ANALYSIS OF FINANCIAL AND TECHNOLOGICAL MECHANISMS IN THE GREEN ECONOMIC TRANSITION

ANÁLISE DE MECANISMOS FINANCEIROS E TECNOLÓGICOS NA TRANSIÇÃO ECONÔMICA VERDE

ANÁLISIS DE MECANISMOS FINANCIEROS Y TECNOLÓGICOS EN LA TRANSICIÓN ECONÓMICA VERDE

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ABSTRACT

This article analyzes the characteristics, potentialities, and challenges of the Web Curriculum in the context of Distance Education (DE), in light of the transformations brought about by digital culture. This bibliographic research is based on academic works, scientific articles, and official documents, aiming to understand how curricula mediated by digital technologies can promote more meaningful, interactive, and inclusive learning. Initially, the evolution of the curriculum concept and its social function is discussed, highlighting the transition from traditional models to more critical and flexible approaches. Then, the specificities of DE and the curricular models that support it are explored, emphasizing pedagogical mediation and personalized learning. The Web Curriculum is presented as an innovative proposal, grounded in principles such as hypertextuality, authorship, and collaboration, aligning with active methodologies and the demands of networked society. The discussion reveals both the advantages and the challenges of this approach, including digital exclusion, teacher training, and assessment in DE. It is concluded that the effective implementation of the Web Curriculum requires public policies, adequate infrastructure, and continuous teacher development, as well as new pedagogical practices that value autonomy and authorship in digital culture.

Keywords*:* Web Curriculum. Distance Education. Digital Culture. Digital Curriculum. Educational Technologies.

RESUMO

Este artigo analisa as características, potencialidades e desafios do Web Currículo no contexto da Educação a Distância (EAD), à luz das transformações provocadas pela cultura digital. A pesquisa, de natureza bibliográfica, fundamenta-se em obras acadêmicas, artigos científicos e documentos oficiais, com o objetivo de compreender como os currículos mediados por tecnologias digitais podem promover aprendizagens mais significativas, interativas e inclusivas. Inicialmente, discute-se a evolução do conceito de currículo e sua função social, destacando a transição de modelos tradicionais para abordagens mais críticas

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e flexíveis. Em seguida, são exploradas as especificidades da EAD e os modelos curriculares que a sustentam, com ênfase na mediação pedagógica e na personalização da aprendizagem. O Web Currículo é apresentado como uma proposta inovadora, baseada em princípios como hipertextualidade, autoria e colaboração, alinhando-se às metodologias ativas e às demandas da sociedade em rede. A discussão evidencia tanto as vantagens quanto os desafios dessa abordagem, incluindo a exclusão digital, a formação docente e a avaliação na EAD. Conclui-se que a efetivação do Web Currículo requer políticas públicas, infraestrutura adequada e formação continuada, além de novas práticas pedagógicas que valorizem a autonomia e a autoria dos sujeitos na cultura digital.

Palavras-chave: Web Currículo. Educação a Distância. Cultura Digital. Currículo Digital. Tecnologias Educacionais.

RESUMEN
En este capítulo se analiza de manera integral los mecanismos financieros y tecnológicos que impulsan la transición hacia una economía verde, en el contexto de los desafíos climáticos globales. Se abordan instrumentos como bonos verdes, blended Finance y el financiamiento multilateral, así como tecnologías emergentes como blockchain, inteligencia artificial e internet de las cosas. Mediante una revisión documental y análisis de indicadores internacionales, se identifican avances significativos, pero también brechas críticas en financiamiento, innovación y gobernanza. Los hallazgos confirman la idea de que la innovación financiera y tecnológica es indispensable para acelerar la transición verde, aunque debe fortalecerse mediante marcos regulatorios robustos, alianzas multisectoriales y políticas inclusivas. Se concluye que, si bien se observan progresos, el ritmo actual no es suficiente para alcanzar las metas climáticas internacionales, lo que demanda intensificar y escalar las acciones globales, priorizando la justicia social y la sostenibilidad integral.

Palabras clave: Instituciones y Servicios Financieros. Medio Ambiente y Desarrollo. Innovación Tecnológica. Fuentes de Energías Alternativas.

