

Circular economy, energy transition, and role of hydrogen

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This article contributes to:



Abstract

Circularity is not a new concept. Activities such as reuse or recycling have been around for centuries. Today, an urgent solution to tackle the increasing harmful emissions resulting in severe climate changes is being proposed and investigated. This is because a link between industry and environment is critically important for business. A more sustainable socio-technical system is therefore urgently needed. There has been a rapid growth of academic articles on the circular economy. The circular economy concept has been considered a solution to many of today's challenges, including resource scarcity and waste generation.

Keywords: Circular economy; Energy transition; Hydrogen

1. Circular economy definition

Recent technology in renewable energy such as the development of biofuel [1]–[3] and electric vehicle [4], [5] has attracted numerous attention. Today, researchers have shown an increased interest in circular economy. By closing the loop production patterns in an economic system, circular economy tries to increase the resource use efficiency, thus achieving an improved balance and harmony between economy, environment, and society. The concept of circular economy concept has attracted much attention from both scholars and practitioners. Circular economy is often defined as a combination of reduce, reuse, and recycle activities. It operates at three levels: (1) micro level (products, companies, consumers), (2) meso level (eco-industrial parks), and (3) macro level (city, region, nation and beyond) [6].

Despite its trend, circular economy is difficult to define. Circular economy has different meanings to different people. There are numerous possibilities to define circular economy [7]. In an effort to conceptualize the circular economy employing an analysis of over 100 definitions, Kirchherr et al. [6] defined circular economy as an economic system which substitutes the 'end-of-life' model by reducing, reusing, recycling resources in the production, distribution, and consumption processes. The circular economy aims particularly to simultaneously achieve economic prosperity, environmental quality, and social equity for the benefit of current as well as future generations.

Lieder and Rashid [7] proposed a comprehensive circular economy framework based on three perspectives (environmental impact, resource scarcity, and economic benefits) along with their relationships as illustrated in Figure 1. In terms of environmental impact, a population with the lowest environmental impacts is always desirable. Therefore, landfill, solid waste, and other emissions should be minimized by means of reuse, remanufacturing, and recycling. Moreover, as far as the resource scarcity is concerned, finite supplies of resource make its regenerative utilization compulsory for circular economy realization. Regarding the economic benefits to secure profitability as well as a competitive edge, an integrative approach is required.

The concept of circular economy has been the subject for many studies as it is regarded as a business operationalization to execute the ambiguous sustainable development concept [8], [9]. This is because the concept of sustainable development is unclear, difficult to implement, thus starting to lose momentum. Some authors even ridicule sustainable development as a 'theoretical dream' [10] and 'sustainable' [11]. The relationship between circular economy and sustainable development was found to be weak [6].

