Received: 13 July 2021 | Revised: 24 August 2021 | Accepted: 30 August 2021

DOI: 10.1002/er.7278

REVIEW PAPER

INTERNATIONAL JOURNAL OF ENERGY RESEARCH WILEY

The dynamics of green supply chain management within the framework of renewable energy

Sidique Gawusu[1] | **Xiaobing Zhang**[1] | **Seidu Abdulai Jamatutu**[2] | **Abubakari Ahmed**[3,4] | **Ayesha Algade Amadu**[5] | **Elvis Djam Miensah**[5]

[1]School of Energy and Power Engineering, Nanjing University of Science & Technology, Nanjing, China

[2]School of Economics and Management, Nanjing University of Science & Technology, Nanjing, China

[3]Sustainable Spatial Development and Governance, Department VI - Spatial and Environmental Sciences, University of Trier, Trier, Germany

[4]Department of Planning, Faculty of Planning and Land Management, SD Dombo University of Business and Integrated Development Studies, Bamahu-Wa, Ghana

[5]Jiangsu Key Laboratory of Chemical Pollution Control and Resources Reuse, School of Environmental and Biological Engineering, Nanjing University of Science and Technology, Nanjing, China

Correspondence
Xiaobing Zhang and Sidique Gawusu, School of Energy and Power Engineering, Nanjing University of Science & Technology, Nanjing, China.
Email: zhangxb680504@163.com (X. Z.)
and
Email: gsidique@outlook.com (S. G.)

Summary

This study provides an overview of green supply chain management (GSCM) in the context of renewable energy sources. Thus, it establishes a green management standard with GSCM that companies can adopt. The environmental, economic, and social components determine the concept of GSCM. However, the development and commercialization of renewable energy and sustainable manufacturing practices play a fundamental role in shaping the traditional supply chain management (SCM) and business models. GSCM means that firms and organizations must balance economic and environmental performance to stay competitive, and conform with regulatory and community pressures. This has forced enterprises to design and implement strategies such as eco-efficiency, greener production, and cleaner environmental practices, for green management practices, which aim at reducing the environmental impacts of their operations. This study further highlights insights needed to significantly improve performance and overcome barriers to the development of renewable energy green supply chain management (REGSCM). It also presents useful techniques by outlining better control chain costs to make renewable energy more affordable and efficient, and a new conceptual model that is mainly grounded within the network of distributed energy systems in the context of GSCM. This concept allows renewable energy producers to sell their surplus electricity based on a peer-to-peer (P2P) network or sell directly via the general market. Specifically, this model brings to bear the linkages to the creation of value by firms.

KEYWORDS

distributed energy, green supply chain management, renewable energy, sustainability, sustainable management

Abbreviations: CO_2, Carbon dioxide; CSP, Concentrated solar power; DESs, Distributed energy systems; DSOs, Distributed system operators; E&E, Electronic and electrical; EPSCM, Electric power supply chain management; ESS, Energy storage system; EVs, Electric vehicles; FiTs, Feed-in-tariffs; GBPs, Green business practices; GHGs, Greenhouse gas emissions; GSCM, Green supply chain management; HSSE, Health, safety, security and environmental; ISO, International Organization for Standardization; MG, Microgrid; MSME, Micro, small, and medium enterprises; P2P, Peer-to-peer; PV, Photovoltaic; REC, Renewable energy certificates; REDM, Renewable energy direct marketing; REET, Renewable energy electricity trader; REI, Renewable energy industry; REGSCM, Renewable energy green supply chain management; RES, Renewable energy sources; SCM, Supply chain management; SM, Smart grid; SMEs, Small- and medium-scale enterprises; SSCM, Sustainable supply chain management; SSCM, Service supply chain management; UNFCCC, United Nation Framework Convention on Climate Change.

1 | INTRODUCTION

The last decade has witnessed an increase in environmental issues around the world, largely due to climate change.[1] This has drawn the attention of several academics and industrialists throughout the world across all sectors as consumer demand increases.[2,3] This has compelled governments to enforce more regulations, forcing individuals, organizations, firms, and countries to adopt stringent means, promoting healthy environmental practices. These policy changes affect all sectors and are applicable across all industries, including the energy industry, specifically, renewable energy sources (RESs).[4-10]

It is undeniable that an impression of unbounded economic growth has been created due to tremendous economic growth propelled by reliable and affordable energy supplies. However, this has resulted in serious energy security and climate change concerns due to the rapid economic growth coupled with a growing population.[11] These concerns bring with them increasing pressure to promote green supply chain (GSC) through the integration of environmentally friendly energy sources.[12-14] To meet these demands, companies/firms are required to adapt and strategized in such a way that they can accommodate any operational changes or requirements. However, supply chain managers who have interests in greening their businesses expressed serious concern about the conversion of their facilities from energy users to energy producers,[15] that is, prosumers (produce and use energy). The production of energy intentionally and unintentionally involves the depletion of natural resources and is a major concern for environmental protection as this process goes with the release of greenhouse emissions. Nevertheless, the adoption of green/clean energy sources by practitioners has been on the increase due to pressures from end users and policymakers. The misconception that the inclusion of environmentally sound initiatives may hinder profit has been proven wrong. It has, however, helped several companies to significantly realize cost savings and financial returns.[16]

Renewable energy (RE) sources such as solar, wind, geothermal, biomass, and hydropower are considered the most widely used sources in the RE industry and are therefore extensively useful in the fight against the utilization of energy sources that are not environmentally friendly.[17-22] The production and consumption of these energy resources are significantly clean, which makes them critically important.[23-27] An increase in the awareness of a clean environment has made the dependence on fossil fuels unpopular, due to associated environmental issues such as CO_2 emissions as well as other greenhouse gases.[28] The excessive energy demand coupled with the desire to keep the environment clean has resulted in a global campaign to replace conventional fuels with RESs[29-31] in both industrial and domestic applications through green supply chain management (GSCM).

The most important objectives in GSCM are among others integration of the operations that are linked with environmental, social, and economic issues, as well as performance assessment.[32-38] The energy sector cannot directly cope with this integration, which could have a significant impact on economic development,[39] without the coordination of all sectors and resources in the RE value chain, in a well-defined sustainability concept.

There have been substantial reviews on GSCM and its related disciplines including, but not limited to, the following.[33,40-50] Most of these reviews have paid more attention to the waste of materials in GSC.[51] However, improper production and consumption of energy can have long-lasting damaging effects on the environment as much as waste, where global warming is becoming a crucial environmental issue. Bhatia and Gangwani[52] assessed the methodologies of 216 empirical studies in GSCM that were published between 2001 and 2019. They observed that the number of empirical papers in GSCM had increased tremendously over the last few years. In Ricardo Saavedra et al,[53] a review of studies published in several journals concerning Renewable Energy Supply Chain (RESC) was presented by focusing on the application of system dynamics in RESC. Srivastava[40] also presented a review of 227 published papers related to GSCM, whereas Gold et al[54] presented a review based on content analysis by exploring the role of sustainable supply chain management (SSCM) in the generation of valuable resources for organizations. Their review highlighted a competitive advantage via collaboration on societal and environmental issues. Sarkis et al[43] also gave an extensive review of GSCM evolution based on an organizational theory in which an additional organizational review was discovered for GSCM research. Malviya and Kant[55] delved into the current status of GSCM research through several dimensions, such as journal, year of publication, methodology, country, publishers, and university.

An effective GSC for the RE sector provides significant support for the development of the power sector and makes it easy for firms to easily adopt these practices. A review of the literature reveals that more research has been carried out exclusively on the renewable energy sector. Comparatively, the available research on the integration of GSC and renewable is profoundly insufficient (see Figure 1). Therefore, the current study aims at comprehensively reviewing exclusive published research on the integration of RE and GSCM to ascertain its status and propose future research direction based on available data. The article also seeks to present the role of customer-supplier flows within the framework of the renewable

energy supply chain. In addition, a model that combines distributed energy systems and GSCM practices for easy implementation by firms is currently not available. The uncertainties and inadequate data on RE as a sustainable source of energy[56] are deeply reflected in the complexities in trying to design and optimize the supply chain. These complexities created the need for an integrated framework for the renewable energy green supply chain (REGSC) systems[53] that will allow for easy implementation. Going into the current study, we hope to provide a timely and comprehensive overview of GSCM from the perspective of renewable energy. More especially,

- The study highlights the fundamental principles of GSCM, discussing the different techniques, as well as the sustainability implications. A significant amount of current knowledge on GSCM is found in traditional academic sources, such as journals and conference proceedings, and nontraditional academic sources such as fora, industrial reports, and blogs. The initial stages of the study coded the key information from these sources, to present the reader with an in-depth comprehension of the dynamics of GSCM.
- The next stage focuses on the development of RE, discussing the different mainstream renewable energy sources. For each of these RESs, we discuss in detail the potential they offer, highlighting the pros and cons of each of them.
- This stage presents an in-depth, systematic overview of GSCM in the context of RE by establishing green management standards, taking into consideration environmental, economic, and social characteristics. The study further outlines how companies can balance economic and environmental goals by presenting better techniques that would allow them to control the costs of the SC for affordable and efficient renewable energy.
- The study further presents a new conceptual model that allows energy producers to sell their surplus electricity based on a peer-to-peer (P2P) network or sell it directly via the general centralized market.
- Finally, an in-depth analysis of the findings and future development of REGSCM is presented. The framework on the adoption, limitations, drivers and barriers to RE use, and the potential for larger implications that might emerge with the integration of GSCM and RE is also discussed. The study highlights the components of REGSCM: financial flows, information flows, as well as the operational considerations for the adoption of renewable energy and the decision-making process associated with that, and the development of new practices.

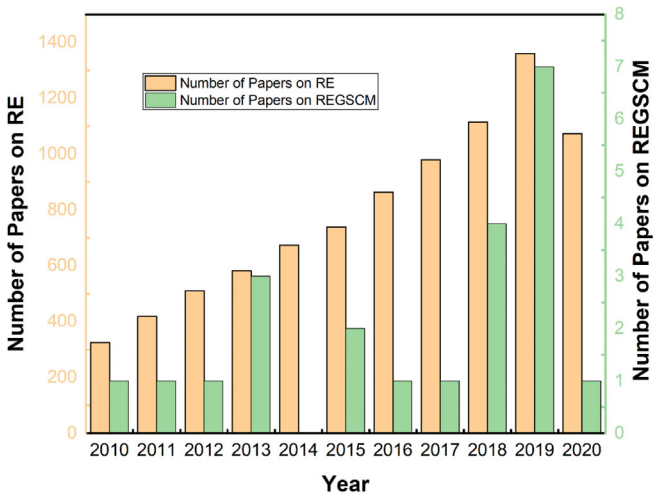

FIGURE 1 The number of papers on renewable energy (RE) and renewable energy green supply chain management (REGSCM)

2 | METHODS

The review was performed by first conducting a general review of green supply chain management (GSCM) several sources of literature explicitly employing the phrase, GSCM. Several scholarly published works on RE and GSCM were included in the review. A series of online searches were performed through several databases including, but not limited to, the Web of Science, ScienceDirect, and Scopus using search terms that are directly related to the subject of the review.

It became evident through these searches that the study needed to be extended further to consider the connection between RE and GSCM. This was carried out by including "renewable energy green supply chain management (REGSCM)," and related terms and phrases. The second round of searches was also performed through the same academic libraries as the first stage.

The literature sources obtained were first of all sorted and coded, and conclusions were drawn. This stage allows additional sources to be included based on references cited within the initial datasets.[57] These sources were then processed by repeated topical sorting of the coded materials to identify clear patterns and relationships. A broad range of topics emerged iteratively and were included in the current review. The decision to approach the coded material through several unique lines of inquiry to more deeply engage with the emergent themes was inspired by the breadth of work reviewed, as well as the topical categories.

The drafting of the initial review sections was guided by sorting the materials within a designed conceptual

framework. The reflections and summaries within the course of the initial stages were revisited, further sorted, and used for sensitization and critically assessing the review. Confirmation or modification of topics and organization of the review was performed at this stage while drawing a significantly close connection and foundation to the theoretical development of the study. According to References 58,59, the scope of this methodology can be presented as shown in Figure 2.

3 | GREEN SUPPLY CHAIN MANAGEMENT (GSCM)

The concept of GSCM is presented in diverse ways in the SCM literature. This can be seen from the different definitions that have been coined for it over the years.[48] For instance, Zhu et al[60] presented GSCM as a concept that embodies all the different phases of the life cycle of a product right from designing the product through to production, distribution, and consumption by the end users and, finally, disposing off the product at end of its life cycle by the consumer. Figure 3 presents an overview of the GSCM process. Hsu and Hu[61] also defined GSCM as a concept that allows for the integration of environmental regulations to improve the performance of processes and products. However, Srivastava[40] observed that GSCM seeks to highlight the common ground between supply chains and the environment and is rooted in the literature of both environmental and SCM. GSCM seeks to enhance the capabilities of SCM,[62] by integrating and coordinating business processes, as well as strategic alignment across the supply chain to satisfy customers.[63-65]

In the concept of SCM, GSCM and SSCM are usually being used interchangeably.[63,66-69] However, these concepts are slightly different. SSCM comprises economic, social, and environmental sustainability issues. This implies that SSCM is a broader field that encapsulates GSCM; that is, GSCM is a subset of SSCM.

GSCM means that firms and organizations must balance economic and environmental performance to stay competitive, and conform with regulatory and community pressures. This has forced enterprises to design and implement strategies for green management practices,[70] which aim at reducing the environmental impacts of their operations.[71] The integrated planning of GSC requires the determination of variables such as inputs, drivers, and enablers throughout the process, including production, transportation and distribution, packaging, and recycling of green products as a first step (Figure 4).

This process further involves monitoring, planning, execution, and control of practices, and tools that permit firms and organizations to be more aware of the environment in a sustainable manner. GSCM has evolved as a significant new pattern to give companies competitive advantages, minimize impacts upon the environment and market share objectives by lowering their environmental risks and impacts, and raise ecological efficiency.[60,70,73-75] Figures 5 and 6 show the delimitation of the GSCM and the pictorial representation of the functional integration of all the components of the product life cycle and the GSCM model, respectively.

