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Review

The Future of the Energy Sector and the Global Economy: Prosumer Capitalism and What Comes Next

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Abstract: This paper describes the present and the future of the energy sector in relation to the dominant and constantly evolving form of the global economic system. These considerations have their starting point in transformations of the energy sector in prosumer capitalism, which has dramatically changed the picture of the global economy in recent years. Subsequently, a futuristic approach is applied to determine the role and importance of energy from renewable sources for further human development. The main objective of the paper is to explain the current situation of the energy sector in prosumer capitalism and to extrapolate these relationships for the future, considering the need to enter the path of sustainable development to eliminate the global warming processes and climate changes. A review of the existing scientific literature was applied as the research method. The historical wave concept, proposed by Toffler, was found to be highly useful because of its high potential in futurology, where it enables one to study megatrends. The Fourth Wave was linked to prosumer capitalism, and it provided the base for defining the next ones: the Fifth Wave of Computing (ecosocialism) and the Sixth Wave in the form of technological and energy communism (solar communism). It also turned out that the key to solving mankind's energy problems lies in the global mean entropy budget. The literature review shows that founding the global energy system on solar radiation is the only known method for eliminating the anthropogenic greenhouse effect, which is the source of global warming and, consequently, of climate change. Therefore, the second law of thermodynamics provides a physical, economic, and logical justification for introducing a new and ultimate management form—solar communism—by 2050.

Keywords: energy transition; prosumer capitalism; synergistically double exploitation; futurology; dot-communism; revised diagram of the Toffler's civilization revolutions; second law of thermodynamics; global mean entropy budget; solar energy; solar communism

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1. Introduction

The future of the energy sector is an urgent topic nowadays, as the survival of humanity and each of us depends on it. However, this sector is part of a larger whole, i.e., of the national or global economy, and it determines its growth. This became particularly obvious recently as it has become necessary to increase the share of renewable energy in the total energy balance to stop global warming, which is the source of climate change. Among the characteristic features of the present energy system, there is an increase in the share of prosumers in energy generation, a feature unknown before. Prosumption is a consequence of the ICT revolution and widespread digitalization of nearly all sectors of the economy and spheres of human life. It has led to the development of new business models, which have transformed previous economic systems. Traditional capitalism, known from economy handbooks and the scientific literature, has been replaced by a new system called prosumer capitalism.

Prosumer capitalism is regarded in this paper as the starting point for describing the future of the energy sector and the global economy. There is every indication that this system of management is now on the decline. Prosumer capitalism is not a stable form

of economic process organization due to the externalization of the labor cost and synergistically double exploitation. Previous management systems—producer capitalism and consumer capitalism—also involved exploitation, although of a different kind. Producer capitalism should be classified as a singly exploitative economic system, as the exploitation of workers is its main feature. Consumer capitalism, in turn, is doubly exploitative, as it makes it possible to exploit both workers and consumers. On the other hand, a new and more intensive form of exploiting people emerged in prosumer capitalism, which permeates many areas of human activity at the same time [1,2]. Other flaws of this system include a self-propelled cycle of production and consumption, a constantly growing debt of work, microfascisms associated with power relations, and the robotization of prosumers and transforming them into a new type of commodity. Other threats may be associated with the emergence of huge multinational corporations, with considerable economic and political power given to them by social media users. All of this may lead to overproduction, overconsumption, social inequalities, ecological disaster, and climate change. Therefore, it becomes manifest that—on the one hand—prosumer capitalism facilitates the energy transition, as it accelerates the growth of the green energy sector and its integration with energy generation from fossil fuels, and—on the other—it can stimulate irrationality and excessive energy consumption. Thus, it is a temporary form of management, and it will have to be transformed into something different in future. Incidentally, proposed solutions to prosumer capitalism problems are, at the same time, strong stimuli for its transformation and improvement. From the futurology perspective, covering the period until the mid-21st century, one can list the successive systems of management, which include ecosocialism, dot-communism, and solar communism.

The visions of the future discussed in this paper are evaluated by means of a tool called terminology management, which is useful in knowledge organization and presentation and helps to imbue words with a sense. It helped to identify prosumer capitalism as the Fourth Wave in Toffler's civilization revolution pattern. It is also known as the Connected Society. The difference between individual waves arises from the importance of prosumption in the respective economic systems, i.e., switching cyclically between marketization and demarketization. This provided the basis for identifying the next two waves, which are consistent with the goals of the global energy transition and involve ensuring a compromise between the sustainable growth of the global economy and the need to eliminate global warming, which is responsible for climate change. The Fifth Wave of Computing is convergent with the socioeconomic agenda of ecosocialism, whereas the Sixth Wave of Technological and Energy Communism is associated with a new economic system called solar communism. The futuristic research horizon in this paper is restricted to the year 2050, as by this time—according to the optimistic scenario—mankind will have eliminated the anthropogenic greenhouse effect, and its whole energy needs will be satisfied with solar radiation.

All of the discussions on the future of the energy sector should start with the second law of thermodynamics and with defining the Earth's heat budget. The concept of thermodynamic entropy was introduced to economics by Nicholas Georgescu-Roegen, which contributed to the emergence of a new trend in economic studies called ecological economics. It involves the following reasoning. Human economic activity consists of transforming the limited natural resources of low entropy into high entropy waste, which shows that there are physical limits to global economic growth. A constant increase in the physical throughput is not possible due to the exhaustion of the sources of energy, raw materials and space, and biosphere destruction. Future knowledge will not be able to eliminate those limitations. Thus, entropy sets the ultimate limits for economic growth processes and becomes the physical basis for many socioeconomic forecasts. Apparently, all this appears sensible and logical, but this reasoning does not lead to a correct outcome due to incorrect assumptions. Nicholas Georgescu-Roegen claimed that the Earth is a closed system, so it cannot exchange matter or energy with its surroundings. However, this is a definition of an isolated system in thermodynamics, whereas closed systems are systems that do not exchange matter with the surroundings, but they are open to energy exchange.

The Earth meets these conditions. Correcting Georgescu-Roegen's error proves that the solar radiation which reaches the Earth can be a source of work whose recycling is infinite. Therefore, not only qualitative but also quantitative human growth is possible. Thus, we are reaching the economic system called solar communism, with dot-communism as its initial phase, as announced by wikinomics.

This paper outlines the genesis of scientific communism and the way it is understood by classical economists. Solar communism, about which little is known so far, does not have to be equivalent to scientific communism. They can be two distinct socioeconomic systems, although some similarities between them can be expected. The main idea of solar communism lies in tapping the whole global economy into the huge stream of solar radiation that is reaching the Earth continuously, which should allow for the gradual elimination of the anthropogenic greenhouse effect and, consequently, of global warming and climate change. Thus, what is left is the natural greenhouse effect, which is beneficial to the biosphere and on which its existence hinges. The issues that were touched on here are elaborated on further in this paper.

The high originality and innovation of studies presented in this paper arise from the following:

1. It is one of the first and one of the few comprehensive futuristic studies concerning energy transition. It presents a global perspective of catastrophic climate change based on the laws of thermodynamics and the global mean entropy budget. The type of the economic system, which is the starting point for the transition, is also taken into account, which is very important and which is often omitted.
2. This paper identifies a rather important mistake made by the creator of ecological economics, Nicholas Georgescu-Roegen, concerning the thinking of the Earth as an isolated system in a thermodynamic sense, i.e., one closed for both the flow of energy and of matter. This misunderstanding became a source of erroneous visions of human civilization's future and ecological catastrophism, as well as various dystopias, such as a global entropic apocalypse. According to these views, mankind is likely to be annihilated in the near future because of the impossibility of continuous economic growth as a consequence of natural resource exhaustion and biosphere destruction. In fact, the Earth is—thermodynamically—a closed system, and it does not exchange matter with space, but it is open to the influx of solar energy. This means that mankind can grow in an unobstructed manner, both qualitatively and quantitatively. It is noteworthy that the Earth—as referred to by Nicholas Georgescu-Roegen—is also a closed system, but understood differently—in fact, his definition of a closed system is the same as what is called an isolated system in thermodynamics.
3. Solar energy is the only one of all renewable resources that is practically unlimited and easily accessible. The Sun is an inexhaustible source of energy, which distinguishes it from other renewable resources. The solar energy received by the Earth's surface during an hour could power the global economy for a year. Moreover, mankind's ability to acquire and store it is increasing.
4. For these reasons, the fourth law of thermodynamics, formulated by Georgescu-Roegen, is redundant and can be reduced to the second law of thermodynamics.
5. Moreover, Georgescu-Roegen's pessimism about mankind's future also included his view that there is a small chance of ever making effective use of solar energy. He considered all the contemporary technologies for harvesting this energy to be parasites of energy technologies based on fossil fuel combustion. This slowed down research aimed at the improvement of solar energy conversion methods and decreased economists' and politicians' interest in its practical use.
6. The literature review, a comparative analysis, and terminology management showed that the three waves concept formulated by Alvin Toffler can be expanded to include another three waves: Fourth—prosumer capitalism, Fifth—ecosocialism, and Sixth—solar communism, which gives it enormous futurological potential, allowing for studying mankind's future until 2050.

7. Solar communism may seem similar to a utopian system today, and it was initially perceived as such, even by the author of this paper. However, there was something in it which made me abandon these prejudices and analyze all the pros and cons of the concept from a logical perspective. Ultimately, it turned out that solar communism is not based on political or social assumptions but on one of the most basic laws of physics and economics—the second law of thermodynamics. The natural entropy budget of the Earth and its imbalance caused by the anthropogenic greenhouse effect, as well as the catastrophic climate change which threatens mankind, do not leave us with any choice of a different path for survival and growth. Pointing out that energy is one of the most valuable goods and—as such—requires socialization on a global scale is another element of originality and innovativeness of this study.

2. Prosumer Capitalism as the Fourth Wave in Alvin Toffler's Terminology

2.1. Definition of Prosumer Capitalism in a World of Networked Technologies

There can be no doubt whatsoever that prosumption is one of the most important economic processes in modern economies. To appreciate how potent that force is, one only needs to realize that even the emergence of the World Wide Web—one of the most powerful knowledge tools of all time—was the result of prosumption [3] (pp. 178–179). Currently, the approach to the concept is twofold, as it may be optimistic or pessimistic. In the former perspective, prosumption implies an expansion of individual freedom, as consumers thus gain greater control over production, while the latter perspective emphasizes facilitated exploitation on the part of the producers since parts of the labor process are transferred to the consumers. In other words, prosumption alleviates alienation, on the one hand, thanks to which consumers become active participants in production processes, yet it exacerbates exploitation, on the other, as customers perform unpaid labor, resulting in the transfer of surplus value and reduced production costs. Fisher argues that these two dimensions of prosumption are mutually complementary and that there exists a dialectical relationship between them. In the era of the dominance of network technologies, prosumption is heralded as a new social compact between capital and labor; therefore, it is hardly surprising that it has become the basis for a new classification of various forms of capitalism [4].

