and study from home measures, travel restrictions, closure of public spaces, and access limitations to facilities and services. Though there were countries with lower levels of restrictions, they experienced a collateral impact. Depending on the stringency of the measures, energy demand was shown to have reduced 9% (limited lockdown), or ca. 17% (due to partial restrictions), or even up to 24% (full-scale lockdown) [25].

Though the setback in emissions in 2020 has proven to be largely temporary, there have been long-term changes in lifestyles, businesses, and institutions [49][50][51]. The direct impacts included reduced economic activity and demand for services, such as mobility, transport, space usage, and related material and energy demand reductions, leading to improvements in air quality and greenhouse gas (GHG) emissions [52][53]. The estimated climate impacts based on country-level, sector-specific CO_2 emissions' bottom-up data indicated an abrupt 8.8–9% decrease (−1551 Mt CO_2) between 2019 and 2020 [54][55]. Furthermore, new practices and reformed social norms have increased due to the pandemic causing potentially deeper energy demand changes [5]. The pandemic caused economic distress at the individual and macro levels and losses of income and jobs, which impacted saving decisions. The experiences of 2020 offered an opportunity for policymakers to build on people's willingness to maintain pro-environmental behavior changes, by identifying and enhancing these behaviors and by counteracting backlash [56]. For example, cycling grew by around 100% in Los Angeles and Houston [57] and increased in Paris (39%), Barcelona (30%), Cologne (11%), Vienna (12%), and Oslo (26%) [58], purely from a change in people's practices. This was reinforced by provisional redistribution of street space in many cities, with pop-up bike lanes appearing during the lockdowns in over 30 countries in Europe, such as 30 km in Paris, 21 km in Barcelona, or 9 km in Budapest, among many others. In addition, calming streets and zones have been added and costs for sharing systems reduced or enlarged, in parallel to focusing on walking and public transport. Many of these changes remained afterward, in 2022. In Paris, the pandemic response to extending the cycling infrastructure reinforced the previously already planned "Plan Vélo", making Paris bike-friendly by 2024 [59]. In other cities car-related measures were added, e.g., car bans in Seattle, speed limits in Milan and Philadelphia, etc. These have seen —though there has been a slowdown—still higher levels of biking than before the pandemic, worldwide.

4. Pandemic and Climate Change: Lessons Learned

Besides the direct impacts on air quality [60] and greenhouse gas reduction [52], the pandemic can also be seen as an example of successful mobilization of the global community to mitigate and adapt to a shared but locally differentiated global crisis [61][62]. Response to the pandemic threat has shown that the world can act swiftly and in unity to tackle an urgent global challenge and is willing to adopt financial and social costs in order to contain the spread of the virus, with responsibility for others [63]. Though they are different in nature, response mechanisms, timespans, and support from the public and authorities, there are a number of lessons that should be acquired from how to mobilize actors for the climate crisis.

First, acting quickly saves lives and costs. Leadership is typically slow and careful, especially in unexpected situations, and policymakers prefer to wait to see what others do [61]. Similar to pandemic responses, earlier action will reduce mitigation costs significantly [64][65], however, successful actions are not popular in hindsight, because they appear as overreactions as the impacts have been avoided. To overcome opposition to timely and increased action, the delegation of the decision to institutions that are involved in long-term decision-making is reasonable [62].

Overall costs are high, but inaction has a significant price. Unprecedented economic recovery packages were seen in response to the pandemic. The green recovery responses to the COVID-19 crisis can contribute to and accelerate the pace of the climate transition, but the majority of stimulus funds are not transformative enough [66]. Analyses have shown that with an economic recovery tilted toward green stimulus and reductions in fossil fuel investments, it is possible to avoid future warming [67] or significantly reduce the cost of keeping warming to 1.5 degrees Celsius above pre-industrial times [55].

Second, collective behavior is the basis of dealing with major crises. It must involve persuading the public to make significant changes to their lifestyles and behaviors, as it was necessary to fight COVID-19 (wearing face masks, exercising social distancing, becoming vaccinated, etc.). Obviously, the climate problem requires even graver public engagement, building individual action and community practices that can contribute to the transformational effect.

Thirdly, a global problem requires global action. Climate change, as a global problem, is best addressed by a global consensus to trigger collective solutions to urgent problems. The pandemic has taught people how to prevent, manage, and overcome a globally sensitive issue. The management of global perspectives has been shown to require international agreements and individual responsibilities, with a renewed value given to multilateral institutions in the phases of evaluation, target setting, standard setting, and coordination.

Finally, ensuring trust in science to inform decisions. It is not easy to connect policy-making and everyday decisions to science. The rise of populism was experienced during the pandemic and the war, including the spread of persuasive yet ill-informed rhetoric to dismiss reporters, expert opinions, and scientific advice. There was a period during the pandemic when the value to follow the science in informing public policy was well-recognized, but this dissipated as the threat was decreasing. Yet, scientific advice is never value-free. In any democratic society, politicians must necessarily take ownership of the public policy. It is their job to navigate difficult value judgments at the science-policy interface, but, when doing so, it is also important to make informed rather than popular decisions [61].

The pandemic exhibited both a challenge and an opportunity to think about the necessary instruments needed to lead the world toward an environmentally friendly and resilient energy system [68]. An economic recovery consistent with the targets of SDG 7 on energy can only be achieved by building on the opportunities that emerged during the pandemic, including the positive, unprecedented lifestyle and behavioral changes that can also be practiced in a post-pandemic world [69].

5. Adverse Impacts and Implications: Health, Social, and Economic Inequalities

The necessary abrupt changes in lifestyles in 2020 have challenged populations everywhere and hit vulnerable groups extensively. Given the digital transformation in the pandemic, low-income populations with lower access to social and energy services at the start have faced imbalanced exposure [70] and are now at a higher risk of poverty as a result of losing their jobs and income due to the economic slowdown [1]. The lack of access to affordable, clean, and modern energy services intensifies existing inequities by the ways vulnerable populations were impacted by the pandemic and the measures taken to contain the virus.

Working and studying at home meant higher home utility bills for many [71]. For those who experienced income losses, well-being at home and thermal comfort could be compromised if the required energy for heating/cooling was unaffordable [72]. Lockdown situations challenged many parents to struggle between family care and job commitments, especially, posing women with a disproportionate burden. These stress factors compromised the productivity of some adults and the education of young people in many regions [73], leaving millions of students with a lack of important education impacting their future lives. A higher reliance on digital solutions and a boom in the development of technologies and services underscored the value of affordable and reliable electricity and access to energy technologies and how these relate to the knowledge needed to use digital services [74]. For families relying on traditional cooking devices and methods, there is a concern that indoor pollution exposure inside homes will increase vulnerability to respiratory diseases such as COVID-19 [75]. The socioeconomic gap widened further due to the economic crisis triggered by the pandemic and the Russian–Ukrainian conflict. Developing countries relying on energy imports have suffered from the energy price hikes due to the conflict. The increase in energy prices combined with inflation and the economic slowdown will shrink the purchasing power of the poor in different regions.

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