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Technological Change and Sustainability: A Patent Analysis of a Human Muscle Energy Generation System

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Abstract

This article analyzes patent WO2015/115884 A1, which proposes a system for generating energy from human muscle power, aiming to contribute to the Sustainable Development Goals (SDGs), particularly in affordable energy (SDG 7), sustainable communities (SDG 11), and climate action (SDG 13). It addresses the technological potential, replicability, and impact of this system in various contexts, from urban to rural areas. The technology, which uses a stationary bicycle to generate energy, offers environmental and public health benefits. However, it faces challenges in mass adoption due to the high cost of components such as storage batteries. The S-Curve analysis reveals that this innovation is in an early stage of development, with a significant increase in patents since the year 2000. The article concludes that, to maximize its impact, it is necessary to overcome economic barriers through public policies that promote research and development (R&D) and create financial incentives from both the public and private sectors. This support would facilitate its implementation in communities with limited access to energy, promoting sustainability and reducing environmental impact.

Keywords: Human energy harvesting, Technological change, Technology transfer, Sustainable energy, Innovation diffusion.

1. Introduction

Energy has constituted a fundamental pillar for the development of humanity since ancient times. The earliest known records of its understanding date back to the 5th century BC, when the Greek philosopher Thales of Miletus documented the phenomenon of static electricity by observing the attraction between amber and a piece of rubbed cloth. Over time, figures such as Theophrastus in the 2nd century BC and Benjamin Franklin in the 18th century expanded the corpus of knowledge regarding electricity, thereby facilitating its application in everyday life (Aitken, 1984). However, it was in 1879 that Thomas Edison patented the incandescent light bulb, marking a significant turning point in the commercialization of electricity. Subsequently, Edison and George Westinghouse jointly inaugurated the first hydroelectric plant at Niagara Falls in 1895, thereby propelling the widespread adoption of electricity, which contributed to the second industrial revolution (IBERDROLA, 2022).

In the contemporary era, energy technologies have undergone a notable evolution, with a discernible shift towards a more sustainable approach. This is evidenced by the intensified efforts to reduce the environmental impact of energy systems and to enhance their overall efficiency(Popp et al., 2010). The development of renewable solutions, including hydroelectric plants, solar and wind energy, and the use of biomass, has led to an increased focus on environmentally friendly technologies(Teece, 2004). Nevertheless, considerable obstacles persist with regard to energy accessibility. As indicated by the World Bank (2020), approximately 10% of the global population remains without access to electricity.

In this context, human energy harvesting represents an innovative and sustainable solution that can be readily implemented on a large scale. These technologies, which harness energy generated by human movement, represent a viable alternative for generating electricity on a small scale, particularly in areas with limited access to conventional energy sources(Stoneman & Battisti, 2010). From portable electronic devices to stationary bicycles that generate electricity, human energy harvesting has the potential to make a significant contribution to sustainability and improve the quality of life, particularly in rural areas and marginalized communities.

Nevertheless, the widespread adoption of these technologies is impeded by a dearth of knowledge and dissemination, creating a disparity between the available technology and society, thus impeding technological change. This study underscores the significance of integrating theoretical principles with practical applications, particularly in the context of technologies that offer tangible solutions to pressing issues such as access to electricity.

To address this challenge, it is essential to analyze the theoretical aspects of invention patents in order to bring innovations closer to society and foster effective interaction between academia and industry, thus promoting technology transfer and the application of innovations in productive contexts(Assefa et al., 2016)(Arenas & González, 2018). Arenas and González (2018) highlight the complexity of the technology transfer process, which involves numerous actors and social factors. They posit that effective management of this process can facilitate the timely arrival of technologies in the market.

Furthermore, recent research indicates that inventors tend to devote less attention to discoveries originating from academic institutions than those emanating from industry. This presents a significant challenge in translating academic science into new technologies(Bikard, 2018). This underscores the necessity for enhanced interconnectivity between the academic and industrial realms to optimize the impact of innovations.

As evidenced by the correlation between patents and regional economic activity, technology transfer plays a pivotal role in the dissemination of knowledge and technological innovation (Ciaramella et al., 2017). As posited by Caviggioli and Ughetto (2013)(Caviggioli & Ughetto, 2013), patent transfer is not merely a strategic instrument for attaining economic advantages; it is also a conduit for technological dissemination that can engender positive impacts on competitiveness and economic advancement.

