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Review

Biomass and Circular Economy: Now and the Future

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Abstract: Biomass is inherently organic and renewable, promoting a circular economy ecosystem. As global consumption patterns change, circular economy strategies have turned into sustainable net-zero strategies for developing countries and developed countries, and its value chain is now included in important biomass energy policies. Many countries are actively transforming their economic growth patterns, developing their own circular economy, targeting ecological sustainable development, and adjusting domestic industrial structures. The concept of a circular society, synergistic with the social economy and developed on the basis of the circular economy, has production and consumption at its core. This research aims to verify the important roles that biomass plays in the circular economy and to initiate a virtuous resource circulation model, promote material recycling and reuse, form a "resources-products-renewable resources" model, and promote better resource use efficiency. It discusses the important roles that the bioeconomy plays when achieving a circular economy and also proposes new economic and policy concepts. The key conclusions cover: (1) the biomass energy–circular economy business model; (2) recognizing the co-benefit of consumers and a prosumer circular economy; and (3) challenges to a renewable cycle under economic applications.

Keywords: biomass business model; circular economy; sustainable development; policy perspective; green energy economy

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1. Introduction

The triple strands (social, economic, and environmental) of biomass products' sustainable development change demand and supply. By investing in commercial R&D technology costs, this will help achieve the development stage goals of the circular bioeconomy. Biomass products have attracted broad attention in the circular biomass model literature [1,2], as they help lower the ineffective waste of natural resources and reduce any negative impact on the environment by maximizing the reuse of biological resources. Following the traditional production and supply model, and after noticing new consumption patterns, the literature has begun to examine the concept of bio-circulation [3], as a circular economy principle, focusing on expansion and maximum reuse, recycling, and product/service design through the properties of the sustainable production of renewable biomaterials. Bio-circulation is inherently renewable. Carus and Dammer [4] mentioned that a bioeconomy entails the production of renewable bio-resources and the processing of waste into value-added product usage. Aragones et al. [5] found that the biomass-to-product value chain could be maximized by fully utilizing all the valuable compounds available in the stream chain. Tan and Lamers [6] noted that a sustainable bioeconomy requires low-carbon energy input, a sustainable supply chain, and the continuous conversion of renewable bio-resources into high-value bio-based products.

Given the transformation of consumption patterns, a circular economy strategy has turned into a sustainable net-zero strategy for the developing countries and major powers, and the circular economy value chain has been included in important biomass energy policies. Holden et al. [7] pointed out that the bioeconomy must embrace circularity in order to extend usage and maximize the production of renewable raw materials. Tumma et al. [8]

established a biological cycle platform to explore the zero-waste concept and to study bio-solid fuel production. In the 2023 book, The Circular Bioeconomy: Theories and Tools for Economists and Sustainability Scientists, Morone et al. [9] mentioned that the circular bioeconomy has now become an important mainstream component of policies to solve the climate crisis. As manufacturing, industry, and academia are committed to it, in order to achieve the goal of sustainable development, the concept of circular economy continues to spread.

Biomass is the oldest energy source used by humans. For instance, before 1800, the U.S. used almost 100% biomass, mainly in the form of wood. Later, other countries began to utilize key renewable energy resources like biomass, hydroelectric, geothermal, solar, and wind [10]. Under global population growth and unpredictable climate change conditions, the emergent green niche technologies are capable of generating heat, electricity, or power through the direct or converted use of biomass as renewable fuel products, derived from cost-effective added value [11]. Many 'waste-to-energy methods' that establish a beneficial biomass resource are becoming increasingly developed and deployed as sustainable economy solutions. From the waste-to-energy concept, the biomass value helps transform low-value biomass within value-added outputs, which include high financial potential solutions [12].

Green technologies, applied for the purpose of upgrading the bioeconomy, including biofuels and bioproducts, are effective strategies for reducing greenhouse gas emissions, addressing global warming, and meeting humans' energy needs [13]. Indeed, the policy development of renewable energy is critical to providing opportunities for new job creation and technological advancement. At the same time, creating a climate-friendly and sustainable energy future, and improving energy efficiency, has become a core growth tactic for the countries driving global progress.

Balancing the relationship between the natural environment and economic development is a global imperative. Therefore, countries are actively seeking circular economy solutions that can establish a low-carbon environment. Over the last few decades, various energy tools have been developed [14,15]. Biomass-based hybrid energy provides a cost-effective and environmentally beneficial alternative. Multi-energy systems are also attracting ever more attention, like the new business model called 'energy as a service' (EaaS) [16].

Sustainability of the agri-food value chain comes from the effective use of biomass energy resources and waste management, and the optimal use of production recycle systems. Castillo et al. [17] found in Spain's regional intensive agricultural system that the economic proportion of agriculture and animal husbandry is gradually expanding, and it is recommended that utilization efficiency should be improved within the framework of a circular economy. Integrating multiple energy services allows for the more efficient implementation of these renewables in developing countries to attain the goal of higher GDP. However, achieving sustainable development requires renewable energy solutions that are flexible and adaptable to changes. Therefore, digital transformation refers to reforming processes to achieve business goals through technological innovation. Future technology will assist the digital transformation and sustainable innovation of renewable energy to enhance the triple benefits of economy, environment and society. We believe the dynamic sustainable process is expected to enable the biomass energy transformation, including generative AI technology, which will become more attractive to young job seekers in the agri-food industry and create a profound impact on the spirit of global green agroecology innovation.

