Abstract: In recent years, the transition to a more sustainable and clean system has focused on the accelerated development of renewable energy technologies. This transition can be perceived as a major priority, especially with the current environmental concerns, threatening various aspects of human life. The objective of this article is, therefore, to highlight the role of the supply chain in the renewable power generation sector. In this context, a detailed assessment of the supply chain contribution to the renewable energy sector is presented. Next, the performance of the renewable energy supply chain is qualitatively evaluated by illustrating the various barriers against continuing development, and the key measures are recommended to overcome these barriers. Then, the main factors influencing the performance of the supply chain are identified and key performance indicators related to the renewable energy supply chain are established to achieve high efficiency and sustainability performances in the power sector.

Keywords: renewable energy; supply chain; performance; power electricity; sustainability; KPI

1. Introduction

1.1. Background

The large-scale use of conventional energy sources leads to increased environmental pollution and economic deficits [1]. However, renewable energy sources (wind, solar, biomass, geothermal, and hydropower) have the potential to substitute fossil fuels and provide a cleaner and more reliable energy supply. Their use to mitigate environmental problems and ensure a clean energy supply is, therefore, a strategic move towards a sustainable future. This transition is expected to play an important role in improving the community’s well-being, welfare, and supporting accelerated industrial development [2,3].

Figure 2 shows the various energy sources used by the electric power sector worldwide. It is shown that the consumption of coal and petroleum for power generation was reduced between 2008 and 2019, while renewable energy sources experienced an increasing trend in the same period [4,5]. In the last decade, the rapid development of renewable energy technologies driven principally by the remarkable unit cost reduction and increasing awareness about the environment has helped the widespread use of these green systems [6].

As is known, electricity is the most suitable form of energy used to power various end-user applications. However, electricity accounts for only 20% of global energy consumption, which implies that further utilization of renewable energy in transportation, HVAC (heating, ventilation, and air-conditioning), and other sectors is crucial to the world’s energy transition [7]. Current energy statistics indicated that the electricity generated from renewables worldwide has increased by 395 TWh during 2018, which represents a further increase of 6.4% since 2017. Totaling 6586 TWh of renewables in 2018, hydropower accounts for about 63% of the total electricity generation (4149 TWh), followed by wind...
power (1263 TWh), solar energy (562 TWh), bioenergy (523 TWh), geothermal energy (88 TWh) and marine energy (1 TWh) worldwide (see Figure 1) [7].

Figure 1. Power generation from renewable energy sources worldwide in 2018 [9,10].

According to International Energy Agency (IEA) report [11], renewable energy in the electricity sector is expected to reach 30% of global electricity generation by 2023, compared to 24% in 2017 (see Figure 3). During this period, renewables in global electricity production are forecasted to account for more than 70% of global growth, with photovoltaic (PV) solar energy, followed by wind, hydropower, and bioenergy as the most promising options. On the other hand, the renewable heat share in the world is expected to increase slightly from 10% in 2017 to 12% in 2023. At the same time, the global share of renewable energy in the transportation sector is supposed to increase marginally from 3% in 2017 to 4% in 2023 (see Figure 3) [9,10].

Figure 2. Energy consumption in the power sector (2000–2019) [8].
Power generation from renewables is highly influenced by the technical maturity and performance of conversion systems [12], climatic conditions [13], economic and social context [14], political stability [15], and readiness of the institutional framework [16].

The progress of electricity generation from renewables in Europe, Asia, North America, South America, and Africa, and the Middle East is depicted in Figure 4 [9,10]. Table 1 tabulates key strategies to promote renewable energy in different countries belonging to these regions as well as their future targets of expanding the renewable energy potential.
Table 1. Comparative strategy for RE in trend regions and their targets for the development of renewable energy potential.

| Regions | Objectives of the Strategy on RE | Share of RE in Power Generation in 2018 | Targets for RE Share in Power Generation for 2030 |
|---------|----------------------------------|----------------------------------------|-----------------------------------------------|
| China   | Upgrade the existing RE capacity to 680 GW by 2020 [17]. Extend the installed wind capacity to 210 GW [18]. Manage technological innovation in RE [19]. Enhance the development of the RE industry in China and reduce dependence on foreign companies in the energy sector [20]. | 29% [21] | 35% [22] |
| United States | The proposed objectives for the strategy on RE in the United States [23]: Increase the development and use of sustainable transport technologies. Boosting the use of RE sources to generate electricity. Integrate clean electricity into a reliable and efficient grid. Provide leadership to improve federal sustainability and the introduction of clean energy solutions. Promote a high-performance and result-oriented culture via strong management approaches and processes. | 11% [8] | 25% [8] |
| Finland | Feed-in tariff [24]; Climate/energy strategy in the long term [25]; Encouraging the use of biofuels via several different programs [25]; Setting up some actions to promote the use of the wood chips for the production of energy and forestry [24]; | 37% [26] | 51% [26] |
| India   | The key objectives outlined in the strategy to promote RE in India are as follows [27]: To develop and define a set of regulatory norms for an independent platform of electricity exchange RE that will support the CER trade (renewable energy certificate). To guarantee the conformity of the RPO (Renewable Purchase Obligation) objectives for different states, using appropriate penalties and enforcement mechanisms. To explore the creation of a regional advisory mechanism to assist regulators in coordinating the integration of RE. | 10% [28] | 40% [28] |
| Morocco | The introduction of regulations and laws to promote the development of RE for electricity generation [29]; The creation of institutions that can manage, supervise and promote RE projects [30]; The realization of projects and important financial investments to put in place the necessary RE installations [31]. | 35% [32] | 52% [33] |
| Turkey  | The main elements of Turkey’s energy strategy can be outlined as: | 29% [35] | 38% [36] |
|         | Prioritization among energy supply security-related activities by considering increasing energy demand and import dependency [34]; Favoring environment all along the energy supply chain within the context of sustainable development; Organizing transparent and competitive market conditions through regulations to increase efficiency and productivity; Broadening R&D activities on RE technologies. | | |
1.2. Paper Scope

Establishing an effective supply chain for the renewable energy sector can provide tremendous support for the development of the power sector [4,37]. For this scope, an extensive literature review has been conducted to identify supply chain trends of renewable energy technologies. As shown in Figure 5, a greater quantity of research and development investigations related to the renewable energy sector is performed globally. Comparatively, however, the relationship between the supply chain and the renewable energy sector was not examined extensively. In this context, the objective of this article is to present a comprehensive discussion about the role of the supply chain in the renewable energy sector for power generation, highlight the main barriers and summarize recommended key measures to overcome these challenges.

![Figure 5. The number of papers on RE (renewable energy) and RESC (renewable energy supply chain).](image)

In this paper, the systematic literature review (SLR) methodology has been adopted. According to [38,39], the scope of the methodology can be presented as illustrated in Figure 6.

![Figure 6. Scope of methodology [38,39].](image)
The remainder of this paper is structured as follows: Firstly, a detailed assessment of the role of the supply chain in the renewable energy sector for electricity generation is presented. Secondly, the performance of the renewable energy supply chain is evaluated qualitatively by identifying various barriers, limiting its development, and recommended key measures to overcome these barriers. Lastly, the main factors influencing the performance of the supply chain are highlighted and key performance indicators (KPIs) related to the renewable energy supply chain are established to achieve efficiency and sustainability performances in the power sector.

2. Renewable Energy Supply Chain

2.1. Definition of the Concept “Renewable Energy Supply Chain”

The renewable energy supply chain (RESC) is defined as “the transformation of raw energy into usable energy and involves an effective set of management principles from the point of acquisition of energy resources to the point of consumption of usable energy” [40]. It is mainly consisting on five phases namely procurement, generation, transmission, distribution, and demand. These phases cover all processes along the supply chain of renewable energy, from raw materials (input) to the final product (output) [41,42]. Alternatively, the RESC can be divided into three processes as upstream, production, and downstream (see Figure 7) [40]. Its main objectives are to provide a regular and consistent supply of raw materials and to encourage and promote the use of renewable energy technologies [43].