The patent selected for this study, titled "System for Generating Electrical Power From Muscle Energy With Control of Connection to a Supply Connection" (WO 2015/115884 A1) (Garza Galicia, A.,2015), was chosen with the aim of contributing to the achievement of the Sustainable Development Goals (SDGs), particularly those related to affordable and clean energy (SDG 7), the promotion of sustainable communities (SDG 11), and climate action (SDG 13). In accordance with the quadruple and quintuple helix models, these goals integrate the interactions between academia, industry, government, civil society, and the environment to generate innovations that respond to contemporary challenges(König et al., 2021). The implementation of patent WO 2015/115884 A1 would facilitate the development of practical solutions for energy generation in public and private settings, thereby reinforcing the principles of sustainability and resilience that are integral to the SDGs.

The objective of this article is to analyse the patent in question through the lenses of technology transfer theory, innovation diffusion, and intellectual property. Furthermore, an evaluation of its potential impact on energy sustainability and its capacity for replication and adaptation in low-infrastructure contexts will be conducted. To this end, the "S-curve" model will be employed, which will facilitate an understanding of the technology's life cycle and its current market position(Hernández Zarta et al., 2016). The following is a description of the structure of the article: Section 2 details the methodology used to analyze patent WO2015/115884 A1, focusing on its technological and economic potential. Section 3 presents the results of the analysis, including an examination of the patent's contribution to sustainable energy solutions and its applicability across different contexts. Section 4 discusses the main challenges related to the adoption and diffusion of this technology, with particular attention to economic barriers and the complexities of technology transfer. Finally, Section 5 concludes the study by highlighting the patent’s significance in terms of sustainability and offering recommendations for future research and policy development.

2. METHODOLOGY

2.1 Procedure

In order to conduct a comprehensive analysis of patent WO 2015/115884 A1, a methodological approach divided into three phases was adopted. This approach allowed the identification of the technological relevance of the patent, the assessment of its potential for technology transfer, and the analysis of its contribution to the Sustainable Development Goals (SDGs). The phases carried out are detailed below.

Phase 1: Identification of the patent and its technological context

In this first phase, patent WO 2015/115884 A1, entitled "System for generating electrical power from muscle energy with control of connection to a supply connection", was selected for its focus on generating energy from human muscle power. This technology offers an innovative solution in the field of sustainable energy, with applications in various environments such as homes, offices, gyms and other places where physical activity takes place.

The identification of these patents was carried out using the World Intellectual Property Organization (WIPO) patent database, selecting those related to energy harvesting from human activity. The International Patent Classification (IPC) system was used as a criterion to filter the most relevant technologies, prioritizing those focused on self-generation of energy and physical conditioning.

Phase 2: Technical analysis of the patent

Once identified, a technical analysis of the patent was performed. This included a thorough review of its key technological components and functionalities, such as the generation of both mechanical and electrical energy, and the ability to connect or disconnect from the local AC power supply.

Key aspects of the technical analysis included

Energy generation: The patent allows for the collection of electrical energy through muscle movement, benefiting both personal health and carbon footprint reduction through the use of a renewable energy source.

Installation flexibility: The technology is adaptable to different spaces, facilitating its installation in areas with limited access to conventional energy, such as rural or off-grid locations.

Grid connection: The proposed system allows controlled connection and disconnection from the electrical grid, facilitating its integration with other energy sources such as solar panels.

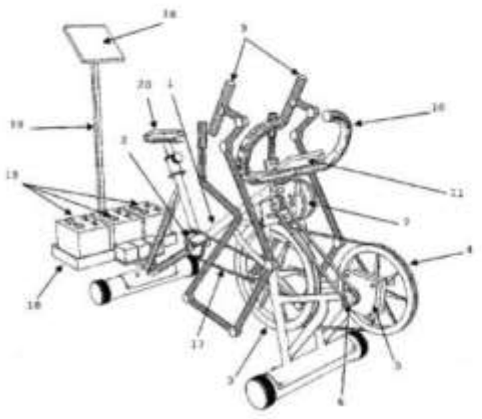
Phase 3: Evaluation of technology transfer and sustainability

In the third phase, the capacity of the technology to be transferred to different markets and its impact in terms of sustainability were evaluated. Criteria based on technology transfer theory were applied, analyzing the replicability of the invention in different contexts and its ability to adapt to emerging economies. Additionally, economic barriers, such as manufacturing costs, were considered, along with the potential of this technology to overcome such limitations as production systems mature.