Nowadays, the most developed countries in the world are dominated by the form of economies' development, which has been called prosumer capitalism [5–8]. This is due to the proliferation of prosumption processes, which are gaining on an unprecedented scale through the use of ICTs. This kind of prosumption is referred to as the digital prosumption [9]. This led to the need to reinterpret the economic history of the world and to redefine forms of development of the capitalist economy. Prosumer capitalism is the successor of the two previous forms—producer capitalism and consumer capitalism. All three forms of capitalism differ from each other in their attitude to the exploitation of workers and prosumers. Producer capitalism is a singly exploitative economic system because it is based on the exploitation of workers. Consumer capitalism is a doubly exploitative economic system in which exploitation of both employees and consumers is a significant source of profit for enterprises. In the case of prosumer capitalism, we are facing a completely new form of exploitation named synergistically double exploitation [2] (pp. 82–83). In order to clarify this issue, two types of prosumption should be distinguished: prosumption-as-production (p-a-p) and prosumption-as-consumption (p-a-c). The first occurs in organizations focused on production and work, such as factories and offices, while the second appears in organizations related to consumption, e.g., in shopping malls. Therefore, we have two types of prosumers, prosumers-as-producers (p-a-ps) and prosumers-as-consumers (p-a-cs), who have been exploited at various places and times. Until recently, the exploitation of p-a-ps occurred in factories and offices and happened during the work day, and the exploitation of p-a-cs was observed mostly in shopping venues after work hours and on weekends. In prosumer capitalism, the exploitation of both types of prosumers is more and more common in the same conditions and occurs at the same time. Thus, the exploitation interpenetrates

two forms of prosumption, p-a-p and p-a-c, which leads to synergy resulting in a new, enhanced form of human exploitation [1,2].

Empirical research on prosumer capitalism is only in the initial stage. Among the few exceptions in this area are studies on the pop culture industry [10], and public administration [11]. Diagnosing the threats of a new form of economy–prosumer capitalism seems to be extremely crucial. For now, the free-of-charge work of prosumers does not appear to be a major barrier to economic growth, but it may soon change. It seems that societies should now develop appropriate remedies to prevent possible future economic crises. The paper formulates the thesis that the first line of defense against prosumer capitalism risks should be the government sector.

2.2. The Socioeconomic Effects of Prosumer Capitalism

2.2.1. Main Threats Related to Prosumer Capitalism

According to Ryder, numerous warnings against the prosumer economy are to be found in the science fiction literature. However, such threats are often dismissed by researchers due to the limitations imposed by the language and the requirements of a purely scientific academic discourse. The dystopias analyzed by that author establish a research framework that not only enables one to determine the impact of mass prosumption on people's lives but also to take a critical look at the emergence of a new economic system known as surveillance capitalism. It turns out that in such an economic system, the activities of the prosumer resemble the mindless behavior characteristic of a robot which obeys and does not even realize that it is being controlled. The principal dangers of prosumer capitalism discussed in dystopias include the alienation of the individual caused by the involvement of robots in the self-perpetuating cycle of production and consumption, as well as the entrapment of citizens in an increasing debt of work. One also stresses the significance of computer-like, internalized microfascisms, which are rooted in a complex network of power relations and shape people's desires, prompting them to intensify and continue prosumption processes indefinitely. This includes such adverse phenomena as overproduction and overconsumption, social inequalities, ecological disasters, and climate change [12].

Moreover, science fiction has long conveyed warnings that prosumption might become a social institution. These fears came true with the development of social media, which resulted in the disempowerment of numerous users who were thus trapped in a cycle of repetitive, meaningless free work. People in this system act in the manner of robots as they perform free labor for multinational corporations, which reap substantial profits as a result, at the simultaneous expense of users who lose personal freedoms and privacy. This endless cycle of prosumption consists of the production and consumption of unnecessary content, while at the same time, social media companies sell users' data and target them with advertising that reinforces and perpetuates this vicious cycle. Increasingly often, the absence of prosumption and manifestations of prosumptive attitudes may be associated with the loss of social status. The progressive robotization of prosumers should be attributed to the fact that advertising agencies and marketers are able to program and manipulate them. The ultimate prosumer is unlikely to be an individual who can autonomously choose and produce a product, but one who becomes a commodity they want to consume and, as a result, consumes a small part of themselves, as exemplified by the users of social media. The emergence of multinational corporations, whose economic and political power matches that of certain countries, is another noteworthy issue [12].

The emergence of prosumer capitalism is associated with two types of economic effects. First of all, prosumption processes certainly accelerate economic growth because, owing to them, enterprises can benefit from additional, external sources of innovation and creativity without incurring the associated fixed costs. Nevertheless, the growing profits of enterprises result from the unpaid labor of workers and prosumers. The basic research question focuses on how society can be saved from the adverse effects of synergistically

double exploitation. Although the threats from the prosumer capitalism do not appear to be too noticeable today, this situation may change in the near future.

2.2.2. Outline of Socioeconomic Policy Counteracting the Harmful Effects of Prosumer Capitalism

The remedy proposed by the author, which aims to avoid the effect of synergistically double exploitation, is based on the method of extinguishing fires known in firefighting as controlled fires. According to this method, combustible materials must be removed by burning them before they are reached by the firefront [13]. Similarly in the economy, there is a large but presumably finite prosumption resource of the society that is mainly used in the private sector in prosumer capitalism. The government sector does not sufficiently use this resource, which is the reason for significant asymmetry between the two sectors. Meanwhile, public administration is a serious economic force that can prevent prosumer exploitation in and outside of the workplace. If this sector had obtained the still free part of the prosumption resource, then, assuming its limited quantity in society, this could constitute a certain barrier in the further acquisition of this resource by the market sector. In the context, the increase in private companies' profits resulting from the use of the prosumption resource of society would be inhibited, which would also mean a limitation of the synergistically double exploitation. A prerequisite for this to happen is lighting a fire in the public sector, and therefore introducing all models of wikinomics, with prosumption in the first place, into this sector [14,15]. In this way, the natural creativity and ingenuity of people would be redirected from the unpaid aid in profit increasing of private enterprises to the realization of socially useful goals, which would also be a factor of economic growth and development. However, for this to happen, public administrations need to adapt many information technologies so far only used in the market sector, which is a prerequisite for establishing a balance between both sectors in the use of society's prosumption resources. The public sector is not currently ready to compete with the market sector for the prosumption resources of society due to the lack of an appropriate technological and organizational base that would enable the implementation of all of the digital prosumption principles.

Harmonization of the public administration sector with the market sector encounters a number of barriers that can be divided into technological and mental ones. The first ones concern the technical requirements of the platforms for participation. Therefore, they can easily be overcome with the right inputs, while the latter ones are not. Breaking the mental barrier is only possible through the transformation of clients into prosumers, which requires simultaneous bottom-up actions of citizens and the implementation of the principle of openness in the public administration itself.

2.3. A New Era of Change in World History Is upon Us

Towards the end of the first decade of the 21st century, societies began to realize that the teleinformatics revolution, which may be dated from 1970 to 2005, had reached its declining phase and that a new age of change was beginning in the history of the world. This era has already begun and though it has received no standard appellation so far, various authors still attempt to identify its key features. The following offers a brief overview of a number of futuristic approaches in order to formulate a common conceptual framework for analyzing changes in the energy sector in the future and, while doing so, subject them to expert validation. These include the following:

1. Maynard and Mehrtens take advantage of Toffler's terminology and refer to the era in question as the Fourth Wave, which sees an integration of the core business principles, environmental concern, personal integrity, and spiritual values [16].
2. Daniel Pink elaborates on the idea of the Conceptual Age based on creators and empathizers as well as the six senses that will prove crucial to success in the new economy: design, story, symphony, empathy, play, and meaning [17].

3. David Houle also draws on Toffler and employs the term "the Shift Age" to describe the 2007–2030 period, where the primary emphasis is on consciousness and where change is driven by three forces: the shift towards globalization of culture and politics, the flow of power and influence to individuals, and the acceleration of electronic connectedness [18,19].
4. Maria Azua explores the vision of a revolution called the Social Age, whose prevalent approach, informed by communication and collaboration, is actuated by three forces as well: information overload created during the Information Age, standardization of technology that has commoditized key conduits of communication, and low-cost two-way Internet communication, including wikis and other social networking tools [20].
5. Jemielniak and Przegalinska define the concept of the collaborative society as a formation of enduring cooperative groups whose members have utilized network technologies to develop specific relationship patterns. Moreover, emerging technologies are greatly important in this case, as they become supermultipliers of cooperative outcomes insofar as they are used by an increasing number of people [21].
6. Hoffman and Ehrenfeld highlight the challenges facing management systems in the Anthropocene, a new geological epoch characterized by a significant impact of human economic activity on the Earth's ecosystems. Their model, based on punctuated equilibrium, distinguishes three waves of environmental management in the period from 1970 to the present: regulatory compliance (1970), strategic environmentalism (1990), and sustainability (2010). Occurring today, the fourth wave is referred to as Managing in the Anthropocene. To prevent adverse changes to the ecosystem on a global scale, it is necessary to adjust the functioning of the autonomous invisible hand by changing our culture and business management models accordingly. Systems thinking plays a paramount role in the pursuit of that goal in that it engenders new forms of the following six elements: partnerships, materials use and supply chains, domains of corporate activity, organizations, economic models, and metrics [22].
7. Klaus Schwab formulated the well-known and much-discussed concept of the Fourth Industrial Revolution, which denotes the fusion of cutting-edge technologies that will gradually eliminate the boundaries between the physical, digital, and biological realms. It is expected that technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing will multiply humanity's creative capabilities, with virtually all areas of life changing as a result [23,24]. This revolution will not only open up numerous opportunities but also pose challenges [25]. In particular, profound changes are to be expected in the labor markets [26]. In this context, one also speaks of Industry 4.0 as a revolutionary reconstruction of the global value chains by smart factories, which will provide flexible cooperation between virtual and physical production systems. An interesting feature within the concept of the Fourth Revolution is its emphasis on the remodeling of legacy energy systems through departure from fossil fuels to prosumer energy based on renewable energy sources [27]. Naturally, prosumption will not be confined to just one sector but will assume a variety of forms in many domains.

As may be seen, all concepts are similar in that they apply to a knowledge-based society, where network technologies have penetrated almost all areas of life, where social networking tools enable balanced and integrated use of information to enhance creativity and cooperation of agents, as well as strengthen their ties with the environment. The future is not entirely predictable, so there are, and must be, terminological differences between the various futuristic approaches, which appear similar in their general formulation. For this reason, some attention is due to a field of knowledge designated as terminology management, which today serves as a community tool for organizing and representing knowledge, as well as aligning concepts with reality. The essential features of the new era of change include meaning-making and understanding. In today's world, terminology

management has shifted from the highly specialized science known as taxonomy to social network users [28].

At this juncture, it is necessary to confront some of the challenges of terminology management and argue that the concept of historical waves proposed by Toffler is a useful tool for studying socioeconomic development of humanity and affords insights far into the future, going well beyond the revolutionary description of the post-industrial society of the Third Wave [29]. In addition, the proposition has been subjected to expert validation consisting of the above seven opinions. Consequently, it may be legitimately stated that prosumption is one of the foremost elements in each of the futuristic scenarios discussed, not to mention the modern energy sector, where it operates as a key transformative factor. This is supported by Ritzer's view that we are now dealing with a form of socioeconomic and political system based on digital prosumption [30]. Hence, the most appropriate name for the fourth industrial revolution in Toffler's nomenclature is prosumer capitalism.

2.4. Prosumer Capitalism as a Herald of the Communist Economy

Wikinomics is a discipline that studies the impact of information technology on economic growth. Teleinformatics has changed the principles of conducting business and encouraged the emergence of new models of global collaboration. The rapid development of the world economy in recent decades is the effect of these changes [14,15]. It resulted in the emergence of a new form of capitalism called prosumer capitalism. However, these successes are supported by exploitation of prosumers both in the workplace and outside of it. In this way, prosumption from the economic growth factor gradually becomes its barrier. However, there seems to be a solution to this problem. It stems from the asymmetry between the market and the government sectors, which is a consequence of poorer adaptation of digital prosumption in the latter. A gradual increase in prosumption in the public sector, especially in public administration, should reduce the extent of prosumer exploitation in the market sector, as long as the services in the public sector coproduced by them are available to them free of charge. This issue is open for the time being, and it may be a promising area of future research. However, one should point out that this leads one towards the reasoning presented by classical economists, who developed a vision of scientific communism.