From the triple (social, economic and environmental) sustainability viewpoint, this paper reviews the literature on biomass and circular economy. We use the search engine Google Scholar to find related academic and technical documents. Along with 'biomass' and 'circular economy', the search keywords also include 'Biomass business model', 'circular economy', 'economy growth', 'sustainable development', 'policy perspective', and 'green

energy economy'. This study looks to provide valuable perspectives by exploring numerous academic papers with economic and management significance.

Figure 1 describes the conceptual structure of this paper. The biomass energy economy is a new consumption and production model that is gaining more attention. Many relevant surveys or works of literature have discussed these and are incorporated into this paper, covering circular economy issues, government policy, prosumer participation, and biomass circular economy development. Finally, based on cradle-to-cradle spirits, we make suggestions for future research on biomass and circular economy.

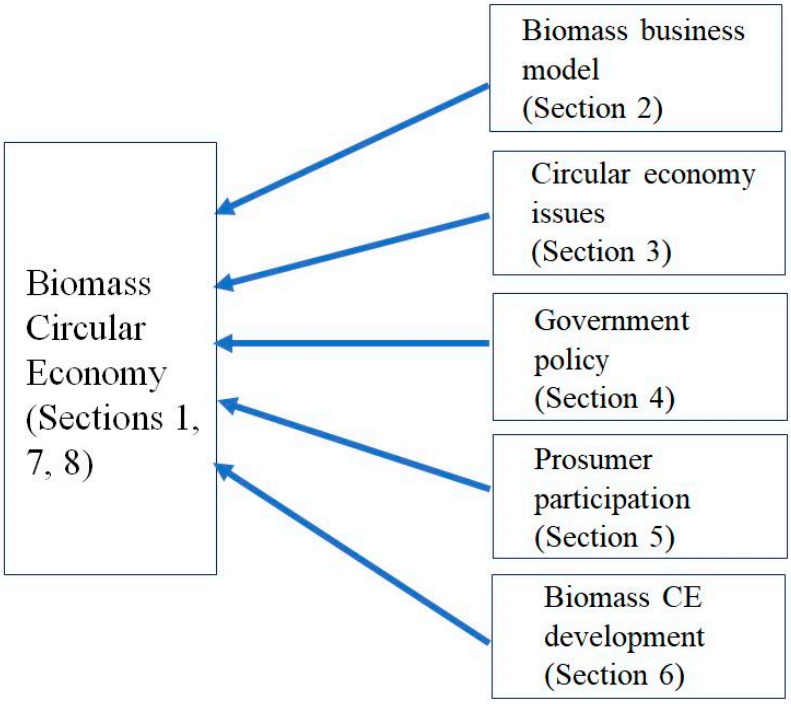

Figure 1. Conceptual framework of a biomass circular economy.

2. Biomass Business Model

Global population growth and climate change emphasize the necessity for biomass production to establish a flourishing sustainable bioeconomy. Environmental psychology focuses on the interaction between people and environment. Antar et al. [18] and Dahiya et al. [19] advocated that biomass products are the future substitutes for fossil-based chemicals and represent the optimal path for transitioning to a low-carbon economy. Out of the environmental psychology theory, they studied the durability of physical products (usually are tangible goods that business can sell and ship to the customers) and the development of the bioeconomy, and whether the sustainable utilization and promotion of energy resources are affected by behavioral knowledge, cognitive motivation, and social learning.

Jamel and Derbali [20] verified that economic growth drives the improvement of energy efficiency and gradually decouples it from energy consumption. It is very important to find a balance between economic growth and environmental protection. Another study highlighted that overcoming this obstacle is vital for the broader acceptance of renewable technologies [21]. Carbon dioxide emissions in the natural environment damage the eco-environment, harm human health, and even negatively affect economic development [22]. Despite renewable energy's economic potential, insufficient public awareness remains a major barrier. Therefore, to facilitate the development of renewable energy technologies, research has found that biomass energy has a positive influence on the public awareness of environmental quality by combining technological innovation to reduce environmental energy consumption.

An increasing number of bio-recycling trends have been developed in recent decades that include plant biomass and even algae in bioprocessing technologies for biomass production, such as reuse and maximize algae productivity for producing algal bioproducts such as fuels, feed, and food. Arun et al. [23] suggested that algal usage is a solution to global warming, energy crisis, water pollution, and even an important biomass conversion technology for biofuel needs. Chen et al. [24] attempted to understand how to expand biomass economic research on the interactions between plants and beneficial microorganisms, so as to promote plant growth while also promoting sustainable cyclic production. Ning et al. [25] found that renewable resources can be altered into various high value-added products, including biofuels, advanced materials, and chemicals. Due to the intricacy of the bio-based value chain, we think setting up a strategy for enhancing biomass production and how best to utilize biomass poses challenges, impacts bioenergy, and spurs agricultural sustainability and the production of other bio-based economy materials.

With respect to the biomass business model involved with business strategy, Miranda et al. [26] supported the agricultural and food industries in adopting sustainability-oriented innovations, using the principles of zero waste and zero carbon emissions to develop dynamic sales processes for high-value crop re-products. The sustainable economic cycle of agriculture and food is increasingly regarded as a business model for the circular and renewable biomass production system. The remaining crops are regenerated to create the assets needed to develop added value and processing equipment, and systematic cooperation or leasing is carried out. Procurement conforms to market transactions and meets the needs of both producers and consumers. We believe that this business model will reuse or transform more environmentally friendly, high-value innovative biomass materials, consider the recycling system of production, life, and ecology, and release new value creation and value propositions.