The evaluation also included an assessment of how this patent contributes to the achievement of the Sustainable Development Goals (SDGs), specifically regarding access to affordable and clean energy (SDG 7) and the promotion of responsible practices in the use of energy resources. Finally, the "S-curve" model was applied to determine the patent's position in the technology life cycle and its capacity to scale in international markets.

2.2 Information of the Selected Patent

Title	System for Generating Electrical Power From Muscle Energy, With Control of Connection to a Supply Connection
N° de publicación internacional	WO 2015/115884 A1
Application N°	2014000202
Filed	Dec 11, 2014

Published	Aug 6, 2015
IPC Classifications	• A63B22/10 • A63B69/16 • F03G5/00
CPC Classifications	• A63B69/16 • A63B21/0054 • A63B22/0605 • A63B2208/0261 • F03G5/06 • H02J7/1415
Abstract	This invention describes a system for generating electrical energy from muscle power with connection control to a supply connection. It allows the generation of both mechanical and electrical energy, which can be used in homes, offices, farms, gyms, or any installation where human muscle power is available. Its main advantages include flexibility for installation, use, transportation to another site, physical exercise, health benefits, and the production of mechanical and electrical energy. It features a system for connection and disconnection from the alternating current supply, solar panels, and an alarm in case of inactivity discharge.
Name of the inventor	GARZA GALICIA, Alejandro; Privada Javerianos No. 69, Colonia Fraccionamiento Leparc, Guadalajara, Jalisco 45066 (MX).
Applicant (Owner) of the patent	INSTITUTO SUPERIOR AUTÓNOMO DE OCCIDENTE A.C. [MX/MX]; Av. Tepeyac No. 4800, Col. Fraccionamiento Prados, Tepeyac, Zapopan, Jalisco 45050 (MX).
Agent that is doing the procedure of the patent	SALGADO NÚÑEZ, Maria del Rosario et al.; Av. Tepeyac No. 4800, Colonia Fraccionamiento Prados Tepeyac, Zapopan, Jalisco 45050 (MX).
International patent classification OMPI – WIPO and description	A63B 22710 (2006.01): Exercising apparatus specially adapted for conditioning the cardio-vascular system, for training agility or co-ordination of movements A63B 69716 (2006.01): Training appliances or apparatus for special sports F03Cr 5700 (2006.01): Positive-displacement engines driven by liquids
Figure	 Figura 1

Source: Garza Galicia, A. (2015). System for generating electrical power from muscle energy with control of connection to a supply connection (WO 2015/115884 A1). World Intellectual Property Organization.

3. RESULTS

3.1 Technology transfer

Technology transfer has been identified as a key process in the diffusion and adoption of innovative technologies, particularly in sectors such as renewable energy, which play a fundamental role in mitigating climate change. According to the technology transfer theory proposed by Lundquist (2003), this process involves the movement of technological capabilities from a developing entity, such as universities or companies, to end users, making it an essential mechanism for achieving large-scale adoption of innovations. In this context, patent WO2015/115884 A1, which proposes a system for generating energy from muscle power, represents a disruptive innovation in the field of renewable energy, with applications in homes, public spaces and gyms.

The global renewable energy landscape has been shaped by the implementation of environmental policies and international agreements, such as those promoted by the United Nations (UN) under the Climate Change Convention. These efforts have promoted the adoption of sustainable technologies throughout the world, and Latin America is no exception, playing a significant role in the development of technologies such as hydroelectric power plants and the use of biomass. However, the technology patented in WO2015/115884 A1 offers a novel approach by proposing the use of mechanical energy generated by the human body, thus integrating the concepts of sustainability and physical well-being within the framework of Distributed Renewable Energy (DRE).

The technology transfer of this patent, according to Rockett's (2010) theoretical framework, is in an intermediate stage, where the functional design has been technically validated, but the appropriability of the technology remains moderate due to economic and implementation barriers, such as the high costs of energy storage (batteries). This is consistent with the challenges identified by (Teece, 2004), who emphasizes that emerging technologies face difficulties in achieving mass adoption due to their high initial cost, which limits their competitiveness in markets where price is a decisive factor. However, as production processes mature, and if manufacturing costs can be reduced, it is likely that this technology could achieve wider diffusion, both in gyms and homes.