As Van Dijck and Nieborg point out, the wikinomics program is in many respects a business manifesto to persuade the public to opt for a different socioeconomic paradigm by introducing a revolutionary way of thinking with respect to the processes of production and consumption. The models of cocreation that it advocates are not subject to choice by economic actors since, according to Tapscott and Williams, they are inevitable owing to historical necessity. In fact, the task of this manifesto of mass creativity and peer production is to develop—relying on network technologies—a concept of public collectivism, which is to fuse the two former opposites into an integral whole: producers and consumers; collective (nonmarket, public) mode of production and commercial (market, private) mode of production; the foundations of traditional business economics and the sociopolitical ideals of the 1960s counterculture; communalist thinking and the rational foundations of business; grassroots values of commonality and fundamental capitalist values; profit-driven platforms and nonprofit virtual collectives; commerce and commons; creativity and consumerism; capital-intensive, profit-oriented industrial production; and labor-intensive, nonprofit peer production. All of this is supposed to take place within a commodity culture. Emerging from this marriage, one sees a picture of the hegemonic ideology of cultural collectivism based on mass collaboration and communal creativity to be supported by all. The capitalist model of enterprise must therefore be supplanted by a modality of value creation relying on a shared public–private system [31].

Van Dijck and Nieborg demonstrated that the above mindset is grounded in several assumptions which are not always true: all content producers are equally creative, while their motivations to participate stem from similar desires; all users display the same spirit of collectivism that inspires them to create communities; users affiliated with commercial

online communities are equated with people who use nonprofit social exchange sites. Simultaneously, they emphasize that, in fact, this is not about user-provided content but about the enormous economic value of metadata, connections, and profiled actions, new commodities of the digital age which enable Web 2.0 platforms to connect people to advertisers and products [31].

The ultimate goal of the wikinomics manifesto is to declare the victory of dot-communism over the final stages of traditional capitalism. Dot-communism stands for an economic system which includes such elements as a workforce composed only of free agents, a decentralized gift or barter economy without property, and a technological architecture which determines the political space [32,33]. Arguably, the first step in this direction is prosumer capitalism, in which the hierarchical model of production and consumption processes has been replaced by the cocreation model. Hence, value-creation processes are shifting from products and enterprises toward active networks of cocreators.

3. Is Solar Communism the Future of the Energy Sector?

3.1. The Origins of Communism as a Socioeconomic System

Schwartzman claims that the roots of communism lie in the Bible [34] (p. 16). It is also asserted that communism is synonymous with practical Christianity and that Jesus Christ was the first communist [35] (p. 593). As the well-known socialist theorist Karl Kautsky notes, Christian communism resulted from the desire of the poor to abolish all private property, and joint ownership was supposed to guarantee that misery and poverty would be eliminated. Their source is the same as in other forms of communism—the disenfranchisement of the popular masses. In early Christianity, the communist sphere encompassed articles of consumption, their distribution, and joint consumption. Furthermore, rural areas witnessed communism in production since jointly organized labor was possible there. In agriculture, consumption was directly linked to production, given that almost all production was intended for private consumption [36]. In other words, Christian communism essentially consisted of agricultural activity in the circumstances of Toffler's First Wave, which is why it occurred mainly in rural regions. Production was mostly undertaken to meet one's own consumption needs rather than to be sold. Using contemporary language, prosumption prevailed there. The factors which united Christian communities were communal suppers and the organization of mutual aid. As soon as wealthy individuals emerged among them, they gradually lost their proletarian character.

In the Middle Ages, monasteries were the primary form of technical and economic improvement since the cooperative mode of production, which was characteristic of those entities, dovetailed perfectly with the existing conditions of rural production. Unsurprisingly, monastic communism was the main form of Christian communism at the time. Within its framework, the Christian ideal of communal consumption and production, i.e., prosumption, could once again be reified. This structure of Christian monasteries has survived to the present day. However, monastic communism could not become the basis of the social economy because it required celibacy and conflicted with individual marriage. As such, it was limited to a minority. On the other hand, the conditions of production in the large urban centers resulted in the dispersion of proletarians [36] (pp. 345, 452, 455). The development of communism in the cities faced enormous obstacles from the very outset due to the separation of production and consumption, which, as Toffler noted, led to the gradual marketization of the world, and that trend deepened even further during the Second Wave associated with the Industrial Revolution. The shape of the economic system is not determined by how consumption is arranged but by the organization of production. The discrepancy between production and consumption was exacerbated by the division of labor, which, in turn, resulted from expanding industrial production. Hence, the cities saw only communism of consumption, confined to joint consumption of foodstuffs and other goods, so it operated within common households and families. In Kautsky's contemporary utopian communism, which functioned in the circumstances of the Second Wave, attempts were made to couple communism of consumption with the communism of production,

but this led to its failure due to disputes and misunderstandings [36] (p. 454). The failure of utopian communism should be attributed to the separation of the consumption and production sectors for the sake of exchange, which resulted in the collapse of prosumption. It may therefore be concluded that communism and prosumption go hand in hand: what supports the former also sustains the latter.

Kautsky also underlines that religion was the primary factor in the development of Christian communism. As the author himself admits, there is no communism without religion. The strength of the Christian community lay in the propagation of messianic ideas, belief in the Christ Crucified and personal resurrection. Not only did it enable the group to survive as a secret organization inside the Roman state, but it also enabled it to become an unassailable power. Originating from the proletariat, the Crucified Messiah accomplished what no one else before had, or has since been able to, achieve: he conquered Rome, coerced Caesars into obedience, and gained dominion over the entire world [36] (pp. 380–381, 451).

According to Kautsky, modern communism is altogether different in its nature from Christian communism. By definition, the former is a macroeconomic system encompassing the entire society whereby the proletariat must acquire state power in order for it to become a reality, whereas the latter is inherently a microeconomic system. Modern communism should be the communism of concentration of wealth and concentration of production [36] (pp. 467–468).

An elaborate paradigm of modern communism was envisioned by Lenin, who emphasized that the basic trait of this socioeconomic system is the complete withering away of the state. In his view, the state is an organization of violence which is brought to bear for one social class to exercise oppression over another. Social classes are in evidence when the members of society differ in their relation to the social means of production. Since under communism, society will be classless, the state as an instrument of oppression will also prove dispensable. A similar fate is destined to befall democracy since, to Lenin, the term denotes a state that presupposes subordination of the minority to the majority, which is tantamount to the systematic oppression of one part of the population by another. It is only in a communist society that democracy may become complete and thus unnecessary, withering away along with the state in consequence. Only then will it be possible to realize the principle of "from each according to his ability, to each according to his needs". The state will wither away during the transition period from the proletarian revolution to the consummation of communism. Under this new system, everyone will be able to partake in the management of socioeconomic life and take over functions previously held by the state [37]. As Engels notes, as social classes disappear, society "will put the whole machinery of state where it will then belong: into the museum of antiquities, by the side of the spinning wheel and the bronze axe" [38] (p. 160). These notions turn out to coincide with the ideas of political prosumerism and correspond to what one understands today as digital prosumer capitalism [30]. In addition, Lenin would have certainly approved of the present-day energy transition based on prosumer electricity markets, given that he fully appreciated the importance of electricity for the socioeconomic development of humanity. In his opinion, "communism is Soviet power plus the electrification of the whole country since industry cannot be developed without electrification" [39] (p. 419).

Priddat and Jansen elaborate on the idea of virtualization of the state, which consists of enhanced political prosumerism, a goal achieved by increasing citizen participation in the political planning process. This translates into delegating responsibility through society to society so that citizens may take control, assume greater responsibility for their own affairs, and focus on local problems. It is the citizens who should run the state, not the other way around. The development of eGovernment will make it possible to tackle the three challenges of civil society: the integration of the citizenry, co-opetition, and policy networks, as well as the virtual production of public goods. As a result, the size of the state will be reduced by half while its influence will grow twofold. The government's use of citizens' advice may allow it to solve problems to better effect. The paradox of the

withering state is also present here: as globalization advances, local politics (glocalization) gains increasing significance. The production of multiple public goods (with the exception of law, infrastructure, and, in part, education) can be outsourced to civic organizations or private enterprises, which can simultaneously cooperate and compete with one another. Another matter of interest is the concept of the zero-gravity state, which utilizes virtual production structures and value-adding networks to optimize its state quota [40].

3.2. The Essence of Global Solar Communism

It is not economic, social, and political ideas which lie at the core of solar communism, but the laws of physics. Prior to discussing this issue, the basic concepts involved have to be defined. According to the second law of thermodynamics, the entropy of an isolated system, i.e., one which does not exchange energy and matter with its surroundings, must increase insofar as any changes occur in it. An increase in entropy is tantamount to decreased ability to perform work, which results from the transformation of low-entropy energy into waste heat. Consequently, thermodynamic entropy can be defined as a randomized state of energy that cannot be utilized to perform work (being unavailable). Thermodynamics also defines closed systems which do not exchange matter with the environment but are open due to the energy flow [41].

The introduction of thermodynamic entropy into economics is credited to Nicholas Georgescu-Roegen, who made it a measure to determine the ultimate limits of the development of economic processes and a physical foundation employed in social predictions [42]. The processes of production and consumption consist of transforming low entropy into high entropy, resulting in waste [42] (p. 18). Since the resources of low entropy in the human surroundings are limited and become gradually depleted, as is the case with fossil fuels, there must exist physical limits to further growth of the world economy. The continued increase of the physical throughput will sooner or later become impossible due to the depletion of energy, materials, and space, with concurrent destruction of the biosphere. Future knowledge will not be capable of removing the strictures imposed on the world economy by finitude, entropy, and ecological dependence [43] (p. 199). The concept of entropy generated by economic processes was expanded by Jeremy Rifkin, who approached entropy as pollution, a marker of cosmic disorder, and a primary cause of environmental destruction [44,45]. Járosi and Kovács attribute the shape of the modern energy transition in Europe to the catastrophic visions and intellectual influence of Jeremy Rifkin, who continued the work of Georgescu-Roegen. The Hungarian authors are skeptical of the European Union's energy policy and emphasize that its efforts have minor significance for global climate protection and cannot prevent the rise of anthropogenic greenhouse gas emissions in emerging economies [46].

To Georgescu-Roegen, a closed system does not exchange matter and energy with the environment [47] (pp. 7–8). He further observes that a closed system cannot ceaselessly perform work at a constant rate [48] (p. 304). However, this is how thermodynamics describes an isolated system as opposed to a closed one [49] (pp. 3–4). If the Earth is an isolated system, then there must indeed be physical limits to the development of the world economy since, under the second law of thermodynamics, matter and energy are irrevocably dissipated [47] (p. 8). However, this is not the case, since the Earth is a closed system and thus does not exchange matter with space (except for space vehicles and meteorites), but remains open to solar energy transfer. David Schwartzman notes the mistake Georgescu-Roegen made and demonstrates that the conversion of low-entropy, high-temperature energy into high-entropy, low-temperature heat can be a source of work whose recycling is infinite. An elucidation of the differences between isolated systems and closed systems helps one understand why Georgescu-Roegen took a pessimistic view of the use of solar energy in the economy—he considered all solar systems known in 1981 to be parasites of fossil-fuel-based energy technologies [50] (pp. 70–71, 198). This confusion of concepts is also crucial in solving the problem of optimizing humanity's relationship with nature, since it supplies the physical foundation for the development

of solar communism [41]. Thus, the vision of an entropic apocalypse culminating in the annihilation of civilization proved erroneous.