The concept of sustainable development over the years has also gained increased attention due to several environmental and social issues.[76-80] These issues are addressed by managers through the integration of environmental effort in the supply chain.[81-87] Pollution reduction, reducing wastes and energy use, and utilizing renewable materials are some of the few ways through which firms realized green business practices (GBPs) to deliver products and services in a manner that is

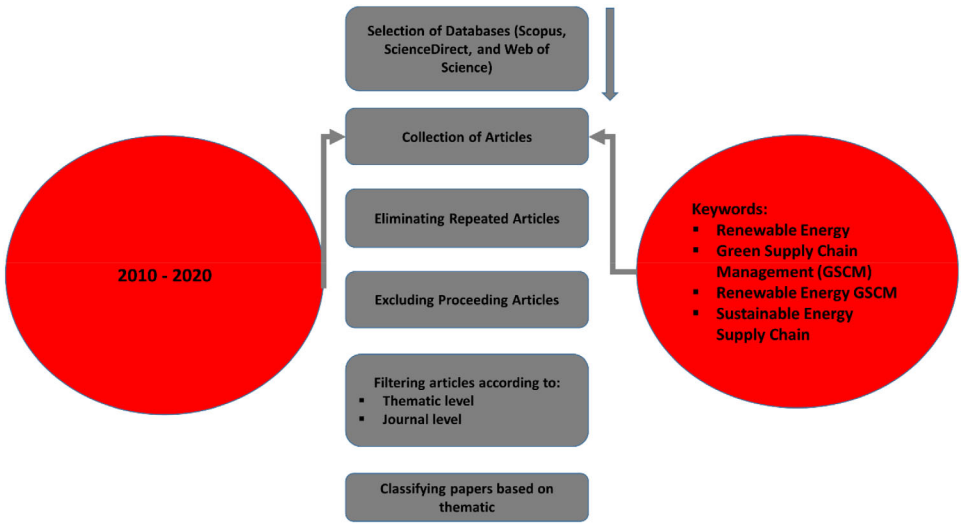

FIGURE 2 Scope of the methodology[58,59]

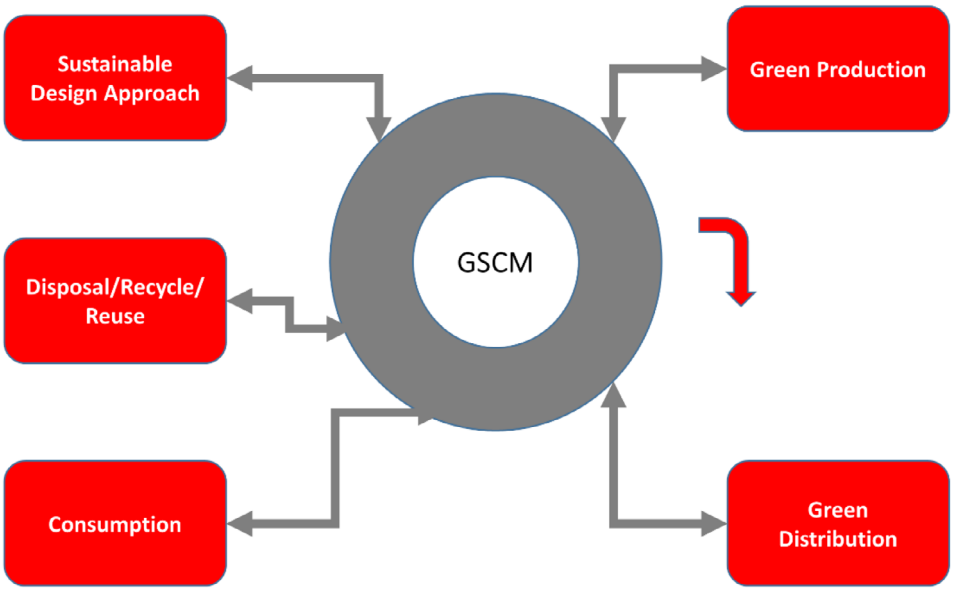

FIGURE 3 The general overview of GSCM

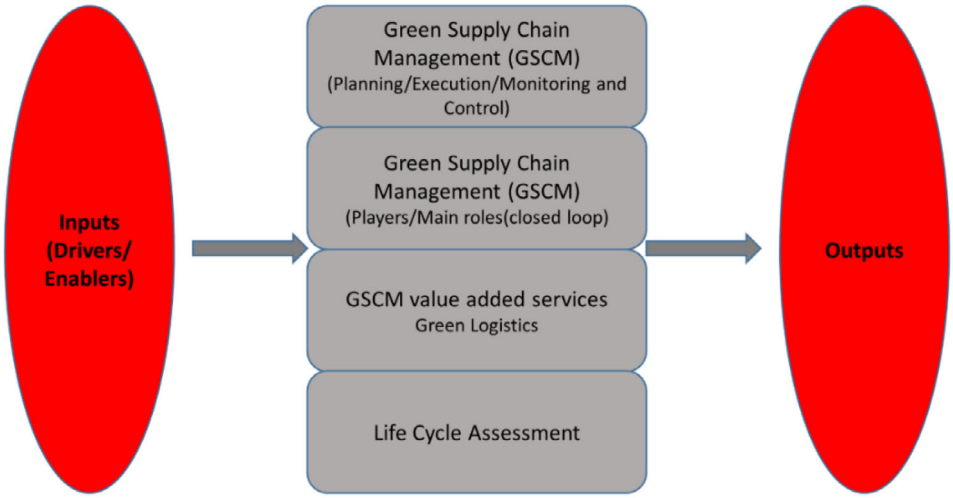

FIGURE 4 Green supply chain management (GSCM) framework[72]

environmentally sustainable.[88,89] There are three techniques in GSCM,[73] which are given as follows:

- Reactive—this allows companies to implement initiatives that lessen their environmental impact by utilizing minimal resources.
- Proactive—this also allows companies to enact preempt new environmental laws by utilizing lesser resources commitment to start the recycling process of various products and designing green products.
- Value seeking—when firms implement green environmental practices such as green purchasing.

The increase in the degree of recyclability and green innovation motivated Pal and Sakar[90] to examine the supply chain from the perspective of the manufacturer, the retailer, the supplier, and the collector. They observed that both the retailer and the manufacturer could do direct sales through a direct channel. However, the level of green innovation can change based on the quality of raw materials. The market demand is solely determined by the promotional strategies of the retailers in the supply chain. Sherif et al[91] observed that four distinct motives can change the dimension of the SC network with effective forms of transportation and efficient scrap collection systems that are environmentally friendly, including the economic concern, legislations on the environment, and potential recycling benefits.

Liu et al[92] observed that the main reasons for the adoption of GSCM are pressures from clients and competitors, with negligible regulatory influence. Thun and Müller[93] revealed that the adoption of GSCM is purely market-driven, and also highlighted that legal regulations

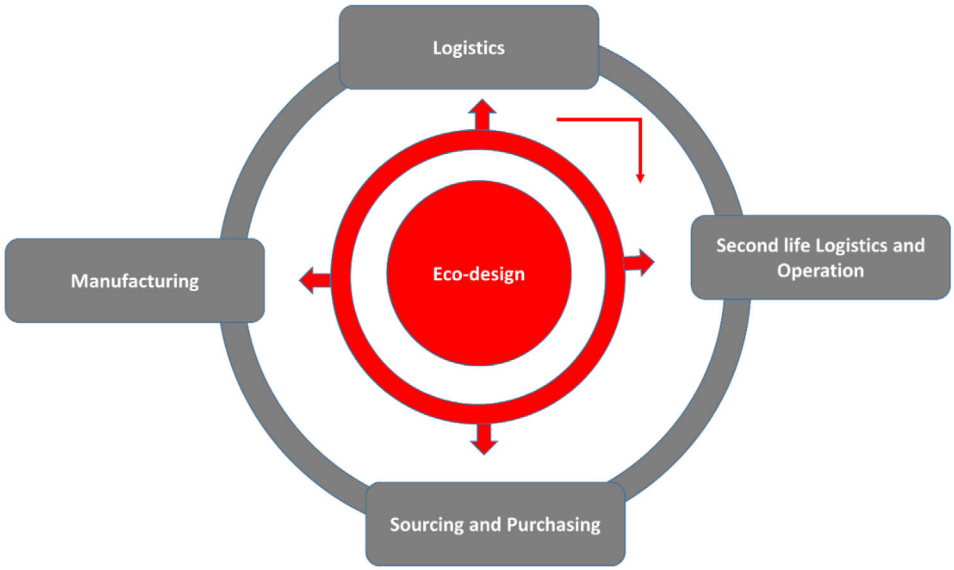

FIGURE 5 Delimiting the green supply chain management (GSCM) [74]

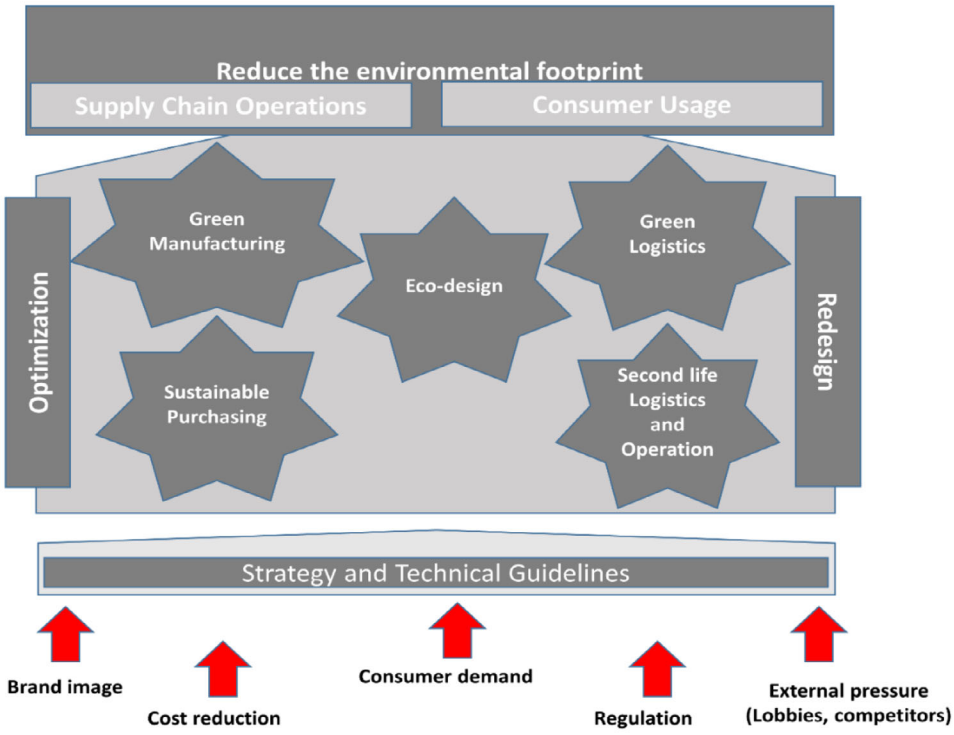

FIGURE 6 Pictorial representation of GSCM model[74]

and environmental protection fulfillment still play a role in GSCM adoption.[94,95] Both Feng et al[96] and Laari et al[97] pointed out that profitability and market share may or may not necessarily be a result of GSCM creation of resources and operational efficiency. Therefore, these two studies present a positive outlook on environmental performance but not on financial performance. It is interesting to note that Feng et al[96] only identified financial performance as when there is integral strategic implementation of the internal and external GSCM practices. This observation was reinforced by References 98,99. Wandosell et al[100] used the design and materials used in green packaging, the costs of green packaging, marketing strategies, and the impact of green packaging on the environment, among other indicators, to determine the impact of the GSC from business and consumer viewpoints.

Zhu et al[101] developed models that can be helpful for companies trying to identify the right GSCM practice for effective and efficient implementation, whereas Chin et al[62] proposed a conceptual model to clarify the connection between GSCM, environmental collaboration, and

sustainability performance (see Figure 7). It was observed that a positive correlation exists between GSCM practices and sustainability performance. The interdisciplinary nature of GSCM implementation opens it to several barriers and challenges, as Govindan et al[12] identified barriers to the implementation of GSCM within the concept of procurement effectiveness. They identified as many as 47 barriers through detailed literature and discussions with industry experts.

3.1 | Sustainability implications of the green supply chain (GSC)

Sustainable is that which can be maintained for a defined time. "*Sustainable energy is derived from resources that can maintain current operations without jeopardizing the energy needs or climate of future generations*."[102] Sustainability can be categorized into three parameters: environmental, social, and economic sustainability. Sustainable practices fully depend on resources that cannot be depleted,[77,103-105] which must be used with a lot of caution to never be used up, run out, or otherwise become unusable.

Generally, an increasing number of companies are coordinating with other companies and organizations along their supply chains due to internal contemplation of implementing sustainable practices, which has led to studies linking environmental sustainability to firm performance increase over the years.[106] Sustainability within the context of GSCM is one of the major concerns in SCM literature. According to Reference 107, the increasing desire towards the implementation of sound environmental practices, and the awareness of the significant role of the SC has generated a significant dataset examining how SC can integrate,[108,109] coordinate,[110,111] facilitate collaboration,[112,113] enhance sustainability,[69,114-116] and innovate performance.[117,118] Carter and Dresner[119] made an argument that management decisions must be taken after considering the impact of SC on the natural environment. Ma et al[120] identified two kinds of revenue-sharing contracts that can coordinate the economic sustainability and environmental sustainability of a dual-channel GSC.

Silvestre[107] made an observation based on supply chain sustainability trajectories that SC learns and evolves just like any other organization, and suggested that continuous learning and innovation can help maintain supply sustainability. He further argued that the concept of sustainability goes beyond the environmental implications of supply chains; it involves economic and environmental dimensions and the social impact of SC projections. In the same study, integration, collaboration, and innovation were identified as distinct interrelated elements for effective, efficient, and sustainable supply chains. Green technology has been evaluated through a new approach based on the significance of the supply chain configuration that gives significant information about environmental as well as economic aspects.[121] Habib et al[122] assessed the strategic impact orientation in three dimensions, including market, green entrepreneurial, and knowledge management on GSCM practice implementation and sustainable firm performance. Jin et al[123] investigated the implications of green optimism on sustainable SSCM and concluded that green optimism may hinder investment in green product development. The authors further noted that retailers benefit from green optimism more than manufacturers.