Figure 7. Renewable energy supply chain [40].

2.2. Supply Chain by Renewable Energy Sources

The renewable energy supply chain differs following the renewable energy source (biomass, wind, solar, hydropower, geothermal) (see Figure 8) [40,44]. A brief overview of the specific supply chain for each renewable energy source is given below.
Figure 8. Supply chain by renewable energy sources [40,44].

(a) The energy supply chain for biomass resources:

The energy supply chain for biomass includes three processes [44] as follows: Firstly, the upstream process includes all operations (collection, storage, pre-processing) performed from the source as an input. Secondly, the production process aims to explore biomass energy sources to produce electricity via conversion devices. Lastly, the downstream process includes specific operations such as securing the availability of electricity stored for end-users.

The biomass energy supply chain is characterized by many particularities. First, biomass as a raw material has different seasonal availability and high purchase costs, which may arise due to the limited availability of the raw material. A further particularity is the low density of biomass as a raw material, which points that the various operating costs (storage, handling, transport, and others) are potentially increased along the whole supply chain [45,46].

The decision-making system specific to the biomass supply chain can be viewed from three levels [44,47,48]:

- **Strategic level:** It is a long-term decision that includes the establishment of appropriate biomass supply systems, the installation of conversion devices, and the setting up of industrial sites and depots.
- **Tactical level:** It is a medium-term decision to establish the overall planning in terms of the logistics operation (storage, transport, collection), and to identify the appropriate means of transportation.
- **Operational level:** It is a short-term decision that involves detailed planning of all operations performed in daily operations within the supply chain as a whole.

In summary, the biomass energy supply chain faces two major challenges as the procurement system and conversion process, due to the constraints such as local infrastructure, geographical constraints, and the competitiveness issue of the actors implicated in the supply chain [49,50]. Therefore, it is important to ensure that all the activities associated with the supply chain should be managed effectively to maintain their smooth operation, particularly through good planning in the transportation of raw materials with strategically located industrial sites and depots [47,51].
(b) The energy supply chain for wind resources:

Similarly, the energy supply chain from wind contains three processes \([44,52,53]\) as follows:

In the upstream process, energy sources from wind are characterized by the generation of electricity through the wind turbine. The latter contains certain components, including the mast, propeller, nacelle, blade, and rotor. It is also important to choose an installation site with high wind intensity. During operation, the system works, firstly, by rotating the blades by the wind, and then the propeller drives an axis into the nacelle so that the alternator produces alternating electric current by rotating the axis. Inside the mast, a transformer is required to adapt the voltage to facilitate transmission to the electrical grid. Most of the wind-generated electricity is not stored, due to storage costs that are caused by technical limitations. In the downstream part, the main challenge focuses on grid integration and load balancing.

In general, there are three phases involved in the implementation of a wind turbine project; namely, the development/planning of the project, installation of the turbine and finally energy production and distribution within the smart grid \([54]\).

Moreover, two types of wind energy plants are available, namely offshore and onshore wind. These two types are distinguished by the infrastructure and installation, the benefit, and the increased risk level. For onshore wind, the level of benefit depends mainly on the wind turbine. For offshore wind, it depends on both the high cost of service and the cost of the installation, which accounts for approximately 25% of the total project value \([55]\).

(c) The energy supply chain for solar resources:

Solar energy has recently been characterized by strong growth in technology investment and a large number of innovative initiatives \([56]\). Solar energy can be harnessed by two means, including solar photovoltaic and solar thermal.

The upstream process is based on the implementation of solar photovoltaic or solar thermal power generation systems. The production process focuses mainly on producing electricity either by PV modules or thermodynamic cycles driven by solar concentrating collectors. Finally, the downstream process in the supply chain consists of a continuous supply of electricity to end-users.

(d) The energy supply chain for water resources:

The hydropower supply chain exploits dams and seas to generate electricity.

Electric power is generated by releasing water through a turbine, which is connected to generators to create an alternating current that must be regulated to the voltage level of the power grid. The downstream process deals with the distribution of electricity to end-users based on their energy needs.

The hydropower supply chain faces several challenges to allow for the development of innovative systems in such a way to mitigate or prevent environmental impacts \([57]\).

(e) The energy supply chain for geothermal resources:

The geothermal energy supply chain is based on three main processes \([44]\) as follows:

The upstream process consists of extracting thermal resources from the earth as an input. In production process, water is infiltrated, heated until it is vaporized. Vapor drives a turbine to produce mechanical energy, which is then converted into electricity via a generator. This energy has to be adjusted to the voltage requirements of the electricity grid. Finally, the downstream process concerns the distribution of electricity to end-users.

The implementation of a geothermal project is typically divided into three phases as project planning, exploration, drilling and construction both above and below ground, and finally exploitation and maintenance operations \([54]\).
3. Barriers, Measures and Performance Assessment for the Development of the Renewable Energy Supply Chain

3.1. Various Barriers to the Development of the Renewable Energy Supply Chain

After a detailed review of the various studies on the renewable energy supply chain, the different barriers to the promotion of renewable energy technologies are examined. These barriers can be categorized into four dimensions as political and regulatory, technical, economic and financial, and managerial.

(a) Political and regulatory dimension

The main limitations are related to the difficulties of improving the policies and regulations to support the development of renewable energy technologies in the power sector. Consequently, these can lead to significant conflicts between the different actors involved in the renewable energy supply chain [58–60].

On the other hand, the transition from fossil fuels to renewables requires the availability of a workforce with solid experience in this field. However, the lack of a skilled workforce in the renewable energy sector is considered a major issue for the development of the power sector [61–63].

(b) Technical dimension

From a technical viewpoint, inefficiencies in terms of the conversion system are the main drawbacks of renewable energy technologies, i.e., the high variability between the input level of renewable energy sources and the output level of electricity, due to inefficient conversion devices [61,64]. For example, in the case of solar energy, several factors are known to affect the efficiency of electricity generation, such as cloud cover and humidity: when weather conditions are cloudy, the performance of solar panels decreases due to the absorption of part of the sun’s rays, which limits the amount of sunlight captured by the panels. However, when the weather is sunny, electricity generated from the sun is reduced by 10–25% due to excessive heat absorption, which increases the conductivity of the semiconductors. On the other hand, when moisture penetrates the solar panels, the efficiency of the solar panels may be reduced, and thus the amount of energy produced may decrease the performance of the solar panels [65].

Another aspect that can be considered as a technical barrier for developing renewables, the lack of grid continuity due to their intermittency and the cost associated with maintaining the power balance in real-time [66]. The intermittency of power generation from renewable can disrupt the operation of the power grid. Indeed, fluctuations in electricity production can be spread over various time horizons and force network companies to adapt the operation of their network in real-time [67]. For example, solar energy can be accessed during the peak sunny period. Therefore, the grid company is required to adjust the daily planning to incorporate generators able to adjust the fluctuations in energy production and thus offset the variations in energy production from solar energy [67].

Further, the unclear procedures governing the functioning of the electricity grid could harm renewable energy investments in case of non-compliance with technical standards [68].

(c) Economical and financial dimension:

The renewable energy projects economically require a higher initial investment compared to fossil fuels, which leads to a significant increase in the unit costs of electricity [58,61]. Similarly, the significant increase in costs of logistics, including operation and maintenance, transportation, and storage costs, is likely to limit the deployment of renewables technologies [59,60]. It is, therefore, necessary to implement specific mechanisms towards improved process control of harvesting, transportation, and processing [69]. Moreover, the difficulty in obtaining credit and government incentives is a major obstacle that limits the development of this sector [64,70].

(d) Managerial dimension
From a management point of view, one of the main barriers limiting the expansion of the renewable energy sector is inadequate communication between actors involved in the supply chain [64].

Further, the roles and responsibilities of power grid operators are not clear, due to confusing procedures [61].

Yet another is the lack of coordination between different government entities and delays in project implementation that renewable energy projects suffer from greatly [63].

3.2. Key Measures for the Development of the Renewable Energy Supply Chain

The key measures are discussed below to overcome the various barriers affecting the performance of the renewable energy supply chain.