Based on the concept of recycling and reuse, we propose Figure 2 (the architecture of the biomass business model) to show that the circular economy has the spirit of a sustainable loop cycle. On the left, we discuss the reproduction and transfer of value from upstream to downstream from the cooperation mechanism of the supply chain, involving value creation and value acquisition, including sales derived from revenue generated from customer payments and value generated from remanufactured recycling/leasing. This business model allows service providers and biomass energy suppliers to form a win-win in terms of common interest, from participating in the circular economy process. Under cooperation and interaction, it can assist suppliers in different industries to achieve independent production, intra-industry application, and cross-industry utilization. This allows prosumers to participate in business collaboration mechanisms with different roles in government policies and ecosystems, forming a dynamic process of a virtuous and sustainable cycle.

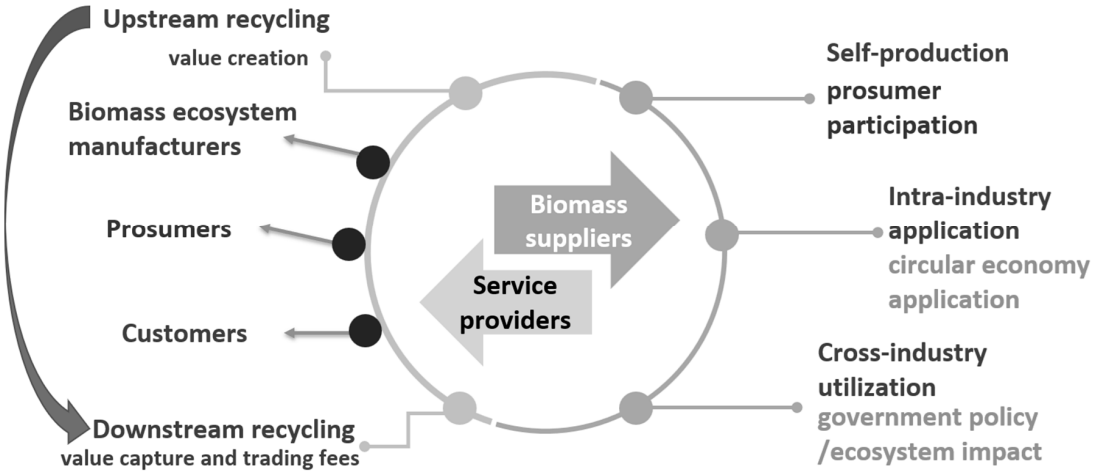

Figure 2. Conceptual architecture of the biomass business model.

3. Circular Economy Issues

The circular economy is regarded as a catalyst to improve the linear economic model and assist sustainable development. It helps to solve the problems of environmental degradation, food resource waste, and long-term economic growth, and promotes recycling. Based on this, issues related to circular economy have been discussed by different scholars, covering areas such as environmental engineering, economic performance, business models, corporate social responsibility, stakeholders, etc. Research has found that government policies are a prerequisite for promoting the positive enhancement of environmental attitudes and behaviors, especially since climate change relates to people's environmental attitudes. Niamir et al. [27] also pointed out that environmental psychology considers attitudes, awareness, perceived behavioral control, and the responsibility to be crucial in the decision-making processes involving personal energy use. Syropoulos and Markowitz [28] noted that as the world pays more and more attention to environmental sustainability solutions, the perceived responsibility to address climate change relates to environmental policy support and behavioral intentions. Moraga et al. [29] emphasized that circular economy is a development plan that makes better use of resource recycling. CE strategies can promote innovative business models that go beyond product value preservation. CE indicators can measure the impact (burden or benefit) of technology cycles on environmental, economic, and social issues in a causal chain model.

The circular economy is not only a model that promotes the recycling of resources but also has the potential to be combined with smart manufacturing methods to successfully transform into sustainable development at the consumer level. It forms a new economic model to protect global air pollution through waste management recycling, to realize green economic development, and to enable the economy to grow and prosper. In the long term, corporate sustainability strategies that engage in refurbishment, reuse, and recycling positively impact the circular economy. Miller et al. [30] believed that the sustainability model of the circular economy can be used as an environmentally friendly model or sustainable development tool. Ungerman and Dědková [31] took data from the Czech Statistical Office to propose a quantitative study of a functional model of corporate participation in the circular economy.

3.1. Circular Economy Applications

Circular economy applications usually relate to product manufacture/disposal. Because it assists in reducing carbon dioxide emissions, it reduces the environmental costs of unsustainable production challenges. Velenturf and Purnell [32] stated in an uncertain and dynamic future environment that taking actions to achieve or maintain a circular economy requires the design of processes or system structures that are mutually beneficial, continuous, and collective learning. Moreno and Charnley [33] explored the concept of redistributed manufacturing and evaluated redistributed manufacturing resources and flexible production through the application of circular innovation.

The literature has conceptualized the sustainable circular business model (CBM) from the perspective of environmental and social sustainable development, and discussed the systematic implementation of circular economy [34,35]. Ramos et al. [36] carried out a circular economy approach under significant investment that has transversal benefits to growing organizations. Silva et al. [37] discussed the practice of a circular economy in three scenarios: ecological design, internal environmental management, and investment recovery related to product flows. They found that most of the actual circular economy implementation relates to product design. We are optimistic that the circular economy can open up new business opportunities, improve the quality of life, and generate more new jobs.