Given the energy budget at the Earth's surface, the solar energy flux reaching the surface/atmosphere is equal to the flux radiating back into space. The natural greenhouse effect is due to the absorption of heat radiation by water and carbon dioxide molecules in the atmosphere which reradiate heat to the surface. Any economy which does not rely on direct solar flux but uses fossil fuels, as well as nuclear and geothermal energy, affects the heat budget of the Earth because the emission of heat radiation exceeds the natural flux from the surface. This also involves the enhanced greenhouse effect, whose principal source is anthropogenic carbon dioxide and methane. The global economy would not have an impact on the Earth's surface heat budget only if the use of solar energy were not associated with net transfers of these greenhouse gases to the atmosphere and ocean systems [41].

The physical underpinning for the development of solar communism is staggering. The world economy could increase its energy consumption tenfold using only 1% of the solar radiation reaching the Earth's surface without changing its current heat budget. This means that anthropogenic greenhouse gas emissions and direct waste heat production can be avoided. The annual flux of solar radiation is ten times the total energy stored in the global coal resource or in one million billion (10^{15}) barrels of crude oil. The energy payback time, or the number of years it takes for photovoltaic panels to generate the amount of electricity needed to produce them, is 1–4 years (as of 1994). The U.S. demand for electricity could be fully met by installing silicon-based photovoltaic panels in an area equal to a square with a side measuring 140 km, which is much smaller than the area currently occupied by U.S. military installations. The introduction of solar communism will not be possible without optimal relations between the technosphere and the ecosphere and, therefore, adherence to the principle of maximizing the containment of the technosphere [41].

3.3. Conditions Necessary for the Implementation of Solar Communism

It follows from the laws of thermodynamics that economic development on the Earth's surface may be continued by humankind even in the relatively distant future, provided that it relies on solar energy. Direct utilization of its minor proportion by humans would mean connecting the world economy to an immense flux of energy capable of performing inconceivable work. This portion of solar energy would eventually be converted into waste heat in any case, as evidenced by the natural heat budget. If the world economy were based solely on solar energy, it would increase the physical throughput (industrial processing) in the technosphere without a negative impact on the biosphere, provided that the production–consumption cycle is closed. This would enable the export of entropy flux into space in much the same way as it happens with the natural biosphere powered by solar energy. However, before these possibilities can be made a reality, the basic principle of communism—"from each according to his ability, to each according to his needs"—has to be reinterpreted in a manner which will render it applicable not only to humans but also to the Earth's ecosystem [51]. For this to be accomplished, the thermodynamic processes taking place in nature must be supported by appropriate socioeconomic policies on a global scale.

As Schwartzman observes, the transition to solar communism requires gradual application of that modified principle already in the near future, i.e., in a mixed social formation referred to as ecosocialism, which should be situated on the timeline immediately after prosumer capitalism. In his view, ecosocialism—a combination of ecological and socialist movements—is a prerequisite for the reification of the ultimate system: a global solar community. Since ecosocialism does not presuppose the occurrence of the phenomenon known as synergistically double exploitation, it must inevitably be clearly distinguished from prosumer capitalism. The end of the era of prosumer capitalism confronts humanity with the great bifurcation: the choice between relegating global capitalism to prehistory

or a climate catastrophe of unimaginable consequences caused by unsustainable capital reproduction processes [52].

The notion that future civilization should rely on the solar radiation flux reaching the Earth's surface stems from the fact that it is the most abundant and most easily accessible source of energy, while its negative impact on health and the environment is negligible compared to fossil fuels. In addition, solar energy technologies are developing globally at a nearly exponential growth rate [34]. Today, the global anthropogenic energy flux (waste heat) equals only 0.03% of the solar flux on land surfaces. This is equivalent to saying that one hour of solar flux reaching the Earth's surface supplies an amount of energy equal to the annual consumption of energy by the global population. In this case, the second law of thermodynamics does not limit economic development. The impact of converting solar energy into useful work poses much less of a threat to ecosystems than the current hazards since the resulting waste heat is discharged into space and does not actually increase the natural flux [53]. In this way, humans may adapt their economic undertakings to the entropic flow from the Earth's surface and take advantage of the existence of a heat sink in outer space, which guarantees ecological balance and biospheric self-organization [54] (pp. 161–172).

The sufficient and necessary conditions for the attainment of solar communism include material and political requirements as well as the demilitarization of the world. The material requirements are as follows: the existence of a global and highly efficient solar energy infrastructure; containment and precautionary measures in environmental policy; demilitarization of technologies and propagation of state-of-the-art information technologies around the world; concentration of the population in green cities and the establishment of large biospheric reserves. Among the political requirements, one should list a transnational workforce organized bottom-up, accelerated democratization of the global society, a transnational ecosocialist political movement, and partial achievement of the material requirements cited above. Further indispensable elements include social governance of production and consumption at all levels (from local to global), universal equity among people, communal ownership of land, and termination of the production of value based on labor time [52] (pp. 483–489).

It has previously been argued that one of the preconditions for the realization of communism is increased labor productivity under capitalism. With respect to solar communism, the list may be supplemented with state-of-the-art information technologies, renewable energy, and organic agriculture based on agroecology [51].

The main goal of ecosocialism is the global class struggle for ecological sustainability [51]. In their quest to end the domination of the big capital, the working class, middle strata, and indigenous peoples represent a countervailing force to the national and transnational ruling classes [52]. Specifically, ecosocialists have targeted the nuclear military industrial fossil fuel complex as the guardian of the interests of the transnational capital class and thus one of the greatest threats to the transformation of current prosumer capitalism into solar communism. In 2015, total defense outlays amounted to USD 2.03 trillion. Ecosocialists consider this sector to be the reproduction center of global capital due to the fact that it exerts a powerful influence on the internal and external policies of the major capitalist powers and seeks to control the world's oil reserves. In addition, the fossil fuel and nuclear industries are closely associated with this sector, which translates into the ability to use the threat of nuclear attack to achieve imperial policy goals. The complex is also seen as a major obstacle to the emergence of a global multiclass alliance striving to reduce global greenhouse gas emissions and transition fully to solar energy [34].

Global prosumer capitalism prioritizes the reproduction of capital over the needs of humans and nature. This results in a reduction in global biodiversity and habitat destruction, which some believe may contribute to pandemics [34]. Therefore, the emergence of solar communism spells the ultimate end of the reproduction of the militarized fossil capital, and the consequent cessation of value creation. In such circumstances, the pursuit

of class power will no longer be feasible [53]. A global solar communist society will be founded on a steady-state biophysical economy [34] (p. 22).

By consuming fossil fuels and using nuclear energy, humankind has incurred an entropic debt with the environment and, therefore, with space. Powering the global economy with solar energy will lead to the repayment of that debt in the form of nonincremental waste heat, which is impossible with unsustainable equivalents of such energy [34].

It is usually asserted that nuclear power does not affect climate change. However, environmentalists see it as a threat not only because of its ties to the military–industrial complex, but also because the existing fossil-fuel-based energy infrastructure powers all subsystems of the nuclear fuel cycle. Realignment of the global economy to solar energy may be delivered in sufficient time to avoid catastrophic climate change and prevent irreversible changes. Environmentalists emphasize that the transition to solar communism will be possible within the next 30 years if 1–2% of the current annual energy consumption, including the 85% involving fossil fuels, is allocated to solar and wind energy production each year [52] (pp. 491–492). The extant fossil fuel reserves will suffice to meet the needs of the global solar community, provided that they are not consumed as fuel. Moreover, solar energy tallies with the decentralized, democratic model of governance and control befitting a future global solar community [51]. Moreover, the current mean harmonized EROI (energy return on energy invested) values for solar photovoltaic systems range from 8.7 to 34.2, depending on the technology used, which is very promising, and these values could be even higher in the future [55].

3.4. The Exemplification: Possibilities of Developing Solar Power Plants in Poland

Solarization of the world—if it indeed takes place—will most likely begin with grassroots efforts by individual regions and countries. The use of solar radiation to produce electricity will be particularly important in this respect. The entire surface of the territory of Poland has similar solar energy resources, ranging from 980 to 1100 kWh/m^2 per year. Under standard test conditions (STC), an optimally located photovoltaic system can approximately yield 1000 kWh annually from each kilowatt of capacity installed. Depending on the technology used, this rate is usually in the 950–1025 kWh/kWp range [56] (pp. 132–133).

In recent years, the market for electricity involving direct solar radiation has grown rapidly. In late April 2022, the total installed capacity of the photovoltaic systems in Poland reached 9998.2 MW, in excess of double the figure for April of the previous year (4739.6 MW). At present, the prosumer share of installed capacity is almost 80%, and the number of devices they use exceeds 1 million. In the first four months of 2022, solar radiation generated 1782.6 GWh of electricity, which accounted for 2.8% of the national production. In the equivalent period last year, it amounted to 760.9 GWh and 1.3%, respectively [57].

In Poland, potential investors can estimate the overall cost of a photovoltaic system based on the following linear function [58]:

$$C(p) = 5845p + 3897, \quad (1)$$

where *C(p)* represents the cost in PLN, while *p* stands for the nominal power expressed in kWp. The calculations show that without external financing, the expected payback period of the system is 16 to 24 years.

At present, one of the most serious obstacles to the development of solar power in the country is the limited availability of connection capacities for new prosumers. Even so, forecasts concerning further development of solar power plants are very optimistic, but they do not appear likely to replace conventional power plants within a reasonable time horizon. Thus, the achievement of solar communism would indeed have to be global and involve the transmission of electrical power from the regions of the world with the highest solar exposure to the rest.

4. Discussion

Converting fossil-fuel-based energy systems to renewable energy is a super wicked problem, as many issues still need to be resolved in areas such as energy and environmental law, distribution, democracy, and cybersecurity. This is the most important challenge today, as previous unsustainable methods of energy extraction have led to unprecedented environmental destruction, impoverished biodiversity, and, ultimately, catastrophic climate change. Continued uncontrolled emissions of pollutants might cause tipping points of irreversible changes in the atmosphere to be crossed, possibly leading to the annihilation of humanity. This raises the question of the future of civilization, but in order to attempt an answer, it is necessary to return to the past.

A useful framework for economic and political futurism was established by Toffler, who developed the concept of three waves in the economic history of humankind, from the earliest times to the ICT revolution [29]. The concept is informed by the division of the economy into two sectors. Sector A includes the production of subsistence goods and services that do not reach the market, whereas sector B spans production intended for sale. Toffler noted that successive waves could be identified by determining the extent to which the share of these sectors in the economy changed. In this way, one can identify certain regularities in the long-term development of economies and even attempt to predict the future. In this concept, modes of energy production are essential, as it is the foundation of all human economic activity.

As shown earlier, the Fourth Wave in the development of civilization is prosumer capitalism. The appearance of prosumer capitalism is not only related to the acceleration of economic development, but also to certain risks. The biggest risk associated with it is that the development factor is the free-of-charge work of prosumers. There is a conviction that, as a result, prosumption processes can turn from a factor of economic development into its barrier. To prevent this, an appropriate economic policy of the state is necessary. The best way to achieve this is to use a fire extinguishing strategy by controlling its inciting in other places. In other words, it would be appropriate, in the light of the experience of the market sector, to introduce prosumption to the public sector and, in particular, to the public administration sphere, which may have key implications here. In this way, the public sector would be synchronized with the market sector. Preventing the negative effects of prosumer capitalism requires the improvement of the existing public services or even the introduction of new ones, which means the need for a thorough reorganization and development of the public administration. This would allow governments to improve their economic policies and prepare for new challenges by taking account of grassroots initiatives of the citizens. Introducing prosumption to the public administration would not be possible without adequate ICT support.

Prosumption in the market sector is rapidly developing, and a long time ago it took a form of the digital prosumption. However, the introduction of prosumption in the public administration is still delayed, which is a source of considerable asymmetry in the development of these sectors. Hence, in many economies worldwide, there is an uncontrolled phenomenon described by Ritzer, which he calls synergistically double exploitation [1,2]. The point is that the basis for economic growth is a doubly free-of-charge work of people. This is more and more common in the situations when the same people once act as employees and another time as prosumers. The public administration sector is predisposed to be the first line of defense against such situations.