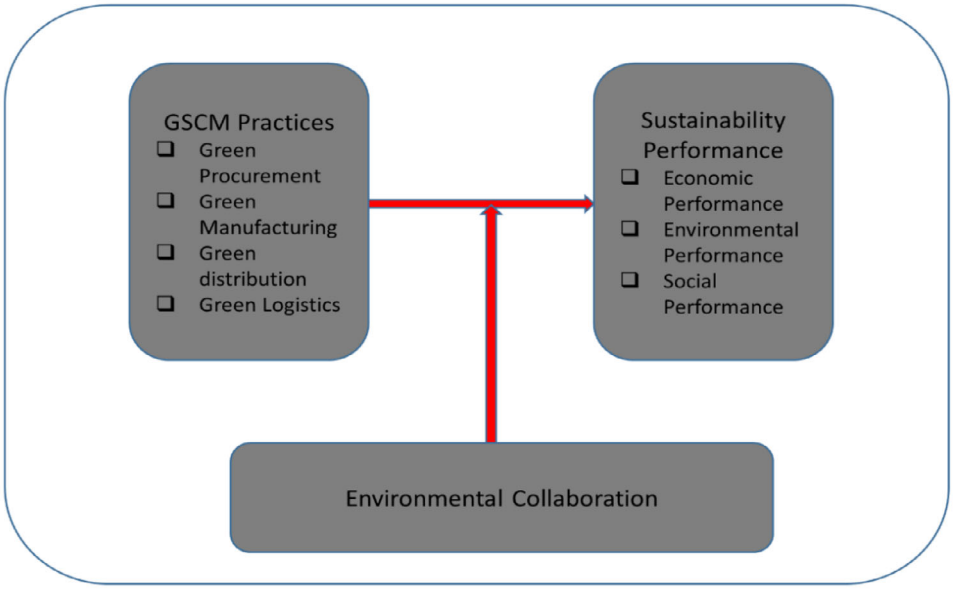

FIGURE 7 Model depicting the relationship between GSCM, environment, and sustainability[62]

4 | RENEWABLE ENERGY SOURCES

The generation and distribution system of electric power is one of the most complex systems to have ever been built.[124] Therefore, it is significantly challenging to green this system, since this process requires diverse processes, and must rapidly undergo adaptation to the diverse portfolio of renewable energy technologies to satisfy the requirements for environmental and energy security. Renewable energy has multiple characteristics such as reduced dependability on fossil fuel and a decline in CO_2 emissions in the atmosphere.[125] The benefits of using renewable energy are not only saving energy sources but also multi-dimensional practices like water transfer. Renewable energy sources are naturally replenishing but limited; renewable resources are almost unlimited but inadequate for energy that is available per unit time, such as sunlight, geothermal heat, wind, water, and various forms of biomass. Two fundamental elements make energy renewable; first, it must be generated from readily replaceable sources and must emit negligible to no greenhouse gases (GHGs).[126-130]

The number of countries installing facilities for renewable energy generation has increased significantly. This move is mainly motivated by the desire for energy security, economic impacts, and reduction of carbon dioxide (CO_2). The most important challenge confronting the growth of RESs is their integrally intermittent nature, as renewable energy generally depends on nature for its generation. Supply and demand are affected by a sudden change in weather conditions, which negatively affects the electricity market and is one of the crucial elements in the energy transition equation.[127] Figure 8 shows world energy consumption by energy source in 2020. These are also the most important basic technologies available in the energy market.

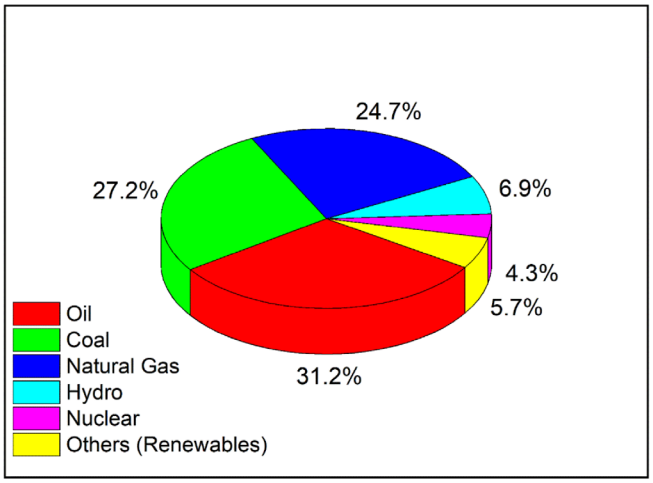

FIGURE 8 World Primary Energy Consumption by Energy Source, 2020[131]

Following the development of the Kyoto protocol in 1997, an important initiative on tackling environmental deterioration, in which reduction of global warming and promotion of sustainable development are considered high global priority,[132] there has been a need to reduce dependence on fossil fuels by promoting RE sources. Wee et al[56] assessed RESs based on their supply chain, performance, barriers, and developmental strategies and implementation. The authors provided managerial insights for the initiation of RE usage, and how to overcome the barriers to its developments. Figure 9 highlights the primary benefits of Renewable Energy Integration into GSCM.

4.1 | Biomass

Biomass as a source of energy is obtained from organic resources, including wood, industrial and domestic waste, microorganisms,[134] and other plant-based materials from agricultural activities.[135-138] These wastes are converted directly or indirectly into usable energy and products, such as biofuels using several technological processes.[139-141]

4.2 | Solar energy

The energy from the sun is enough to power the world for more than two straight hours per every second of energy emitted. This propels solar energy to be the fastest growing and largest source of energy on a commercial scale. Solar energy can be harnessed from the sun using three main technologies: photovoltaic (PV), concentrated solar power (CSP), and solar thermal.[142] These technologies convert sunlight into heat or electrical energy.[143] However, the biggest challenge confronting the development of solar energy is the ability to store the harnessed energy for future use.[144,145] Also, large-scale arrays of solar panels are intrusive and can compete with wildlife habitat as well as hinder crop production.[78,146-148]

4.3 | Wind energy

Wind energy is a form of energy that is derived from the movement of air. The moving air operates a wind turbine located onshore or offshore,[149,150] which generates electricity. The air around a rotor, which is attached to the main shaft that spins the generator and generates electricity, turns the blades of the wind turbine. The

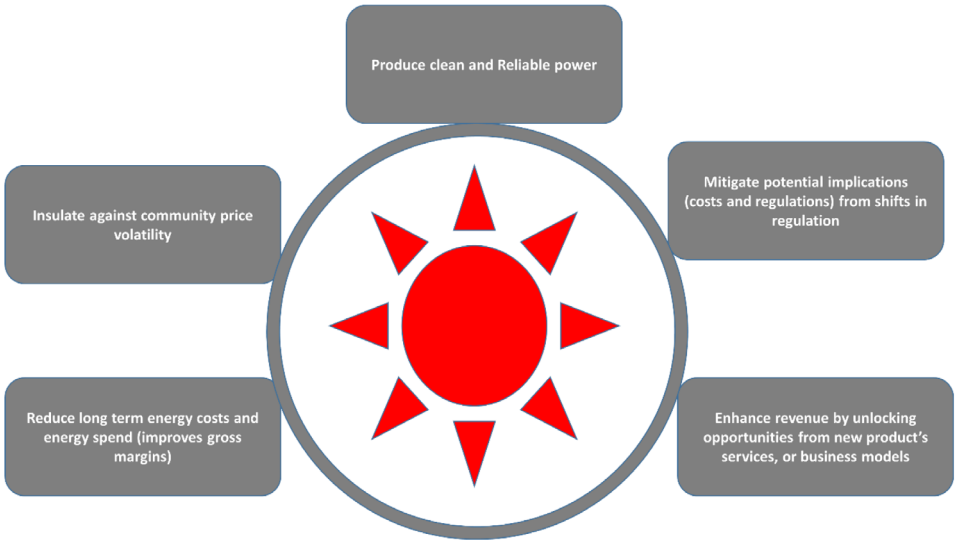

FIGURE 9 Primary benefits of renewable energy integration into green supply chain systems[133]

challenges confronting wind energy are issues that periodically arise as a result of installed turbines affecting the movement of migrating birds and bats,[151] which can as well occupy a significant portion of land.

4.4 | Geothermal energy

This form of energy is harnessed from deep below the surface of the Earth because of the existence of hot water at varying temperatures within the Earth's core. The temperature in the core of the Earth exceeds 5800°C, and the energy stored inside the Earth is unlimited compared to other commercial sources of RE.[152] The underground reservoirs are accessed through deep wells of a significant height to facilitate the process of bringing the steam to the surface for use in a range of applications.[142] Geothermal energy is increasingly used to compensate for heating and cooling costs in various establishments.[153] Barbier[154] and Zhu et al[155] gave an in-depth analysis of geothermal energy. In comparison with solar and wind, geothermal energy releases minimal CO_2 emissions, is more stable, and has attracted more attention over the past decade.[156]

4.5 | Hydropower

The energy generated from the movement of water significant enough to move turbines for the generation of electricity is hydropower. Gravity provides the primary energy and the height as water falls onto the turbine.[149] Hydropower comes with several advantages, such as abundance and reliability as well as low cost of operation. It can also be used as surplus energy in the baseload and peak load conditions.[157,158] Hydropower reservoirs are noted for multiple uses, for instance, flood and drought control,[149] irrigation purposes, drinking and domestic usage, and navigation.[142] The type of hydropower plant deployed depends on several factors, including topography, installed capacity, and conveyance system. While hydro is considered renewable with practically no particulate pollution,[159] large-scale hydropower projects can, however, have a large ecological footprint.

5 | RENEWABLE ENERGY GREEN SUPPLY CHAIN MANAGEMENT (REGSCM)

For some time now, there have been growing interests in energy and environmental issues in many countries with both individuals and organizations advocating for responsible production and consumption of energy resources.[133] As a result, several organizations have reviewed and continue to review their energy management initiatives. In this course, renewable energies became the most preferred energy source with a multi-national corporation such as Apple Inc., and Kohl's "going all-in" for renewables.[133] Through the RE100 initiative, about 154 companies adopted and signed the American Business Act on Climate Pledge with 81 of them pledging to pursue 100% renewable energy.[160] Today, there is a plethora of evidence pointing to the fact both larger and small business entities in America, Europe, the Middle East, and Asia have considered renewable energies in their supply chains.

Previous literature established the connection between RE and GSCM with most of these studies revealing a strong connection between the concepts in terms of

contribution towards sustainability, integrating the "Green" concept into a RE supply chain and thus REGSC.

It is found in Reference 161 that, the production of renewable energy, and the principles of GSCM play a very critical role. To support this, the work of Reference 162 argued that the extensive consumption of energy couples with resource scarcity among industry makes sustainable GSCM indispensable. Similarly, the study by Reference 163 noted that the volatile nature of energy prices and the transition from conventional energy generation to RE sources have real implications for the SC. The real intent of renewable energy is best achieved when GSCM is integrated with RE initiatives. When this is done, the efficiency of RE is likely to be achieved or obtained throughout the supply chain. According to Reference 56, REGSC thus encompasses the physical flow of RE products. It demonstrates the movement of renewable goods and services from the point of production through a series of distribution channels to the final point of consumption. In a simple framework, Aslani et al[164] presented REGSC from the perspective of five components, supply, generation, transmission, distribution, and demand (see Figure 10), thus from the raw materials (input) to the end-user product (output).

The general RESC involves the transformation of raw energy resources into usable energy for both domestic and commercial purposes. According to Reference 163 the management of the RESC encapsulates a set of management principles and practices that are effective enough to cover the entire supply chain. An effective RESC covers the original point at which the renewable resources are extracted through to the demand and transmission of energy to end users. Like many other supply chains, REGSC contains various interrelated sub-chains. It comprehensively covers the technologies and the infrastructure linking energy vendors and consumers, the resources, labor, equipment, installation, and operation systems aiding the production and distribution of RE.[165] As demonstrated in previous studies,[163] integrating RE with SCM does not only improves energy accessibility but also simplifies the process of replacing fossil fuels with systems of supply and RE conversion.[163] For RE to dominate the energy market, its prices must be competitive, but this can only be achieved by improving the cost control systems in the supply chain.[166] Similarly, increasing the flexibility of the supply chain can help enhance the performance of RESC, which can result in efficient production.[167] In any case, ensuring efficiency in the RESC also creates and increases the awareness of the benefits of energy-saving among producers, vendors/distributors, and consumers.[168] REGSC has brought a decrease in long-term costs, mitigation of risk, improvement in revenues, enhancement of brand values, and the improvement of stakeholder engagements in the corporate world.

Figure 11 is a depiction of a typical RESC flow that demonstrates how energy production and consumption are connected. A key factor in the RESC is the technology that has spearheaded the efficiency improvement in the distribution network of RE. For demand, the commercialization of RE would be a significant step towards replacing conventional energy. Among other factors, critical to innovations in RE is the efficiency in RE generation and capacities of storage technologies to deliver the desired results.

The composition of the RE is diverse and as such, contains five key stakeholders: investors, consumers, policymakers, utilities, and SC, and each of these stakeholders faces several challenges[168] in their day-to-day operations. Across the RESC, the different challenges hinder the implementation process of RE technologies. In order to mitigate these challenges, all the stakeholders need to take full responsibility for their actions. In a study by Fernando et al,[161] three dimensions of energy management practice exist—commitment by top management, energy awareness, and energy auditing, which were previously linked with the development initiatives of REGSC, and concluded that lack of technical know-how means that organizations struggle to effectively manage energy to support operational targets.

Sustainable usage of power goes beyond the production of power as it covers distribution and consumption. Across the energy supply chain, there are always significant losses of energy at almost every major point of the supply chain. Although much of the literature had focused on the point of changing power to electricity or storing it, there are many ways of preventing energy waste or reusing it. Sustainable usage of power also goes beyond the production of power. Changing power to electricity or storing it is very common; thus, there are many ways of preventing energy waste or reusing it. As highlighted in the previous sections, most of the papers published were more focused on wastes of materials and other aspects of GSCM, with very little or negligible attention on energy. An extensive review of the literature

FIGURE 10 The domain of RESCM[164]

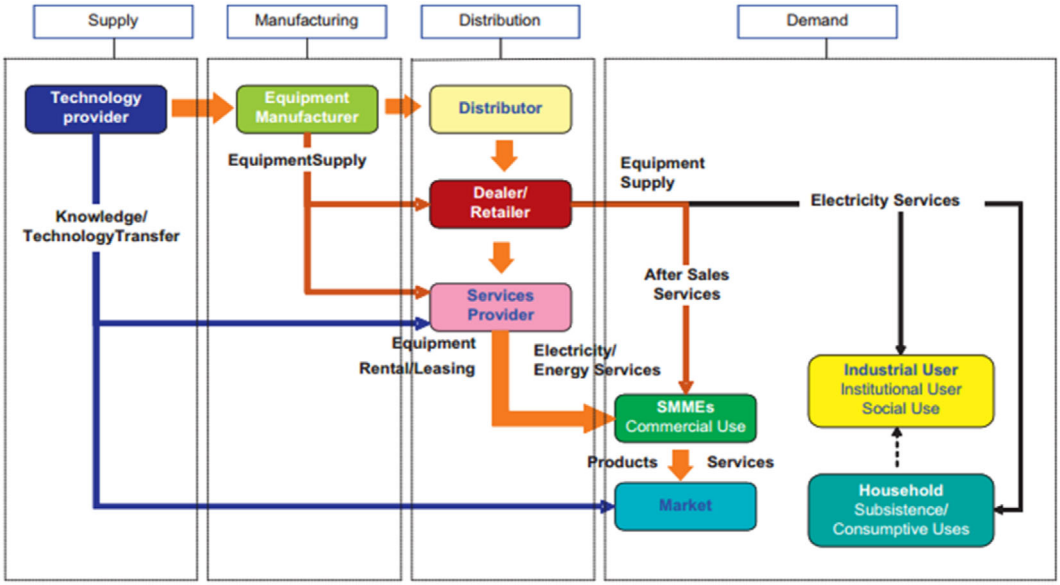

FIGURE 11 Renewable energy supply chain processes[56]

further revealed that the scanty literature available is largely based on the reduction of the level of GHG emissions and progress in the energy sector with an emphasis on policies. However, policy improvement alone is inadequate to realize the changes necessary to replace fossil fuels with RE. One of the strategies adopted by governments is effective REGSC as one of the most efficient strategies as it is significant in analyzing the industry from an integrated perspective.[169] This allows for the implementation of a network of REGSCs where there is a target goal for everyone in the chain through collaboration, and exploitation of the internal and external business drivers.[170]

Lee,[171] and Hongjuan and Jing[172] observed that consumers are consistently becoming aware of the growing threat climate change and global warming pose to our well-being. Sada et al[173] as well noted that this growing awareness by consumers should be factored into the decision-making process by policymakers and businesses. In a survey conducted by Mckinsey Global,[174] this point of view is further reinforced as an important business for managers who are interested in greening and energy efficiency. Huang et al[175] examined the impact of stakeholder resources (regulatory, internal, and market) on GSCM and green corporate resources as well as their effects on the economic and environmental performance.

