Paper	Concluding Remarks and Recommendations
40	When it comes to the energy transition, change management and complexity management must be redefined to make those approaches global in nature. However, this may not be enough to solve the major issues related to energy transition. All attempts at alleviating complexity catastrophes by developing and implementing proper methods of change management and complexity management directed towards reducing the energy transition complexity may be doomed to failure. This is caused by the lack of a central organization in the form of a global super-organization responsible for solving the problem on a global scale. Since the problem is global, its solution must also be global.
41	Nonetheless, assisted by R&D in novel materials and technologies, the SCP are set to enhance the functionalities of pre-existing industries, as well as precipitate the debut of new and innovative ones, forever altering society as we currently know it. Through the seamless integration of flexible, light weight, and conformable electronics this future paradigm no longer looks like the distant reality once pictured in the movies. As for now, value and risk are still being weighted as the SCP reach small ecosystems.
42	IoT combined with blockchain technology has the potential to increase transparency and trust between different stakeholders, as it offers both privacy and confidentiality. It can also enhance data security thorough encryption, cryptography and consensus protocols. Moreover, this combination in the new decentralized energy system can minimize transaction costs, support processes automation and facilitate the active participation of small consumers and prosumers in the smart grid (SG). Blockchain is an emerging technology that can use enterprise data with the use of secure transactions between parties. Blockchain-enabled systems are a new trend rising fast in the area of engineering.
43	Artificial intelligence is full of promising prospects in energy supply, energy storage, district demands and energy management. Future studies can focus on expansion on input parameters for reliability of prediction models, development of selection approach for appropriate ML algorithms for specific case analysis, development of advanced optimisation algorithms with high convergence speed, together with national solar potential predictions for the carbon-neutrality transition.
44	For developing countries like Malaysia and Indonesia, the ongoing digital revolution may provide opportunities to overcome the challenges of establishing a high value. Various operations are widely discussed with numerous ongoing experiments and evidence found around the world, such as the concept of the 'smart factory'. Applications are wide, ranging from an Internet of Things(IoT) platform that ingests voluminous data from sensors to artificial intelligence (AI) that runs complex algorithms for data analytics and optimizes operations. For the oil palm sector, this implies exciting possibilities for upgrading and diversifying downstream industries. An interesting prospect is the convergence of digital innovation and biotechnology.93The application of sophisticated bio-processing such as enzymatic processes in producing oleochemicals is a core part of this strategy.
45	blockchain technology is generally considered a transparent way to manage smart grid transactions. In terms of P2P trading, the blockchain is used both as a means of developing consensus among energy trading parties and performing transparent transactions. Similarly, IoT has also been proposed by various researchers as a technology that can enable P2P energy trading utilizing inherited features of the technology.
46	To fulfil the need of P-OPF in modern electric power systems, the simultaneous integration of hybrid renewable DGs and wireless EVs or PEVs need to be investigated with solution methodology proposals.
47	We suggest numerous research directions and recommend that practitioners and agriculture stakeholders investigate the IoT's impact on their performance. We recommend an integrative perspective for evaluating the impact of the IoT on agricultural sustainability.
48	To fully utilise its potential in the power grid, the topology and control of PCS for ESS still require further research. This section addresses the open research topics surrounding the improved and efficient applications of ESSs in power systems
49	For effective management of the digital transition that achieves sustainability goals, the study identifies and discusses new alternative approaches that include innovating by experimenting, incremental strategies, and dynamic, sustainable advantages achievable through temporary benefits
50	Urban planning can offer more opportunities in enabling energy sustainability in cities, such as population density planning for net zero goals, building height limits for utilizing solar energy, and urban forms for wind utilization
51	Future research should analyze the interrelationships between the SDGs, identify and prioritize the most important SDGs, and evaluate whether the use of data-driven approaches/AI is effective in achieving the prioritized SDGs.
52	Emerging technologies such as AI and IoT are rapidly improving and their application in the energy sector is expected to shift the energy transition as technological progress related to all stages of energy usage, ranging from production to consumption, has accelerated. Furthermore, autonomous robots with AI will become more common in the future and are expected to be particularly useful in places where human operation is difficult, such as mountainous areas and deep seas, as well as in harsh environments.
53	Finally, future academic research in the area of blockchain governance and peer-to-peer energy trading will require to address the following aspects. First, the capacity of blockchain governance including the stakeholders' roles and its bargaining power to adapt in time. Second, the communication and accountability mechanisms placed (off-chain/on-chain) to mitigate centralized legacy. Third, the construction and application of blockchain governance frameworks and indicators that allow for comparison among ecosystems.