(a) General key measures for the development of the renewable energy supply chain:

(1) Liberalization of the energy sector The liberalization of the energy sector is one of the main measures, which requires the implementation of various policy initiatives to organize a transparent and competitive market [71]. All these initiatives represent significant progress towards the liberalization of the sector, but their successful change will require new regulatory mechanisms (e.g., external regulatory institutions to ensure the effective execution of these initiatives). In general, the objective of liberalizing the energy sector is to increase efficiency and competitiveness in the market [29,72].

(2) Elimination of subsidies for conventional energy It is worth noting that fossil energy technologies indirectly receive subsidies because of the international agreements related to the energy sector. Therefore, the government should impose new policies and regulations limiting the use of fossil energy technologies and trigger a transition towards renewable energy technologies, which offer considerable socio-economic and environmental benefits. For this reason, financial support for the development of the renewable energy sector will help to maintain a cost-effective energy pricing policy for consumers [73,74].

(3) Public–private partnership The participation of the private and public sectors to finance projects related to the renewable energy sector is increasingly important in terms of enhancing efficiency in project implementation. Therefore, an intensive support mechanism for public–private partnerships should be formed to achieve the sustainable development of this sector. This can make a significant contribution to the smooth running of projects [29].

(4) Access to financial incentives Establishing financial incentive mechanisms to stimulate renewable energy utilization has helped to meet the logistics costs for sector expansion and to ensure competitiveness in the market. This initiative also offers various types of financial incentive mechanisms, such as low-interest credits, reductions based on electricity production [75,76].

(5) Measures to facilitate administrative procedures Governments adopted important measures to facilitate administrative procedures, such as guidelines on financing procedures for renewable energy projects and the assessment of the resources needed for the implementation of such projects [77].

(b) Specific key measures for renewable energy supply chain development: The following specific key measures can be classified into three categories in line with renewable energy sources:

(1) Recommendations for the development of the supply chain for biomass Sustainable production of adequate quantities of biomass is a major issue in addition to storage constraints for biomass energy. Basically, three methods can be retained: storage on the ground with low storage costs, intermediate storage between farmers and stations which require higher delivery costs, and finally storage close to the station which optimizes delivery costs [46]. Therefore, optimized storage solutions for biomass sources make an important
contribution in terms of cost reduction, the flexibility of the supply system, and sustainability of the supply chain [78].

(2) Recommendations for the development of the supply chain for wind Some of the main best practices in the supply chain for wind energy include [52,53]: optimal location of wind farms, addressing specific factors such as being far away from urban areas, improving the efficiency of power grids by using advanced technologies to maintain a balance between electricity supply and demand, and incorporating technical standards for the grid integration of wind turbines.

(3) Recommendations for the development of the supply chain for other renewables Other key measures recommended for tackling the barriers throughout the supply chain of other renewables are [1,43,70] mainly the introduction of an efficient energy storage system to guarantee the availability of energy while ensuring low cost-efficient conversion devices. Environmentally, it is also crucial to minimize the lifecycle carbon footprint of all the equipment used.

3.3. Identification of Appropriate Criteria for Measuring the Performance of the Supply Chain

Performance measurement is key to establish better governance in the supply chain. It is also important for various actors involved in the supply chain to assess the effectiveness of their processes [79].

Moreover, the development of the performance measurement system is vital to improve the monitoring and control of the processes, leading to progress towards the achievement of predetermined objectives. Thus, performance measurement refers to the evaluation of the results obtained from the analysis of supply chain processes and comparing with predetermined objectives, and to generate relevant information for facilitating decision-making in the supply chain [80,81].

The following graphical illustration highlights the main factors that affect supply chain performance (see Figure 9) [82–84].

3.4. Definition of Indicators for Improving the Performance of the RESC

The recommended key measures in Section 3.2 must be implemented without deviating from the targets. Therefore, in case of gaps between planned targets and actual results, an effective review of the long-term risks and opportunities is crucial for the whole renewable energy supply chain [85]. Therein, the introduction of a logistics dashboard with Key Performance Indicators (KPIs) helps to measure and visualize the evolution of the observed gaps. These indicators can thus be effectively compared to the predefined target [86].

The implementation of a logistics dashboard and its indicators that include three processes of the renewable energy supply chain can be fragmented into four dimensions (see Table 2) [87–89] as follows:

(a) Economic dimension

Economically, it is necessary to determine the cost-effectiveness of each process in the renewable energy supply chain to respond effectively to market needs. Some key performance indicators from an economic point of view are considered, such as capital investment, transportation cost, return on investment for the procurement of renewable energy feedstocks, operating and maintenance (O&M) cost, and delivery cost of electricity to end-users.
(b) Technical dimension

The introduction of several indicators assists assessors to evaluate technically the performance of processes throughout the renewable energy supply chain by considering technological constraints. It also ensures that these indicators are used to monitor the efficiency of the system components and quality of service. Several technical indicators are considered, such as supplier delivery performance, efficient conversion rate, energy losses, renewable energy consumption, and satisfaction rate.

(c) Environmental dimension

The development of indicators related to the environmental perspective can generate information to support decision making and monitoring of the actions performed by the actors involved in the renewable energy supply chain. Some key performance indicators are considered, such as renewable energy consumption, CO$_2$ emissions (carbon footprint), and reduction rate of fossil fuel consumption.

(d) Social dimension

It is of particular interest to establish social indicators to measure consumer interest and motivation for renewable energy projects. They can also be used to assess the social impact of renewable energy technologies and policies. Some key performance indicators are socially relevant, such as job creation rate, workforce maturity, and access to electricity (% of the population).

---

**Figure 9.** Main factors influencing the performance of the supply chain [82–84].
Table 2. Classification of key performance indicators for three processes of the RESC in four dimensions [87–89].

| Supply Chain Processes | Dimensions          | Key Performance Indicator                                                                 | How to Calculate                                                                 | Unit   |
|------------------------|---------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------|
|                        |                     | Economic dimension                                                                        |                                                                                  |        |
| Upstream process of the supply chain | Capital investment | The budget invested in renewable energy technologies used for electricity generation. | €                                                                                 |        |
|                        | Transportation cost | The total cost of fuels from RE sources and especially biomass for electricity generation. | €                                                                                 |        |
|                        | Procurement ROI     | The measure of the financial profitability of acquiring RE sources.                       | %                                                                                 |        |
|                        | Technical dimension | Supplier delivery performance                                                              | The ability of a supplier to deliver orders in full and on time.                  | %      |
|                        | Environmental dimension | Combustible renewables (% of total energy) | The percentage of total energy from RE sources used to deliver the various resources and components related to RE technologies. | %      |
|                        | Social dimension    | Job creation rate                                                                         | The percentage of people working in the procurement department for RE to generate electricity. | %      |
|                        |                      | Maturity of workforce                                                                     | The percentage of people with valuable expertise in RE technologies, by region, in the procurement process. | %      |
|                        | Economic dimension  | Operating and maintenance (O&M) cost                                                      | Total annual expenditure on RE technologies, e.g., operation and maintenance (O&M) costs. | €      |
| Internal supply chain   | Technical dimension | Efficient conversion rate                                                                 | The ratio between input and output efficiency of equipment used for energy conversion. | %      |
|                        | Energy losses       | The sum of energy losses that occur when using the smart grid to meet the electricity demand. | kWh/year                                                                         |        |
|                        | Environmental dimension | CO₂ emissions (carbon footprint) | The amount of CO₂ released at production sites.                                     | kg CO₂/kWh |        |
|                        | Social dimension    | Job creation rate                                                                         | The percentage of people employed in the production department responsible for generating electricity from RE technologies. | %      |
|                        |                      | Maturity of workforce                                                                     | The percentage of people with valuable expertise in RE technologies in the production process, depending on the region. | %      |
|                        | Economic dimension  | Cost of power delivery                                                                    | Cost of delivering power to end-users                                              | €      |
| Downstream supply chain | Technical dimension | Satisfaction rate                                                                         | The percentage of the volume of energy delivered to end-users and the total volume of energy demand expressed by end-users. | %      |
|                        | Environmental dimension | CO₂ emissions (carbon footprint) | The amount of CO₂ released during the activities of ensuring the availability of electricity to end-users. | kg CO₂/kWh |        |
|                        | Social dimension    | Access to electricity (%) of the population                                              | The percentage of the population with access to electricity.                       | %      |
4. Discussion

The renewable energy sector is characterized by the ability to rationally manage the activities carried out to meet market demand for energy at the lowest cost. For this purpose, the expertise of the renewable energy supply chain becomes essential to effectively manage the circulation of different natural resources throughout the various processes involved in the production of electricity for end-users [42].