The digital economy plays a pivotal role in driving key industries' digital and green transformation with significant potential, especially in carbon emission reduction. New applications such as blockchain, big data, and SDGs have been integrated into the manufacturing industry [38,39]. In a new stage of digital financial development, improving

energy utilization efficiency and carbon reduction efficiency, and reducing regional carbon emissions together offer a positive economic effect [40]. As the low-carbon economy becomes the focus of sustainable development, Zhou et al. [41] suggested that national policies can actively provide financial support to enterprises and promote the development and promotion of low-carbon technologies. In their innovative green finance paper, Zhuang et al. [42] believed that green finance is the financing goal of "achieving economic growth and improving energy efficiency", and companies should pay attention to using financial tools to achieve green and low-carbon development. Green business services, including finance and green carbon rights, have become important in driving suitable and supportive financing strategy tools. Ma et al. [43] found that green finance promotes green energy innovation in the high-carbon sector, with solutions in the area of digital asset transactions verifying the resource compensation effect.

3.2. ESG and CSR

The era of pricing carbon emissions has already approached. Companies with the insight to adapt to climate change continue to invest in corporate social responsibility (CSR) actions. They have developed from charity plans in the past to real practical actions, while creating dual value for shareholders and customers [44]. The ecosystem concept of industrial clusters uses circular cooperation to enlarge the evolution and development of the circular economy ecosystem, such as circular economy, cluster economy, industrial ecology, etc. [45] The transformation of substantial waste into recycled resources, along with the integration of the sharing economy model and the enhancement of resource efficiency, is a shining factor in determining the sustainable operation of industries. More and more companies take CSR actions to avoid environmental, society, and governance (ESG) and reputational risks [46]. Because the supply chain management of the circular economy involves key challenges in the reuse or production of materials in the product life cycle and relies on systematic design, one paper highlighted that blockchain technology can play a supporting role in the process of circular transformation and improve environmental resource efficiency [47].

4. Government Policy

Climate change, caused by global warming and the greenhouse effect, has become the biggest environmental threat in recent years. Therefore, a circular economy based on sustained growth and adopting a manufacturing-utilization-recycling model is of great help in solving environmental problems. Countries around the world are paying attention and formulating relevant policies. The "Circular Gap Report 2021" also points out that narrowing the circular gap can narrow the greenhouse gas emission gap and contribute to the development of a circular economy. Gisellini et al. [48] discussed how biomass value chains span biological and technological cycles to drive economic development. Some countries have formulated overall policies to make use of relevant geographical environments to adjust the planned utilization of biomass resources. Under various energy price shocks and upstream and downstream inflationary pressures, countries that rely on energy imports attach great importance to biomass energy. However, this has also triggered debates about the efficiency of sustainable biomass resources and the promotion of economic development. Can a "win-win" between nature protection and economic growth be achieved? After all, even enforcing some policies out of concerns about energy security and environmental pollution will bring possible inflationary pressures and increase transaction costs, reducing the willingness of some countries to adopt [49,50]. Taylor et al. [51] acknowledge that the renewable energy transition process may face the challenge of unexpected changes in social, environmental and economic status quo, and political and economic policies determine the effectiveness of using biomass to achieve net-zero goals. From another perspective, considering that the challenges faced by a very small number of countries are seen as economic opportunities for other major countries, we specially select a few countries to illustrate circular economy development policies.

The United Nations General Assembly in 2015 adopted the Sustainable Development Goals. The Kyoto Protocol, later, attracted worldwide attention and became a global consensus to reduce carbon emissions and stabilize greenhouse gas emissions, providing a mechanism for promoting economic development in the future as an international agreement to combat climate change [52,53]. Narassimhan et al. [54] proposed the concept of "carbon pricing in practice", which refers to the effective operation of the carbon reduction activities of carbon emissions trading driven by policies, with double dividend tracking income reinvested in the generation and use of energy. However, the environmental and social risks triggered by the global (COVID-19) pandemic have led to significant changes, altering many industry supply chain models and working patterns. Khan et al. [55] investigated how countries can learn from each other about the implementation of carbon emissions trading systems, including the relationship between environmental regulatory policies and circular economy practices in the context of the COVID-19 outbreak. In 2023, Skripnuk et al. [56] used a mathematical model that simulates zero-waste production and predicts how to optimize a comprehensive circular economy system in specific municipal developing areas.

Some countries have signed Multilateral Environmental Agreements (MEAs). Increasing numbers of Regional Trade Agreements (RTAs) have also incorporated environmental provisions. Through 2023, there are more than 520 policies and regulations already promoting circular economy goals at the national or regional level. The World Customs Organization (WCO) has made environmental concerns one of the priorities of its Strategic Plan 2022–2025 [57], to strengthen biomass sustainability in support of achieving the UK's net-zero target, including the "Biomass Policy Statement" and the "Powering up Britain Strategy", which emphasized the important role that biomass will play in Britain's fully decarbonized power system by 2035, subject to security of supply [58].

4.1. European Union (EU)

The European Commission, in 2015, introduced the EU Circular Economy Action Plan. After the release of the Sustainable Finance Action Plan in 2018, sustainable finance became a top priority in the EU legislative agenda [59]. In 2020, a new Circular Economy Action Plan estimated that applying circular economy principles will increase GDP and create about 700,000 new jobs in the next ten years [60]. Arion et al. [61] believed that circular economy indicators should be quantified from the perspective of sustainable development, and further explored the impact of key variables. The European Commission proposed new packaging rules, improved packaging design proposals in 2022, and revised rules covering persistent organic pollutants (POP). The new regulations introduced harsher restrictions and set 2025 as a carbon neutral, environmentally friendly year. The supervisory agendas of the EU aim for a sustainable, non-toxic, and fully circular economy [62].