A key aspect of the transfer of this technology is overcoming intellectual property barriers, as the technology is protected under the patent registered by Garza Galicia (2015). Nevertheless, it is crucial to promote mechanisms that facilitate its commercialization and adaptation in various markets. According to recent studies on patent transfer, such as those by Caviggioli and Ughetto (2013) and Ciaramella et al. (2017), the creation of partnerships between academia and industry can accelerate the adoption of innovative technologies by facilitating knowledge transfer and reducing barriers related to intellectual property.

With regard to replicability, the patented technology offers the possibility of adaptation in contexts with restricted access to electricity, including rural areas and off-grid communities. Nevertheless, a significant challenge remains its economic feasibility. The large-scale implementation of this technology must overcome economic barriers, as Denicolo and Franzoni (2004) argue. They contend that while the social and environmental benefits of green technologies can be significant, the high cost of adoption continues to hinder their widespread diffusion.

The technology has currently completed four of the six requisite testing stages, thereby meeting the criteria for investment (Figure 1). The technology has been subjected to rigorous technical validation, and intellectual property protections have been established. Furthermore, the materials utilized have been certified as safe, and the technology offers significant value to consumers, particularly in markets driven by sustainability concerns. Nevertheless, the elevated costs associated with manufacturing and battery replacement persist in limiting its appeal to investors, even in sectors with promising economic potential, such as gyms.

Moreover, the successful implementation of this technology to emerging economies, where sustainable energy policies are still in development, has yet to be fully achieved. Although its adoption in public spaces is noteworthy, broader integration into household settings could yield greater social and environmental benefits, in alignment with the Sustainable Development Goals (SDGs), particularly those pertaining to affordable and clean energy access (SDG 7) and climate action (SDG 13) (König, Suwala & Delargy, 2020).

Figure 1: Test Levels for Investment in Technologies. Source: Own elaboration with information from (Lundquist, 2003)

3.2 Intellectual Property

Patent WO2015/115884 A1 represents a significant advancement in the field of renewable energy. It has the potential to generate positive social impacts in various contexts, from households to gyms, by harnessing residual energy produced during physical exercise. This innovation optimizes energy efficiency by converting mechanical energy into electricity for domestic consumption and offers a sustainable solution for areas not connected to conventional electrical grids. This aligns with the Sustainable Development Goals (SDGs), particularly SDG 7, which seeks to ensure access to affordable and clean energy (König, Suwala & Delargy, 2020).

As Rockett (2010) notes, once a patent is granted, it can be commercialized, transferred to other entities, or eventually abandoned. Given the socially and environmentally beneficial nature of patent WO2015/115884 A1, it would be prudent to prioritize its transfer, particularly to emerging markets and rural communities with limited access to energy. This prioritization is consistent with recent studies on technology transfer, which emphasize the importance of adapting innovations to local contexts, allowing for faster and more efficient adoption (Ciaramella et al., 2017; Caviggioli & Ughetto, 2013).

The patent was filed with the Mexican Institute of Industrial Property (IMPI), with a validity period of 20 years from the filing date and a filing fee of $5,278.00 MXN (value-added tax included). In terms of the cumulative nature of innovation, Rockett (2010) classifies the technology of patent WO2015/115884 A1 within a cumulative innovation model, where technological advancements build upon previous developments, generating positive externalities that benefit society at large. This model is particularly relevant in sectors such as renewable energy, where the combination of research efforts from different areas, such as sustainable energy and health, amplifies the social and environmental impact of innovations (Denicolo & Franzoni, 2004). In this instance, the convergence of advancements in renewable energy and technologies applied to physical well-being has resulted in the creation of an innovative product with high social value.

Nevertheless, one of the most significant challenges to the expansion of this technology is the dissemination of patented knowledge. As Rockett (2010) notes, the fundamental objective of the patent system is to transform private ideas into public knowledge, thereby fostering collaborative innovation and preventing unnecessary duplication of efforts. In this case, however, it is observed that similar patents have been registered in different countries, such as Mexico and Colombia. This could indicate a duplication of efforts due to inadequate dissemination. This situation highlights the necessity for improvements to be made to the dissemination mechanisms within intellectual property systems. Such improvements would serve to avoid redundancies and encourage greater cooperation among inventors, facilitating the effective transfer of innovative technologies (Bikard, 2018).