In this paper, the assessment of the renewable energy supply chain in the context of power generation highlights some relevant insights, mainly discussed as follows [90]:

From a technical point of view, the technical specifications have to meet practically market requirements. Efficient devices should be introduced to guarantee the performance of the conversion system during the production phase of the supply chain for preventing losses. In this regard, as an example, one of the objectives of all EU Member States needs to implement support schemes for renewable energy equipment from the perspective of establishing clear technical specifications for each renewable energy equipment to ensure the effective functioning of these support schemes for such equipment. These technical specifications will need to be developed in accordance with European standards, namely eco-labels, energy labels, and other technical references developed by the European standardization institutions [91]. The expended use of renewables is still limited, due to their inability to generate energy under unfavorable weather conditions [5]. The use of energy storage systems allows energy production to be stabilized to make these renewables more competitive and to ensure regular electricity production in the case of low peak demand. This way, efficient and viable energy storage systems can help to make renewable energy affordable for grid operators [92]. There are different technologies for energy storage (see Figure 10), such as mechanical storage systems, electrochemical storage systems, electrical storage systems, chemical energy storage, and thermal storage systems [93]. Energy policymakers are increasingly aware of the ultimate role that energy storage systems can play to accelerate the transition towards a renewables sector. As an example, there is an ongoing innovative project for energy storage 45 MW is planned to be implemented by 2025, in Morocco and Francophone Africa. This project is led by the two companies, AZELIO and JET ENERGY. This project will be achieved through the installation of a 50 kW facility in 2021, 5 MW in 2022, 10 MW in 2023, 15 MW in 2024 with the same amount in 2025. Moreover, the project is conceived for the solar PV installations projected in Morocco as well as for the existing installations. The storage technique is based on the concept of electric thermal energy storage [94].

![Mechanical storage systems](image1)
![Electrochemical storage systems](image2)
![Electrical storage systems](image3)
![Chemical energy storage](image4)
![Thermal Storage Systems](image5)

**Figure 10.** Classification of energy storage technologies [93].

From an environmental point of view, the preservation of the environment is a key factor in terms of low carbon power generation through renewable energy sources. However, these sources can never eliminate all environmental concerns. They emit fewer greenhouse
gases and air pollution than fossil fuels during the production and transportation process. For example, photovoltaic (PV) cells generate toxic substances during their production, which can lead to potential contamination of water resources. To limit these impacts, therefore, it is important to assess the extent to which renewable energy technologies can have an impact on the environment when selecting appropriate designs, production methods, the geographical location of projects, etc [95].

From a social point of view, the deployment of renewable energy projects within industrial zones contributes significantly to job creation and promises a better life quality for the communities. However, social acceptance and awareness should be improved, especially in developing countries.

For the successful implementation of renewable energy projects, there are many barriers to the smooth functioning of the renewable energy supply chain, including the siting of renewable energy projects. It is, therefore, critical that renewable energy plants are located in the right place. For instance, the cost of transporting and storing biomass resources has become an important factor in choosing a suitable site [75]. In general, the ideal location for the installation of renewables technologies depends on some factors, such as the readiness level and the cost-effectiveness of the technology, the green electricity demands, as well as the environmental constraints [96].

Further barriers to the performance of the supply chain in the renewable energy sector include inadequate policies and regulations that limit the progress of renewable energy projects, in particular policies involving the participation of private actors. Such barriers, therefore, cause delays in approving and allocation of funds for renewable energy projects [97,98]. Additionally, what hampers most is the current configuration of the electricity to integrate renewable energy sources, resulting in non-compliance with specific technical standards [61,64].

Lastly, apart from the barriers related to economic and financial aspects, more barriers are identified in financing renewable energy projects, such as the perception of high risk [99]. By implementing policies aimed at minimizing some of the risks faced by actors in the renewable energy sector, obtaining financing for R&D activities plays a central role in the development of renewable energy technologies. However, these technologies face significant difficulties in the market. One of the key drivers to ensure a large uptake of renewable energy technologies depends on access to investment funds that are not only supported by the public sector but also need the intervention of the private sector [95,100].

The presence of the previously mentioned barriers in the renewable energy supply chain requires implementing some measures, including research and development activities in the renewable energy sector. These activities play an important role in making renewable energy technologies more efficient [101]. Another measure to increase the efficiency of the renewable energy supply chain is the use of the so-called “smart-grid”, which enables better utilization of the electricity grid and contributes to energy savings. The implementation of smart grids can also contribute to reducing greenhouse gas (GHG) emissions through renewable energy integration. Consequently, the system becomes more flexible and efficient in the daily management and distribution of electricity [102].

On the other hand, the emerging collaboration of the private and public sectors has become increasingly practical, given the need for certain particularities required for the successful implementation of renewable energy projects. For example, such projects in Morocco, particularly in solar and wind energy, are developed mainly through strong coordination between the private and public sectors, which involves the private sector to bring its expertise for the implementation and make them operational [29]. It is also necessary to take necessary actions to speed up administrative procedures with the competent administrative authorities. These would lead to time savings in obtaining permits and authorizations swiftly and promote coordination between the competent public authorities [103]. Turkey has also been regularly updating regulations for renewable energy investments to provide a suitable ground for private and public sectors. The YEKA regula-
tions outline the process for renewable energy zone and both wind and solar projects are tendered within this framework [104,105].

Some advanced technologies are relevant to the renewable energy sector for power generation to achieve optimal efficiency in the renewable energy supply chain, notably the Hybrid Renewable Energy System (HRES) and the “Power To X” concepts. HRES refers to the combination of two or more renewable energy sources, operating in stand-alone or grid-connected mode [106]. The stand-alone mode is characterized by a decentralized production and large storage capacity. On the other hand, the grid-connected mode has a relatively low storage capacity due to the grid [107]. The main features of the HRES system are the possibility of integrating different renewable energy sources and configuring them differently to achieve higher performances and efficiencies. Overall, the hybrid renewable energy system can successfully address some of the barriers in terms of flexibility, efficiency, reliability, emissions, and fuel economy [108,109]. To decide the ideal combination, it is important to consider the local availability of resources at a given site, the efficiency of energy conversion, and the land requirements [106]. On the other hand, the “power to X” system allows for a multi-stage production process based on the transformation of power into “X”, where X denotes various forms of energy such as heat, hydrogen, gas, liquid, methane, ammonia, etc. [110]. Therefore, the main benefits of this technology are, principally, the contribution to the sustainable energy ecosystem, the provision of efficient methods of energy storage that have economic potential, and the optimal configuration of the energy flow in the system, taking into account the particularities of all energy supply systems [111,112]. For example, Morocco considers the “Power To X” system is an interesting option in the development of the electricity sector for major reasons as it represents a significant opportunity in terms of wind and solar energy, particularly in the south of the country. In addition, it reduces the cost of renewable energy technologies, and offers great market potential due to geographical proximity to Europe [113].

In summary, with the focus on sustainability as a strategic priority for firms in the power sector, it is important to highlight the specific policies and regulations that need to be implemented to support the development of the renewables supply chain. For this reason, the following five main policy tools and strategies can be highlighted: (i) taxes and incentives, (ii) pricing policy mechanisms, (iii) renewable electricity quota systems, (iv) customer engagement for supply chain sustainability, and (v) energy savings in the supply chain.