4.2. Netherlands and Germa

The Netherlands' government proposed National Circular Economy Plan 2023–2030 and suggested ways to achieve a circular economy as soon as possible, such as reducing the use of raw materials, extending product life, and promoting high-end processing. It wants to fully realize a circular economy by 2050 and is particularly optimistic about the application of biomass, because it is a raw material made from plants, trees, and food waste that can reduce dependence on fossil resources [63]. In 1996, Germany enacted the Substance Closed Cycle and Emission Management Act, which has prohibited the burial of pre-treated emissions since 2006. The German Resource Efficiency Program (ProgRess) proposes a comprehensive strategy to protect natural resources, including focusing on the theme of resource-saving business models [64].

4.3. Japan and South Korea

From the perspective of promoting green innovation policies, both the Japanese and South Korean governments strive to implement policies to promote becoming circular

economies and achieving carbon neutrality goals [65]. These two countries, like other implementing countries, support that the circular economy can reuse resources that have been divided, leased, shared, or refurbished. Doing so extends the product life cycle, reduces carbon emissions or resource abuse, and also generates added value.

4.4. China

China views the circular economy policy as a top-down strategy, like the EU, Japan and other developed countries. Major Chinese cities, since 2019, have emphasized internal circular economy growth by releasing consumer potential, transforming economic structures, and seeking new points of economic growth. The circular economy is considered a core element of China's green development [66]. As the global market shifts towards a sustainable consumer economy, its government is optimistic about the potential of future circular economy development to link resource and energy supply with environmental restoration, and has adopted a national political strategy to promote the building of an ecological civilization [67,68].

4.5. Association of Southeast Asian Nations (ASEAN)

The circular economy can promote better product reuse, resource regeneration, carbon waste elimination, and new systems for urban economic development. Thus, economists and scientists are paying attention to economic development issues, and articles have appeared in famous sustainability journals [69,70]. When utilizing financial technology solutions to expand ASEAN's carbon market, some challenges, such as a lack of adjustment and regional coordination, persist, including technological, logistical, and MRV (measurement, reporting, and verification) cost problems that need to be resolved. ASEAN wants to address climate change and environmental issues through large-scale regional or a voluntary carbon market policy.

4.6. Taiwan

Taiwan intends to add new momentum to economic growth, prioritizing the circular economy as one of its "Five Plus Two" innovative industries. "Five Plus Two" means intelligent machinery, green energy, Asia Silicon Valley, national defense, biomedicine, aerospace, new agriculture, and the circular economy. Some studies have been investigating how Taiwan is developing an industrial-level circular economy. Chen and Yang [71] noted that Taiwan could propose an important and effective ESG momentum strategy. Tserng et al. [72] applied the case study method and utilized 30 circular economy practices to find suggestions for the implementation stage. Wu et al. [73] stated out how developing countries should combine technology and adaptive systems for the circular economy of small-and medium-size enterprises (SMEs), which are abundant throughout Taiwan in all industries.

5. Prosumer Participation

The circular economy symbolizes the way transnational trade acquires, distributes, sells, and consumes energy. Products, processes, and systems have cross-influence in the upstream and downstream of the transnational circular economy chain. The circular economy model involves the labor economic value that production and marketing may create, the recyclable circular business model, and the extended producer responsibility policy. Hu [74] pointed out that ESG provides a strong impetus for corporate energy transformation and creates investment opportunities. That paper also noted, under the influence of ESG investment opportunities created, that prosumers have begun to pay more attention to continuously amplifying ESG actions and transforming them into mainstream activities. This provides forward-looking insights for investment decisions, helps companies understand their own strengths and weaknesses, enhances sustainable competitiveness through ESG practices, and meets the multiple needs of investors and consumers.

Nowadays, the concept of a prosumer is accepted in public. It is a fusion of the words product and consumer. 'Prosumer' was mentioned in a book, '*The Third Wave*', by

Alvin Toffler in 1980. Lin and Hsu [75] discussed how prosumers' better resource utilization can generate economic benefits while alleviating environmental pressure. Even though sustainable development is regarded as a key promotion of the circular economy, some issues still need to be overcome, such as whether actions are taken to support environmental sustainability and economic development, and how to plan transformation policies for the circular economy. Echoing the prosumer mentioned in Figure 2, we admit Hu and Chuang [76] pointed out that energy prosumers efficiently facilitate new energy business models and achieve sustainable energy targets.

5.1. Sustainable Development (SD)

Energy writer Smir [77], in his book, discussed the impact of energy and globalization on human survival and prosperity, including future visions of a renewable energy and sustainability revolution. Morseletto [78] examined a fresh view on the targets of transitioning to circular economy goals. Kircheerr et al. [79] systematically and conceptually analyzed the definition of circular economy in current scholarly thinking. Chrispim et al. [80] evaluated the contributions and limitations of circular economy tools, including exploring social dimensions, stakeholder participation, and industrial symbiosis. Nandy et al. [81] studied sustainable production and consumption solutions under blockchain technology, suggesting that a social transformation strategy and globally linked supply chain system with blockchain opportunities must carefully detect supply chain risk and resilience before executing any response.