Currently, the development of political prosumerism, which manifests itself as the virtualization of the state and an increase in the share of public goods produced by citizens, is the most important method of counteracting human exploitation. This will mean that the state is shrinking. Thus, assuming the simultaneous development of information and computing technologies, the dot-communism ideas will be implemented, which will create the basis for further transformations and may contribute to the emergence of solar communism. Therefore, one of the basic weaknesses of prosumer capitalism—founding economic growth on exploitation—becomes the main stimulus for the implementation of

the global solar communist program. Making use of the power of prosumption in acquiring solar energy may make it possible to solve one of mankind's major problems: to successfully complete the energy transition, thereby liquidating the anthropogenic greenhouse effect.

Figure 1 shows the concept of economic and political development of humankind from the earliest times, which witnessed the agricultural revolution, until the near future (from the current point in time until the mid-21st century), including the Fifth Wave of Computing (ecosocialism) and the Sixth Wave—technological and energy communism (solar communism). In each of these waves, the share of A and B sectors in the economy fluctuated, which was indicative of either demarketization or marketization of the world's production and consumption systems. In other words, prosumption and production for exchange are the main driving forces of human economic activity. Considering the first four waves, i.e., the agricultural, industrial, and teleinformatics revolutions, as well as digital prosumer capitalism, one sees that the two forces act alternately: the growth of the prosumption sector is accompanied by diminution of the production-for-sale sector, and conversely. This brings to mind the steady, slow breathing of the gigantic economic and political structure created by societies called civilization, which not only encompasses the present but also extends into the past and future. Every aspiration must be followed by expiration. The agricultural revolution involved a strong prosumption sector, while the industrial revolution led to a massive increase in production for exchange. The ICT revolution restored the importance of prosumption and triggered processes of demarketization; the subsequent digital prosumer capitalism reversed the trend, mainly due to the rise of powerful global corporations linked to social media. Since the first four waves have already been quite thoroughly studied and belong to the past, it might be worthwhile to devote a certain amount of attention to futurology and focus on the last two waves, the germs of which can already be observed.

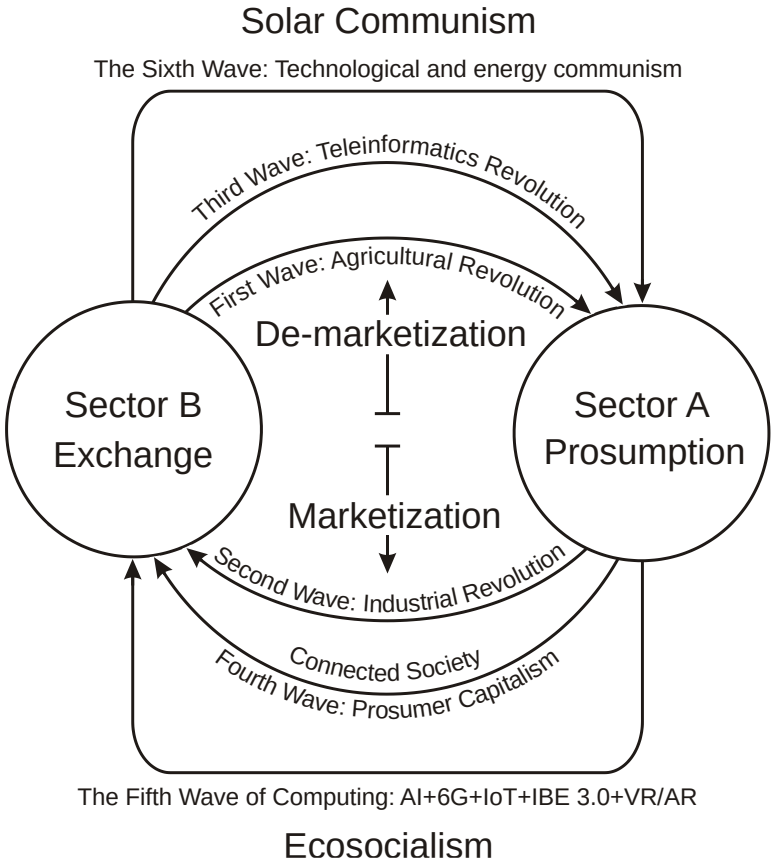

Figure 1. The revised diagram of Toffler's civilization revolutions.

The existence of all these waves would not have been possible without the energy systems which supported production processes in each era. The use of particular energy sources has always been contingent on the degree of technological advancement. However, the third wave introduced a new quality, i.e., digitalization, the potential of which was only fully appreciated during the Fourth Wave—digital prosumption capitalism. Digitalization should be distinguished from digitization [59]. Digitization denotes the formal conversion of data from analog to digital using information and communication technology. The meaning of digitalization is much broader, as it refers both to the digital transformation of technology as well as business models and processes at all levels of the economy [60,61]. Without digitalization, it would be impossible to decentralize the energy sector and gear it toward renewable energy sources. Decentralization causes electricity prices to drop, enabling the electrification of key sectors in the economy. Moreover, electricity is essential to digital technologies. Thus, digitalization, decentralization, and electrification together form a virtuous cycle in which all elements reinforce one another [62]. Moreover, without digitalization, humanity could not even attempt to prevent catastrophic climate change. Its absence in the government sector would hamper bottom-up energy transition [63]. Moreover, digitalization prompts the merging of the energy system into an integral whole, which not only fosters the development of energy production but also yields advantages in the heating sector, communications, and mobility [64].

Figure 1 shows that following the Fourth Wave, also known as the Connected Society, the cycle of the alternating rise of prosumption (demarketization) and production for exchange (marketization) as the driving forces of economic development came to an end. Immediately after the Fourth Wave, civilization will take another deep breath in, and the Fifth Wave will ensue, continuing the transformation which started with digitalization and consisting of the refinement of computational methods. Numerous innovative companies are expected to emerge in the future, which will temporarily strengthen the market sector even further. Only just beginning, the Fifth Wave is associated with the development of the Internet of Things (IoT), which will prospectively combine all manifestations of human life, including physical assets, into one large integrated network. Within such a system, people will interact with other people, but things will also interact with things. In particular, power grids will be fully interactive, with smart meters and other devices balancing energy production and consumption over time and space to an unprecedented extent. It is predicted that by 2025 the IoT market will span tens of billions of connected devices, reaching a value in excess of USD 11 trillion. The interoperability of encrypted data and authentication of users and devices will be critical in that system. The issues concerning privacy and security, as well as the management of tens of billions of digital certificates and standard keys, are likely to be resolved and aided thanks to the latest developments in Identity Based Encryption 3.0 (IBE 3.0) [65].

In the course of the Fifth Wave, one can expect the rapid spread of the fourth paradigm of science, a concept advanced by Jim Gray, which involves a shift in research methodology due to the increasing use of data. This means the emergence of data-intensive science, also known as eScience, which provides an integrating framework for the three previous paradigms: empirical evidence, scientific theory, and computational methods (large-scale computational simulation). The new paradigm gives rise to a scientific cycle in which the former three paradigms interact and augment one another. The main goal of the fourth paradigm is to find a way to integrate humans and computers so that researchers obtain increased capabilities of combining data from different sources with a view to discovering new patterns in that data [66,67].

It is likely that the Fifth Wave will see the spread of the sixth generation (6G) standard for wireless communications technologies supporting broadband cellular data networks, which will replace the 5G standard currently being deployed worldwide. It is presumed that 6G networks will support applications far beyond the current mobile experience through solutions such as virtual and augmented reality (VR/AR), instant communications anywhere, pervasive intelligence, and the IoT. It will be a combination of the physical

world, software-based digital systems, artificial intelligence, and biological systems [68]. The 6G networks will use frequencies from 100 GHz to 3 THz, which substantially surpass the 5G range. In all probability, these bands harbor major potential since they are within the unused and unexplored spectrum [69]. The new system means higher speeds, lower latency, and masses of bandwidth. It is likely that 6G will deliver data at a rate of 1 TB per second, far exceeding the 10 to 20 gigabits per second capacities of current 5G networks [70].

Artificial intelligence (AI) is also expected to develop rapidly in the Fifth Wave, which may culminate in a technological singularity. The latter concept was developed and popularized by Vernor Vinge, who noted that technological advances in programming may lead to the creation of agents capable of self-improvement, resulting in a powerful superintelligence which is far superior to human intelligence in qualitative terms [71]. Ray Kurzweil predicts that this might happen as early as 2045 [72]. Given that the upper limit of intelligence and, therefore, the capabilities of superintelligent machines are unknown, all events beyond the time horizon of a technological singularity should be considered unpredictable and unfathomable. Should this come to pass, however, the future of solar communism would also be called into question unless that superintelligence finds the above thermodynamic evidence sufficient and accelerates the use of solar energy.

All of this is in line with the ecosocialist agenda since, as observed previously, one of the chief aspirations of ecosocialism is to promote the development of state-of-the-art information technologies. Additionally, taking social aspects into account, the Fifth Wave may be labelled as ecosocialism as it anticipates continued global class struggle to restore ecological balance and reverse catastrophic climate change, in which the middle class has a considerable role to play [73]. Here, the development of prosumer energy markets and the thermal retrofitting of the existing building stock constitute some of the major challenges.

Four future scenarios have been advanced concerning the transition from the present-day digital prosumer capitalism (the Connected Society), through the Fifth Wave of Computing (ecosocialism), to what is expected to emerge in the middle of this century (solar communism). At that point, having taken a double deep breath in, occasioned by the Fourth and Fifth Waves, civilization will exhale in the form of the Sixth Wave. Some of these predictions may resemble visions familiar from science fiction, but they are nevertheless worth quoting here since the future is unknown and nothing can be ruled out in advance. In the order of increasing probability, they are as follows [74]:

- Scenario 1: A 0.1% likelihood of occurrence. Current trends in global capitalism are upheld, and economic development continues to rely on fossil fuel energy. The implemented climate protection programs do not match the scale of the threat. Still, the projected effects of global warming are not in evidence due to the emergence of unforeseen negative feedback occurring in the climate system. Admittedly, an increase in atmospheric carbon dioxide levels will trigger acidification of the oceans, but this will be neutralized by the remarkable adaptive abilities of marine organisms.
- Scenario 2: A 10% chance of occurrence. The proliferation of high-efficiency thin-film photovoltaics and the use of ocean currents and high-altitude wind energy will lead to the rapid decarbonization of the global economy and the emergence of cheap green energy, thus undermining the position of the military–industrial complex. Massive grassroots civic initiatives will precipitate the rise of the ecosocialist movement, which, gaining political power as time goes by, will restore peace and justice, as well as accelerate solarization processes around the world.
- Scenario 3: A 30% likelihood of occurrence. A transnational ecosocialist movement proves to be the only remedy to resource wars and the increasing impact of global warming. High-efficiency solar power supplants fossil fuels and nuclear power, promoting the removal of atmospheric carbon dioxide to levels below 350 ppm (parts per million). This is the minimum level marking the tipping points of irreversible climate change. Once this value is exceeded, humanity may lose control of the climate altogether (at present, CO_2 concentration is at an alarming 410 ppm). In this scenario, per capita energy consumption is at a level which ensures an average life expectancy

for all citizens, along with state-of-the-art health and education. At the same time, biodiversity is preserved, and organic farming expands around the world. Unsustainable production and consumption processes gradually abate.