Article info

Submitted:
2022-05-14

Edited:
2022-06-07

Published:
2022-06-08



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Publisher

Universitas Muhammadiyah
 Magelang

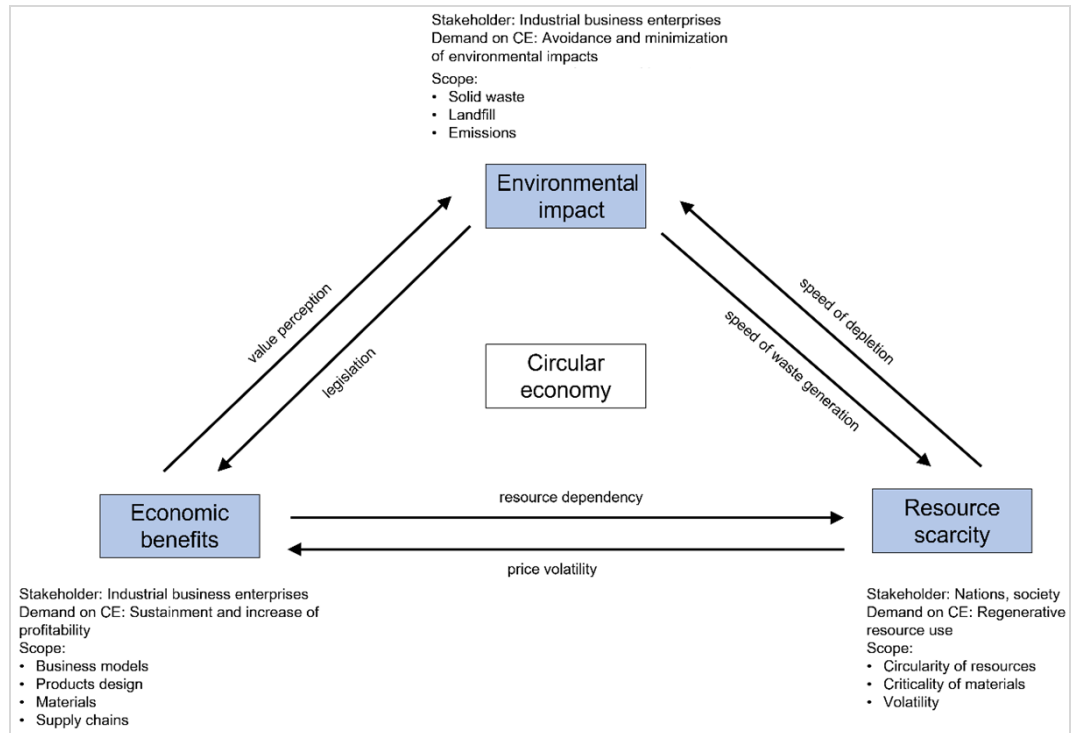


Figure 1. Circular economy framework proposed by Lieder and Rashid. Reproduced from [7]

2. Energy transition trend

Global climate change as well as depleting petroleum supplies have forced us to consider sustainable energy systems. Several countries have been successful such as Brazil which has successfully shifted from a petrol-based fuel to a sugarcane-ethanol biofuel [12]. Various factors may promote and accelerate energy transition, which are interrelated [13]. These include (i) the depleted and shortage supply, (ii) higher cost of one energy source compared to another, (iii) pollution from one energy source, (iv) technological change and innovation, and (v) efficiency improvements. All of these may speed up the energy transition.

Today, the world is undergoing an energy transition. Human civilization has been tied to petroleum-based fossil fuels in the last century, creating strong dependency between the two. We cannot deny the fact that fossil fuels have resulted in major technological breakthrough. One of the biggest shortcomings of conventional fossil fuels is the rising pollution. The detrimental effects from fossil fuels can be seen in various forms with the most prominent one being linked to the climate change. From the perspective of society, climate changes signify the major reason for an energy transition, which is unfortunately often considered economically unprofitable.

The current situation does not provide evidence that we are moving towards successful energy transition. A significant huge proportion of the global economy is still powered by conventional fossil fuels. However, it is not also suggesting that we are at the beginning of the energy transition. This is because energy transition had probably started a couple of decades ago when new energy sources such as wind and solar were firstly realized prior to massive renewable energy sector expansion. Technological development from this stage led to significant scientific breakthrough, especially in the utilization of hydrogen. The role of hydrogen role as an important part in the energy transition was realized from the beginning of the 21st century.

3. Role of hydrogen

Hydrogen (H₂) as a unique technological symbol of energy transition with zero carbon dioxide as well as greenhouse gasses emissions, unceasingly induced inquisitiveness and hope for future energy development. Despite the lengthy and expensive development path to practical and established technology, H₂ shows a promising trait. For that reason, hydrogen nowadays has an indispensable role in the renewable energy sector [14]. Electrolysis is renowned as a crucial process with the greatest possibility for decarbonisation. However, the focal problem is still the economic facet of the development so the essential role remains in the research and development area to reduce the production costs.

Authors' Declaration

Funding – No funding information from the author.

Availability of data and materials - All data are available from the author.

Competing interests - The author declares no competing interest.

Additional information – No additional information from the author.

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