4.1. Taxes and Incentives

Several policies aim to promote investments in renewable energy technologies by making these investments more profitable. Among these policies, the main policy that is enhanced the supply chain: tax reductions and subsidies.

4.2. Tax Deduction and Subsidies

Governments can help investors in renewable energy systems reduce their initial investment costs through tax reductions or subsidies. Tax reductions can provide better conditions for producers with high-efficiency systems to compete with other firms. However, also, the introduction of subsidies allows for increased control of consumers’ energy consumption behavior through reforms of electricity prices [114]. For example, Morocco offers a reduction in value-added tax (VAT) on the procurement and trade of renewable energy equipment [115].

4.3. Pricing Policy Mechanisms

The most important of these policies aim to improve the supply chain: feed-in tariff schemes.
4.4. Feed-In Tariffs Schemes

One of the existing policies used to stimulate the growth of the renewable energy market is feed-in tariff schemes, which emerged as one of the main policy schemes with significant growth potential [116]. The “feed-in tariff” is a price paid to third party providers per unit of electricity from renewables. This price is set through regulations to encourage private producers. However, electricity produced from renewables will cost more than electricity produced from conventional sources [117]. For example, feed-in tariffs are used in many countries, including some African countries such as Algeria, Kenya, Uganda, Ghana, and Tanzania. In the case of Ghana, the feed-in tariff for solar PV was fixed in the range of 0.20 to 0.25 USD per kWh of electricity [118].

4.5. Renewable Electricity Quota Systems

One of the most important policies that promote the development of the supply chain via a quota system of electricity from renewable energies: Renewable Portfolio Standards.

4.6. Renewable Portfolio Standards

A Renewable Portfolio Standard, as a sustainable policy instrument for the promotion of renewable energy, is the regulation of electricity generation in a given country or region, requiring a specific share of the electricity consumed or produced on the market from renewables [43,119]. Indeed, the implementation of a renewable portfolio standard offers significant gains to the countries involved, such as continued stability of electricity tariffs, economic development and protection of the environment against greenhouse gas emissions [119]. For example, China has implemented the renewable portfolio standards in 2019, which includes a special regulation to impose a mandatory quota on energy providers and consumers to purchase or trade their share of renewables in electricity generation [120].

4.7. Customer Engagement toward Supply Chain Sustainability

The emergence of new technologies, as well as significant innovations in the renewables sector, represents a major lever that is driving change for supply chain actors, especially customers. Indeed, recent studies highlight that the engagement of customers along the supply chain leads to increased interest in energy savings [121]. This makes customer engagement at all stages of the supply chain the most important driver for efficient growth within firms, especially in light of higher energy consumption, strong competition, and globalization [122]. However, also, increased awareness of customer relationships will increase their revenue and economic development of the country [123].

Furthermore, the importance of customer engagement is increasing throughout the supply chain, due to a more complex energy ecosystem in the power sector, especially in the use of renewables. These developments in electrical engineering require a more flexible and extended relationship between customers and firms [124]. As a result, all customers are enabled to generate, store, and exchange their electricity, as well as to monitor and manage electricity [125]. In summary, an increasingly complex interaction between customers and firms is emerging, thanks to the many benefits of digital interactivity, such as demand response, that occur with the development of facilities along the energy supply chain [125].

4.8. Energy Savings in the Supply Chain

The government can address the environmental and economic impacts of excessive energy consumption in a sustainable pathway towards the development of energy-saving as a policy. A study was conducted to investigate the impact of energy-savings on energy prices within a supply chain with retailers and producers dealing with consumer demand. It used an energy-savings strategy to achieve optimal price levels and energy efficiency, through the setting of energy consumption targets by policymakers [40]. Another study was performed to examine the impacts of energy consumption along the supply chain. It has developed an alternative approach that identifies materials flow pathways to shift from non-renewable energy use to renewable energy use. It supports a global supply chain
aimed at addressing issues of climate change emissions and energy savings, to protect the environment and energy resources [126]. For example, most countries recommend policies to improve environmental protection and economic development, while encouraging energy savings practices within firms to boost power generation performance [127]. In the case of the European Union, some countries have implemented energy-saving strategies to reduce energy consumption by 17% during the next three decades [127].

5. Conclusions

In this article, the impact of the supply chain in the renewable energy sector was examined and the main critical related aspects were discussed. In addition to highlighting the characteristics of renewables (biomass, solar, wind, hydropower, and geothermal), their relevance to the supply chain was particularly investigated. Moreover, the various barriers that limit the development of the renewables supply chain were examined in terms of political and regulatory, technical, economic and financial, and managerial aspects. Thus, key measures to overcome these barriers were defined to ensure the effectiveness of this supply chain. The development and integration of the logistics dashboard with Key Performance Indicators (KPIs) on the renewable energy supply chain in four dimensions (economic, technical, environmental, and social) were detailed to achieve greater efficiency in this supply chain while ensuring its sustainability. It was concluded that achieving an effective supply chain for the renewable energy sector can provide tremendous support for the development of the power sector.

Author Contributions: Conceptualization, F.J. and A.A.; writing—original draft preparation, F.J.; writing—review and editing, A.A. and M.S.B.; supervision, R.S. and A.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not Applicable.

Informed Consent Statement: Not Applicable.

Data Availability Statement: Not Applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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. [CrossRef]

2. Palander, T. Modelling renewable supply chain for electricity generation with forest, fossil, and wood-waste fuels. *Energy* 2011, 36, 5984–5993. [CrossRef]

3. Ryu, J.h.; Han, J.H.; Lee, I.B. Development an Optimization Model for Green Supply Chains: Integration of CO2 Disposal and Renewable Energy Supply; Elsevier: London, UK, 2012; Volume 30, pp. 317–321.

4. Kousksou, T.; Allouhi, A.; Belattar, M.; Jamil, A.; Rhafighi, T.E.; Arid, A.; Zeraouli, Y. Renewable energy potential and national policy directions for sustainable development in Morocco. *Renew. Sustain. Energy Rev.* 2015, 47, 46–57. (In English) [CrossRef]

5. Hinrichs-Rahlwes, R. Renewable energy: Paving the way towards sustainable energy security. Lessons learnt from Germany. *Renew. Energy* 2013, 49, 10–14. [CrossRef]

6. Murdock, H.E.; Collier, U.; Adib, R.; Bianco, E.; Mueller, S. Renewable Energy Policies in a Time of Transition; IRENA: Abu Dhabi, UAE, 2018.

7. IEA-International Energy Agency. Available online: https://www.iea.org/ (accessed on 21 April 2020).

8. Birol, F. *Renewables 2018: Market Analysis and Forecast from 2018 to 2023*; IEA: Paris, France, 2018.

9. IRENA-International Renewable Energy Agency. Available online: https://www.irena.org/ (accessed on 21 April 2020).

10. Whiteman, A.; Esparrago, J.; Elsayed, S. *Renewable Energy Statistics 2018*; The International Renewable Energy Agency: Abu Dhabi, UAE, 2018.