1 INTRODUCTION

In a global context marked by the climate crisis, environmental degradation and growing socioeconomic inequalities, we have sought to move towards a green economy that is a central axis in global economic policies (UNEP, 2011). In the green economy, the concept of economic development is intended to have environmental sustainability and social equity so that they cease to be marginal conditions and become fundamental pillars of progress (Carfi and Schiliró, 2012). In this sense, the green economy emerges as a comprehensive strategy that seeks to redefine production systems under principles of circularity, energy efficiency and intergenerational justice.

The conceptual framework of this transition to a green economy has its origins in the debates on sustainable development in Rio de Janeiro in 1992, but in recent years it has gained relevance due to the current context of climate emergency. The green economy proposes that there is an articulation between economic prosperity through regenerative business processes, social inclusion through equitable access to resources, and the protection of ecosystems through decarbonization and conservation of diversity (Herrán, 2012; UNEP, 2011). This vision has been formalized in international agreements. For example, in the Paris Agreement (2015) and in the 2030 Agenda, which recognize the existence of environmental and social challenges, which are deeply interconnected.

However, this model faces different obstacles, with financing being one of the most critical. According to the International Energy Agency (IEA), although investments in clean energy have increased, they have not been enough to meet the goals established by the 2030 agenda. Due to financial inequality, the need to establish innovative mechanisms that can mobilize capital is evident. In this context, instruments such as green bonds, *blended finance*, multilateral financing and green fiscal policies are emerging.

At the same time, the technological revolution is shaping the possibilities of transition to disruptive technologies such as *blockchain*, which seeks to increase transfer in green markets through immutable records that combat *greenwashing.* On the other hand, artificial intelligence seeks to optimize the reallocation of resources through predictive analysis of environmental impact. Meanwhile, the Internet of Things is enabling energy efficiency gains (*International Renewable Energy Agency (IRENA),* 2023). Therefore, it should be noted that these innovations not only improve the profitability of sustainable projects, but also create new paradigms in natural resource management and impact measurement.

However, it should be considered that there are structural challenges that limit the potential of the green transformation, among which are: the lack of global standardization, technological asymmetries between developed and developing countries, and the risks of *greenwashing* (Forest, 2023; United Nations, 2018; Tukhtabayev, 2024). As the OECD (2020) points out, the effectiveness of innovative mechanisms depends critically on robust regulatory frameworks, international cooperation, and institutional capacities that currently present significant gaps.

This work aims to analyze the financial and technological mechanisms, to achieve this it will be structured in four sections. The first offers a conceptual framework on the transition to the green economy. The second section addresses a critical analysis of financing mechanisms and their effectiveness. Section three addresses the role that technological innovations play in the green transition. In the fourth section, the key indicators are analysed in order to assess the results of the transition, as well as how these international indicators allow the process to be monitored. Finally, a section is devoted to the main conclusions.

2 GLOBAL CONTEXT OF THE GREEN ECONOMY

2.1 CONCEPTUALIZATION AND HISTORICAL CONTEXT OF THE GREEN ECONOMY

The green economy emerged as an alternative to the traditional model, known as the *brown economy*, since it prioritized growth without considering environmental and social impacts. This new approach is born out of the urgent need to be able to address three interconnected crises: environmental degradation, social inequality and the depletion of natural resources. The main difference with the traditional model is that it proposes the integral development of economic prosperity with social justice and ecological protection (UNEP, 2011).

The concept of green economy emerged approximately two decades ago, as an extension of the paradigm of sustainable development, its origins date back to the first Earth Summit in Rio 1992, where the first global commitments were established. However, it was not until the Rio+20 Conference, held in the city of Rio de Janeiro in 2012, that it acquired international relevance, when it was formally adapted by the United Nations (UN) as a strategic axis to achieve sustainability (Herrán, 2012).

According to the United Nations (2018), the green economy is an innovative model that aims to transform traditional production systems through three main axes, which are: efficiency in the use of resources, greater social inclusion, and climate change mitigation. In

an environmental aspect, it seeks a transition towards circular systems that minimize the waste of materials and energy, based on the adoption of renewable energies, the implementation of clean industrial processes and the development of resilient infrastructures.

Currently, the green economy is considered a key aspect for the fulfillment of the Sustainable Development Goals (SDGs), according to the United Nations report (2018). This model provides a practical framework for simultaneously addressing economic, social and environmental challenges. However, its implementation requires structural transformations in production and consumption patterns, in addition to the creation of public policies that integrate sustainable innovation.