54	The ability of BC to combine reduction in trading costs with improved efficiency in security and privacy could encourage participation in energy trading. Despite the technical challenges facing BC, BC can facilitate the management of DGs in MGs and are useful for energy trading and optimization applications. Combining BC with AI is necessary to overcome user integration issues in terms of trading, control, and regulation functions.

55	Both underdeveloped and emerging countries, like developed countries, should begin developing policies to make their grid systems smarter and cleaner.
1	Energy-ICT is still in the process of evolving. It includes technological, economic, and management aspects. The whole world is now interconnected through the IoT, and the ongoing inquiry into energy-ICT is part of the IoT's evolution. More opportunities and challenges are ahead as all networks connected by ICT strive to meet SDGs. The future evolution of energy-ICT has to comply with the SDGs in order to help build a smarter green human society.
56	This perspective aims at emphasizing the necessity to adopt a holisticway (i.e. environmental instead of energetic only) of considering the use of POW based blockchain technology to promote renewable energies this can be done only if one can ensure that the cryptographic functioning of this technology will not have any environmental impact – if this condition cannot be observed, there is a paradoxical situation in the use of this technology to promote green energies. Finally, this perspective calls for more investigation on the need to use alternative solutions to replace the algorithm validating all POW-based blockchain transactions.
57	The role of digitalization and the technologies associated with the internet of things (IoT) have been discussed for their potential to solve big challenges in the food-water-energy nexus, and enabling Industry 4.0, improving social wellbeing, and reducing the effects of climate change.
58	Utility-scale hybrid wind–solar PV power plants (which might include some storage as well) are an attractive option for the transition of conventional grids to incorporate high renewable energy (RE) shares. Along with lower generation costs, they offer increased dispatch capabilities and flexible operation.
59	Available and affordable 5G networks will be better able to support this emerging technology and address public interest concerns. One area that could be optimized for 5G usage is the IoE which offers huge benefits to the communities on the wrong side of the digital divide.
60	Recent advancements in the Industrial Internet of Things (IIoT) and Deep learning (DL) have made the industrial setup smarter for various applications. According to Industry 4.0 standardization, there is a huge potential for DL in IIoT.
61	blockchain technology can be efficiently developed due to the presence of IoT technology in SGs, but the security issues caused by high-volume data transactions should be addressed. In addition, applications of the blockchain technology are thoroughly discussed in terms of the decentralized energy management and the energy trading between the distributed prosumers and the consumers.
62	The following aspects can be recommended as the medium-term objectives for the Russian state policy in the electric power industry: • Launching open modular digital platforms for organizing cyber-physical systems and environments in the power industry; • Developing the intelligent multi-agent control systems; • Formation of the market segment of energy storage systems (from batteries for electric vehicles and the household sector to large energy storage systems capacities, including technologies for storing electricity in the hydrogen cycle); • Developing the advanced high-voltage and high-frequency power electronics sector; • Introducing the technologies leading to the "Internet of Things" (e.g., digital sensors, sensors, actuators and communication tools); • Using digital financial technologies (blockchain, smart contracts, decentralized autonomous organizations).
63	Private investments, both national and foreign, will be increasingly necessary, and that can only be satisfactorily achieved by advancing the current reform. However, the state will continue to have an essential role in regulation and market design. Huge private investments will happen and be correctly directed to the overall social benefit if they can find a stable and coherent set of rules, favoring meritocracy. Transparency in the government policy is essential, and the government must continue listening to all stakeholders and specialists since any reform of such dimensions is always a continuous learning process.
64	Smart contracts and peer-to-peer transactions, as the basis and important component of regional energy trading models, will remain hot topics in blockchain and energy research in the future. The application of blockchain technology in the field of renewable energy, electric vehicle charging and shared charging infrastructure will always be the focus of blockchain and energy research.
65	The limited adoption of BC technology and the fact that it has not been able to create satisfactory trust in terms of social perception is one of the most important problems in BC. Therefore, it would be beneficial to test different scenarios by investigating all kinds of incentive mechanisms so that everyone can adapt to this system. Additionally, with the regulation arrangements, citizens can act more freely. Nevertheless, the applicability of BC in the energy system and the considerable need for the current operation of DSOs have not been extensively addressed. Although BC has an excellent problem-solving capacity, the transition from conventional to modern BC-based power grids is significantly expensive and difficult to realize in a short time. In the short term, building a completely distributed power system will be nearly impossible. Moreover, the transition must be examined comprehensively.
66	Demand response can be regarded as a promising technology to promote the functionality of end-users to be more involved not only in electricity bill management but also in increasing the efficiency of the electricity market. It is pointed out that behavioral science might assist in unlocking the potentials of a successful smart grid transformation.