- Scenario 4: A 60% chance of occurrence. This is a genuine dystopia and displays the highest likelihood of occurrence. Crises in the world economy are suppressed as a result of fascist repression by the authorities and the introduction of inexpensive drugs. A new ruling caste emerges to gain the upper hand in the ongoing class struggle, while the military–industrial complex plays an ever-greater role in the reproduction and expansion of global capital. A quarter of humanity consumes 95% of all produced goods and services, which is taking place in the midst of a deepening global ecocatastrophe starting as early as 2025. Melting permafrost is releasing methane, which prompts rapid melting of the ice caps and flooding of coastal cities around the world. Ocean acidification destroys marine life, and the quantity of hydrogen-sulfide-producing bacteria increases, causing most of humanity to die from starvation and disease by 2050. A few thousand of the richest people survive along with their families; they live in air-conditioned rooms powered by nuclear energy and grow organic food in greenhouses.

Scenario 1 has very little chance of occurring on its own while being fraught with too great a risk of human passivity if the presumed negative feedback in the climate system does not exist. Scenarios 2 and 3 are considered the most desirable solutions, although they may be difficult to accomplish as they necessitate demilitarization, solarization, and the creation of organic agriculture [75].

In the contemporary world, there are visible germs of future change, and it seems that they increase the probability that scenarios 2 and 3 will come to pass. The post-pandemic period saw a distinct acceleration in the process of advanced technology use, mainly artificial intelligence and machine learning, which resulted in productivity increase in many economic sectors. The acceleration of digitalization of the global economy supports the decentralization of energy systems and the development of electrification. Moreover, the pandemic helped to make people aware of what the next climate crisis may look like, i.e., to show such of its features as its fast-moving, systemic nature, and global range. It would certainly affect many spheres of social and economic life. Making people aware of such threats may accelerate beneficial changes in such areas as power engineering, mobility, and agriculture, and so this happened. Currently, we see the acceleration of the measures aimed at reducing pollution and intensifying the struggle against climate change, as many countries' recovery plans take into account environmental policy priorities. Electric cars are becoming increasingly popular, and new methods of carbon capture from the atmosphere are being developed. The development of stakeholder capitalism, which creates a bridge between businesses and communities, is also noteworthy. In this system, businesses are legally required to take into account the interests of all stakeholders in the decision-making processes, even at the expense of changing their governance structures [76]. Other systemic changes in the form of cross-cultural solidarities, increased interest in the transnational dimension of prosumption, and the emergence of technology-empowered prosumer global citizenship are also consistent with ecosocialism and solar communism [77]. Moreover, energy prosumerism, which includes not only material changes in the infrastructure but also visions of social, cultural, political, economic, and institutional changes, is growing rapidly. It also came to embrace both the market paradigm and its supplements in the form of municipal and communal paradigms [78]. Furthermore, work aimed at the development of new methods for solving the optimal scheduling of combined heat and power units is of great importance [79].

Solar radiation is the largest renewable energy resource that exists, and the possibilities of using and storing it have increased with the advancement of technical progress. Examples include concentrated solar power plants, which not only generate electricity but can also store solar energy. The principle of the operation of such systems lies in using light-reflecting surfaces to concentrate the direct solar radiation. There are four main technologies

used to focus beams of solar light: linear Fresnel reflectors, parabolic troughs, central receivers, and parabolic dishes. Photons are focused on a container with a special liquid, which is heated up to high temperatures. The heat obtained in this manner powers a steam turbine, which generates electricity [80]. Owing to such solutions, solar radiation becomes a dispatchable form of energy, as stored heat can be used to generate electricity when needed, both at night and during the day. As of the end of 2021, the cumulative installed global solar thermal power capacity amounted to 6800 MW, which is clear progress since 2014, when 4584 MW was reported [81] (pp. 7–8). It is noteworthy that the conversion of solar energy to heat and further to electricity does not increase the natural greenhouse effect, i.e., it is neutral from a climate change perspective.

Technical progress also helps to overcome the intermittent nature of solar radiation as a source of energy. It has been found that photovoltaic panels can generate electricity under very adverse conditions, even at night. Such weather conditions as a high level of cloudiness and rain considerably reduce the performance of solar cells. However, this can be helped by creating an energy harvesting system comprising not only a solar cell, but also a triboelectric nanogenerator, which converts mechanical energy into electricity [82–84]. This device helps to produce electricity both from solar radiation and from falling raindrops. Energy is also produced at night, as long as it rains. Another solution that can help to overcome the limitations of photovoltaic panel use is to equip them with a thermoelectric generator, which can produce electricity at night by making use of the temperature difference between a solar cell and the surrounding air. In this manner, with a clear night sky, one can achieve 50 mW/m^2 nighttime power generation. The generator also works during the day and provides additional power, which adds to the direct output of photovoltaic panels [85]. Another idea is to use a nighttime photovoltaic cell, also known as a thermoradiative cell, which generates electrical current while emitting infrared radiation (heat) towards extremely cold deep space. The Earth is used as a heat source in this device, and the night sky performs the function of a heat sink. Such cells can generate 50 W/m^2 under ideal conditions, i.e., a quarter of what a conventional solar panel can generate during a day. Moreover, it will operate during the day if direct sunlight is blocked [86]. In this manner, it may be easier to balance the power grid in the day–night cycle.

5. Conclusions

The second law of thermodynamics and the global mean entropy budget point to the precise direction for the energy transition. According to the revised diagram of Toffler's civilization revolutions, the starting point is prosumer capitalism, which—on the basis of the digitalization of economic processes—changed the traditional business models dramatically. This enabled the decentralization of the existing energy system and incorporating in it the energy from renewable sources. The Fifth Wave is linked to further digitalization of the energy system and the global economy, improvement of computation methods, and the development of the Internet of Things. Both waves, the Fourth and the Fifth, are supposed to pave the way for the Sixth Wave associated with solar communism, which should take place by 2050. However, this kind of development requires a radical reconstruction of socioeconomic systems existing around the world currently, and its success relies on common demilitarization, solarization of the global energy infrastructure, and efficient organic agriculture.

It is worth attempting to analyze solar communism and how it will be different from scientific communism known from the works of classical economists. There is every chance for Engels' and Lenin's vision of the withering away of the state to be fulfilled, which is testified to by the current trends in political prosumerism development, consisting of the virtual production of public goods becoming widespread and the growth of importance of glocalization processes. The same should be expected in terms of democracy. The emergence of modern technologies that enable one to use energy from renewable sources favors the development of prosumption in the energy sector, which leads to decentralization and democratization. If energy democracy becomes complete, it could turn out to be no

longer needed, similar to the state itself. Moreover, energy democracy can be a bottom-upward force which initiates and enforces political democracy. Furthermore, electricity generation with highly efficient thin-film photovoltaic panels is in line with Lenin's idea, according to which communism is equivalent to the electrification of the whole country and its expansion to the whole world. Obviously, this new system will be based on sharing and participation, which will make it similar to Christian communism. Kautsky's predictions of the concentration of wealth and concentration of production in solar communism will probably not come true. A great role in it will be played by prosumption, not limited to the energy sector, and the negative processes associated with it will be alleviated or completely eliminated. The main features of solar communism also include a certain type of universality, which consists of the ability to function on all economic levels, starting with the microeconomics and mesoeconomics and ending with the macroeconomics of the world economy. This may come true provided mankind creates a worldwide social community, with generating energy from solar radiation being its major unifying factor. Energy will probably be owned collectively, whereas when it comes to the private ownership of the means of production, one would expect a considerable reduction of its share in the global economy. Thus, the categorization of people into social classes would tend to disappear. However, much less can be said about the moral values in such a community and its belief systems.

Today, two main methods for achieving solar communism are defined in the ecosocialist program. The first one is a multidimensional class struggle, whose aim is to eliminate the rule of transnational militarized fossil and financial capital, whereas the other consists of progress in the development of digital technologies. Close international cooperation will be required to pursue this goal. The road to the new system should be marked out by the developing social and political movement called ecosocialism. It proposes that a global entity should be established to lead and coordinate class struggle. It should unite the global working class, its allies, and indigenous communities, which requires constant reinforcing of transnational solidarity. When it comes to the material conditions necessary for solar communism to emerge, an important role can be played by such countries as Venezuela, as it has the largest proven oil reserves in the world, which can be used to accelerate the global solar energy transition, or China, which has the largest renewable energy capacity and is the leading producer of renewable energy technology in the world [87,88]. Looking from the perspective of current knowledge, this is the only possibility of solving the super wicked problem of the current energy transition. However, one cannot exclude the possibility that completely new solutions to problems associated with global warming and climate change will appear by 2050.

The conclusions from this study can be summarized as follows:

1. Prosumer capitalism, which facilitates the energy transition, is not a stable system because of its many adverse phenomena. Two of them are of the greatest importance: the externalization of the labor cost and synergistically double exploitation. This makes it a provisional economic system which has to be replaced with something else in future.
2. An in-depth review of many methods for examining the future showed Toffler's three waves concept to have the greatest futurological potential as it provides for predicting megatrends. Taking the studies conducted so far and using the terminology management, one can conclude that prosumer capitalism, also referred to as the Connected Society, can be identified as the Fourth Wave. With this point of reference, the next two waves could be determined: the Fifth Wave as ecosocialism, which will involve the improvement of computation methods, and the Sixth Wave as solar communism, i.e., the use of the global infrastructure of solar energy conversion by the whole of mankind.
3. Toffler's expanded concept of waves of civilization development covers the period until 2050, and it is based on the laws of physics, especially the second law of thermodynamics and the entropy budget of the Earth. For these reasons, its futurological

potential is the highest compared to the other available methods for predicting the future.

4. In the most probable scenario, the present and future socioeconomic systems can be placed on a time axis in the following sequence: prosumer capitalism as the present moment and the starting point, followed by ecosocialism, dot-communism, and solar communism.
5. Nicholas Georgescu-Roegen, the creator of ecological economics, wrongly regarded the Earth as an isolated system in a thermodynamic sense, i.e., one that does not exchange matter or energy with the environment. This had immense consequences for the environmental policy and became a source of particularly strong ecological pessimism, which resulted in delays and errors in the energy transition. These mainly included underestimating the role and importance of solar energy. It affected the whole of mankind, which was wrongly informed that there was an absolute limit to economic growth and development, whereas now we know that, basically, there is no such limit.
6. Because of Georgescu-Roegen's mistake, his fourth law of thermodynamics is redundant, and it can be reduced to the second law of thermodynamics.
7. In fact, the Earth is—thermodynamically—a closed system, which means that it does not exchange matter with space, but it is open to the influx of solar energy. In consequence, solar radiation of low entropy and high temperature can be a source of work which can be repeated in perpetuity. Therefore, there are no limits to mankind's economic growth.
8. Due to Georgescu-Roegen's pessimistic views of an entropic apocalypse, the potential of solar energy was not appreciated in time. He regarded all of the technologies for acquiring this type of energy as parasites feeding on fossil-fuel-based energy technologies.
9. The outlook for solar energy is astounding, and it is developing along with technological progress. Solar energy can be converted into heat and stored, and modern photovoltaic panels can generate electricity even under adverse conditions, e.g., in cloudy or rainy weather. There are also thermoradiative cells, which can work not only during the day but also at night.
10. The basic idea of solar communism involves the whole global economy being powered by inexhaustible solar energy. Only this method can prevent global warming and catastrophic climate change. The global nature of solar communism is the condition of its effectiveness, which means that the cooperation of all countries is required.
11. Currently, all methods of energy generation other than solar power engineering, for example, fossil fuel combustion or nuclear fission, disrupt the natural greenhouse effect and interfere with the environment by emitting excess entropy as waste heat. Likewise, solar geoengineering can disturb the natural entropy budget of the Earth.
12. Elimination of the anthropogenic greenhouse effect and restoring the balance of the natural entropy budget of the Earth is the main goal of the energy transition.
13. Mankind has to pay the entropic debt, i.e., a type of thermal debt, to the cosmos, which is constantly growing, as soon as possible. It disturbs the natural relationships, not only in the Earth's ecosystem but also in the universe.
14. Fundamental conditions for introducing solar communism include demilitarization, solarization of the global energy infrastructure, and the development of organic agriculture.
15. One can agree with Schwartzman's opinion that China is likely to play the leading role in the energy transition by 2050 because it is already the global leader in solar power engineering. This is consistent with the Polish Prophecy from Tęgoborze of 1893 on the future of the world. It claims that "the Dragon will renew its face" [89] (p. 6). This view is confirmed by contemporary studies of globalization and geopolitics, particularly considering the New Silk Road [90].