The reduction of energy costs and CO_2 emissions involves a well-managed combination of several processes, including energy-efficient activities, techniques, and process management.[176] These processes consist of the energy management guidelines by the International Standardization Organization (ISO), which was published in 2011.[177] It is believed that these standards significantly support energy processes and as well improve energy efficiency.[178,179] However, Böttcher and Müller[180] observed that these standards are not broad, and significantly inefficient on energy and carbon efficiency. Generally, the energy consumed in the management of the supply chain is intensive and typically produced from conventional sources of energy, such as fossil fuels,[181,182] generating CO_2 emissions.[183]

Figure 11 shows that there is a direct relationship within the loop for electricity flows in this supply chain. Technology is key to the success of renewable energy supply chain management.[56] RGSCM can be seen as a response to the impact of climate change since energy efficiency is a significant component of the UN Framework on Climate Change (COP 21) (UNFCCC[184]). Zhang et al[185] highlighted that there are commonalities between RESC supply chains, including, but not limited to data, physical and financial flows. The physical flow has to do with activities that are more relevant to supply chain performance, including increasing awareness of green manufacturing, logistics, and products. These flows ensure that businesses use energy efficiently and effectively, and are more energy independent, while on a path towards sustainable business performance.

de Sousa Jabbour et al[186] identified the contributions of the ISO 50001 support concerning the adoption of GSCM, by considering several critical components such as energy efficiency and reduction of CO_2 emissions. Rahbauer et al[187] presented case studies that identified barriers to the implementation of green electricity with Small- and Medium-Scale Enterprises (SMEs) as case studies. Tognetti et al[188] illustrated a mathematical model for reducing CO_2 emissions by 30% in the supply chain

by optimization of the energy mix, at almost zero variable cost increase. Ahi and Searcy[189] analyzed the consumption of energy metrics in the green supply theme, whereas Lee and Cheong[190] highlighted the emissions of CO_2 management in an automotive supply chain.

The transition towards a greener economy requires in-depth information on the environmental impacts of the supply chain on a global scale.[191] In the study,[191] it was highlighted that far more action is needed to move towards a greener economy globally, and suggestions for efficient strategies for greening the economy were provided. Fernando and Yahya[170] explored the implementation challenges of RE management and how organizations manage low carbon issues in the SC. The authors noted that the electronic and electrical (E&E) firms have limited resources to manage RE and categorized the challenges into subthemes, as internal and external. The internal challenges relate to the logical cost-benefit scenario, in which the issue of the non-profitability of RE was identified as one of the key internal challenges, as well as investment cost and lack of knowledge. The external challenges captured government policy, supplier involvement, and social acceptance. Figure 12 presents a model of the internal and external challenges of RE implementation in the SC.

5.1 | Components of REGSCM

The performance of REGSCM is hindered by several components/elements just as in any supply chain, including physical, information/data, and financial flows.[53] The next section highlights an overview of these flows. These components of the supply chain determine how the relationship between suppliers and customers is managed in every single phase/stage of the chain to realize the target goals.

5.1.1 | Physical flow

These are the tangible aspect of the supply chain, including, but not limited to, production, distribution, and products. This determines the effectiveness of management performance of the supply chain. Sahu et al[192] utilized green productivity tools to overcome the challenges faced by SMEs, such as productivity enhancement, material usage, waste management, and sustainability.

5.1.2 | Information flow

This consists of the transfer of data and information for physical transformation in the supply chain. It allows for effective and efficient implementation of green practices for "*improved supply chain relationships to achieve a sustainable competitive advantage*."[166] Hong et al[193] observed that quality information disclosure is necessary for green manufacturing. They provided a new decision tool that assists manufacturers in the GSCM to make decisions on sourcing quality information from a third party before disclosing the quality information.

5.1.3 | Financial flow

This is the most important component of supply chains as it controls the other elements of the supply chain. Financial flow to the GRSCM can be realized from several sources,

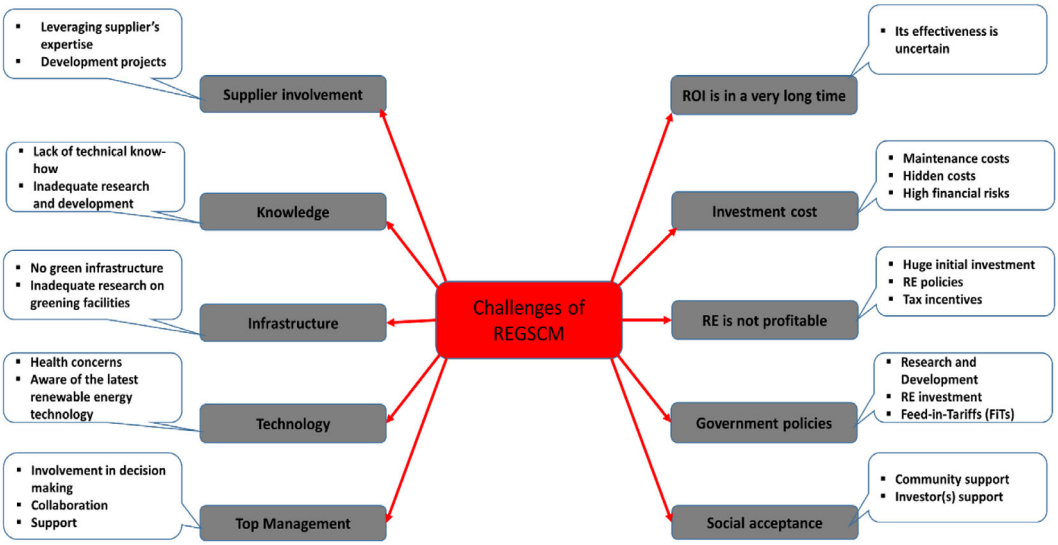

FIGURE 12 A model depicting internal and external challenges of REGSCM[170]

including stakeholders, the general public, and environmental NGOs, as well as internal sources. Khan et al[99] examined the performance of financial and environmental practices and concluded that it is influenced by intellectual capital with a meditating role of GSCM and a moderating role of financial resources. Memon et al[194] observed that firms traditionally inclined financial performance and profitability to surge shareholder's wealth. However, innovation and environmental performance have taken the center stage within the GSCM context. The authors further observed that SMEs need adequate financial resources to flourish in terms of achieving financial targets, innovativeness, and environmental performance. They highlighted that the role of these instruments can be examined with a meditating role of opportunity recognition.

6 | EVALUATION AND ADOPTION OF RENEWABLE ENERGY GREEN SUPPLY CHAIN

6.1 | Operational considerations

The use of renewable energy can be increased across the supply chain using a well-developed energy procurement profile based on the profile of the company and its specific needs. Table 1 presents the five attributes that can shape renewable energy decisions and determine the potential overall return on the company's RE investment.

TABLE 1 Operational considerations for the adoption of renewable energy (RE)

Operational considerations	Attributes
Size and profile of the company	The procurement options for RE largely depend on the size of the company, and energy profile. Procurement options largely depend on the following: • Size of the company, small, mid-cap, or enterprise company • Level of energy consumption per year • Whether the profile of the company relies on purchased energy or more on on-site generation
Profile of the facility	The procurement options should factor in the kind of ownership of the facility, whether it is owned or leased. Owning the facility gives decision-making power to the business and makes it less challenging to implement renewable energy projects in a timely and effective manner.
Locations and markets	The physical location of the facility determines the available options for power generation and ownership models. The availability of energy incentives and regulations varies from country to country.
Investments	Renewable energy procurement should limit risks based on overall investments. Renewable energy should be seen as a hedge against unstable energy markets.
Proximity and visibility	The aim of procuring RE should determine where it should be set up within the facility since it potentially sends across a visible corporate responsibility statement. This takes the pressure off environmental activists, customers, etc. advocating for green practices. Several businesses adopt clean renewable energy to be seen as socially responsible. Therefore, proximity and visibility are more important for such companies than the type of renewable energy source, as long as the financials and technical viability are sound.

6.2 | Decision-making process

The implementation and facilitation of an optimal RE strategy can be realized by leveraging industry-leading practices. The fundamental goals for renewable energy in the supply chain must align with the vision and goals of the organization, as well as its ability to improve continuously (Figure 11). Firms should make RE investments a priority to achieve their energy procurement and sustainability goals. Investment in RE takes a long time to realize returns but needs the firms to first implement several specific variables in the supply chain for optimal portfolio, and to achieve the desired objectives. The returns for each of the key-value driver areas outlined in Figure 13 will be dependent on the kind of renewable energy investments.

The available procurement options are evaluated based on the goals of the firm or organization after the desired outcome is realized for increased renewable energy adoption in the supply chain. There may be other financing options in addition to the listed sources for renewable energy, including third-party sponsors, environmentally-related NGOs, and the public. More often than not, firms adopt one or more of these sources of financing. Table 2 highlights the procurement options for renewable energy. The fundamental ingredient for green procurement is that it includes environmental

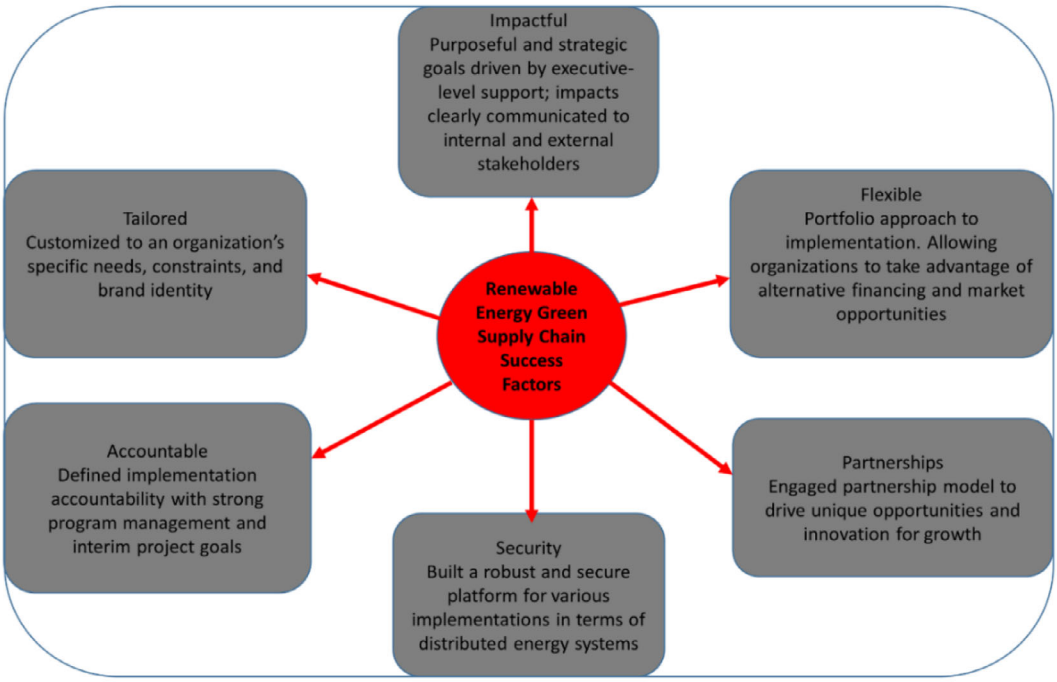

FIGURE 13 Renewable energy success factors in the context of GSCM[133]

TABLE 2 Renewable energy procurement options

	Onsite generation	Offsite generation	Green certificates
Overview	The source of RE is within the property of the firm or organization.	The source of RE is located off the premises of the firm by either a third party and then sold to the firm or self-generated by the firm.	This allows green energy to be traded anywhere within the electrical grid.
Energy impact	Direct	Indirect	Zero
Visibility	High	Medium/Low	Low
Difficulty of implementation	High/medium	Medium/Low	Low

elements as a criterion in the purchasing decision-making.[195,196]

6.3 | Development and design practices

Throughout the product life cycle, the environmental related issues are addressed through green product development approaches.[197,198] The environmental life cycle considerations are systematically included in the product design through eco-design. This reduces or eliminates the environmental impacts of the product throughout its life cycle[199] by completely dictating all the phases in the SC, including the extraction of materials, the production processes, distribution, and consumption of the product to its disposal phase or reuse/recycle. Through eco-design, organizations or firms can substantially reduce the environmental impacts of their products and services through improved environmental performance, and be able to close the supply chain loop via product functionality handling.[200,201]

7 | DRIVERS AND BARRIERS TO REGSCM

Renewable GSCM involves moving away from the conventional SCM to GSCM. This process involves several activities that either accelerate or hinder this transition. These activities influence every single step of the greening practices.[202] Zhang et al[203] investigated the practices of SMEs concerning environmental management, and identified several drivers and barriers to engage business in green initiatives, and found out that SMEs pay less

attention to green initiatives than relatively larger companies. Their results also highlighted legislation as a key driver to engage SMEs in environmental management initiatives. Dhull and Narwal[204] also gave an overview on drivers and barriers for the implementation of Green initiatives in the SC. Walker et al[202] examined several factors that hinder or accelerate the implementation of green initiatives by businesses. They categorized these drivers into two separate groups—internal and external drivers, as well as different sets of factors, including organizational, regulatory, customers, competitors, and society.

Luthra et al[205] structurally developed a model based on the barriers hindering the implementation of green initiatives in the automobile industry. The dependent variables in their study were identified as market competition and uncertainties, financial implications, the unwillingness of suppliers to quickly adapt and implement GSCM, and the unawareness of customers. Handayani et al[206] in a recent study identified the drivers of stakeholders to implement green practices and the barriers they faced in the implementation of these practices. Agarwal et al[207] used structural equation modeling to evaluate different barriers of GSCM.

7.1 | Motivators and drivers

The factors that motivate firms and organizations, such as manufacturing industries, to be socially responsible are adding green practices to their supply chain via reduction of environmentally damaging substances, green image of the firm, etc. These drivers are categorized into several factors for easy identification, including internal and external factors, and, according to the type of customers, the available competition, the marketing strategies, and the suppliers. The tremendous increase in economic development has brought several serious environmental issues such as pollution through the release of toxic substances or liquid into the environment by manufacturing industries. Governments around the globe in their bid to curb this alarming situation developed several policies for companies to adopt through green environmental practices in their operations. Stakeholders, environmental activists, trade organizations, customers, suppliers, employees, etc. also support these policies (see Table 3).