Furthermore, the safeguarding of this technology on an international scale necessitates the implementation of an effective intellectual property management strategy. As recent studies on patent transfer demonstrate, collaboration between universities, research centers, and the private sector is essential to maximize the impact of innovations in the global market (Appiah-Adu et al., 2016). Patent WO2015/115884 A1 has the potential to serve as a clear exemplar of how universities can become pivotal actors in technological innovation, provided they can surmount the obstacles of dissemination and technology transfer to industry.

3.3 Diffusion

Diffusion is a dynamic process that requires time and favorable conditions for its widespread adoption (Popp et al., 2010). With regard to patent WO2015/115884 A1, the diffusion of energy harvesting technology from muscle power is confronted with considerable challenges pertaining to its visibility and comprehension in diverse contexts. In his diffusion of innovations theory, Rogers (1962) posits that the adoption process of an innovation is contingent upon a number of factors, including the perception of relative benefit, compatibility with existing values and systems, and the observability of the technology in question.

In accordance with Rogers' model, it is of paramount importance that the technology in question be effectively disseminated not only in gyms and homes but also in public spaces, where residual energy generated by physical exercise can be harnessed. In this regard, the visibility and observability of the technology's results are of significant importance in promoting its adoption. It is therefore essential that the technology be designed in such a way that users can readily discern the immediate benefits, thereby increasing the probability that others will adopt the innovation.

Rogers underscores the significance of "early adopters" in the dissemination of technologies, as their influence within social networks can facilitate the adoption process. In the case of this patent, if the technology is adequately promoted in gyms and high-traffic spaces, it has the potential to serve as a model for other institutions and individual users to emulate. Moreover, the technology must align with the values and needs of potential users, necessitating adaptation to diverse cultural and economic contexts.

To facilitate broader diffusion, it is essential to allocate sufficient financial and technical resources, particularly to reduce the initial production costs, which currently represent a significant barrier to its adoption (Popp et al., 2010). As Stoneman and Battisti (2010) observe, research on technology transfers oriented toward energy efficiency remains limited. They identify a need for further investigation in this area. Furthermore, as Rogers indicates, the utilisation of suitable communication channels and local influence networks can assist in overcoming initial barriers and facilitating the accelerated adoption of this technology in rural communities and off-grid areas, where its impact could be most significant.

3.4 Technological Change

Patent WO2015/115884 A1 addresses the potential of self-generation of energy as an accessible alternative from two key perspectives: social and technical. From a social perspective, the technology is based on the use of a stationary exercise bike, a piece of equipment that is widely available and commonly used. From a technical standpoint, the ability to connect and disconnect from the local electrical grid endows the technology with adaptability to diverse environments, thereby facilitating its installation in a multitude of settings, including homes, gyms, and other public or private spaces.

This technology, which enables the capture of energy from physical exertion, has the potential to alter the perception of residual energy generated during routine activities, such as exercise. From a commercial standpoint, this innovation has the potential to reduce both the marginal costs of energy consumption and the costs associated with mitigating environmental impact. This is due to the fact that the energy produced by stationary bikes could be efficiently reused. Moreover, the technological change promoted by this patent anticipates an enhancement in energy efficiency, not only in the domestic sphere but also in outdoor gyms and other public spaces, thereby enabling the local energy grid to be shared with a self-generated supply. This feature is directly linked to improvements in public health and reductions in environmental impact.

According to the guidelines of Popp et al. (2010) and the observations of Balakrishnan and Wernerfelt (1986) on technological change, it is important to note that this type of technology faces market failures, particularly in relation to its diffusion and adoption. Positive externalities, such as the reduction of marginal costs and the generation of knowledge, are often underestimated in the absence of adequate public policies. In line with the points made by Balakrishnan and Wernerfelt (1986), the frequency of technological change can reduce vertical integration in industries, which negatively affects the diffusion of innovations when companies do not fully internalize the benefits of these technologies. In this sense, patent WO2015/115884 A1, being aligned with environmental objectives, should be supported by policies that encourage its adoption. However, the current design of environmental policies has failed to provide clear guidance for this type of emerging technology.

It is evident that there is a need to develop mechanisms that include market-based environmental policies, supported by research and development (R&D), as well as greater incentives and funding from both the public and private sectors. These elements are essential to overcome the barriers to technological change and maximize the impact of this innovation in social, economic, and environmental areas.

