Utilize Human Kinetic Energy for Sustainable Energy Generation

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Renewable energy has become increasingly relevant in recent years as concerns about climate change and the depletion of fossil fuels have grown across the globe. The energy generated through exercise, sports, and other forms of physical exertion can be harnessed and used to generate electricity for homes, businesses, and even communities. This type of energy generation is becoming increasingly popular as a means of generating renewable energy and reducing our dependence on non-renewable sources of energy.

COVID-19 gym human kinetic energy renewable energy sustainable development

1. Introduction

Renewable energy has become increasingly relevant in recent years as concerns about climate change and the depletion of fossil fuels have grown across the globe. An interesting area of exploration within this context, though not a major contributor to the overall energy balance, is human kinetic energy (HKE). This concept pertains to the energy generated by the movement of individuals and can be harnessed through various means that include the use of treadmills, bicycles, or other exercise equipment. People who are frequently visiting gymnasium centers for recreation or sports, also known as gym-goers, emerge as a potentially significant source of HKE because they engage in regular and intense physical activity. While research on harnessing HKE for renewable energy generation is still in its early stages, it holds the potential to contribute significantly to the renewable energy mix in various localities and regions. Offering intriguing possibilities for sustainability and energy awareness, HKE can promote a more informed approach to energy generation and consumption. However, the success of this approach depends on consumer willingness to participate, and it is important to understand how this willingness may be impacted by various factors, such as the COVID-19 pandemic.

The energy generated through exercise, sports, and other forms of physical exertion can be harnessed and used to generate electricity for homes, businesses, and even communities. This type of energy generation is becoming increasingly popular as a means of generating renewable energy and reducing our dependence on non-renewable sources of energy. Still, the number of academic studies on the topic remains limited. In recent years, there have been numerous initiatives to harness HKE for energy generation [1][2]. Although most efforts cannot be traced beyond initial proposals, special exercise equipment has been developed that captures the energy generated by users and converts it into electricity [3]. This type of equipment is envisioned to be eventually installed in gyms, parks, and other public spaces, where people can exercise and generate electricity at the same time. Additionally, scholars highlighted the possibility of engineering wearable and implantable solutions that can be employed to

power an individual's personal gadgets and devices [4]. The two most promising technologies that are being actively studied in the context of HKE include triboelectric and piezoelectric nanogenerators, both of which can be leveraged to create miniature devices that are capable of energy harvesting and conversion [4]. Apart from traditional generators, other proposed solutions include electrostatic energy converters as well as electromagnetic induction generators based on smart materials that change their properties in response to certain physical stimuli.

While HKE is currently not a significant source of renewable energy, it holds broader implications for sustainability by contributing to energy efficiency in specific settings and stimulating discussions about sustainability. However, its implementation is associated with certain challenges. For example, there are concerns about the cost of installing HKE systems, as well as the sustainability of the energy generated through these systems. There are also questions about the efficiency of HKE systems and their ability to generate significant amounts of electricity [5]. Although an individual might be receptive to using a small portable HKE-generating device, there are expected to be objections to implantable solutions and burdensome wearable frames or exoskeletons. On the other hand, researchers mention that insufficient output power and storage constraints create a bottleneck in the sphere's development until efficient HKE-generating equipment can be introduced to the public [1][6]. Although the energy conversion efficiency of HKE-based renewable energy generation is currently limited, with harvested energy levels reported in the microwatts range [5], there is ongoing research focused on improving the efficiency by altering physical and geometric parameters of harvesters. Some studies have reported generated electricity values ranging from 0.25 W to 7.4 [1][2][5], demonstrating the potential for this approach to contribute to the overall renewable energy mix if efficiency improvements can be achieved. Despite these challenges, HKE remains a promising area of research and development, and many believe that it will play an important role in our transition to a more sustainable energy future.

2. Consumer Attitudes and Behaviors towards Renewable Energy

Consumer attitudes and behaviors towards renewable energy are important factors in the transition to a more sustainable energy mix. A number of studies investigated consumer attitudes and behaviors towards renewable energy, with a focus on factors such as awareness, knowledge, willingness to pay, and willingness to participate in renewable energy generation [7]. One of the key findings from these sources is that consumer awareness and knowledge of renewable energy are generally low, as many consumers have a limited understanding of the benefits and potential associated with renewable energy [8][9]. For example, several international studies found that only a limited portion of participants tends to have a good understanding of renewable energy, while the majority show various misconceptions about the costs and feasibility of renewable energy [10][11]. A lack of knowledge can be a barrier to the adoption of renewable energy solutions. In comprehensive research focused on Greek consumers, Ntanos et al., demonstrated that only 28% of respondents were willing to cover the additional cost of renewable energy [12]. Although these observations are often tied to a lack of understanding of renewable energy's benefits, another concern pertains to the inadequate competitiveness of green energy solutions [13]. On the other hand, most researchers tend to agree that a certain group of consumers have a strong positive attitude towards

renewable energy and are willing to cover the premium cost. The size of the group encompassing environment-conscious consumers varies from country to country [14]. Still, several authors showed that at least 10% are willing to pay a premium for renewable energy despite the supposed advantages of fossil fuels [15]. Factors that have been found to influence consumer attitudes and behaviors toward renewable energy positively include environmental concerns, government regulations, and social norms.