7.1.1 | Internal motivators and drivers

Internal motivators and drivers are initiatives put in place to enhance efficiency. They may be in the form of economic incentives, GSC pressure, customers, society, and environmental activists. These can be examined by implementing GSCM practices, in which the role of management is paramount, as well as understanding the social capital between buyers and suppliers.[233]

7.1.2 | External motivators and drivers

External motivators and drivers include measures or initiatives that see to it that policies enacted by governmental organizations are strictly followed. These may include, but are not limited to, pollution prevention or reduction, training, economic incentives, codes of practice, legislative compliance, peer networks, supply chain pressure, financial stakeholders, pressure from society, customer and supplier influence, and international trading.

7.2 | Barriers to renewable energy green supply chain

The industries may understand the importance of REGSCM, but most of the time, it may not be possible to put it into practice. The successful implementation of renewable energy GSC is hindered by several factors, including the cost of implementation, government policies, and organizational factors. These factors are referred to as barriers and are categorized into internal and external barriers (see Table 4). The proper understanding of these barriers is key to successfully implementing REGSC practices.

7.2.1 | Internal barriers

Internal barriers are hindrances that affect a firm's transition to GSC practices. These may include lack of technical knowledge, inadequate financing, and communication gaps, short-term profits, misconceptions about environmental issues, bounded rationality implications, and middle management change inertia.

7.2.2 | External barriers

External barriers as well hinder the successful implementation of GSC practices but from a different perspective. These barriers may include the following; governmental policies, prohibition of cleaner technologies, limited access to funding, and unstable economic environment conditions.

TABLE 3 Motivators and drivers for REGSCM

Motivators and drivers for REGSCM [Ref.]	Influencing factors					
	Company related	Regulatory	Customers	Competition	Society	Suppliers
Internal						
Costs reduction[208]	✓					
Quality improvement[209]	✓					
Employee involvement[210]	✓					
Investor pressure	✓					
Pressure from investors, and economic risk[211]	✓					
Values of the founder[212]	✓					
External						
Legislative and regulatory compliance[211,213-216]		✓				
Proactive action pre-regulation[208,217,218]		✓				
Environmental management systems and continuous improvement	✓					
Enhancing efficiency	✓					
Skillful policy entrepreneurs[219]	✓					
Environmental accounting		✓				
Environmental reporting		✓				
Voluntary initiatives	✓				✓	
Environmental leadership	✓					
Economic incentives				✓		
Green consumers			✓			
Environmental auditing						
Pressure by customers to green supply chain[211-213,215,220]			✓			
International trade						
Regulations		✓				
Self-regulation						
Codes of practice		✓				
Education and training	✓					
Peer networks					✓	
Supply chain pressure			✓		✓	✓
Financial stakeholders						
Community stakeholder power					✓	
Customer demand[119]			✓			
Collaborating with customers[221]			✓			
Marketing pressures[222]			✓			
Supply integration[76]						✓
E-logistics and environment[196]			✓			
Improve firm performance[223-228]				✓		
Gaining competitive advantages[196,220,222,229-231]				✓		

(Continues)

TABLE 3 (Continued)

Motivators and drivers for REGSCM [Ref.]	Influencing factors					
	Company related	Regulatory	Customers	Competition	Society	Suppliers
The stakeholder can encourage environmental strategy					✓	
Potential for receiving publicity[232]					✓	
Non-economic stakeholders					✓	
Public pressure[214]					✓	
Reduce the risk of consumer criticism						
Pressure by environmental activists[215]					✓	
Collaborating with suppliers[221]						✓

8 | IMPROVING REGSCM

8.1 | Integration

Power[234] observed that it is difficult to separate investment in cooperative arrangement supply chain processes integration, considering independently of the strategic positioning of organizations. The implementation of a chain that is uninformed by strategy will fail to produce results or benefits or at best produce little in the ways of tangible benefits, and at the worst impact the performance of the firm by eroding its competitiveness, the author argued. The basis of supply chain integration is rooted in the ability of agents to cooperate, collaborate, share information, establish trust, and form partnerships and technology sharing.[235]

8.2 | Collaboration

Collaboration among members or agents is a fundamental ingredient for GSCs to function properly. Successful collaboration in GSCM demands several ingredients to keep it going, such as sharing information and resources, and risks, as well as rewards.[111] Silvestre[236] argued that it is important to harness relationships and collaborations between a member of the chain and other external stakeholders just as collaboration within the supply chain itself. Collaboration enhances innovation and sustainability performance in the supply chain.[237,238]

8.3 | Innovation and sustainability

The concept of the evolutionary approach in the GSC states that firms undergo a series of stages before finally performing new activities. These stages allow firms to learn over time and gradually accumulate knowledge.[115,239] Silvestre[236] argued that supply chain trajectories can be well understood by adopting this evolutionary approach; that is, it allows these dynamic entities to learn and evolve into important components of the chain. What makes this position important is that an organization can only compete with its supply chain partners.[240] Innovation is seen as an important component in GSCM.[239]

8.4 | Distributed energy systems

There are many use case applications already developed in the quest to transition to a more decentralized, decarbonized, and digitized new energy world, such as automated bill payment systems and renewable-based cryptocurrencies. Blockchain provides a platform for interactive transactions that gives true participants a high degree of autonomy. It also ensures that utilities and grid operators are more effective and efficient as it allows them to balance energy supply and demand, as they engage prosumers directly, in real time. This permits a cost-effective integration of renewable energy into central control systems.

Industries across the globe have come to understand the positive implications of blockchain right from the time of its invention. The critical use case of blockchain technology in the renewable energy space has become an essential part of the energy markets in terms of distribution and accessibility of energy. Energy, seen as an asset, like other commodities, from the perspective of blockchain has made it immune from attacks and manipulations. Transactions are made online and are settled instantaneously, allowing reporting to be automated as well as instant verification. This goes a long way to lower costs and ease access, thereby enhancing market participation.

TABLE 4 Barriers to REGSCM

Barriers to renewable green supply chain management (REGSCM) [Refs.]	Influencing factors						
	Costs	Regulation	Customers	Competition	Society	Suppliers	Industry-specific barriers
Internal							
Cost[232]	✓						
Lack of know-how and experts[56]				✓			✓
Misunderstanding of incorporating green practices into buying	✓						✓
Reduction of cost at the expense of green practices[216]	✓						
Non-commitment from management							✓
Unaware buyers			✓				
Lack of training and commitment[119]							✓
Costs hinder greening in the forest industry	✓						
Accounting methods limit green reporting	✓						
Pressure for lower prices			✓				
Misconceptions about environmental issues[72]					✓		
PR exercise as greenwash					✓		✓
Financial accounting under-auditing and misrepresentation of environmental benefits and cohorts							✓
Short-term profit effect on cleaner technologies adoption[72]	✓						
Bounded rationality implications[72]			✓				
Financial performance pressure[72]							✓
Interorganizational communication gap[72]							✓
Middle management change inertia[72]							✓
Labor force issues[72]					✓		
Challenges in transitioning to green technologies[72]							✓
External							
The regulatory approaches fail points[72]		✓					
Location selection[56]					✓		
Distribution network[56]			✓				
Clean technologies access prohibiting factors[72]					✓		

(Continues)

TABLE 4 (Continued)

Barriers to renewable green supply chain management (REGSCM) [Refs.]	Influencing factors						
	Costs	Regulation	Customers	Competition	Society	Suppliers	Industry-specific barriers
Restricted access to external funding[72]	✓						
Counteracting policies and subsidies[72]		✓					
Lack of suitable markets for recycled goods			✓				
Economic environmental fluctuations[72]							✓
Inhibits innovation[223]		✓					

The energy market is currently going through a transition from conventional systems to smart systems. Given the addition of large volumes of renewable energy, grid management has become a challenge. Besides, the deployment of decentralized energy resources and the emergence of prosumers, and the management of energy systems have tremendously increased the numerous hurdles in the energy industry.

The integration of blockchain and energy has proven to be one of the most significant technological advancements in recent history, as seen in the trading and crediting of energy instruments. Participants on the chain create a virtual grid by leveraging this technology to facilitate transactions of energy-related instruments on a distributed or wholesale level. This allows consumers to trade among their own devices and resources, with their neighbors, and with the grid. Smart contracts could help automate the entire transaction.

9 | PROPOSED CONCEPTUAL MODEL

In contemporary times, there has been a sweeping transition from the current electricity grids to the use of more decarbonized, digitized, and decentralized energy platforms. This transition has been very successful following the deployment of blockchain technology for automation and formidable data management strategies.[241-243] As widely noted, these strategies have delivered low costs operations, which are crucial for REGSM without compromising the security of energy systems.[244]

The current real-world projects based on blockchain technology are much more focused on energy trading platforms, grid optimization, e-mobility, and the management of Certificate of Origin. Energy trading applications currently target wholesale, retail, and P2P electricity trading systems. It is required that corporations produce Renewable Energy Certificates (RECs) as proof that particular energy used has been generated from renewable sources such as solar or wind power. Such certificates can be purchased on trading platforms.

The proposed conceptual model (Figure 14) permits prosumers to choose their desire-trading partner. Excess energy produced is sent back to the grid for a small Feed-in Tariff rate. The model is mainly grounded within the REGSCM term network in the context of GSCM and VPS, which was articulated by Reference 245. This concept allows renewable energy producers to directly sell their electricity based on a P2P network or sell directly in the general market. Specifically, businesses can create value linkages with other businesses to achieve their desired goals. In conclusion, robust testing and more research are still needed to some extent to further refine the proposed model before it can apply to energy-intensive firms, such as manufacturing companies.

10 | CHALLENGES AND PERSPECTIVES

Renewable energy supply is all about achieving a balance between physical flows, information flows, and financial flows. However, these elements are further controlled by a series of sub-components. For instance, the effectiveness and level of efficiency of the manufacturing industry fall under physical flows, which are controlled by logistics. This further highlights the complex nature of GSCM. It is, therefore, necessary to observe the flow elements that determine the effectiveness of RESC as bidirectional.

Since most of the activities within the context of RECM are found in remote areas across the globe where logistics are a challenge, it is difficult to sometimes

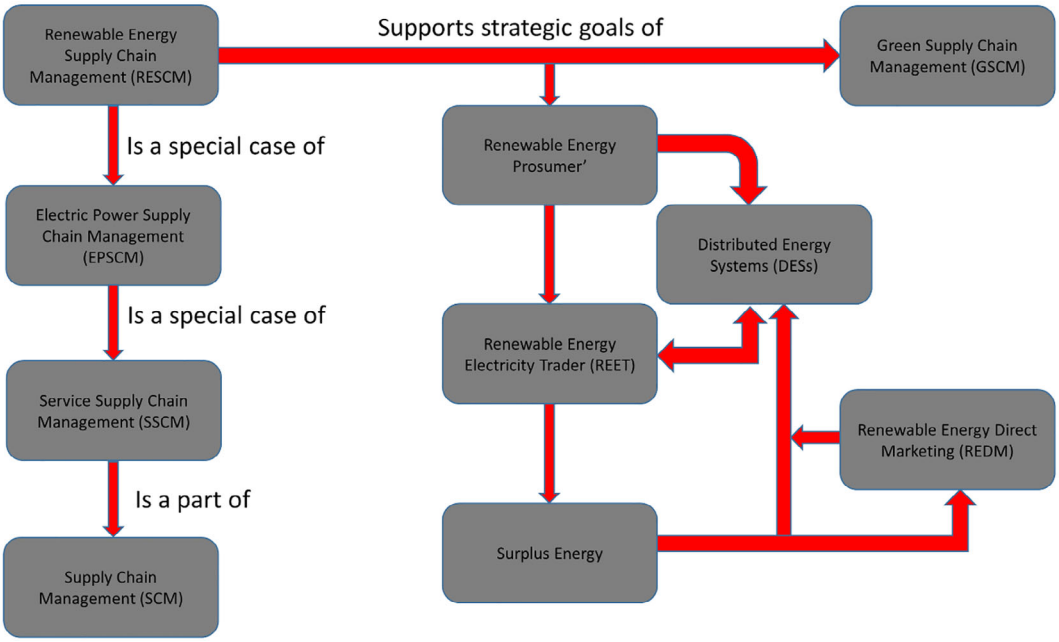

FIGURE 14 Proposed renewable energy conceptual model in the context of GSCM

comply with strict regulations on the environment, health, and safety. There is also a challenge in trying to overcome fragmented cross-border supply chains, which makes operations particularly demanding. Besides, regulations on the environment are constantly changing and are strictly need to be followed without any compromise.

Renewable energy has become one of the cheapest, accessible, and affordable forms of energy, due in part, to a reduction in the cost of the technology. There are low capital requirements as a result of improved access to new financing vehicles, as well as favorable regulation in many parts of the world that has made incentives available for selling surplus supply back to the grid. Companies/firms are forced are review and modify their initiatives on energy management, of which RE is typically a core component, because of the desire to shift public sentiment.

There are cost and risk benefits across the SC provided by RE when it is treated as a strategic asset rather than a tactical expense.

Renewables also have the potential to provide other forms of benefits, such as company culture enhancement, increasing engagement by employees and accelerating sustainability agenda, as well as advancing sustainability goals. They also help to strengthen the reputation of the company/firm and serve as a driving force for the growth of the company. Companies should re-evaluate their strategies in the procurement of energy as and when these technologies and regulations mature, to take advantage of these benefits.

The scale of the adoption of P2P trading platforms is currently limited, as these platforms are still in infancy. Nonetheless, they can potentially change the established roles of the current practices of several companies.

11 | SUMMARY AND CONCLUSION

RE is getting popular nowadays, and REGSCM could catalyst for sustainable business practices. This can be achieved by exploring the various drivers for effective implementation. The concept of green practices in the supply chain is novel and, if well implemented, will benefit future generations and make firms more profitable. The consensus among several stakeholders has propelled businesses to adopt GSCM practices in recent years. Therefore, GSCM influences the entire supply chain, including design, production, distribution/logistics, consumption, and disposal/reuse/recycle. GSCM practices have been increasingly adopted by businesses, globally, due, in part, to the paybacks it brings to these firms. This has placed the GSCM concept on a path to become a popular trend in a short time. However, its usage in Micro, Small, and Medium Enterprises is still unpopular despite the increasing correlation between GSCM practices and enhanced economic performance. With more enterprises increasing their bottom lines with more efficient power sources over resource-intensive fuel-based systems, the future of the renewable GSC is clear. The desire to adopt GSCM practices is just more than increasing profits; it is more to do with serving

customers and being socially responsible, by reducing the environmental impact of their products and services.

Renewable energy can significantly enhance the adoption of GSCM if the necessary actions are taken for its successful implementation. In the RESCM space, the network of distribution determines technological advancement while economic development measures market competition. The advanced storage and energy efficiency components are developed without leaving behind a high carbon footprint and encourage reuse, recycling, and the energy recovery of full elements. Successful integration of RE into the SC helps promotes green job creation and encourages the participation of citizens. The implementation of a GSSC allows firms to increase profits while helping the environment.

The proposed conceptual model is mainly grounded within the REGSCM term network in the context of SCM and VPS. This concept allows renewable energy producers to directly sell their electricity based on a P2P network or sell directly in the general market. Specifically, this model provides insight into how firms can develop value-creating linkages with others to achieve their desired outcomes. Robust testing and more research are still needed to some extent to further refine the proposed model before it can apply to energy-intensive firms, such as manufacturing companies.