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References

1. Ritzer, G. Prosumer capitalism. *Sociol. Q.* **2015**, *56*, 413–445. [CrossRef]
2. Ritzer, G. Prosumption: Contemporary capitalism and the "new" prosumer. In *The Oxford Handbook of Consumption*; Wherry, F.F., Woodward, I., Eds.; Oxford University Press: New York, NY, USA, 2019; pp. 75–93. ISBN 9780190695583.
3. Toffler, A.; Toffler, H. *Revolutionary Wealth: How It Will Be Created and How It Will Change Our Lives*; Doubleday: New York, NY, USA, 2007; ISBN 978-0-385-52207-6.
4. Fisher, E. The dialectics of prosumption in the digital age. In *Digital Labour and Prosumer Capitalism: The US Matrix*; Frayssé, O., O'Neil, M., Eds.; Palgrave Macmillan: Hampshire, UK, 2015; pp. 125–144. ISBN 978-1-137-47390-5. [CrossRef]
5. Ritzer, G.; Jurgenson, N. Production, consumption, prosumption: The nature of capitalism in the age of the digital 'prosumer'. *J. Consum. Cult.* **2010**, *10*, 13–36. [CrossRef]
6. Antonio, R.J. Is prosumer capitalism on the rise? *Sociol. Q.* **2015**, *56*, 472–483. [CrossRef]
7. Zwick, D. Defending the right lines of division: Ritzer's prosumer capitalism in the age of commercial customer surveillance and big data. *Sociol. Q.* **2015**, *56*, 484–498. [CrossRef]
8. Dusi, D. Beyond prosumer capitalism: Retaining the original understanding of prosumption. *Curr. Sociol.* **2017**, *66*, 663–681. [CrossRef]
9. Dusi, D. The perks and downsides of being a digital prosumer: Optimistic and pessimistic approaches to digital prosumption. *Int. J. Social. Sci. Humanit.* **2016**, *6*, 375–381. [CrossRef]
10. Siuda, P.; Troszyński, M. Natives and tourists of prosumer capitalism: On the varied pro-prosumer activities of producers exemplified in the Polish pop culture industry. *Int. J. Cult. Stud.* **2016**, *20*, 545–563. [CrossRef]
11. Jakimowicz, A.; Rzeczkowski, D. Prosumption in the public administration sector. *Acta Phys. Pol. A* **2016**, *129*, 1011–1017. [CrossRef]
12. Ryder, M.J. Lessons from science fiction: Frederik Pohl and the robot prosumer. *J. Consum. Cult.* **2020**, *22*, 246–263. [CrossRef]
13. Sutherland, C.R. Encountering the burn: Prescribed burns as contact zones. *Environ. Plan. E Nat. Space* **2019**, *2*, 781–798. [CrossRef]
14. Tapscott, D.; Williams, A.D. *Wikinomics: How Mass Collaboration Changes Everything*; Portfolio: New York, NY, USA, 2006; ISBN 978-1-59184-138-8.
15. Tapscott, D.; Williams, A.D. *Macrowikinomics: Rebooting Business and the World*; Portfolio/Penguin: New York, NY, USA, 2012; ISBN 978-1-59184-356-6.
16. Maynard, H.B., Jr.; Mehrtens, S.E. *The Fourth Wave: Business in the 21st Century*; Berrett-Koehler Publishers: San Francisco, CA, USA, 1996; ISBN 978-1-881052-15-9.
17. Pink, D.H. *A Whole New Mind: Why Right-Brainers Will Rule the Future*; Riverhead Books: New York, NY, USA, 2006; ISBN 1-59448-171-7.
18. Houle, D. *The Shift Age*; Sourcebooks: Naperville, IL, USA, 2011; ISBN 978-140-227-390-2.
19. Houle, D. *Entering the Shift Age: The End of the Information Age and the New Era of Transformation*; Sourcebooks: Naperville, IL, USA, 2012; ISBN 978-140-227-21-72.
20. Azua, M. *The Social Factor: Innovate, Ignite, and Win through Mass Collaboration and Social Networking*; IBM Press: Upper Saddle River, NJ, USA, 2010; ISBN 978-0-13-701890-1.
21. Jemielniak, D.; Przegalińska, A. *Collaborative Society*; The MIT Press: Cambridge, MA, USA, 2020; ISBN 978-026-253-791-9.
22. Hoffman, A.J.; Ehrenfeld, J.R. The fourth wave: Management science and practice in the age of the Anthropocene. In *Corporate Stewardship: Achieving Sustainable Effectiveness*; Mohrman, S.A., O'Toole, J., Lawler, E.E., III, Eds.; Routledge—Taylor & Francis Group: New York, NY, USA, 2017; pp. 228–246. ISBN 978-1-78353-259-9.
23. Schwab, K. *The Fourth Industrial Revolution*; World Economic Forum: Cologny/Geneva, Switzerland, 2016; ISBN 978-1-944835-01-9.
24. Wieczorek, P. Czwarta Rewolucja Przemysłowa. Wizja Przemysłu Nowej Generacji—Perspektywa Dla Polski. *Kontrola Państwowa* **2018**, *63*, 89–115. Available online: https://bibliotekanauki.pl/articles/416919 (accessed on 26 September 2021).
25. Xu, M.; David, J.M.; Kim, S.H. The Fourth Industrial Revolution: Opportunities and challenges. *Int. J. Financ. Res.* **2018**, *9*, 90–95. [CrossRef]
26. Hirschi, A. The Fourth Industrial Revolution: Issues and implications for career research and practice. *Career Dev. Q.* **2018**, *66*, 192–204. [CrossRef]
27. Schwab, K.; Davis, N. *Shaping the Future of the Fourth Industrial Revolution: A Guide to Building a Better World*; Currency: New Yorke, NY, USA, 2018; ISBN 978-198-482-261-1.
28. Albuquerque, A.; Costa, R. Terminology as a Sense Making Social Tool. In *ECSM 2015—The Proceedings of the 2nd European Conference on Social Media: School of Accounting and Administration at the Polytechnic Institute of Porto, Portugal, 9–10 July 2015*; Mesquita, A., Peres, P., Eds.; Academic Conferences Ltd.: Reading, UK, 2015; pp. 11–18. ISBN 978-1-910810-31-6. Available online: https://run.unl.pt/handle/10362/26665?mode=full (accessed on 30 October 2021).
29. Toffler, A. *The Third Wave*; William Morrow and Company: New York, NY, USA, 1980; ISBN 0-688-03597-3.

30. Ritzer, G.; Jandrić, P.; Hayes, S. The velvet cage of educational con(pro)sumption. *Open Rev. Educ. Res.* **2018**, *5*, 113–129. [CrossRef]
31. Van Dijck, J.; Nieborg, D. Wikinomics and its discontents: A critical analysis of Web 2.0 business manifestos. *New Media Soc.* **2009**, *11*, 855–874. [CrossRef]
32. Kelly, K. The New Socialism: Global Collectivist Society Is Coming Online, Wired—Culture, 22 May 2009. Available online: https://www.wired.com/2009/05/nep-newsocialism/?currentPage=1 (accessed on 3 June 2022).
33. Moglen, E. The dotCommunist Manifesto, January 2003. Available online: http://moglen.law.columbia.edu/publications/dcm.html (accessed on 4 June 2022).
34. Schwartzman, D. *The Global Solar Commons, the Future That Is Still Possible: A Guide for 21st Century Activists*; The Solar Utopia.org Press: Galesburg, IL, USA, 6 October 2020. Available online: https://www.theearthisnotforsale.org/solarcommons2021.pdf (accessed on 15 December 2021).
35. McLellan, D. Marxism. In *Jesus in History, Thought, and Culture: An Encyclopedia*; Houlden, L., Ed.; ABC-CLIO, Inc.: Santa Barbara, CA, USA, 2003; Volume 1, Entries A–J; pp. 593–597. ISBN 1-57607-857-4.
36. Kautsky, K. *Foundations of Christianity: A Study in Christian Origins*, 2nd ed.; International Publishers CO., Inc.: New York, NY, USA, 1925.
37. Lenin, V.I. *The State and Revolution: The Marxist Theory of the State and the Tasks of the Proletariat in the Revolution*; Haymarket Books: Chicago, IL, USA, 2014; ISBN 978-1-60846-498-2.
38. Engels, F. *The Origin of the Family, Private Property, and the State*; Resistance Books: Chippendale, Australia, 2004; ISBN 187-664-635-7.
39. Lenin, V.I. Our foreign and domestic position and the tasks of the party: Speech delivered to the Moscow Gubernia Conference of the R.C.P.(B.), 21 November 1920. In *Collected Works*, 2nd ed.; Lenin, V.I., Ed.; Progress Publishers: Moscow, Russia, 1974; Volume 31, April–December 1920; pp. 408–426.
40. Priddat, B.P.; Jansen, S.A. From civil society to eGovernment: The virtualisation of the state. In *Progressive Governance for the XXI Century: Contributions to the Berlin Conference*; Schröder, G., Kocka, J., Neidhardt, F., Eds.; Kluwer Law International: The Hague, The Netherlands, 2002; pp. 51–61. ISBN 978-90-41-11774-8.
41. Schwartzman, D. Solar communism. *Sci. Soc.* **1996**, *60*, 307–331. Available online: https://www.jstor.org/stable/40403574 (accessed on 10 November 2021).
42. Georgescu-Roegen, N. *The Entropy Law and the Economic Process*; Harvard University Press: Cambridge, MA, USA, 1971; ISBN 0-674-25781-2.
43. Daly, H.E.; Cobb, J.B., Jr.; Cobb, C.W. *For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future*, 2nd ed.; Updated And Expanded; Beacon Press: Boston, MA, USA, 1994; ISBN 0-8070-4705-8.
44. Rifkin, J.; Howard, T. *Entropy: A New World View*; The Viking Press: New York, NY, USA, 1980; ISBN 0-670-29717-8.
45. Rifkin, J.; Howard, T. *Entropy: Into the Greenhouse World, Revised ed.*; Bantam Books: New York, NY, USA, 1989; ISBN 0-553-34717-9.
46. Járosi, M.; Kovács, P. Energy policy of Hungary. *Civ. Rev.* **2018**, *14*, 67–80. [CrossRef]
47. Georgescu-Roegen, N. *Energy and Economic Myths: Institutional and Analytical Economic Essays*; Pergamon Press Inc.: New York, NY, USA, 1976; ISBN 0-08-021027-9.
48. Georgescu-Roegen, N. Afterword. In *Entropy: Into the Greenhouse World, Revised ed.*; Rifkin, J., Howard, T., Eds.; Bantam Books: New York, NY, USA, 1989; pp. 299–307. ISBN 0-553-34717-9.
49. Kolesnikov, I.M.; Kolesnikov, S.I.; Vinokurov, V.A.; Zaikov, G.E. *Thermodynamics of Spontaneous and Non-Spontaneous Processes*; Nova Science Publishers, Inc.: Huntington, NY, USA, 2001; ISBN 1-56072-904-X.
50. Georgescu-Roegen, N. Energy, matter, and economic valuation: Where do we stand?/Reply. In *Energy, Economics, and the Environment: Conflicting Views of an Essential Interrelationship*; Daly, H.E., Umaña, A.F., Eds.; Routledge—Taylor & Francis Group: New York, NY, USA, 2018; pp. 43–79, 193–200. ISBN 978-0-367-01910-5. [CrossRef]
51. Schwartzman, D. Beyond eco-catastrophism: The conditions for solar communism. In *Socialist Register 2017: Rethinking Revolution*; Panitch, L., Albo, G., Eds.; The Merlin Press: London, UK, 2016; Volume 53, pp. 143–160. ISBN 978-0-85036-725-6.
52. Schwartzman, D. The great bifurcation and prospects for solar communism in the twenty-first century. *Int. Crit. Thought* **2013**, *3*, 480–495. [CrossRef]
53. Schwartzman, D. Ecosocialism or ecocatastrophe? *Capital. Nat. Social.* **2009**, *20*, 6–33. [CrossRef]
54. Schwartzman, D. *Life, Temperature, and the Earth: The Self-Organizing Biosphere*; Columbia University Press: New York, NY, USA, 1999; ISBN 0-231-10212-7.
55. Bhandari, K.P.; Collier, J.M.; Ellingson, R.J.; Apul, D.S. Energy payback time (EPBT) and energy return on energy invested (EROI) of solar photovoltaic systems: A systematic review and meta-analysis. *Renew. Sustain. Energy Rev.* **2015**, *47*, 133–141. [CrossRef]
56. Szymański, B. *Małe Instalacje Fotowoltaiczne. Teoria, Praktyka, Prawo, Ekonomika*; Globenergia—Geosystem Burek, Kotyza S.C.: Kraków, Poland, 2013.
57. Mikołajuk, H.; Zatorska, M.; Stępniak, E.; Wrońska, I. *Informacja Statystyczna o Energii Elektrycznej*; Biuletyn Miesięczny—Ministerstwo Klimatu i Środowiska—Agencja Rynku Energii S.A.: Warsaw, Poland, 2022; Volume 4. Available online: https://www.are.waw.pl/badania-statystyczne/wynikowe-informacje-statystyczne/publikacje-miesieczne (accessed on 20 June 2022).
58. Mikulik, J.; Jurasz, J. Determination of photovoltaic installation nominal power based on electrical energy consumption profile in the context of prosumer policy. *Przegląd Elektrotechniczny* **2015**, *91*, 99–101. [CrossRef]