3.5 S-Curve Analysis of Technologies Related to the Patent

In accordance with the methodology proposed by Hernández Zarta et al. (2016), an exhaustive search of patents related to the technology described in patent WO2015/115884 A1 was conducted using the lens.org database. The search was conducted with a focus on three primary categories within the International Patent Classification (IPC), which encompass the essential functionalities of the invention.

A63B 22710 (2006.01): The apparatus is designed for the conditioning of the cardiovascular system, training in agility, and the coordination of movements.

A63B 69716 (2006.01): Training devices or apparatuses designed for specific athletic activities.

F03Cr 5700 (2006.01): Positive displacement engines that are driven by liquids.

A review of the aforementioned categories revealed a total of 36,840 registered inventions, indicating a growing interest and technological development in areas related to energy generation through physical exertion. Table 1 illustrates the annual distribution of the number of related patents, demonstrating a notable increase over the past few decades.

Table 1: Number of Patents for Similar Technology by Year

Year	Patents
1919	1
1976	2
1980	2
1982	5
1983	1

1984	3
1985	1
1986	5
1987	3
1988	1
1989	4
1990	8
1991	7
1992	9
1993	7
1994	10
1995	12
1996	18
1997	19
1998	31
1999	37
2000	107
2001	115
2002	187
2003	275
2004	239
2005	385
2006	450
2007	604
2008	671
2009	681
2010	700
2011	681
2012	650
2013	837
2014	1228
2015	1231
2016	1614
2017	2062
2018	2853
2019	4328
2020	5167
2021	6004
2022	5585
Total	36840

Source: Own elaboration with information from

lens.org S-Curve Analysis Models

To analyze the evolution of patents, a number of mathematical models were employed, with the composite and exponential models representing the most representative approaches. A summary of the evaluated models, along with their parameter estimates, is presented in Table 2.

Table 2: Summary of Models and Parameter Estimates

Dependent Variable: Patents

	Model Summary					Parameter Estimates			
Ecuación	R cuadrado	F	gl1	gl2	Sig.	Constant	b1	b2	b3
Logarithmic	,320	19,721	1	42	,000	-747921,994	98516,094		
Quadratic	,626	34,261	2	41	,000	4570666,812	-4665,221	1,190	
Cubic	,629	34,690	2	41	,000	1508196,017	,000	-1,178	,000
Compound	,709	102,210	1	42	,000	5,647E-116	1,144		
S	,691	94,108	1	42	,000	265,710	-522532,298		
Growth	,709	102,210	1	42	,000	-265,369	,135		
Exponential	,709	102,210	1	42	,000	5,647E-116	,135		

Source: Own elaboration. Note: The independent variable is Year.

The S-Curve analysis indicates a notable inflection point in the 2000s, when the number of patents related to energy generation from physical exertion experienced a substantial increase. This growth reflects a greater interest in and advancement of technologies that allow for the conversion of mechanical energy generated by the human body into electrical energy, particularly in environments such as gyms, homes, and public spaces.

The most pronounced change occurred around 2010, though it was insufficient to alter the projection of the exponential model. The results indicate that the technology under examination, as exemplified by patent WO2015/115884 A1, is part of a continuous growth cycle in terms of innovation and technological adoption.

In consideration of the results yielded by the evaluated models, the R^2 value obtained is notably high (0.702), indicating a robust and significant fit. Both the F-test and the T-test yield a p-value of 0, thereby confirming the relevance of the model. This fit is illustrated in Figure 2, which demonstrates how the S-Curve accurately represents the evolution of patents in this technological area.

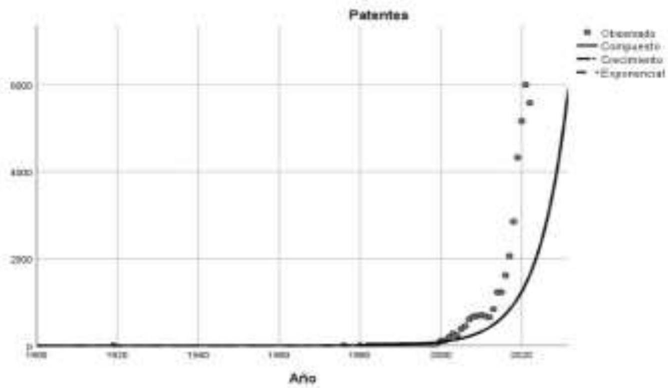


Figure 2: S-Curve for the technology of an electrical energy generation system from muscle power, differentiated by the connection control to the supply, used to produce electrical energy. Source: Own elaboration.