From a multilevel perspective framework, Maher et al. [82] studied how circular business models enhance SMEs' niche innovation of sustainability development. They also recommended how government policies can support and foster circular economy transitions. Robaina et al. [83] estimated and discussed the resource productivity efficiency of the European circular economy. Silvestri et al. [84] built two comprehensive indicators and proposed using static and dynamic indexes (CESI and CEDI) to evaluate the circular economy performance of the European region. Additionally, Spain and other EU agricultural exporters attach great importance to the impacts of food security and resource sovereignty. Castillo-Diaz et al. [85] suggested, in response to the challenge of generational change, that digital transformation innovations in the agri-food industry can make it more sustainable for young farmers and ranchers, including improving working conditions, increasing rural productivity, and reducing the environmental footprint of food production. Tamasiga et al. [86] studied material flow analysis and bio-based circular economy and even explored food waste systems and anaerobic digestion recycling technologies, including food supply chain strategies that encourage consumers.

5.2. Innovative Resources for Prosumers

Based on Mhatre et al. [87], the most widely used approach to circular strategies is to recycle materials. Sverko et al. [88] explored whether the GDP development of EU member states affects economic growth variables from 2008 to 2016, based on the concept of a circular economy. To understand which items in the environment can act as intermediaries to improve urban land ecological efficiency, Ma et al. [89] evaluated the intermediary effects of use ecological efficiency, green innovation, and industrial structure optimization on urban land. Abuatwan [90] examined whether green financing impacts sustainable development performance from its interaction with social, economic, and environmental aspects, and represented by the green credit balance in sustainability reports. Ashta [91] suggested that advanced services out of lateral thinking and work-sharing help stimulate more green finance offerings. Ulaşan [92] and Tao et al. [93] researched how cryptocurrency and blockchain technology lead to the development of financial technology (fintech), which contributes to a smoother transition of the economy towards lower carbon and greenhouse gas emissions.

China has carried out many carbon reduction implementation actions in response to climate change. To achieve a win-win situation between ecological and economic benefits,

the government promotes the construction of a low-carbon urban system. Qin et al. [94] discussed how digital finance and its relation to greener consumption can influence household CO_2 emissions. Shi and Xu [95] studied and analyzed the benefits of the implemented urban pilots from the perspective of industrial carbon emission efficiency. Wang et al. [96] suggested that the planning and construction of low-carbon ecological cities should be implemented from a multi-faceted perspective.

The financial market attaches great importance to ESG as a concrete manifestation of sustainable development. Fu and Li [97] investigated China's A-share listed companies (2015–2021) and found that ESG actions have a significantly positive impact on corporate financial performance. Chen et al. [98] examined the interrelation between ESG presentation and corporate performance, and changing brand image by sharing ESG data. Sun et al. [99] indicated that promoting corporate ESG performance and green finance policy needs to be taken seriously, as they both have a positive effect on firms' ESG performance.

5.3. Biomass Application to Energy Generation

The importance of biomass comes from promoting the regeneration of products and energy recycling supplies. Hu et al. [100] suggested that the energy–ICT nexus is a must to efficiently interlink multiple energy sources and socio-economic sectors. Sherwood [101] studied sustainable biomass production and its function as a raw material, such as using the anaerobic digestion of food waste in waste treatment. Kumar and Verma [102] mentioned future circular bioeconomy and analyzed the concept of bio-based refineries in biomass utilization model systems. As Niu et al. [103] pointed out, although biomass may become the world's largest renewable energy source, its inherent shortcomings include the low energy and mass density of some biomass, poor grinding ability, etc., which seriously limit its subsequent widespread use.

Majeed et al. [104] examined the long-term relationship within global biomass resources, economic growth, urbanization, and environmental quality. Yamakawa et al. [105] concluded that a bio-based economy brings benefits to the future development of society and creates new employment and entrepreneurial opportunities. Herbert et al. [106] studied how a biomass energy economy brings benefits to the future development of society, yet attention must still be paid to environmental monitoring and control problems.

Toklu [107] mentioned that Turkey's biomass energy has important potential for climate change mitigation and energy sustainability. Based on agricultural economics-related literature, Tun et al. [108] discussed that most Southeast Asian countries have forest resources rich in biomass. They proposed that biomass energy can help social and economic development, but attention needs to be paid to related applications and optimization of resource utilization. Zabochnicka et al. [109] studied the utilization of algal biomass and the impact of raw materials in producing environmentally friendly products, pharmaceuticals, and animal feeds.

5.4. Sustainable Circular Economy Development

Kunwar [110] found that although CE and sustainable development are related, the circular economy cannot be regarded as a magic panacea that completely solves the problem of reducing carbon emissions, climate change, and energy consumption. Fan and Fang [111] looked at some circular economy mechanisms on resources in 31 provinces of China in 2017, and put forward suggestions to promote effective development. Nechifor et al. [112] thought that developing countries should be evaluated from an economic perspective, for potential co-benefits as well as a need for green international partnerships. Kirchherr and Urban [113] believed that government and international aid program promotion can be the main driving force for low-carbon development policies. From the literature related to carbon neutrality, Lin et al. [114] found that it is crucial to attain low-carbon policies that drive improved air quality. Esposito [115] analyzed the relationship between economic growth and renewable energy consumption in Finland from 1990 to 2019.

Kuo and Chang [116] noted that larger enterprises and environmentally sensitive industries aim to meet the needs of different stakeholders by disclosing more circular economy activities or execution. Khan et al. [117] stated that circular economy implementation positively relates to technological innovation and drives environmental performance. Abad et al. [118] mentioned that the implementation of training and awareness can help understand opportunities and competitiveness of sustainable development. Ngan et al. [119] offered that the key factor of increasing the benefits of a circular economy and triggering stakeholders to support sustainable development is to increase public acceptance. Karuppiah et al. [120] examined the opportunities, challenges, and innovation with a sustainable business model (SBM). Zafar et al. [121] conducted research on the impact of biomass energy consumption on environmental quality, from the perspective of education and technological innovation.