11. Jiang, K. Technological Progress in Developing Renewable Energies. *Aust. Econ. Rev.* 2017, 50, 469–477. (In English) [CrossRef]

12. Allouhi, A.; Saadani, R.; Buker, M.S.; Kousksou, T.; Jamil, A.; Rahmoune, M. Energetic, economic and environmental (3E) analyses and LCOE estimation of three technologies of PV grid-connected systems under different climates. *Sol. Energy* 2019, 178, 25–36. [CrossRef]

13. Omer, A.M. Environmental and socio-economic aspects of possible development in renewable energy use. *Handb. Environ. Policy* 2011, 2, 79–114.
14. Burke, M.J.; Stephens, J.C. Political power and renewable energy futures: A critical review. *Energy Res. Soc. Sci.* 2018, 35, 78–93. [CrossRef]
15. Iyechettira, K.K.; Hakvoort, R.A.; Linares, P. Towards a comprehensive policy for electricity from renewable energy: An approach for policy design. *Energy Policy* 2017, 106, 169–182. [CrossRef]
16. Fernando, Y.; Yahya, S. Challenges in Implementing Renewable Energy Supply Chain in Service Economy Era. *Procedia Manuf.* 2015, 4, 454–460. [CrossRef]
17. Ridley, D. *The Literature Review: A Step-by-Step Guide for Students*; Sage: Newcastle upon Tyne, UK, 2012.
18. Colicchia, C.; Strozzi, F. Supply chain risk management: A new methodology for a systematic literature review. *Supply Chain Manag.* 2012, 17, 403–418. (In English) [CrossRef]
19. Halldórsson, A.; Svanberg, M. Energy resources: Trajectories for supply chain management. *Supply Chain Manag.* 2013, 18, 66–73. [CrossRef]
20. Aslani, A.; Helo, P.; Feng, B.; Antila, E.; Hiltunen, E. Renewable energy supply chain in Ostrobothnia region and Vaasa city: Innovative framework. *Renew. Sustain. Energy Rev.* 2013, 23, 405–411. (In English) [CrossRef]
21. Marroquin, M.S.; Fontes, C.; Freires, F. Sustainable and renewable energy supply chain: A system dynamics overview. *Renew. Sustain. Energy Rev.* 2018, 82, 247–259. [CrossRef]
22. Wee, H.M.; Yang, W.H.; Chou, C.W.; Padilan, M.V. Renewable energy supply chains, performance, application barriers, and strategies for further development. *Renew. Sustain. Energy Rev.* 2012, 16, 5451–5465. [CrossRef]
23. de Meyer, A.; Catryssse, D.; Rasimäki, J.; van Orshoven, J. Methods to optimise the design and management of biomass-for-bioenergy supply chains: A review. *Renew. Sustain. Energy Rev.* 2014, 31, 657–670. [CrossRef]
24. Wolfsmeyr, U.J.; Rauch, P. The primary forest fuel supply chain: A literature review. *Biomass Bioenergy* 2014, 60, 203–221. [CrossRef]
25. Rentizelas, A.A.; Tolis, A.J.; Tatsiopoulos, P.I. Logistics issues of biomass: The storage problem and the multi-biomass supply chain. *Renew. Sustain. Energy Rev.* 2009, 13, 887–894. [CrossRef]
26. Balaman, Ş.Y.; Selim, H. Biomass to Energy Supply Chain Network Design: An Overview of Models, Solution Approaches and Applications. *Handb. Bioenergy 2015*, 1–35. [CrossRef]
27. Iakovou, E.; Karagiannidis, A.; Vlachos, D.; Toka, A.; Malamakis, A. Waste biomass-to-energy supply chain management: A critical synthesis. *Waste Manag.* 2010, 30, 1860–1870. [CrossRef]
28. Sharma, B.; Ingalls, R.G.; Jones, C.L.; Khanchi, A. Biomass supply chain design and analysis: Basis, overview, modeling, challenges, and future. *Renew. Sustain. Energy Rev.* 2013, 24, 608–627. [CrossRef]
29. Gold, S. Bio-energy supply chains and stakeholders. *Mitig. Adapt. Strateg. Glob. Chang.* 2011, 16, 439–462. [CrossRef]
30. Mirkouei, A.; Haapala, K.R. A network model to optimize upstream and midstream biomass-to-bioenergy supply chain costs 2015, 2, 1–11. [CrossRef]
31. Yuan, J.; Sun, S.; Shen, J.; Xu, Y.; Zhao, C. Wind power supply chain in China. *Renew. Sustain. Energy Rev.* 2014, 39, 356–369. (In English) [CrossRef]
32. Zhang, S.; Li, X. Large scale wind power integration in China: Analysis from a policy perspective. *Renew. Sustain. Energy Rev.* 2012, 16, 1110–1115. [CrossRef]
33. Magagna, D.; Shortall, R.; Telsnig, T.; Uhllein, A.; Hernández, C.V. *Supply Chain of Renewable Energy Technologies in Europe*; Publications Office of the European Union: Luxemburg, 2017.
34. Wüstemeyer, C.; Madlener, R.; Bunn, D.W. A stakeholder analysis of divergent supply-chain trends for the European onshore and offshore wind installations. *Energy Policy* 2015, 80, 36–44. [CrossRef]
35. Davies, J; Joglekar, N. Supply Chain Integration, Product Modularity, and Market Valuation: Evidence from the Solar Energy Industry. *Prod. Oper. Manag.* 2013, 22, 1494–1508. [CrossRef]
36. Cotrell, J.R. Hydropower Manufacturing and Supply Chain Analysis. Available online: https://www.osti.gov/servlets/purl/1416135 (accessed on 30 April 2020).
37. Kariuki, D. *Barriers to Renewable Energy Technologies Development*; Keele University: Newcastle-under-Lyme, UK, 2018. [CrossRef]
38. Seetharaman, A.; Sandanaraj, L.L.; Moorthy, M.K.; Saravanan, A.S. Enterprise framework for renewable energy. *Renew. Sustain. Energy Rev.* 2016, 54, 1368–1381. [CrossRef]
39. Mafakheri, F.; Nasiri, F. Modeling of biomass-to-energy supply chain operations: Applications, challenges and research directions. *Energy Policy* 2014, 67, 116–126. [CrossRef]
40. Luthra, S.; Kumar, S.; Garg, D.; Haleem, A. Barriers to renewable/sustainable energy technologies adoption: Indian perspective. *Renew. Sustain. Energy Rev.* 2015, 41, 762–776. [CrossRef]
41. Engelken, M.; Römer, B.; Drescher, M.; Welpe, I.M.; Picot, A. Comparing drivers, barriers, and opportunities of business models for renewable energies. A review. *Renew. Sustain. Energy Rev.* 2016, 60, 795–809. [CrossRef]
42. Moorthy, K.; Patwa, N.; Gupta, Y. Breaking barriers in deployment of renewable energy. *Helijon* 2019, 5, e01166.
43. Jaisat, L.; Hattar, C. The Awareness of Renewable Energy efficiency for Supply Chain Management. *Energies* 2017, 10, 1618.
44. Gordo, E.; Khalaf, N.; Strangeowl, T.; Dolino, R.; Bennett, N. Factors affecting solar power production efficiency. *Supercomput. Chall. Miyamura High Sch.* 2015, 7, 5.
45. Notton, G.; Nivet, M.L.; Voyant, C.; Paoli, C.; Darras, C.; Motte, F.; Fouilloy, A. Intermittent and stochastic character of renewable energy sources: Consequences, cost of intermittence and benefit of forecasting. Renew. Sustain. Energy Rev. 2018, 87, 96–105. [CrossRef]

46. Boulakibar, M.; Lebrouhi, B.; Kousksou, T.; Smouh, S.; Jamil, A.; Maaroufi, M.; Zazi, M. Towards a large-scale integration of renewable energies in Morocco. J. Energy Storage 2020, 32, 101806. [CrossRef] [PubMed]

47. Miller, M.; Cox, S. Overview of Variable Renewable Energy Regulatory Issues: A Clean Energy Regulators Initiative Report; National Renewable Energy Lab,(NREL): Golden, CO, USA, 2014.

48. Lam, H.L.; Varbanov, P.S.; Klemes, J. J. Optimisation of regional energy supply chains utilising renewables: P-graph approach. Comput. Chem. Eng. 2010, 34, 782–792. [CrossRef]

49. Alemán-Nava, G.S.; Casiano-Flores, V.H.; Cárdenas-Chávez, D.L.; Díaz-Chavez, R.; Scarlat, N.; Mahlknecht, J.; Dallemand, J.-F.; Parra, R. Renewable energy research progress in Mexico: A review. Renew. Sustain. Energy Rev. 2014, 32, 140–153. [CrossRef]

50. Bensch, G. The effects of market-based reforms on access to electricity in developing countries: A systematic review. J. Dev. Eff. 2019, 11, 165–188. [CrossRef]

51. Streimikiene, D.; Bruneckiene, J.; Cibinskaite, A. The review of electricity market liberalization impacts on electricity prices. Transform. Bus. Econ. 2013, 12, 30.