4. DISCUSSION AND PRACTICAL IMPLICATIONS

The analysis of patent WO2015/115884 A1 indicates the potential of human energy harvesting technologies as a sustainable solution to enhance access to electricity, particularly in rural areas or regions with limited infrastructure. The integration of this technology would not only facilitate the achievement of several Sustainable Development Goals (SDGs) but also represents an opportunity to reduce reliance on non-renewable energy sources and promote public health through the use of devices like stationary bicycles.

Technological and Economic Challenges: Nevertheless, the technology still encounters several impediments to its large-scale implementation. The high costs of key components, such as storage batteries, and the lack of adequate infrastructure in many of the areas where it could have the greatest impact represent the most significant challenges. These limitations restrict the commercial viability of the technology in its current stage of development, underscoring the necessity for increased investment in research and development (R&D) to enhance efficiency and reduce costs.

Implications for Policy: To surmount these impediments and optimize the impact of this technology, robust backing from public policies oriented toward sustainability and technological advancement is imperative. Market-based environmental policies can play a pivotal role in this regard by offering economic incentives to reduce adoption costs, promoting research, and facilitating public-private partnerships that can expedite the development of technologies like that of patent WO2015/115884 A1.

Technology Transfer and Sustainability: Another crucial element is the enhancement of technology transfer mechanisms. Research indicates that technologies developed in academic or industrial settings frequently encounter challenges in being transformed into innovations that are readily accessible to end users (Bikard, 2018). In this context, public policies must incorporate strategies that foster collaboration between universities, research institutions, and businesses with the aim of reducing adoption barriers and ensuring effective technology transfer.

5. CONCLUSIONS

The analysis of patent WO2015/115884 A1 demonstrates that the technology for generating energy from human muscle power represents a novel and sustainable solution to the current challenges of accessing electricity, particularly in off-grid areas or regions with limited infrastructure. This technology presents a distinctive opportunity to make a substantial contribution to the attainment of several Sustainable Development Goals (SDGs), including access to affordable and clean energy (SDG 7), the establishment of sustainable communities (SDG 11), and climate action (SDG 13). By leveraging a ubiquitous resource such as physical exertion, it offers a viable alternative to conventional energy generation.

A S-Curve analysis of the technology indicates that it is in an early stage of development, with a notable increase in patents since 2000. Nevertheless, despite the advancements that have been made, economic and technological transfer barriers continue to impede its widespread adoption. The high costs of essential components, such as energy storage batteries, present a significant challenge to the commercial viability of this innovation. The reduction of costs and the enhancement of storage system efficiency represent key areas of focus for future research and technological advancement.

With regard to the transfer of technology, the patent evinces considerable potential for replication and adaptation in a multiplicity of contexts, encompassing both urban and rural areas. Nevertheless, for this technology to realize its full social and environmental potential, it is imperative to surmount economic constraints through sustained investment in research and development (R&D). The deployment of this technology in public spaces has yielded encouraging outcomes. However, its integration into domestic and rural communities could potentially enhance the social and environmental benefits, thereby facilitating access to clean energy in regions that are currently underserved.

From the perspective of intellectual property, patent WO2015/115884 A1 is consistent with a model of cumulative innovation, whereby technological advancements build upon previous developments. This process gives rise to positive externalities, including the generation of new knowledge and the promotion of technological advancement. Nevertheless, the analysis indicates deficiencies in the mechanisms of dissemination and technology transfer, which have resulted in the replication of efforts at the international level. To circumvent this fragmentation, it is imperative to reinforce international collaboration networks, thereby facilitating the exchange of knowledge and promoting greater coordination among the relevant actors.

Ultimately, to optimize the impact of this technology and facilitate its widespread adoption, it is crucial that public policies assume an active role in its promotion. The implementation of market-based environmental policies, in conjunction with economic incentives, fiscal support, and financing programs from both the public and private sectors, is crucial for the commercialization and expansion of this innovation. It is only through a coordinated approach between governments, businesses, and research institutions that this technology can be ensured of reaching its full potential, benefiting both society and the environment, while contributing to the SDGs and the fight against climate change.

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