67	Here, both scientists and governments are facing a solution to the consequences of the digitalization of companies, for which it will be necessary to find a social consensus, which will have to be supported by concrete research both among companies and the public. This research should focus on finding solutions to mitigate the effects of both digitization and the requirements of the United Nations Sustainability Goals, which include new sustainable policy programs that will offer various new forms of employment in the Universal Basic Income (UBI).

68	Big data CMMs also have a narrow focus, either on data management (analytics) or exchange, which is why each CMM is adaptable to any of the DG use-cases. Stakeholders should, therefore, use the findings in Table 5 to critically evaluate their current standing in big data capabilities and maturities when initiating or extending the specific use-cases.
69	Adaptation of industrial AI solutions needs to be moderated, and AI providers need to address industry-specific requirements, like the introduction of Industrie 4.0 technologies. Especially ethical implications need to be addressed, as they are currently heavily discussed in politics and among industrial partners. The development process for data-driven services needs to be integrative and put the customer value into focus. Furthermore, it should follow a structured process like CRISP-DM with particular attention to process simplicity.
70	The concept of energy 4.0 is still nascent, and thus, much research is required to ensure its success because the amount of energy requirement has reached unprecedented level due to the automation of the industrial plants to make them industry 4.0-compliant. Energy 4.0 is a digital revolution in the energy sector and also known as smart energy or green energy. It presents opportunities for companies to establish new business models and sustainable strategies of producing and delivering energy.
71	In this context, I4.0 impacts manufacturing in several ways, and can be used as a potential strategy for the development of sustainable production capable of social, economic and ecological changes. The sustainable perspective on smart companies can be developed primarily by using technologies to react more quickly to change, reduce overproduction and waste, and incorporate smart grids for efficient energy management, which seems to be happening according to our results.
72	The study summarizes which technologies and green processes are important for achieving a higher level of sustainability. Green logistics and supply chain, green manufacturing and green design and development should be key enterprise processes. This provides a general, yet practical solution for managerial decisions, policy and strategy development and investment. Enterprises should focus on sustainability based on processes analysis rather than implementing new technologies without strategic direction.
73	Modern technologies such as IoT can help the energy sector transform from a central, hierarchical supply chain to a decentralized, smart, and optimized system.
74	The way into the future leads probably along two routes. The first is the intensification of research focused on the potential application of smart technologies that can improve life quality, especially in urban areas, from air quality to public transportation for instance. The second is the improvement of the cost effectiveness of smart technologies, which will provide a boost for their propagation. A finding met in most publications is that more case studies are needed, to demonstrate these factors to convince the public and the stakeholders of the benefits that can be achieved.
75	Regarding the architecture and infrastructure to develop a SC, cities should start by designing the architecture and the standards that projects and applications implemented in the city will use.
76	The viability and scalability of business models in the DRE sectors is highly dependent on a conducive policy and regulatory enabling environment. Dedicated electrification policies, fiscal incentives, regulations, auctions and exemptions on value-added tax (VAT), and import duties, foreign ex-change policies, quality assurance frameworks, and certification programs are among the critical enabling factors to achieve the promise of DRE entrepreneurship in sub-Saharan Africa.
77	This field of research has just recently started to emerge, and developments in key fields such as high-performance computing, big data analysis and Internet of Things will allow not only to improve the models and validate them, but also to create models of this level of detail for entire countries and continents. The better the models are, the more accurate strategic decision making in integrated spatial and energy planning can be supported by social learning processes of decision makers, planners and the public, so that governmental planning and bottom-up action can determine the path for a global energy transition to 100% renewables jointly and democratically.
78	In coming two decades, the SG's real implementation will be the foremost requirement due to its promising benefits and a reliable energy supply. The SG will radically revolutionize the electrical networks that are vital to any nation's infrastructure. The technologies acting as base functionalities for the SG implementation need a more research in above SG domains.
79	We showed that a smart grid built on the technologies of sensing, communications, and control technologies offer a very promising future for utilities and users. Efficiency, reliability and security of interconnected devices and systems are critical to enabling smart grid communication infrastructures.
80	Energy Digital Twin (EDT) applications in the literature and public domain covered all aspects of the product or asset life cycle. However, there has been a focus on the design and operations phases predominately at the nano and micro scales. EDTs can unlock greater energy efficiency and renewable energy uptake through expanding the scale of application to include the
81	Therefore, this review concludes that by incorporating the blockchain and AI, the smart grids can support the integration of prosumers with the functions of trading, control, and policy. Nonetheless, this is achievable only if the vital issues and barriers on the regulation, market, and operation are overcome.