From the studies of these scholars above, we agree that training on circular economy awareness is important. In order to pursue stock price performance or attract investors' favor, companies sometimes engage in socially responsible investment and corporate activities, focusing on the sustainable circular economy with deliberate publicity, although this may be mere superficiality.

6. Biomass CE Development

The Biomass Action Plan had announced more than 20 actions, with most of them to be implemented from 2006. It aims to promote the use of biomass energy, and appropriately regenerate waste energy into a usable resource from the forestry and agriculture industry. Canada, China, and the U.S. have announced that they have been significantly investing in biofuels R&D since 2021 [122]. The cases concerning biomass CE development can be at the country and enterprise levels. Efforts from both the country and enterprise levels are needed to implement all the feasible ways of cooperation and coordination.

6.1. Country Cases

Investment in renewable energy up until now also varies globally. Moreover, the number of policies is still increasing. Thus, we collected some biomass circular economy policies from representative countries.

The U.S.: Reducing carbon emissions by 40% by 2030 is its goal. In August 2022, the U.S. Senate approved the Climate Investment Act, which includes reducing the federal deficit to combat inflation, increasing investment in domestic energy production and manufacturing to drive greenhouse gas emissions, and allowing some households to receive up to $7500 in tax breaks to buy electric vehicles or $4000 in subsidies to buy used electric vehicles [123].

Brazil: Brazil is the country that has made the most efforts to develop biomass energy. Since 1975, it has promoted the "National Alcohol Plan" (Proálcool) to quickly mobilize national resources to develop biomass ethanol. This is a national strategy to maximize advantages, and requires the domestic energy industry and agriculture to work with the automotive industry [124]. The Brazil government encourages the use of microcredit to finance the installation of solar panels, wind turbines, and other renewable energy technologies, making them affordable for low-income earners [125].

India: The Indian government has committed to enabling a circular bioeconomy by advancing 'high-performance bio-manufacturing'. Based on its net-zero carbon economic vision, the main goal of BioE3 (that is, biotechnology promotes the economy, environment, and employment) is to create a bio-based circular carbon economic model in 2070 [126]. From the 2021 IEA World Energy Balances and Renewables Information, the traditional use of biomass for residential heating is going down slightly. The modern use of biomass for power production is growing.

Spain: Spain considers the bioeconomy as an essential strategy of national economic activity. In 2016, the Spanish Bioeconomy Strategy Horizon 2030 was published. In 2020, Spain issued the Climate Change and Energy Transition Law, setting the goal that at least 35% of the final energy consumption must come from renewable energy by 2030, the

proportion of renewable energy must reach at least 70%, and climate neutrality must be achieved by 2050 [127].

Germany: In 2023, the German government published basic principles for the National Circular Economy Strategy (NKWS). The strategy is supported by multiple stakeholders, including industry, science, civil society, and the relevant units of Germany's states and municipalities [128]. New biomass utilization strategies will continue to produce and use sustainable biomass with consideration for the protection of natural ecosystems, along with respecting the "food first" principle [129].

Japan: In 2021, the world's first government-led disclosure and dialogue guidance, specifically for the circular economy, was developed by the Ministry of Economy, Trade and Industry (METI). Based on the "Circular Economy Vision 2020", Japan continues to formulate strategies for transforming towards circular economy growth, and announced the goal of achieving carbon neutrality by 2050 [130]. Additionally, a biomass industrialization strategy was drawn up as a principle to create a regional green industry and fortify an independent and distributed energy supply system [131].

Poland: Due to the mature development of its domestic agriculture, according to statistics, the Polish economy is over 10% circular, above the world average. More than 80% of biomass production comes from food and feed production. The government's agricultural department effectively manages resources and promotes sustainable livestock policies to reduce the use of artificial fertilizers [132].

Australia: Great attention is paid to waste reduction treatment and reuse, and this country believes that further opportunities come from bioenergy development. Australia has invested over $1 billion to boost waste management and resource recycling products. By 2030 it aims to have over 80% of waste reused or discarded for material reduction. The Australian government believes that this will help reduce carbon emissions, contribute to the circular economy, provide reliable power supply, and cut the amount of waste entering landfills [133].

New Zealand: The New Zealand government views the circular economy as seizing the opportunities, trends, and consumer preferences of the bioeconomy. It pays special attention to native biodiversity and wants more recycling of resources and energy. The goal is to achieve protection and restoration, as detailed in the 2050 Ecosystem service goals [134].

China: China's government aims to achieve carbon neutrality in 2060, and has stepped up efforts to promote the application of biomass energy and support biomass power generation plans (the scale of competitive allocation funding will increase year by year). In addition to targeting a peak in carbon emissions in 2030, relevant mechanisms include encouraging local governments to establish biomass power generation systems and collect, store, and process agricultural and forestry waste [135].

6.2. Enterprise Cases

Amazon: The U.S. encourages domestic companies to invest in recycling systems. Amazon has made long-term investments in response to this, supporting the sustainable processing and recycling of packaging and products. Its circular economy activity also includes providing customers with options to reuse, repair, and recycle their products, thus reducing the need to send them back to the warehouse [136].

BASF: BASF has launched a new circular economy plan to double the sales generated by circular economy solutions (to 17 billion €) by 2030. It is developing new circular economy business models, and continually increasing recycling and the use of renewable recycled raw materials as a future business strategy [137].