59. Kotilainen, K. Energy prosumers' role in the sustainable energy system. In *Affordable and Clean Energy. Encyclopedia of the UN Sustainable Development Goals*; Leal Filho, W., Azul, A.M., Brandli, L., Salvia, A.L., Wall, T., Eds.; Springer Nature: Cham, Switzerland, 2021; pp. 1–14. ISBN 978-3-319-95863-7. [CrossRef]
60. Cont, W.; Romero, C.; Lleras, G.; Unda, R.; Celani, M.; Gartner, A.; Capelli, L.; Zipitría, L.; Besfamille, M.; Figueroa, N.; et al. *IDEAL 2021: Reducing Service Gaps: How Digitalization Can Improve the Use of Infrastructure*; Corporación Andina de Fomento—Development Bank of Latin America: Caracas, Venezuela, 2021; ISBN 978-980-422-223-8. Available online: http://scioteca.caf.com/handle/123456789/1763 (accessed on 3 January 2022).
61. Collin, J.; Hiekkanen, K.; Korhonen, J.J.; Halén, M.; Itälä, T.; Helenius, M. (Eds.) *IT Leadership in Transition—The Impact of Digitalization on Finnish Organizations; Aalto University Publication Series: Science + Technology, 7/2015*; Aalto University, School of Science, Department of Computer Science, ACIO Research Program: Helsinki, Finland, 2015; ISBN 978-952-60-6243-3. Available online: http://urn.fi/URN:ISBN:978-952-60-6243-3 (accessed on 4 January 2022).
62. Astarloa, B.; Kaakeh, A.; Lombardi, M.; Scalise, J. *The Future of Electricity: New Technologies Transforming the Grid Edge*; World Economic Forum: Cologny/Geneva, Switzerland, 2017. Available online: https://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf (accessed on 5 January 2022).
63. Jakimowicz, A.; Rzeczkowski, D. The impact of public administration digitalization on the decarbonization of the economy. *Energies* **2021**, *14*, 5739. [CrossRef]
64. Kucharska, A. Społeczny wymiar "Energiewende"—rozwój energetyki prosumenckiej w Austrii. *Studia Humanist. AGH* **2018**, *17*, 67–84. [CrossRef]
65. Montgomery, B. The 5th Wave. *The IOT Magazine*, 26 October 2016. Available online: https://theiotmagazine.com/the-5th-wave-4ee1ad8b3e9e (accessed on 10 June 2022).
66. Hill, C.A. Moving social science into the fourth paradigm: The data life cycle. In *Big Data Meets Survey Science: A Collection of Innovative Methods*; Hill, C.A., Biemer, P.P., Buskirk, T.D., Japec, L., Kirchner, A., Kolenikov, S., Lyberg, L.E., Eds.; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2021; pp. 713–731. ISBN 978-111-897-632-6. [CrossRef]
67. Hey, T.; Tansley, S.; Tolle, K. (Eds.) *The Fourth Paradigm: Data-Intensive Scientific Discovery*; Microsoft Research: Redmond, WA, USA, 2009; ISBN 978-0-9825442-0-4.
68. Kinney, S. Bell Labs President Says 6G Will Mix Physical, Digital and Biological Systems. *RCR Wireless News*, 24 April 2019. Available online: https://rcrwireless.com/20190424/5g/6g-physical-digital-biological (accessed on 15 June 2022).
69. Rappaport, T.S.; Xing, Y.; Kanhere, O.; Ju, S.; Madanayake, A.; Mandal, S.; Alkhateeb, A.; Trichopoulos, G.C. Wireless communications and applications above 100 GHz: Opportunities and challenges for 6G and beyond. *IEEE Access* **2019**, *7*, 78729–78757. [CrossRef]
70. Boxall, A.; Lacoma, T. What Is 6G, How Fast Will It Be, and When Is It Coming? *Digital Trends*, 3 June 2021. Available online: https://www.digitaltrends.com/mobile/what-is-6g/ (accessed on 17 June 2022).
71. Vinge, V. Technological singularity. *Whole Earth Rev.* **1993**, *81*, 88–95. Available online: https://frc.ri.cmu.edu/~{}hpm/book98/com.ch1/vinge.singularity.html (accessed on 18 June 2022).
72. Kurzweil, R. *The Singularity Is Near: When Humans Transcend Biology*; Duckworth Overlook: London, UK, 2008; ISBN 978-0-7156-4016-6.
73. Svobodová, I. Energy efficiency in buildings: Middle-class status as a trigger for the European fight against climate change. *Eur. View* **2019**, *18*, 163–170. [CrossRef]
74. Schwartzman, D. 4 Scenarios for 2050. *Capital. Nat. Social.* **2013**, *24*, 49–53. [CrossRef]
75. Schwartzman, P.; Schwartzman, D. *The Earth Is Not for Sale: A Path Out of Fossil Capitalism to the Other World That Is Still Possible*; World Scientific Publishing Co. Pte. Ltd.: Singapore, 2019; ISBN 978-981-3234-24-6.
76. Sneader, K.; Singhal, S. *The Next Normal Arrives: Trends That Will Define 2021—And Beyond*; McKinsey Global Publishing: New York, NY, USA, January 2021. Available online: https://www.mckinsey.com/featured-insights/leadership/the-next-normal-arrives-trends-that-will-define-2021-and-beyond (accessed on 5 November 2022).
77. Zhang, L. Fashioning the feminine self in "prosumer capitalism": Women's work and the transnational reselling of Western luxury online. *J. Consum. Cult.* **2017**, *17*, 184–204. [CrossRef]
78. Brown, D.; Hall, S.; Davis, M.E. What is prosumerism for? Exploring the normative dimensions of decentralised energy transitions. *Energy Res. Soc. Sci.* **2020**, *66*, 101475. [CrossRef]
79. Goudarzi, A.; Zhang, C.; Fahad, S.; Mahdi, A.J. A hybrid sequential approach for solving environmentally constrained optimal scheduling in co-generation systems. *Energy Rep.* **2021**, *7*, 3460–3479. [CrossRef]
80. Van Sark, W.; Corona, B. Concentrating solar power. In *Technological Learning in the Transition to a Low-Carbon Energy System: Conceptual Issues, Empirical Findings, and Use, in Energy Modeling*; Junginger, M., Louwen, A., Eds.; Academic Press: London, UK, 2020; pp. 221–231. ISBN 978-0-12-818762-3. [CrossRef]
81. China Solar Thermal Alliance. *Blue Book of China's Concentrating Solar Power Industry 2021*; China Solar Thermal Alliance: Beijing, China, 2021. Available online: https://www.solarpaces.org/wp-content/uploads/Blue-Book-on-Chinas-CSP-Industry-2021.pdf (accessed on 10 November 2022).
82. Liu, Y.; Sun, N.; Liu, J.; Wen, Z.; Sun, X.; Lee, S.-T.; Sun, B. Integrating a silicon solar cell with a triboelectric nanogenerator via a mutual electrode for harvesting energy from sunlight and raindrops. *ACS Nano* **2018**, *12*, 2893–2899. [CrossRef] [PubMed]
83. Wang, Y.; Yang, Y.; Wang, Z.L. Triboelectric nanogenerators as flexible power sources. *NPJ Flex. Electron.* **2017**, *1*, 10. [CrossRef]

84. Kim, D.W.; Lee, J.H.; Kim, J.K.; Jeong, U. Material aspects of triboelectric energy generation and sensors. *NPG Asia Mater.* **2020**, *12*, 6. [CrossRef]
85. Assawaworrarit, S.; Omair, Z.; Fan, S. Nighttime electric power generation at a density of 50 mW/m^2 via radiative cooling of a photovoltaic cell. *Appl. Phys. Lett.* **2022**, *120*, 143901. [CrossRef]
86. Deppe, T.; Munday, J.N. Nighttime photovoltaic cells: Electrical power generation by optically coupling with deep space. *ACS Photonics* **2020**, *7*, 1–9. [CrossRef]
87. Schwartzman, D.; Saul, Q. The Path to Climate Justice Passes through Caracas. *MRonline*, 25 June 2019. Available online: https://mronline.org/2019/06/25/the-path-to-climate-justice-passes-through-caracas/#_edn3 (accessed on 1 October 2022).
88. Schwartzman, D. Is Transition Possible? China and the Prospects for a Global Ecological Civilization. *Climate and Capitalism*, 17 September 2019. Available online: https://climateandcapitalism.com/2019/09/17/china-and-the-prospects-for-a-global-ecological-civilization/ (accessed on 9 November 2021).
89. "Gdy Czarny Orzeł Znak Krzyża Splugawi . . . " Sensacyjna Przepowiednia z Roku 1893 o Przyszłych Losach Świata. *Ilustrowany Kuryer Codz.* **1939**, *30*, 6. Available online: http://mbc.malopolska.pl/dlibra/docmetadata?id=77196&from=publication (accessed on 11 November 2022).
90. Fereński, P.J.; Soboń, G. Why Is the New Silk Road Considered a Threat for the Western World, Including Poland? National-conservative Tendencies in North America and Europe. *Kult. Hist. Glob.* **2017**, *22*, 63–72. Available online: http://www.khg.uni.wroc.pl/files/7%20KHG_22%20Ferenski_Sobon.pdf (accessed on 11 November 2022).