52. Choukri, K.; Naddami, A.; Hayani, S. Renewable energy in emergent countries: Lessons from energy transition in Morocco. Energy Sustain. Soc. 2017, 7, 25. [CrossRef]

53. Sovacool, B.K. Reviewing, reforming, and rethinking global energy subsidies: Towards a political economy research agenda. Ecol. Econ. 2017, 135, 150–163. [CrossRef]

54. Li, H.; Bao, Q.; Xie, Y.; Ren, J.; Yang, Y. Reducing rebound effect through fossil subsidies reform: A comprehensive evaluation in China. J. Clean. Prod. 2017, 141, 305–314. [CrossRef]

55. Mondal, M.A.H.; Kamp, L.M.; Pachova, N.I. Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh—An innovation system analysis. Energy Policy 2010, 38, 4626–4634. [CrossRef]

56. El-Karmi, F.Z.; Abu-Shikhah, N.M. The role of financial incentives in promoting renewable energy in Jordan. Renew. Energy 2013, 57, 620–625. [CrossRef]

57. Yaqoot, M.; Diwan, P.; Kandpal, T.C. Review of barriers to the dissemination of decentralized renewable energy systems. Renew. Sustain. Energy Rev. 2014, 32, 140–153. [CrossRef]

58. Darr, M.J.; Shah, A. Biomass storage: An update on industrial solutions for baled biomass feedstocks. Biofuels 2012, 3, 321–332. [CrossRef]

59. Nivet, M.L.; Notton, G.; Boyer, J.M.; Jezequel, S. Towards a large-scale integration of renewable energies in Morocco. J. Energy Storage 2020, 32, 101806. [CrossRef] [PubMed]

60. Thanki, S.; Thakkar, J. A quantitative framework for lean and green assessment of supply chain performance. Int. J. Product. Perform. Manag. 2018, 67, 366–400. [CrossRef]

61. Galankashi, M.R.; Memari, A.; Anjomshoae, A.; Ma’aram, A.; Helmi, S.A. Selection of supply chain performance measurement frameworks in electrical supply chains. Int. J. Ind. Eng. Manag. 2014, 5, 131–137. (In English)

62. Jouenne, T. Les quatre leviers de la logistique durable. Rev. Française Gest. Ind. 2010, 29, 1–24.

63. Lehyani, F.; Zouari, A. Towards modeling the supply chain’s performance evaluation criteria, presented at the First International Conference on Transportation and Logistics (ICTL 2015). Sousse, Tunisia, 13 May 2015; Available online: https://hal.archives-ouvertes.fr/hal-01893165 (accessed on 21 April 2020).

64. Zervos, A.; Lins, C.; Tesnière, L.; Smith, E. Mapping Renewable Energy Pathways Towards 2020; European Renewable Energy Council: Brussels, Belgium, 2011; p. 6.

65. Ahmad, K.; Zabi, S.M. The deployment of performance measurement system under the supply chain management environment: The case of Malaysian manufacturing companies. Manag. Prod. Eng. Rev. 2018, 9, 3–12. (In English) [CrossRef]

66. Eckerson, W.W. Performance Dashboards: Measuring, Monitoring, and Managing Your Business; John Wiley & Sons: Hoboken, NJ, USA, 2010.

67. Bunse, K.; Vodicka, M.; Schönsleben, P.; Brühlart, M.; Ernst, F.O. Integrating energy efficiency performance in production management-Gap analysis between industrial needs and scientific literature. J. Clean. Prod. 2011, 19, 667–679. [CrossRef]

68. Pramangioulis, D.; Atsonios, K.; Nikolopoulos, N.; Rakopoulos, D.; Grammelis, P.; Kakaras, E. A methodology for determination and definition of key performance indicators for smart grids development in island energy systems. Energies 2018, 11, 305. [CrossRef]

69. Demirgöz, O. Evaluating the best renewable energy technology for sustainable energy planning. Int. J. Energy Econ. Policy 2013, 3, 23–33.

70. Cambero, C.; Sowlati, T. Assessment and optimization of forest biomass supply chains from economic, social and environmental perspectives-A review of literature. Renew. Sustain. Energy Rev. 2014, 36, 62–73. [CrossRef]

71. Union, E. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Off. J. Eur. Union 2009, 5, 2009.

72. Kousksou, T.; Bruel, P.; Jamil, A.; el Rhoufi, T.; Zeraouli, Y. Energy storage: Applications and challenges. Sol. Energy Mater. Sol. Cells 2014, 120, 59–80. [CrossRef]
73. Koohi-Fayegh, S.; Rosen, M. A review of energy storage types, applications and recent developments. *J. Energy Storage* 2020, 27, 101047. [CrossRef]
74. Morocco: Azelio in Solar Storage Venture. Available online: https://www.africa-energy.com/article/morocco-azelio-solar-storage-venture (accessed on 21 April 2020).
75. National Research Council. *The Power of Renewables: Opportunities and Challenges for China and the United States*; National Academies Press: Washington, DC, USA, 2011.
76. Tran, T.T.D.; Smith, A.D. Evaluation of renewable energy technologies and their potential for technical integration and cost-effective use within the U.S. energy sector. *Renew. Sustain. Energy Rev.* 2017, 80, 1372–1388. [CrossRef]
77. Verbruggen, A.; Fischel, M.; Moomaw, W.; Weis, T.; Nadaï, A.; Nilsson, L.J.; Nyboer, J.; Sathaye, J. Renewable energy costs, potentials, barriers: Conceptual issues. *Energy Policy* 2010, 38, 850–861. [CrossRef]
78. Masini, A.; Menichetti, E. Investment decisions in the renewable energy sector: An analysis of non-financial drivers. *Technol. Forecast. Soc. Chang.* 2013, 80, 510–524. [CrossRef]
79. Komendantova, N.; Patt, A.; Williges, K. Solar power investment in North Africa: Reducing perceived risks. *Renew. Sustain. Energy Rev.* 2011, 15, 4829–4835. [CrossRef]
80. Amer, M.; Daim, T.U. Application of technology roadmaps for renewable energy sector. *Technol. Forecast. Soc. Chang.* 2010, 77, 1355–1370. [CrossRef]
81. Emomi, N. Integrating Renewable Energy and Smart Grid Technology into the Nigerian Electricity Grid System. *Smart Grid Renew. Energy* 2014, 5, 220–238. [CrossRef]
82. de, G.K.; Albert, M. Towards Efficient Administrative Procedures for Renewable Energy Projects? The Dutch Experience with the Crisis and Recovery Act. In *Renewable Energy Law in the EU*; Edward Elgar Publishing: Cheltenham, UK, 2014.
83. Toklu, E.; Güney, M.; Işık, M.; Comakli, O.; Kaygusuz, K. Energy production, consumption, policies and recent developments in Turkey. *Renew. Sustain. Energy Rev.* 2010, 14, 1172–1186. [CrossRef]
84. İskınsungur, Ö.D. Regulatory Framework for Development of Renewable Energy Generation in Turkey. In *Renewable Energy*; Springer: Berlin, Germany, 2019; pp. 159–179.
85. Ibrahim, M.; Khair, A.; Ansari, S. A review of hybrid renewable energy systems for electric power generation. *Int. J. Eng. Res. Appl.* 2015, 5, 42–48.
86. Bhandari, B.; Poudel, S.R.; Lee, K.-T.; Ahn, S.-H. Mathematical modeling of hybrid renewable energy system: A review on small hydro-solar-wind power generation. *Int. J. Precis. Eng. Manuf. Green Technol.* 2014, 1, 157–173. [CrossRef]
87. Bajpai, P.; Dash, V. Hybrid renewable energy systems for power generation in stand-alone applications: A review. *Renew. Sustain. Energy Rev.* 2012, 16, 2926–2939. [CrossRef]
88. Rekioua, D. *Hybrid Renewable Energy Systems: Optimization and Power Management Control*; Springer Nature: Berlin/Heidelberg, Germany, 2019.
89. Koj, J.C.; Wulf, C.; Zapp, P. Environmental impacts of power-to-X systems-A review of technological and methodological choices in Life Cycle Assessments. *Renew. Sustain. Energy Rev.* 2019, 112, 865–879. [CrossRef]
90. Li, X.; Yang, X.; Zhou, G.Y.; Mu, S.; Lemmon, J. Sustainable energy ecosystem based on Power to X technology. *Int. Conf. Appl. Energy* 2019, 112, 865–879. [CrossRef]
91. Kaya, O. Hierarchical MPC for Energy Management of Multi-Energy Systems: Case Study Based on a Power-to-X Concept. In *Proceedings of the 2020 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe)*; The Hague, The Netherlands, 26–28 October 2020.
92. Rachidi, N.N.S.; Hirt, A.; Ourya, I.; Ouchani, F.Z.; Ghenniou, A.; Benmeziane, M.; Ikken, B. La filière des « Power-TO-X »: Un gisement de pétrole vert pour le Royaume. *Le Mag. de la Fédération de l’Énergie* 2020, 5, 42–48.
93. Safarzadeh, S.; Rasti-Barzoki, M. A game theoretic approach for pricing policies in a duopolistic supply chain considering energy productivity, industrial rebound effect, and government policies. *Energy* 2019, 167, 92–105. [CrossRef]
94. Redouane, A.; Masaki, M.; Meijer, M.; Essakkati, H. Business Opportunities Report for Morocco’s Renewable Energy Sector; Netherlands Enterprise Agency RVO: Utrecht, The Netherlands, 2018.
95. Alizamir, S.; de Ricourt, F.; Sun, P. Efficient feed-in-tariff policies for renewable energy technologies. *Oper. Res.* 2016, 64, 52–66. [CrossRef]
96. Rickerson, W. Feed-in Tariffs as a Policy Instrument for Promoting Renewable Energies and Green Economies in Developing Countries; UNEP: Nairobi, Kenya, 2012.
97. Meyer-Renschhausen, M. Evaluation of feed-in tariff-schemes in African countries. *J. Energy South. Afr.* 2013, 24, 1–20. [CrossRef]
98. Xin-gang, Z.; Ling, W.; Ying, Z. How to achieve incentive regulation under renewable portfolio standards and carbon tax policy? A China’s power market perspective. *Energy Policy* 2020, 143, 111576. [CrossRef]
99. Bu, Y.; Zhang, X. The prospect of new provincial renewable portfolio standard in China based on structural data analysis. *Front. Energy Res.* 2020, 8, 59. [CrossRef]
100. Kaur, A.; Bhardwaj, R. Sustainable Supply Chain through Greater Customer Engagement. In *Green Practices and Strategies in Supply Chain Management*; IntechOpen: London, UK, 2019.
101. Marchi, B.; Zanoni, S. Supply chain management for improved energy efficiency: Review and opportunities. *Energies* 2017, 10, 1618. [CrossRef]
102. Gong, M.; Gao, Y.; Koh, L.; Sutcliffe, C.; Cullen, J. The role of customer awareness in promoting firm sustainability and sustainable supply chain management. *Int. J. Prod. Econ.* 2019, 217, 88–96. [CrossRef]