As evidenced by the overview of studies mentioned above, there are limited results on this specific topic. However, some authors have investigated the consumers' attitudes and behaviors towards renewable energy in general. A comprehensive categorization of 58 articles on the topic by El Haffar et al., highlighted the consumers' willingness to pay for green electricity, which includes renewable energy, while indicating that a significant proportion of consumers are willing to pay a premium for green electricity [8]. Similarly, a study by Ayodele at al. found that Nigerian consumers who are environmentally conscious are more willing to adopt renewable energy solutions [14]. Another study in Greece focused on the factors that influence public perceptions towards renewable energy and found that environmental awareness, trust in the government, and personal values were significant factors [12]. Regarding the use of HKE for renewable energy generation specifically, there is a lack of research on consumer attitudes and behaviors. However, a study by Liobikienė and Dagiliūtė suggests that while consumers are generally willing to participate in HKE generation, the extent of their willingness is dependent on the perceived benefits of HKE generation [13]. In the given context, more research is needed on the use of HKE for renewable energy generation and consumers' attitudes and behaviors towards it.

3. Impact of COVID-19 on Industries and Consumer Behaviors

The COVID-19 pandemic had a significant impact on various industries, including the fitness industry. Many gyms closed or experienced reduced capacity due to social distancing measures. Multiple sources from different countries revealed that both private and public gyms were closed during the pandemic, while some only experienced reduced capacity [16][17][18]. The phenomenon resulted in a decline in the number of gym-goers leading to a gradual shift towards home-based workouts [19]. This has significant implications for the use of HKE for renewable energy generation, as the reduction in the number of gym-goers directly translates to a diminished potential for HKE to be generated. While most studies focused on the period of strictest anti-COVID-19 measures found that the number of gym-goers declined, several authors confirm that a significant portion of people unable to visit gyms reported doing more home-based workouts during the pandemic [20][21]. The shift towards home-based workouts also means that there are fewer opportunities for HKE to be captured and used for renewable energy generation. The described observations highlight the need for alternative methods of capturing HKE and finding ways to integrate it into renewable energy generation. In the given context, the impact of the pandemic on the fitness industry and how it has affected the potential for HKE generation is an important area for future research.

From another perspective, the emerging body of evidence suggests that the pandemic has led to an increase in consumer awareness due to growing concerns about the environment and sustainability [22]. These findings are likely connected to the increased focus on issues such as air quality and the need for clean energy during the

pandemic [23]. However, Caputo and Reichert propose that the pandemic has led to a decrease in consumer willingness to participate in programs that involve HKE generation, such as those requiring the use of exercise equipment to generate electricity (2020) [24]. The shift towards home-based workouts and the reduced number of gym-goers during the pandemic may have contributed to this change. Furthermore, the COVID-19 pandemic resulted in a significant shift concerning consumer attitudes and behaviors toward energy consumption, with a study by García et al., demonstrating that the pandemic has led to an increase in energy consumption as people spend more time at home (2021) [25]. Research suggests that there is a need for further investigation of the impact of the pandemic on the fitness industry and consumer behavior toward renewable energy and HKE generation, as well as alternative methods of capturing HKE [26]. This can provide valuable insights for policymakers, energy providers, and researchers in the field of renewable energy and HKE.

4. Renewable Energy and Saudi Vision 2030

Saudi Vision 2030 is a plan for the future development of Saudi Arabia that aims to diversify the economy and promote sustainable development. A key pillar of this plan is the development of a sustainable energy sector, with ambitious targets for the development of renewable energy, including HKE [27]. The country's authorities launched a number of initiatives and programs to support the development of renewable energy. One of the most notable examples is the National Renewable Energy Program, an initiative aimed at developing the technical and institutional capabilities needed to implement renewable energy projects [28]. As suggested by the available data, Saudi Arabia has yet to start investing in research and development in the field of HKE, with a focus on developing technologies to capture and convert HKE into electricity [29][30]. Overall, the literature review pointed to a multitude of sources of evidence reaffirming the importance of renewable energy in achieving sustainable development and its potential to contribute to the goals set by Saudi Vision 2030 [31]. Additionally, the Saudi government has set ambitious targets for the development of renewable energy, including HKE. For example, the Saudi Vision 2030 aims to increase the percentage of individuals engaging in regular exercise and athletic activities from 13% to 40% by promoting widespread participation in sports [32]. In line with this vision, Saudi Arabia has launched the National Renewable Energy Program managed by the Office of Renewable Energy Projects as part of the broader National Transformation Program [27].

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