Huawei: Huawei's practice of the circular economy is to create a business model by integrating ecological design into the product life cycle. Its sustainable development vision is to connect with the future. Based on the concept of the circular economy, Huawei improves resource and energy efficiencies, supports recycling raw materials and parts, and sustainably utilizes resources [138]. The biomass business strategy, paving the way for

net-zero operations, has been announced on the official website, stating that by 2050, all buildings will achieve net-zero operations [139].

Toyota: Being optimistic about the future popularity of the electric vehicle market, Toyota promotes circular economy activities, including establishing a recycling ecosystem for the batteries used in vehicles and adopting its "Battery 3R" partnership strategy (Reduce, Rebuild/Reuse and Recycle) [140]. Toyota uses biomass, as well as the efficient production of bioethanol fuel for automobiles, through the optimized circulation of hydrogen, oxygen, and CO_2 during production to achieve a carbon neutral society.

Yuen Foong Yu (YFY): This firm echoes the vision of a circular economy, promotes the development of renewable energy cycles, uses a recycling water system to produce biogas for power generation, and converts papermaking process residues into alternative fuels for power generation. Their goal is to reach 60% of renewable energy power usage in 2030, and to hit 80% by 2035 [141].

7. Discussions

7.1. Research Implications and Contributions

The circular economy emphasizes the recycling of resources to protect the environment, save resources, and achieve economic development. Countries around the globe are facing challenges such as the pursuit of a balance with the environment, the promotion of renewable energy, and carbon reduction. Large global companies are also looking for unique energy transition paths that are aligned with organizational development goals and take into account socioeconomic priorities.

Sioshansi [142] and Bednarz [143] both looked at developing and developed countries in order to emphasize the importance of biomass and the circular economy to achieve net-zero emissions, energy efficiency, and sustainable development. The purpose is not only to increase the market share of renewable energy in global energy supply, but also to improve the balance between the supply and demand of renewable energy. Everett [144] combined the ideas of circular economy, permaculture and donut economy and proposed that future CE must be closely related to sustainable development and a society-centered overall economic model. The donut economy mixed the concept of planetary boundaries with the complementary concepts of social boundaries to build a visual framework for sustainable development.

In the process of a circular economy, biomass circular elements should be added from the rethinking and design of the manufacturing process, from the use and business model of products and services, and from discussions about disruptive innovation and the value chain of the composite biomass circular economy model. We found that the development of the circular economy internationally drives the operation of the biomass energy industry chain. We also noted that new job opportunities are created, especially for new job "circulation agents", meaning service providers. The service innovation economy is driven by three main actors: producers, consumers, and prosumers. Contemporary consumers live in a time of profound change related to the development of new technologies that shape attitudes and social awareness. They are picky consumers, full of doubts about the broadest economic and social aspects, including consumption issues. Circular agents continue emerging and promoting the transition to a circular economy, with companies facing a potential global growth opportunity of $4.5 trillion [145]. The first step to transforming the prosumer economic model is creating millions of new jobs.

7.2. Research Limitations

In an era of green sustainable development and biomass technology transformation, studying how prosumers impact sustainability and exploring the symbiotic value creation in the circular economy become essential. This study looks at how to develop valuable biomass energy, and green and sustainable innovation, and incorporate them into international development policies and corporate cases, for the creation and acquisition of circular economy value for the stakeholders involved in the biomass energy industry chain.

New research ideas can offer an economic model focused on the future sustainability of prosumers, or firm opportunities for continued development.

Two types of consumers, prosumers and buying-consumers, (especially as enterprises), seek performance development. Customer communication is a transition from one-way communication to a dialogue between businesses and consumers. However, we have not completely studied how to achieve and balance 'value creation and value capture' in the system and process of the circular economy. Future research is suggested to explore the realization and balance of 'co-benefits and energy justice' and 'biomass resource allocation value creation' in the circular economy process.

8. Conclusions and Suggestions

Biomass resources exhibit significance in the cycle of the circular economy value chain. Globalization has developed the economic model of 'take-make-waste', and hence the circular economy is positioned as a potential solution that can better utilize biomass resources and align with the principles of sustainable development. It particularly helps stakeholders in the resource value chain to recognize the practical impact of biomass resource utilization throughout the value chain. Sustainable energy justice drives more and more consumers around the world to become important participants in energy production, storage, use, and management. Many countries are actively adjusting their industrial structures, transforming their economic growth models, and establishing ecologically sustainable development via the circular economy as a key strategy.

Biomass's circular role is needed in realizing a circular economy, and so we propose new economic and policy concepts. A transformative model towards the combination of bioenergy and circular economy business models will produce many revolution-embracing innovative jobs or start-ups. The concept of a circular society, synergistic with the social economy and developed on the basis of a circular economy, has production and consumption at the core. Echoing the ecosystem impact mentioned in Figure 2, we verify a virtuous resource circulation model, promote material recycling and reuse, and form a "resources-products-renewable resources" model. The main conclusions cover: (1) the biomass energy–circular economy business model; (2) recognizing the co-benefit of consumers and a prosumer circular economy; and (3) challenges to a renewable cycle under economic applications.

Companies should understand the importance of embracing changes in the circular bio-economic business model through the relationship between the triple strand of sustainability and the circular economy. It would be ambiguous and difficult at this stage to predict with precision the prosumer buying choice trajectory during the transition to a circular economy. Given the global trend in circular economy policies, researchers can pay attention to circularity, optimizing the use of biomass, and biomass energy justice.

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