103. Espe, E.; Potdar, V.; Chang, E. Prosumer communities and relationships in smart grids: A literature review, evolution and future directions. *Energies* 2018, 11, 2528. [CrossRef]

104. Schwieters, N. Customer engagement in an era of energy transformation. *Puc Glob. Power Util.* 2016, 5, 1–24.

105. Xie, G. Modeling decision processes of a green supply chain with regulation on energy saving level. *Comput. Oper. Res.* 2015, 54, 266–273. [CrossRef]

106. Chen, B.; Xie, W.; Huang, F.; Li, X. Energy-saving and pricing decisions in a sustainable supply chain considering behavioral concerns. *PLoS ONE* 2020, 15, e0236354. [CrossRef] [PubMed]

107. Javadi, T.; Alizadeh-Basban, N.; Asian, S.; Hafezalkotob, A. Pricing policies in a dual-channel supply chain considering flexible return and energy-saving regulations. *Comput. Ind. Eng.* 2019, 135, 655–674. [CrossRef]

108. Capuano, L. *International Energy Outlook 2018 (IEO2018)*; US Energy Information Administration (EIA): Washington, DC, USA, 2018; p. 21.

109. Hannah, E. Murdock, Duncan Gibb and Thomas André. In *Renewables 2019 Global Status Report*; REN21: Paris, France, 2019.

110. Skea, J.; van Diemen, R.; Hannon, M.; Gazis, E.; Rhodes, A. *Energy Innovation for the Twenty-First Century*; Edward Elgar Publishing: Cheltenham, UK, 2019.

111. Huang, C.; Su, J.; Zhao, X.; Sui, J.; Ru, P.; Zhang, H.; Wang, X. Government funded renewable energy innovation in China. *Energy Policy* 2012, 51, 121–127. [CrossRef]

112. Wang, F.; Yin, H.; Li, S. China’s renewable energy policy: Commitments and challenges. *Energy Policy* 2010, 38, 1872–1878. [CrossRef]

113. Spencer, D. *BP Statistical Review of World Energy Statistical Review of World*; BP: London, UK, 2019; Volume 68, pp. 1–69.

114. Liu, Q.; Lei, Q.; Xu, H.; Yuan, J. China’s energy revolution strategy into 2030. *Ressour. Conserv. Recycl.* 2018, 128, 78–89. [CrossRef]

115. Browner, C.M.; Baussan, D.; Bovarnick, B.; Hernandez, M.; Kasper, M. *Clean Energy Investment in the United States: The View to 2030*; Center for American Progress: Washington, DC, USA, 2014; pp. 1–13.

116. US Energy Information Administration. International Energy Outlook. 2010. Available online: https://www.eia.gov/outlooks/ieo/index.php (accessed on 21 April 2020).

117. Aslani, A.; Helo, P.; Naaranoja, M. Role of renewable energy policies in energy dependency in Finland: System dynamics approach. *Appl. Energy* 2014, 113, 758–765. (In English) [CrossRef]

118. Peura, P.; Hyttinen, T. The potential and economics of bioenergy in Finland. *J. Clean. Prod.* 2011, 19, 927–945. [CrossRef]

119. Finland, S.; Piirainen, A. Metadata-Enriched Statistical Production at Statistics Finland. In Proceedings of the Nordic Statistical Meeting, Helsinki, Finland, 26–28 August 2019.

120. Chatterjee, S.K. The Renewable Energy Policy Dilemma in India: Should Renewable Energy Certificate mechanism compete or merge with the Feed-in-Tariff Scheme? *Harv. Kennedy Sch. Mossavar Rahmani Cent. Bus. Gov.* 2017, 61.

121. Sharma, N.K.; Tyagi, N.; Rana, V. Renewable Energy Scenario in India: A Current Status. *Gas* 2019, 637, 1–18.

122. Fritzschke, K.; Zejli, D.; Tänzler, D. The relevance of global energy governance for Arab countries: The case of Morocco. *Energy Policy* 2011, 39, 4497–4506. [CrossRef]

123. Leidreter, A.; Boselli, F. 100% Renewable energy: Boosting development in Morocco. *World Future Counc.* 2015, 11, 12–20.

124. Šimelytė, A. Promotion of renewable energy in Morocco. In *Energy Transformation Towards Sustainability*; Elsevier: Amsterdam, The Netherlands, 2020; pp. 249–287.

125. Azeroual, M.; el Makrini, A.; el Moussaoui, H.; el Markhi, H. Renewable Energy Potential and Available Capacity for Wind and Solar Power in Morocco Towards 2030. *J. Eng. Sci. Technol. Rev.* 2018, 11, 1–24. [CrossRef]

126. Erdoğan, S.; Gedikli, A.; Genç, S.Y. An overview of Turkey’s national energy policies. *Politico Econ. Eval. Curr. Issues* 2018, 143.

127. Menr, M.K. *Ministry of Energy and Natural Resources; Ministry of Energy and Natural Resource*: Ankara, Turkey, 2012.