As organizations in the public sector have scarcely been at the forefront of REGSCM implementation, future research should concentrate on the public sector and also explore the contrasts between public and private sector implementation of these practices, as well as explore the role that small- and medium-size organizations play.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported here.

AUTHOR CONTRIBUTIONS

Sidique Gawusu: Conceptualization; writing - original draft; visualization; data curation; investigation. **Xiaobing Zhang:** Conceptualization; review & editing. **Abubakari Ahmed and Seidu Abdulai Jamatutu:** Writing - review & editing; investigation. **Ayesha Algade Amadu and Elvis Djam Miensah:** Writing - review & editing.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

ORCID

Sidique Gawusu https://orcid.org/0000-0003-1877-1092

REFERENCES

1. Kousksou T, Allouhi A, Belattar M, Jamil A, El Rhafiki T, Zeraouli Y. Morocco's strategy for energy security and low-carbon growth. *Energy*. 2015;84:98-105.
2. Abdallah T, Diabat A, Rigter J. Investigating the option of installing small scale PVs on facility rooftops in a green supply chain. *Int. J. Prod. Econ.* 2013;146(2):465-477.
3. Wang Z, Mathiyazhagan K, Xu L, Diabat A. A decision making trial and evaluation laboratory approach to analyze the barriers to Green Supply Chain Management adoption in a food packaging company. *J Clean Prod*. 2016;117:19-28.
4. Assi AF, Zhakanova Isiksal A, Tursoy T. Highlighting the connection between financial development and consumption of energy in countries with the highest economic freedom. *Energy Policy*. 2020;147:111897.
5. Gallagher KS. Why & how governments support renewable energy. *Daedalus*. 2013;142(1):59-77.
6. Raybould B, Cheung WM, Connor C, Butcher R. An investigation into UK government policy and legislation to renewable energy and greenhouse gas reduction commitments. *Clean Technol Environ Policy*. 2020;22(2):371-387.
7. Johnstone N, Haščič I, Popp D. Renewable energy policies and technological innovation: evidence based on patent counts. *Environ Resource Econ*. 2010;45(1):133-155.
8. Cullen R. Evaluating renewable energy policies. *Aust J Agric Resour Econ*. 2017;61(1):1-18.
9. Ghorashi AH, Maranlou H. Essential infrastructures and relevant policies for renewable energy developments in oil-rich developing countries: case of Iran. *Renewable Sustainable Energy Rev*. 2021;141:110839.
10. Zhakanova Isiksal A. The financial sector expansion effect on renewable electricity production: case of the BRICS countries. *Environ Dev Sustainability*. 2021;23(6):9029-9051.
11. Abdalla AM, Hossain S, Nisfindy OB, Azad AT, Dawood M, Azad AK. Hydrogen production, storage, transportation and key challenges with applications: a review. *Energy Convers Manage*. 2018;165:602-627.
12. Govindan K, Kaliyan M, Kannan D, Haq AN. Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *Int. J. Prod. Econ.* 2014;147:555-568.
13. Wu T, Jim Wu Y-C, Chen YJ, Goh M. Aligning supply chain strategy with corporate environmental strategy: a contingency approach. *Int. J. Prod. Econ.* 2014;147:220-229.
14. Gunasekaran A, Hong P, Fujimoto T. Building supply chain system capabilities in the age of global complexity: emerging theories and practices. *Int. J. Prod. Econ.* 2014;147:189-197.
15. Cort A. The Realities of Green Manufacturing. https://www.assemblymag.com/articles/86140-the-realities-of-green-manufacturing. Accessed March 24, 2021.
16. Esty DC, Winston A. *Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage*. Canada: John Wiley & Sons; 2009.
17. Duić N, Krajačić G, da Graça Carvalho M. RenewIslands methodology for sustainable energy and resource planning for islands. *Renewable Sustainable Energy Rev*. 2008;12(4):1032-1062.
18. Raheem A, Abbasi SA, Memon A, et al. Renewable energy deployment to combat energy crisis in Pakistan. *Energy Sustainable Soc*. 2016;6(1):16.

19. Ashfaq A, Ianakiev A. Features of fully integrated renewable energy atlas for Pakistan; wind, solar and cooling. *Renewable Sustainable Energy Rev*. 2018;97:14-27.
20. Ludin NA, Mustafa NI, Hanafiah MM, et al. Prospects of life cycle assessment of renewable energy from solar photovoltaic technologies: a review. *Renewable Sustainable Energy Rev*. 2018;96:11-28.
21. Stambouli AB, Khiat Z, Flazi S, Kitamura Y. A review on the renewable energy development in Algeria: current perspective, energy scenario and sustainability issues. *Renewable Sustainable Energy Rev*. 2012;16(7):4445-4460.
22. Lotfi R, Kargar B, Hoseini SH, Nazari S, Safavi S, Weber G. Resilience and sustainable supply chain network design by considering renewable energy. *Int J Energy Res*. 2021;45:17749-17766.
23. Panwar NL, Kaushik SC, Kothari S. Role of renewable energy sources in environmental protection: a review. *Renewable Sustainable Energy Rev*. 2011;15(3):1513-1524.
24. Danish Zhang B, Wang B, Wang Z. Role of renewable energy and non-renewable energy consumption on EKC: evidence from Pakistan. *J Clean Prod*. 2017;156:855-864.
25. Bélaïd F, Youssef M. Environmental degradation, renewable and non-renewable electricity consumption, and economic growth: assessing the evidence from Algeria. *Energy Policy*. 2017;102:277-287.
26. Salim RA, Hassan K, Shafiei S. Renewable and non-renewable energy consumption and economic activities: further evidence from OECD countries. *Energy Econ*. 2014;44:350-360.
27. Li R, Leung GCK. The relationship between energy prices, economic growth and renewable energy consumption: evidence from Europe. *Energy Rep*. 2021;7:1712-1719.
28. Assi AF, Zhakanova Isiksal A, Tursoy T. Renewable energy consumption, financial development, environmental pollution, and innovations in the ASEAN + 3 group: evidence from (P-ARDL) model. *Renew Energy*. 2021;165:689-700.
29. Borovik MR, Albers JD. Participation in the Illinois solar renewable energy market. *Electr J*. 2018;31(2):33-39.
30. Hepbasli A. A key review on exergetic analysis and assessment of renewable energy resources for a sustainable future. *Renewable Sustainable Energy Rev*. 2008;12(3):593-661.
31. Apergis N, Payne JE. Renewable and non-renewable electricity consumption–growth nexus: evidence from emerging market economies. *Appl Energy*. 2011;88(12):5226-5230.
32. Seuring S, Müller M. From a literature review to a conceptual framework for sustainable supply chain management. *J Clean Prod*. 2008;16(15):1699-1710.
33. Seuring S. A review of modeling approaches for sustainable supply chain management. *Decis Support Syst*. 2013;54(4):1513-1520.
34. Hassini E, Surti C, Searcy C. A literature review and a case study of sustainable supply chains with a focus on metrics. *Int J Prod Econ*. 2012;140(1):69-82.
35. Abu Seman NA, Govindan K, Mardani A, et al. The mediating effect of green innovation on the relationship between green supply chain management and environmental performance. *J Clean Prod*. 2019;229:115-127.
36. Dogan E. The relationship between economic growth and electricity consumption from renewable and non-renewable sources: a study of Turkey. *Renewable Sustainable Energy Rev*. 2015;52:534-546.
37. Ohler A, Fetters I. The causal relationship between renewable electricity generation and GDP growth: a study of energy sources. *Energy Econ*. 2014;43:125-139.
38. Destek MA, Aslan A. Renewable and non-renewable energy consumption and economic growth in emerging economies: evidence from bootstrap panel causality. *Renewable Energy*. 2017;111:757-763.
39. Dincer I. Renewable energy and sustainable development: a crucial review. *Renewable Sustainable Energy Rev*. 2000;4(2):157-175.
40. Srivastava SK. Green supply-chain management: a state-of-the-art literature review. *Int J Manage Rev*. 2007;9(1):53-80.
41. Khan SAR, Yu Z, Golpira H, Sharif A, Mardani A. A state-of-the-art review and meta-analysis on sustainable supply chain management: future research directions. *J Clean Prod*. 2021;278:123357.
42. Asif MS, Lau H, Nakandala D, Fan Y, Hurriyet H. Adoption of green supply chain management practices through collaboration approach in developing countries – From literature review to conceptual framework. *J Clean Prod*. 2020;276:124191.
43. Sarkis J, Zhu Q, Lai K. An organizational theoretic review of green supply chain management literature. *Int. J. Prod. Econ.* 2011;130(1):1-15.
44. Luthra S, Garg D, Haleem A. Green supply chain management. *J Adv Manage Res*. 2014;11(1):20-46.
45. Fahimnia B, Sarkis J, Davarzani H. Green supply chain management: a review and bibliometric analysis. *Int. J. Prod. Econ.* 2015;162:101-114.
46. Maditati DR, Munim ZH, Schramm H-J, Kummer S. A review of green supply chain management: from bibliometric analysis to a conceptual framework and future research directions. *Resour. Conserv. Recycl.* 2018;139:150-162.
47. Fang C, Zhang J. Performance of green supply chain management: a systematic review and meta analysis. *J Clean Prod*. 2018;183:1064-1081.
48. Ahi P, Searcy C. A comparative literature analysis of definitions for green and sustainable supply chain management. *J Clean Prod*. 2013;52:329-341.
49. Igarashi M, de Boer L, Fet AM. What is required for greener supplier selection? A literature review and conceptual model development. *J Purch Supply Manage*. 2013;19(4):247-263.
50. Rajeev A, Pati RK, Padhi SS, Govindan K. Evolution of sustainability in supply chain management: a literature review. *J Clean Prod*. 2017;162:299-314.
51. Iqbal MW, Kang Y, Jeon HW. Zero waste strategy for green supply chain management with minimization of energy consumption. *J Clean Prod*. 2020;245:118827.
52. Bhatia MS, Gangwani KK. Green supply chain management: scientometric review and analysis of empirical research. *J Clean Prod*. 2021;284:124722.
53. Ricardo Saavedra M, de O. Fontes CH, Freires FGM. Sustainable and renewable energy supply chain: a system dynamics overview. *Renewable Sustainable Energy Rev*. 2018;82:247-259.
54. Gold S, Seuring S, Beske P. Sustainable supply chain management and inter-organizational resources: a literature review. *Corp Soc Respon Environ Manage*. 2009;17:230-245.
55. Malviya RK, Kant R. Green supply chain management (GSCM): a structured literature review and research implications. *Benchmarking: Int J*. 2015;22(7):1360-1394.

56. Wee H-M, Yang W-H, Chou C-W, Padilan MV. Renewable energy supply chains, performance, application barriers, and strategies for further development. *Renewable Sustainable Energy Rev*. 2012;16(8):5451-5465.
57. Burke MJ, Stephens JC. Political power and renewable energy futures: a critical review. *Energy Res Soc Sci*. 2018;35:78-93.
58. Seetharaman A, Sandanaraj LL, Moorthy MK, Saravanan AS. Enterprise framework for renewable energy. *Renewable Sustainable Energy Rev*. 2016;54:1368-1381.
59. Mafakheri F, Nasiri F. Modeling of biomass-to-energy supply chain operations: applications, challenges and research directions. *Energy Policy*. 2014;67:116-126.
60. Zhu Q, Sarkis J, Lai K. Green supply chain management: pressures, practices and performance within the Chinese automobile industry. *J Clean Prod*. 2007;15(11–12):1041-1052.
61. Hsu CW, Hu AH. Green supply chain management in the electronic industry. *Int J Environ Sci Technol*. 2008;5(2):205-216.
62. Chin TA, Tat HH, Sulaiman Z. Green supply chain management, environmental collaboration and sustainability performance. *Procedia CIRP*. 2015;26:695-699.
63. Luthra S, Garg D, Haleem A. The impacts of critical success factors for implementing green supply chain management towards sustainability: an empirical investigation of Indian automobile industry. *J Clean Prod*. 2016;121:142-158.
64. Ho DCK, Au KF, Newton E. Empirical research on supply chain management: a critical review and recommendations. *Int. J. Prod. Res.* 2002;40(17):4415-4430.
65. Sarkis J, Gonzalez-Torre P, Adenso-Diaz B. Stakeholder pressure and the adoption of environmental practices: the mediating effect of training. *J Oper Manage*. 2010;28(2):163-176.
66. Mitra S, Datta PP. Adoption of green supply chain management practices and their impact on performance: an exploratory study of Indian manufacturing firms. *Int J Prod Res*. 2014;52(7):2085-2107.
67. Flint DJ, Golicic SL. Searching for competitive advantage through sustainability. *Int J Phys Distrib Logist Manage*. 2009; 39(10):841-860.
68. Wu Z, Pagell M. Balancing priorities: decision-making in sustainable supply chain management. *J. Oper. Manage*. 2011; 29(6):577-590.
69. Carter CR, Liane Easton P. Sustainable supply chain management: evolution and future directions. *Int. J. Phys. Distrib. Logist. Manage*. 2011;41(1):46-62.
70. Zhu Q, Sarkis J, Geng Y. Green supply chain management in China: pressures, practices and performance. *Int J Oper Prod Manage*. 2005;25(5):449-468.
71. Sarkis J. Manufacturing's role in corporate environmental sustainability - Concerns for the new millennium. *Int J Oper Prod Manage*. 2001;21(5/6):666-686.
72. Achillas C, Bochtis DD, Aidonis D, Folinas D. *Green Supply Chain Management*. Abingdon, Oxon, New York: Routledge; 2019.
73. van Hoek RI. From reversed logistics to green supply chains. *Supply Chain Manage*. 1999;4(3):129-135.
74. Donval Y, Wohlfart M, Houot X. *Green Supply Chain: From Awareness to Action*; 2012.
75. Yan K, Hua G, Cheng TCE. Green supply chain management with cooperative promotion. *Sustainability*. 2021;13(6): 3204.
76. Vachon S, Klassen RD. Extending green practices across the supply chain. *Int J Oper Prod Manage*. 2006;26(7): 795-821.
77. Gasparatos A, Ahmed A, Naidoo M, et al., eds. *Sustainability Challenges in Sub-Saharan Africa II*. Singapore: Springer Singapore; 2020.
78. Gasparatos A, Doll CNH, Esteban M, Ahmed A, Olang TA. Renewable energy and biodiversity: implications for transitioning to a Green Economy. *Renewable Sustainable Energy Rev*. 2017;70:161-184.
79. Gasparatos A, Ahmed A, Naidoo M, Karanja A, Fukushi K. *Sustainability Challenges in Sub-Saharan Africa I: Continental Perspectives and Insights*. Singapore: Springer Nature; 2020.
80. Franchina L, Calabrese A, Inzerilli G, Scatto E, Brutti G, de los Ángeles MV. Thinking green: the role of smart technologies in transforming cities' waste and supply chain's flow. *Clean Eng Technol*. 2021;2:100077.
81. Zhu Q, Sarkis J, Lai K. Initiatives and outcomes of green supply chain management implementation by Chinese manufacturers. *J Environ Manage*. 2007;85(1):179-189.
82. Li P, Rao C, Goh M, Yang Z. Pricing strategies and profit coordination under a double echelon green supply chain. *J Clean Prod*. 2021;278:123694.
83. Laari S, Töyli J, Solakivi T, Ojala L. Firm performance and customer-driven green supply chain management. *J Clean Prod*. 2016;112:1960-1970.
84. Jemai J, Do Chung B, Sarkar B. Environmental effect for a complex green supply-chain management to control waste: a sustainable approach. *J Clean Prod*. 2020;277:122919.
85. Kumar P, Singh RK, Kumar V. Managing supply chains for sustainable operations in the era of industry 4.0 and circular economy: analysis of barriers. *Resour Conserv Recycl*. 2021; 164:105215.
86. Mishra U, Wu J-Z, Sarkar B. A sustainable production-inventory model for a controllable carbon emissions rate under shortages. *J Clean Prod*. 2020;256:120268.
87. Liu P, Long Y, Song H-C, He Y-D. Investment decision and coordination of green agri-food supply chain considering information service based on blockchain and big data. *J Clean Prod*. 2020;277:123646.
88. Amankwah-Amoah J. Stepping up and stepping out of COVID-19: new challenges for environmental sustainability policies in the global airline industry. *J Clean Prod*. 2020;271:123000.
89. Hendiani S, Liao H, Jabbour CJC. A new sustainability indicator for supply chains: theoretical and practical contribution towards sustainable operations. *Int J Logist Res Appl*. 2020; 1-26.
90. Pal B, Sarkar A. Optimal strategies of a dual-channel green supply chain with recycling under retailer promotional effort. *RAIRO-Oper. Res*. 2021;55(2):415-431.
91. Sherif SU, Asokan P, Sasikumar P, Mathiyazhagan K, Jerald J. Integrated optimization of transportation, inventory and vehicle routing with simultaneous pickup and delivery in two-echelon green supply chain network. *J Clean Prod*. 2021; 287:125434.
92. Liu X, Yang J, Qu S, Wang L, Shishime T, Bao C. Sustainable production: practices and determinant factors of Green supply chain management of Chinese companies. *Bus. Strategy Environ.* 2012;21(1):1-16.