82	One of the most significant findings to emerge from the SG comparison study is that government bodies of developing countries, including Malaysia have huge investments and supports for moving towards SG implementation. It could be beneficial for regional development in modernizing the grids if the developing nations collaborate in terms of their experiences, efforts, and comprehensive strategy on integrating DRG.
83	To conclude, blockchain or distributed ledger technologies can clearly benefit energy system operations, markets and consumers. They offer disintermediation, transparency and tamper-proof transactions, but most importantly, blockchains offer novel solutions for empowering consumers and small renewable generators to play a more active role in the energy market and monetise their assets.

84	Essential for common prosumer-based DES is the application of peer-to-peer deliverance (P2P). Policy must avoid to interfere in this and also should remove legal obstructions and transaction costs for P2P and coproduction. As space is the prime scarcity factor for DES, prosumers' communities should also be empowered in co-producing land use decisions for construction of their DES infrastructures
85	Transition towards 4GDH requires lowering the heat supply temperature thereby reducing network heat losses and facilitating the integration of renewable energy sources and waste heat. Seasonal storage is expected to play a crucial role in maximizing renewable energy use. A reshaping of the interaction with the electric grid is also expected due to changes in CHP and HP use.
86	What emerges is that HV bulk transport links, storage technologies and the so-called digital revolution are taking a leading role in different parts of the world for the development of a deep decarbonization of the electricity sector, of new energy business models at distribution level and of new power distribution architectures.
87	Recent digital innovations such as Internet of Things, GSM connectivity, Software platforms and mobile money have paved the way for countless application in a continent which is fast-moving. Delivery of utility services on a pay-as-you-go basis integrated with mobile payments is a successful example of it, as many start-ups have developed their concept in the last five years.
88	Rural areas are the main source of carbon emissions in China, and the REI contributes to a high proportion of renewable energy for rural energy through the energy transition change, which can effectively reduce rural carbon emissions and promote the realization of the ''carbon peak" goal. Considering the carbon sink role of rural agriculture, the construction of Rural Energy Internet (REI) is expected to realize the low- carbon or zero-carbon emissions of rural energy, which is a powerful measure to promote the goals of ''carbon peak" and ''carbon neutrality" in China.
89	The review has been suggested potential solutions to the challenges regarding microgrids. The technology moves onto adaptive control and stability management by incorporating advanced machine learning and deep learning-based control and stability dispatch. Grid resilience isa necessity while enforcing the latest technologies and equipment.
90	There is an increasing pace of other renewable energy in the African region as access to energies, out of wind and solar has improved a lot. It is leading to decentralization systems that can operate efficiently for both off-grid and on-grid systems. There is the persistent necessity of actions for technological advancements, especially for renewable energy technologies in order to tackle issues like access to electricity, climate mitigation, and lowering the air pollution (caused due to fossil fuel-based generation systems). The deployment of sustainable systems needs strong and effective policies in the region with the right approaches and best suitable practices.
91	On the other hand, data related to future policies shows that the area of the social aspect of living is falling behind on the agenda of further development. That is why in the future, the focus should be placed on the issues of infrastructure and basic services and the social aspect of living, including policies related to education, free time activities, cultural activities and others related to the general well-being of people as they are noticeably lagging behind in comparison to other areas.
92	A new communication strategy is needed to facilitate the transition from traditional centralized systems to decentralized systems. With the goal of improving the performance of communication networks for their use in microgrids, various advanced wireless technologies in LPWANs, such as Sigfox, NB-IoT and LoRaWAN, are detailed.
93	Developments in solar and other clean energy technologies have enabled a significant increase in deployment in the energy sector to decarbonize the global electricity system. Despite these advancements, many challenges have been addressed in this study for reaching 100% renewable electricity future.
94	In essence, policymakers in developing countries like Nepal should promote the smart grid approach to minimize energy loss, lower energy costs, utilize clean energy, and improve power system reliability and management. This will also result in new employment opportunities, which will help the country's overall socio-economic growth. In a broader sense, the advent of smart grid technologies will not only serve as a solution to existing energy-related problems across developing countries but will also reduce global carbon footprint and contribute to the achievement of global sustainable energy goals, and thus lessen the impacts of global climate change in the years to come.
95	It was identified that the main bottleneck in microgrid management were constraints placed on the energy side of the sector. Where changes in legislature and government commitment (even at the local level) support a decarbonizing, digitizing, and democratic system, it motivates and drives change from the utilities, financial, and economic sectors. This will lead to an energy equilibrium between centralized bulk energy and decentralized systems.
