Renewable Energy Supply Chain

Subjects: Business

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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”.

Keywords: Renewable Energy ; Supply Chain

1. Introduction

The renewable energy supply chain 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) [1][2]. Alternatively, the RESC can be divided into three processes as upstream, production, and downstream (see Figure 1) [3]. 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 [4].

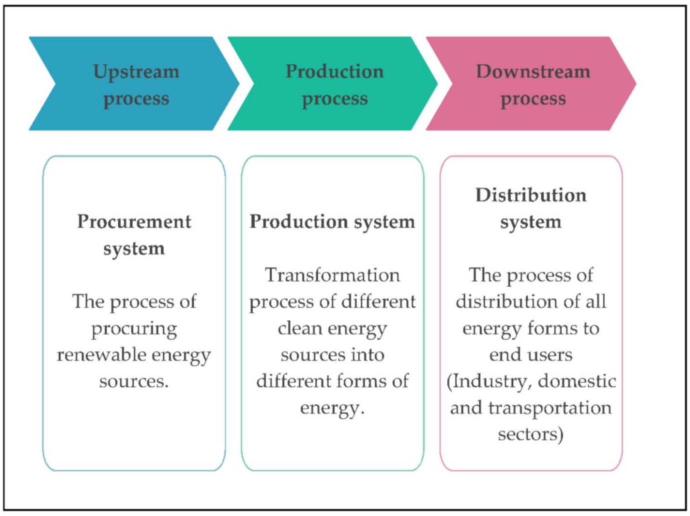

Figure 1. Renewable energy supply chain [3].

The renewable energy supply chain differs following the renewable energy source (biomass, wind, solar, hydropower, geothermal) (see Figure 2) [3][5]. A brief overview of the specific supply chain for each renewable energy source is given below.

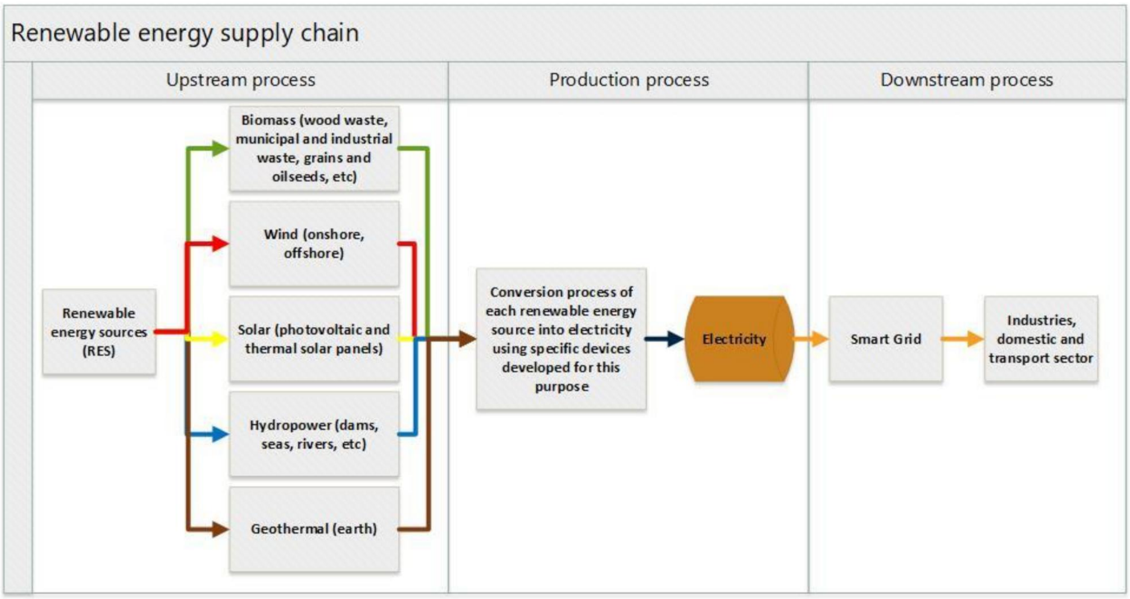

Figure 2. Supply chain by renewable energy sources [3][5].

(a) The energy supply chain for biomass resources:

The energy supply chain for biomass includes three processes [5] 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 [6][7].

The decision-making system specific to the biomass supply chain can be viewed from three levels [5][8][9]:

- **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 [10][11]. 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 [8][12].

(b) The energy supply chain for wind resources:

Similarly, the energy supply chain from wind contains three processes [5][13][14] 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 [15].

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 [16].

(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 [17]. 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 [18].

(e) The energy supply chain for geothermal resources:

The geothermal energy supply chain is based on three main processes [5] 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 [15].

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 [19]. 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 [20][21].

(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 socioeconomic 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 [22][23].

(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 [20].

(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 [24][25].

(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 [26].

(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 [7]. 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 [27].

(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 [13][14]: 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 [4][28][29] 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.

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