93. Thun J-H, Müller A. An empirical analysis of green supply chain management in the German automotive industry. *Bus. Strategy Environ.* 2009;19(2):119-132.
94. Liu S, Eweje G, He Q, Lin Z. Turning motivation into action: a strategic orientation model for green supply chain management. *Bus. Strategy Environ.* 2020;29(7):2908-2918.
95. Malviya RK, Kant R, Gupta AD. Evaluation and selection of sustainable strategy for green supply chain management implementation. *Bus. Strategy Environ.* 2018;27(4): 475-502.
96. Feng M, Yu W, Wang X, Wong CY, Xu M, Xiao Z. Green supply chain management and financial performance: the mediating roles of operational and environmental performance. *Bus Strategy Environ*. 2018;27(7):811-824.
97. Laari S, Töyli J, Ojala L. The effect of a competitive strategy and green supply chain management on the financial and environmental performance of logistics service providers. *Bus Strategy Environ*. 2018;27(7):872-883.
98. An S, Li B, Song D, Chen X. Green credit financing versus trade credit financing in a supply chain with carbon emission limits. *Eur J Oper Res*. 2021;292(1):125-142.
99. Khan NU, Anwar M, Li S, Khattak MS. Intellectual capital, financial resources, and green supply chain management as predictors of financial and environmental performance. *Environ Sci Pollut res*. 2021;28:19755-19767.
100. Wandosell G, Parra-Meroño MC, Alcayde A, Baños R. Green packaging from consumer and business perspectives. *Sustainability*. 2021;13(3):1356.
101. Zhu Q, Sarkis J, Lai K. Choosing the right approach to green your supply chains. *Mod Supply Chain Res Appl*. 2019;1(1): 54-67.
102. GEO-6. GEO-6 for Youth Africa: A Wealth of Green Opportunities. Nairobi. United Nations Environ. Program. 2019.
103. Jenden J, Lloyd E, Stenhouse K, Strange M, Yyelland B, Donev J. Energy Education-Renewable and Sustainable Energy (Online) https://energyeducation.ca/encyclopedia/Renewable_and_sustainable_energy. Accessed January 14, 2021.
104. Sandberg M. Sufficiency transitions: a review of consumption changes for environmental sustainability. *J Clean Prod*. 2021; 293:126097.
105. Gasparatos A, Ahmed A, Naidoo M, et al., eds. *Sustainability Challenges in Sub-Saharan Africa I*. Singapore: Springer Singapore; 2020.
106. Golicic SL, Smith CD. A meta-analysis of environmentally sustainable supply chain management practices and firm performance. *J Supply Chain Manage*. 2013;49(2):78-95.
107. Silvestre BS. Sustainable supply chain management in emerging economies: environmental turbulence, institutional voids and sustainability trajectories. *Int. J. Prod. Econ.* 2015;167: 156-169.
108. Alshurideh M, Alsharari NM, Al Kurdi B. Supply chain integration and customer relationship management in the airline logistics. *Theor. Econ. Lett*. 2019;09(02):392-414.
109. Fawcett SE, Magnan GM. The rhetoric and reality of supply chain integration. *Int J Phys Distrib Logist Manage*. 2002;32(5): 339-361.
110. Simatupang TM, Sridharan R. The collaborative supply chain. *Int J Logist Manage*. 2002;13(1):15-30.
111. Soosay CA, Hyland PW, Ferrer M. Supply chain collaboration: capabilities for continuous innovation. *Supply Chain Manage: Int J*. 2008;13(2):160-169.
112. Barratt M. Understanding the meaning of collaboration in the supply chain. *Supply Chain Manage: Int. J.* 2004;9(1):30-42.
113. Vachon S, Klassen RD. Environmental management and manufacturing performance: the role of collaboration in the supply chain. *Int J Prod Econ*. 2008;111(2):299-315.
114. Carter CR, Rogers DS. A framework of sustainable supply chain management: moving toward new theory. *Int. J. Phys. Distrib. Logist. Manage*. 2008;38(5):360-387.
115. Hall J, Matos S, Silvestre B. Understanding why firms should invest in sustainable supply chains: a complexity approach. *Int J Prod Res*. 2012;50(5):1332-1348.
116. Mota B, Gomes MI, Carvalho A, Barbosa-Povoa AP. Towards supply chain sustainability: economic, environmental and social design and planning. *J Clean Prod*. 2015;105: 14-27.
117. Roy S, Sivakumar K, Wilkinson IF. Innovation generation in supply chain relationships: a conceptual model and research propositions. *J Acad Mark Sci*. 2004;32(1):61-79.
118. Choi TY, Krause DR. The supply base and its complexity: implications for transaction costs, risks, responsiveness, and innovation. *J Oper Manage*. 2006;24(5):637-652.
119. Carter CR, Dresner M. Purchasing's role in environmental management: cross-functional development of grounded theory. *J. Supply Chain Manage.* 2001;37(3):12-27.
120. Ma W, Cheng Z, Xu S. A game theoretic approach for improving environmental and economic performance in a dual-channel green supply chain. *Sustainability*. 2018;10(6):1918.
121. Rinaldi M, Caterino M, Fera M, Manco P, Macchiaroli R. Technology selection in green supply chains - the effects of additive and traditional manufacturing. *J Clean Prod*. 2021; 282:124554.
122. Habib MA, Bao Y, Nabi N, Dulal M, Asha AA, Islam M. Impact of strategic orientations on the implementation of green supply chain management practices and sustainable firm performance. *Sustainability*. 2021;13(1):340.
123. Jin M, Zhang X, Xiong Y, Zhou Y. Implications of green optimism upon sustainable supply chain management. *Eur J Oper Res*. 2021;295:131-139.
124. Amin M. Security challenges for the electricity infrastructure. *Computer (Long. Beach. Calif)*. 2002;35(4):supl8-supl10.
125. Klimenko VV, Ratner SV, Tereshin AG. Constraints imposed by key-material resources on renewable energy development. *Renewable Sustainable Energy Rev*. 2021;144:111011.
126. BRICKS. BRICS Youth Energy Outlook-2020. BRICS Energy Agency. 2020. https://yeabrics.org/en/outlook-2020/. Accessed January 18, 2021.
127. Mikulčić H, Baleta J, Klemeš JJ, Wang X. Energy transition and the role of system integration of the energy, water and environmental systems. *J Clean Prod*. 2021;292: 959-6526.
128. Moner-Girona M, Bódis K, Morrissey J, et al. Decentralized rural electrification in Kenya: speeding up universal energy access. *Energy Sustainable Dev*. 2019;52:128-146.
129. Tambari IT, Dioha MO, Failler P. Renewable energy scenarios for sustainable electricity supply in Nigeria. *Energy Clim Change*. 2020;1:100017.

130. Gulagi A, Alcanzare M, Bogdanov D, Esparcia E, Ocon J, Breyer C. Transition pathway towards 100% renewable energy across the sectors of power, heat, transport, and desalination for the Philippines. *Renewable Sustainable Energy Rev*. 2021; 144:110934.
131. Looney B. *Statistical Review of World Energy*. Globally consistent data on world energy markets and authoritative publications in the field of energy. Review World Energy Data. 70th ed.; 2021.
132. Wang Y-F, Chen S-P, Lee Y-C, Tsai C-T(S). Developing green management standards for restaurants: an application of green supply chain management. *Int J Hosp Manage*. 2013;34: 263-273.
133. Motyka M, Fitzgerald J, Mellinger J, Quasney E, Shirmer J. Using renewable energy to drive supply chain innovation. 2016. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-manufacturing-supply-chain-of-the-future-renewable-energy.pdf. Accessed March 24, 2021.
134. Chu WL, Phang SM. Biosorption of heavy metals and dyes from industrial effluents by microalgae. *Microalgae Biotechnology for Development of Biofuel and Wastewater Treatment*; Singapore: Springer; 2019:599-634.
135. Banja M, Sikkema R, Jégard M, Motola V, Dallemand J-F. Biomass for energy in the EU – the support framework. *Energy Policy*. 2019;131:215-228.
136. Mandley SJ, Daioglou V, Junginger HM, van Vuuren DP, Wicke B. EU bioenergy development to 2050. *Renewable Sustainable Energy Rev*. 2020;127:109858.
137. Panoutsou C. Supply of solid biofuels: potential feedstocks, cost and sustainability issues in EU27. *Solid Biofuels for Energy*; New York: Springer; 2011:1-20.
138. dos Santos IFS, Braz Vieira ND, de Nóbrega LGB, Barros RM, Tiago Filho GL. Assessment of potential biogas production from multiple organic wastes in Brazil: impact on energy generation, use, and emissions abatement. *Resour Conserv Recycl*. 2018;131:54-63.
139. Long H, Li X, Wang H, Jia J. Biomass resources and their bioenergy potential estimation: a review. *Renewable Sustainable Energy Rev*. 2013;26:344-352.
140. Kumar A, Kumar N, Baredar P, Shukla A. A review on biomass energy resources, potential, conversion and policy in India. *Renewable Sustainable Energy Rev*. 2015;45:530-539.
141. Al Seadi T, Drosg B, Fuchs W, Rutz D, Janssen R. Biogas digestate quality and utilization. *The Biogas Handbook*. UK: Elsevier; 2013:267-301.
142. Edenhofer O, Pichs-Madruga R, Sokona Y, et al. *Renewable Energy Sources and Climate Change Mitigation*. UK: Cambridge University Press; 2011.
143. Sobri S, Koohi-Kamali S, Rahim NA. Solar photovoltaic generation forecasting methods: a review. *Energy Convers Manage*. 2018;156:459-497.
144. Ghiani E, Pisano G. Impact of renewable energy sources and energy storage technologies on the operation and planning of smart distribution networks. *Operation of Distributed Energy Resources in Smart Distribution Networks*. UK: Elsevier; 2018: 25-48.
145. Zafirakis DP. Overview of energy storage technologies for renewable energy systems. *Stand-Alone and Hybrid Wind Energy Systems*. UK: Elsevier; 2010:29-80.
146. Kannan N, Vakeesan D. Solar energy for future world: - A review. *Renewable Sustainable Energy Rev*. 2016;62:1092-1105.
147. Tian Y, Zhao CY. A review of solar collectors and thermal energy storage in solar thermal applications. *Appl Energy*. 2013;104:538-553.
148. Bahadori A, Nwaoha C. A review on solar energy utilisation in Australia. *Renewable Sustainable Energy Rev*. 2013;18:1-5.
149. Owusu PA, Asumadu-Sarkodie S. A review of renewable energy sources, sustainability issues and climate change mitigation. *Cogent Eng*. 2016;3(1):1167990.
150. Asumadu-Sarkodie S, Owusu PA. The potential and economic viability of wind farms in Ghana. *Energy Sources Part A Recover. Util. Environ. Eff*. 2016;38(5):695-701.
151. Dai K, Bergot A, Liang C, Xiang W-N, Huang Z. Environmental issues associated with wind energy – A review. *Renewable Energy*. 2015;75:911-921.
152. Stober I, Bucher K. *Geothermal Energy*. Berlin, Heidelberg: Springer; 2013.
153. Amponsah NY, Troldborg M, Kington B, Aalders I, Hough RL. Greenhouse gas emissions from renewable energy sources: a review of lifecycle considerations. *Renewable Sustainable Energy Rev*. 2014;39:461-475.
154. Barbier E. Nature and technology of geothermal energy: a review. *Renewable Sustainable Energy Rev*. 1997;1(1–2):1-69.
155. Zhu J, Hu K, Lu X, Huang X, Liu K, Wu X. A review of geothermal energy resources, development, and applications in China: current status and prospects. *Energy*. 2015;93:466-483.
156. Li K, Bian H, Liu C, Zhang D, Yang Y. Comparison of geothermal with solar and wind power generation systems. *Renewable Sustainable Energy Rev*. 2015;42:1464-1474.
157. Saw MMM, Ji-Qing L. Review on hydropower in Myanmar. *Appl Water Sci*. 2019;9(4):118.
158. Enerdata. Global Energy Statistical Yearbook-Share of renewables in electricity production. https://yearbook.enerdata.net/renewables/renewable-in-electricity-production-share.html (Online). Accessed January 20, 2021.
159. Hamann A *Coordinated Predictive Control of a Hydropower Cascade*; March, 2015.
160. FACT SHEET: White House Launches American Business Act on Climate Pledge | whitehouse.gov. https://obamawhitehouse.archives.gov/the-press-office/2015/07/27/fact-sheet-white-house-launches-american-business-act-climate-pledge. Accessed April 13, 2021.
161. Fernando Y, Bee PS, Jabbour CJC, Thomé AMT. Understanding the effects of energy management practices on renewable energy supply chains: implications for energy policy in emerging economies. *Energy Policy*. 2018;118:418-428.
162. Sarkis J, Zhu Q. Environmental sustainability and production: taking the road less travelled. *Int. J. Prod. Res.* 2018;56(1–2): 743-759.
163. Halldórsson Á, Svanberg M. Energy resources: trajectories for supply chain management. *Supply Chain Manage: Int. J.* 2013; 18(1):66-73.
164. Aslani A, Helo P, Feng B, Antila E, Hiltunen E. Renewable energy supply chain in Ostrobothnia region and Vaasa city: innovative framework. *Renewable Sustainable Energy Rev*. 2013;23:405-411.
165. Hoggett R. Supply chains and energy security. *New Challenges in Energy Security*. London, England: Palgrave Macmillan; 2013:161-181.
166. Cucchiella F, D'Adamo I. Issue on supply chain of renewable energy. *Energy Convers Manage*. 2013;76:774-780.