96	The integration of MGT cycle data with smart tools based on AI techniques can potentially increase the useful operational hours and thus higher investment returns. Digitalization based on intelligent tools is, therefore, needed to conduct real-time analysis, considering the key parameters such as components' conditions, power demand patterns, and market prices to identify a smart combination and deliver high efficiency from existing installations.
97	The current review's conclusion is summarized as follows: (i) Advancements in smart grid with big data analytics enable the investigation of demand and supply concerns through efficient communication networks; (ii)The smart grid involving public and private sector along with big data analytics encourages prosumers towards the achievement of sustainable goals; (iii) Big data analytics with the advanced computing technologies and energy theft monitoring help to attain the sustainable goals by economic operations based on real-time data obtained from the different sectors and consumer behaviour; (iv) Real-time big data analytics in the smart grid finally achieve equity in society, green environment, secured energy and an efficient economy, with artificial intelligence and machine learning technologies to promote the sustainable future.

98	Finally, it is also important for us to point out that more socioeconomic research will be needed to understand the impacts of blockchain on the market, including on customers and the value of services offered to them, and at what cost to users. A related but very important political science question also to researchers and policy-makers is about how more traditional subsidies in the energy sector will relate to developments in blockchain, as well as subsidies for renewable energy.
99	This review study summarizes the potential benefits and needs for incorporating and adapting IV tools (series games), game engines, and 3D modeling tools for producing the simulation of the RES collaborative virtual environment. In supplementary confrontations, it can be expressed that the IV tools, simulation packages, and VR series games can help in the process of energy plant designing and in the computation of energy demand-supply simulation analysis.
100	In terms of future improvements, it is highly recommended that consumers and the market pair with blockchain technology to ensure customer efficiency and enhance multidisciplinary electrical home appliances. SG 2.0 and blockchain standards will be enhanced by ongoing research. Blockchain technology and remote management security can be combined efficiently. The long-term vision will provide potential consumers with a better environment with reliable and intelligent mandates and keep consumer costs low.
101	As Vernay et al. (2020) emphasize, several projects have not yet been implemented because the ECs faced difficulties with financing this stage. That is why opening for new community members, other than households, and for broader collaboration between them may bring new financial possibilities. Next, all the projects analysed proved that the participation of community members is crucial to succeed. Finally, we believe that implementing technology-advanced EC projects according to the Scrum framework may prove very useful in the pursuit of designing tailor-made solutions.
102	Since SMGs can be applied or adopted differently according to regiona requirements, there is a need for context-based analysis to study the inter-dynamics between institutions, technology and actors. Using an approach that only addresses attempts to solve or mitigate separate barriers falls short and leads to ineffective solutions. A broader systemic perspective of socio-technical innovations is required. Therefore, we suggest applying theoretical approaches and research methods from the Innovation Studies research domain to discern potential interventions to resolve these barriers.
5	The access to large datasets collected during the crises, e.g., the transport pattern during the pandemic or the state of energy efficiency responses to the energy price hikes, will improve analyses of individual behaviors, lifestyles, and social practices. Furthermore, identifying policy options to incentivize positive behavioral changes and discourage unsustainable practices is key.
103	Big data for energy analytics, digital twins in smart grid modeling, virtual power plants with Metaverse, and green IoT are the major vital recommendations that are discussed in this study for future enhancement.
104	Finally, more research is needed from the energy and power systems community to develop smart contracts with capabilities to enable intelligent management of power networks. Smart contracts that integrate uncertain generation/loads and perform, e.g. ADMM computations have already been proposed, but augmented by AI-capabilities, smart contracts could play a key role in achieving more decentralised, flexible and ‘‘self-healing" energy networks of the future.
105	Considering future work several themes appear highly promising: • resilience quantification that represents the resilience curve more comprehensively than arbitrary proxy while retaining ease of use would be very useful for studying the resilience of energy systems undergoing structural changes; • mapping landscape of defense measures over different threat types distinguishing disruption phases (as it was done for the extreme weather events in this paper) and time until the disruption (preparatory versus reactive actions) may complement the resilience perspective; • applicability of defense theories against diverse and unexpected threats from other fields like military to energy systems; • resilience tradeoffs for electrification and sector coupling; • robustness of energy system development scenario preferences in case of major disruption.
106	Thanks to developments in recent years, it is seen that digital technologies and data-driven techniques have the potential to transform agriculture more precisely, efficiently, and sustainably. Furthermore, while providing greater transparency for consumers on how food is produced, decision-making support has helped farmers in many practices, in terms of environmental and agricultural performance. Beyond farming, while digital technologies make the job more attractive to new generations, they offer many opportunities to reduce problems related to remoteness and improve access to services.