167. Edenhofer O, Pichs-Madruga R, Sokona Y, Seyboth K, Matschoss P, Kadner S, von Stechow C. *IPCC special report on renewable energy sources and climatechange mitigation*. Prepared By Working Group III of the Intergovernmental Panel on Climate Change; 2011.
168. UNDP. *Transforming on-Grid Renewable Energy Markets*. United Nations Development Programme; 2012.
169. Bazmi AA, Zahedi G. Sustainable energy systems: role of optimization modeling techniques in power generation and supply—A review. *Renewable Sustainable Energy Rev*. 2011; 15(8):3480-3500.
170. Fernando Y, Yahya S. Challenges in implementing renewable energy supply chain in service economy era. *Procedia Manuf*. 2015;4:454-460.
171. Lee K-H. Integrating carbon footprint into supply chain management: the case of Hyundai Motor Company (HMC) in the automobile industry. *J Clean Prod*. 2011;19(11):1216-1223.
172. Hongjuan Y, Jing Z. The strategies of advancing the cooperation satisfaction among enterprises based on low carbon supply chain management. *Energy Procedia*. 2011;5:1225-1229.
173. Sada R, Shrestha A, Kumar Shukla A, Anna Melsen L. People's experience and facts of changing climate: impacts and responses. *Int J Clim Change Strategies Manage*. 2014;6(1):47-62.
174. Bonini S, Görner S. The business of sustainability McKinsey Global Survey results.pdf. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/The%20business%20of%20sustainability%20McKinsey%20Global%20Survey%20results/The%20business%20of%.
175. Huang Y-C, Borazon EQ, Liu J-M. Antecedents and consequences of green supply chain management in Taiwan's electric and electronic industry. *J Manuf Technol Manag*. 2021; 32(5):1066-1093.
176. Kannan R, Boie W. Energy management practices in SME-case study of a bakery in Germany. *Energy Convers Manage*. 2003;44(6):945-959.
177. Fiedler T, Mircea P-M. Energy Management Systems According to the ISO 50001 Standard—Challenges and Benefits. Craiova, Romania: IEEE; 2012.
178. Bruton K, Raftery P, Kennedy B, Keane MM, O'Sullivan DTJ. Review of automated fault detection and diagnostic tools in air handling units. *Energy Effic*. 2014;7(2):335-351.
179. Bunse K, Vodicka M, Schönsleben P, Brülhart M, Ernst FO. Integrating energy efficiency performance in production management – gap analysis between industrial needs and scientific literature. *J Clean Prod*. 2011;19(6–7): 667-679.
180. Böttcher C, Müller M. Insights on the impact of energy management systems on carbon and corporate performance. An empirical analysis with data from German automotive suppliers. *J Clean Prod*. 2016;137:1449-1457.
181. Halldórsson Á, Kovács G. The sustainable agenda and energy efficiency. *Int. J. Phys. Distrib. Logist. Manage*. 2010;40(1/2): 5-13.
182. Michelsen O. Investigation of relationships in a supply chain in order to improve environmental performance. *Clean Technol Environ Policy*. 2007;9(2):115-123.
183. Oshita Y. Identifying critical supply chain paths that drive changes in CO2 emissions. *Energy Econ*. 2012;34(4):1041-1050.
184. UNFCCC. The Race to Zero Emissions Gains Momentum-UNFCCC. https://unfccc.int/. Accessed March 26, 2021.
185. Zhang X, Song H, Huang GQ. Tourism supply chain management: a new research agenda. *Tour Manage*. 2009;30(3): 345-358.
186. de Sousa Jabbour ABL, Verdério Júnior SA, Jabbour CJC, Leal Filho W, Campos LS, De Castro R. Toward greener supply chains: is there a role for the new ISO 50001 approach to energy and carbon management? *Energy Effic*. 2017;10(3): 777-785.
187. Rahbauer S, Menapace L, Menrad K, Decker T. Adoption of green electricity by small- and medium-sized enterprises in Germany. *Renewable Sustainable Energy Rev*. 2016;59:1185-1194.
188. Tognetti A, Grosse-Ruyken PT, Wagner SM. Green supply chain network optimization and the trade-off between environmental and economic objectives. *Int. J. Prod. Econ*. 2015; 170:385-392.
189. Ahi P, Searcy C. *Measuring Energy Issues in Sustainable Supply Chains*, 2014;19(1):33-45.
190. Lee K, Cheong I. Measuring a carbon footprint and environmental practice: the case of Hyundai Motors Co. (HMC). *Ind. Manage. Data Syst*. 2011;111(6):961-978.
191. Cabernard L, Pfister S. A highly resolved MRIO database for analyzing environmental footprints and Green Economy Progress. *Sci Total Environ*. 2021;755:142587.
192. Sahu AK, Padhy RK, Das D, Gautam A. Improving financial and environmental performance through MFCA: a SME case study. *J Clean Prod*. 2021;279:123751.
193. Hong X, Cao X, Gong Y, Chen W. Quality information acquisition and disclosure with green manufacturing in a closed-loop supply chain. *Int. J. Prod. Econ*. 2021;232:107997.
194. Memon A, Yong An Z, Memon MQ. Does financial availability sustain financial, innovative, and environmental performance? relation via opportunity recognition. *Corp Soc Respon Environ Manag*. 2020;27(2):562-575.
195. Mallidis I & Vlachos D A Framework for Green Supply Chain Management; 2019. Retrieved from: https://cm.ihu.gr/logistics/images/logisticsdocs/icsc2010/fullabstracts/1_3_ICSC2010_002_Mallidis_Vlachos.pdf. Accessed September 14, 2021.
196. Sarkis J. A strategic decision framework for green supply chain management. *J Clean Prod*. 2003;11(4):397-409.
197. Uhlaner Hendrickson L, Tuttle DB. Dynamic management of the environmental enterprise: a qualitative analysis. *J Organ Change Manage*. 1997;10(4):363-382.
198. Mudgal RK, Shankar R, Talib P, Raj T. Greening the supply chain practices: an Indian perspective of enablers' relationships. *Int J Adv Oper Manage*. 2009;1(2/3):151.
199. Parikka-Alhola K. Promoting environmentally sound furniture by green public procurement. *Ecol Econ*. 2008;68(1–2): 472-485.
200. Zhu Q, Sarkis J, Lai K. Green supply chain management implications for "closing the loop.". *Transp. Res Part E Logist Transp Rev*. 2008;44(1):1-18.
201. Zhu Q, Sarkis J, Lai K. Confirmation of a measurement model for green supply chain management practices implementation. *Int. J. Prod. Econ*. 2008;111(2):261-273.
202. Walker H, Di Sisto L, McBain D. Drivers and barriers to environmental supply chain management practices: lessons from

the public and private sectors. *J Purch Supply Manage*. 2008; 14(1):69-85.
203. Zhang B, Bi J, Liu B. Drivers and barriers to engage enterprises in environmental management initiatives in Suzhou Industrial Park, China. *Front Environ Sci Eng China*. 2009; 3(2):210-220.
204. Dhull S, Narwal MS. Drivers and barriers in green supply chain management adaptation: a state-of-art review. *Uncertain Supply Chain Manage*. 2016;4:61-76.
205. Luthra S, Kumar V, Kumar S, Haleem A. Barriers to implement green supply chain management in automobile industry using interpretive structural modeling technique: an Indian perspective. *J Ind Eng Manage*. 2011;4(2):231-257.
206. Handayani NU, Rinawati DI, Wibowo MA, Gabriella T, Ulkhaq MM. The driver and barrier of implementation green supply chain management (GSCM) in construction projects. *IOP Conf Ser: Mater Sci Eng*. 2019;673:012045.
207. Agarwal S, Tyagi M, Garg RK. Assessment of barriers of green supply chain management using structural equation modeling. *Recent Advances in Mechanical Engineering*; Singapore: Springer Nature; 2021:441-452.
208. Carter JM, Driscoll KE. The role of inflammation, oxidative stress, and proliferation in silica-induced lung disease: a species comparison. *J Environ Pathol Toxicol Oncol*. 2001;20-(Suppl.1):12.
209. Pil FK, Rothenberg S. Environmental performance as a driver of superior quality. *Prod Oper Manage*. 2009;12(3):404-415.
210. Hanna MD, Rocky Newman W, Johnson P. Linking operational and environmental improvement through employee involvement. *Int J Oper Prod Manage*. 2000; 20(2):148-165.
211. Green K, Morton B, New S. Purchasing and environmental management: interactions, policies and opportunities. *Bus Strategy Environ*. 1996;5(3):188-197.
212. Handfield RB, Walton SV, Seegers LK, Melnyk SA. 'Green' value chain practices in the furniture industry. *J. Oper. Manage*. 1997;15(4):293-315.
213. Walton SV, Handfield RB, Melnyk SA. The green supply chain: integrating suppliers into environmental management processes. *Int J Purch Mater Manage*. 1998;34(1):2-11.
214. Beamon BM. Designing the green supply chain. *Logist Inf Manage*. 1999;12(4):332-342.
215. Hall J. Environmental supply chain innovation. *Greening the Supply Chain*. London, England: Springer; 2001:233-249.
216. Min H, Galle WP. Green purchasing practices of US firms. *Int J Oper Prod Manag*. 2001;21(9):1222-1238.
217. Bowen FE, Cousins PD, Lamming RC, Farukt AC. The role of supply management capabilities in green supply. *Prod. Oper. Manage*. 2009;10(2):174-189.
218. Bowen F, Cousins P, Lamming R, Faruk A. Horses for courses: explaining the gap between the theory and practice of green supply. *Greening the Supply Chain*. London, England: Springer: 2006:151-172.
219. Drumwright ME. Socially responsible organizational buying: environmental concern as a noneconomic buying criterion. *J Mark*. 1994;58(3):1-19.
220. Lamming R, Hampson J. The environment as a supply chain management issue. *Br J Manage*. 1996;7(s1):S45-S62.
221. Klassen RD, Vachon S. Collaboration and evaluation in the supply chain: the impact on plant-level environmental investment. *Prod. Oper. Manage*. 2009;12(3):336-352.
222. Zhu Q, Sarkis J. An inter-sectoral comparison of green supply chain management in China: drivers and practices. *J Clean Prod*. 2006;14(5):472-486.
223. Porter ME, van der Linde C. Green and competitive: ending the stalemate. Harv Bus Rev. 1995;73:120-134.
224. Carter CR, Kale R, Grimm CM. Environmental purchasing and firm performance: an empirical investigation. *Transp. Res. Part E Logist. Transp Rev*. 2000;36(3):219-228.
225. Melnyk SA, Sroufe RP, Calantone R. Assessing the impact of environmental management systems on corporate and environmental performance. *J. Oper. Manage*. 2003;21(3):329-351.
226. González-Benito J, González-Benito Ó. Environmental proactivity and business performance: an empirical analysis. *Omega*. 2005;33(1):1-15.
227. Chen C-C. Incorporating green purchasing into the frame of ISO 14000. *J Clean Prod*. 2005;13(9):927-933.
228. Rao P, Holt D. Do green supply chains lead to competitiveness and economic performance? *Int J Oper Prod Manage*. 2005; 25(9):898-916.
229. Sharma S, Vredenburg H. Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities. *Strategy Manage J*. 1998;19(8): 729-753.
230. Noori H, Chen C. Applying scenario-driven strategy to integrate environmental management and product design. *Prod. Oper. Manage*. 2009;12(3):353-368.
231. Ferguson ME, Toktay LB. The effect of competition on recovery strategies. *Prod. Oper. Manage*. 2009;15(3):351-368.
232. Wycherley I. Greening supply chains: the case of The Body Shop International. *Bus. Strategy Environ*. 1999;8(2): 120-127.
233. Chu S, Yang H, Lee M, Park S. The impact of institutional pressures on green supply chain management and firm performance: top management roles and social capital. *Sustainability*. 2017;9(5):764.
234. Power D. Supply chain management integration and implementation: a literature review. *Supply Chain Manage: Int. J.* 2005;10(4):252-263.
235. Akkermans H, Bogerd P, Vos B. Virtuous and vicious cycles on the road towards international supply chain management. *Int J Oper Prod Manage*. 1999;19(5/6):565-582.
236. Silvestre BS. A hard nut to crack! Implementing supply chain sustainability in an emerging economy. *J Clean Prod*. 2015;96: 171-181.
237. Sahay BS. Supply chain collaboration: the key to value creation. *Work Study*. 2003;52(2):76-83.
238. Swink M. Building collaborative innovation capability. *Res Technol Manage*. 2006;49(2):37-47.
239. dos Santos Silvestre B, Dalcol PRT. Conexões de conhecimento e posturas tecnológicas das firmas: evidências da aglomeração industrial de petróleo e gás da Bacia de Campos. *Gestão & Produção*. 2007;14(2):221-238.
240. Lummus RR, Vokurka RJ. Defining supply chain management: a historical perspective and practical guidelines. *Ind Manage Data Syst*. 1999;99(1):11-17.

241. Pop C, Cioara T, Antal M, Anghel I, Salomie I, Bertoncini M. Blockchain based decentralized management of demand response programs in smart energy grids. *Sensors*. 2018; 18(2):162.
242. Karavas C-S, Kyriakarakos G, Arvanitis KG, Papadakis G. A multi-agent decentralized energy management system based on distributed intelligence for the design and control of autonomous polygeneration microgrids. *Energy Convers Manage*. 2015;103:166-179.
243. Noor S, Yang W, Guo M, van Dam KH, Wang X. Energy Demand Side Management within micro-grid networks enhanced by blockchain. *Appl Energy*. 2018;228:1385-1398.
244. Andoni M, Robu V, Flynn D, et al. Blockchain technology in the energy sector: a systematic review of challenges and opportunities. *Renewable Sustainable Energy Rev*. 2019;100: 143-174.
245. Sprick S, Grieger M, Werner A. *Renewable Energy Supply Chain Management in the Context of Virtual Power Systems*. Vienna: IEEE; 2013.

How to cite this article: Gawusu S, Zhang X, Jamatutu SA, Ahmed A, Amadu AA, Djam Miensah E. The dynamics of green supply chain management within the framework of renewable energy. *Int J Energy Res*. 2022;46(2):684-711. https://doi.org/10.1002/er.7278