2.2 IMPORTANCE OF THE ENERGY TRANSITION

The energy transition is a cornerstone for the green economy, as it allows the decoupling of economic growth from environmental deterioration, as it seeks to replace fossil fuels with renewable energies, reduce carbon emissions, and ensure energy security in the long term (IRENA, 2023).

This transition process requires global and coordinated action that combines public policies, innovative financial mechanisms (e.g. green bonds) and international technological cooperation. However, this process entails several challenges, which must be addressed through solid regulatory frameworks and financial ecosystems capable of promoting sustainable projects (Plaza, 2024).

It should be noted that the effectiveness of the energy transition is directly related to the availability of financial and technological resources. For example, according to IRENA (2023), in order to achieve the climate goals set out in the Paris Agreement, annual investments of approximately trillions of dollars are needed until 2030. However, this figure represents almost triple the current levels of investment, which underscores the magnitude of the financial challenge. In this regard, it is important to identify and implement innovative and efficient financial mechanisms in order to direct resources effectively and equitably.

2.3 SUSTAINABLE FINANCING AND INNOVATIVE FINANCIAL MECHANISMS

Financing is an essential element for the transition process towards a green economy, which must be accompanied by an innovative process, in order to ensure environmental sustainability and mitigate the effects of climate change (Kahn *et al*., 2022). This perspective is reinforced by Chabán-García (2024), who states that the promotion of a green economy

requires the implementation of green finance and the development of technological innovation.

This is materialized by the fact that the energy transition to a low-carbon economy demands significant financing as well as a strong innovative framework, given that this process entails an estimated economic cost of between 92 and 173 trillion dollars, so a solvent green financial ecosystem must be created. stable and supported by certification mechanisms that can guarantee the sustainability of the projects (Plaza, 2024). The United Nations (2018) argues that significant mobilization of financial resources, both from the public and private sectors, is needed.

In this context, innovative financing mechanisms emerge, which are strategies used for the mobilization of financial resources for projects and activities for the transition to the green economy. These complement traditional sources of financing and facilitate access to capital for sustainable investments. Among the most prominent instruments are green funds and bonds, along with impact investments, grants and green *crowdfunding*, which can be complemented by environmental insurance and tax incentives (UNEP, 2011).

2.4 TECHNOLOGICAL INNOVATION FOR A GREEN ECONOMY

Technological innovation is a key element for the green economy, its objective is to minimise environmental impact and promote sustainability, in addition to being essential to achieve the development of energy efficiency. In addition, technologies such as the Internet of Things (IoT) and artificial intelligence (AI) optimize the use of resources in order to improve efficiency in industries and cities. In addition, digitalization through *big data* and real-time monitoring systems allows for smarter management of resources (UNEP, 2021: IRENA, 2023; Plaza, 2024), elements that will be addressed later.

Technological innovation also facilitates the creation of new sustainable business models, such as the circular economy, which seeks to maximise resources and minimise waste. In addition, access to information and data processing can contribute to sustainable practices in various sectors. However, in order to harness the potential of technological innovation, it is necessary to have appropriate policies that are capable of promoting research, development, and the adoption of sustainable technologies (ECLAC, 2021).

2.5 KEY INDICATORS FOR THE EVALUATION OF THE ENERGY TRANSITION

Currently, there are different indices that allow us to evaluate progress towards the energy transition, one of them is the Energy Transition Index (ETI) which is a tool developed by the World Economic Forum that seeks to provide a data framework that allows us to appreciate the performance of energy systems and their willingness to transition, which is divided into two groups: core factors (legislation, political commitment, finance and investment) and enabling factors (innovation, infrastructure, education and human capital). The final score is made up of the scores you achieve in each of the sub-indices (World Economic Forum, 2024).

Additionally, there is the Global Carbon Intensity Index, which is measured in grams of co_2 per kWh produced, this is a key indicator to know if there really is a significant reduction in carbon emissions. It should be noted that this index has decreased in recent years. For example, in 2019 it was 475 while in 2024 it decreased to 421, confirming the need to establish mechanisms that continue to mitigate carbon emissions (Ember Climate, 2024).$gCO_2/kWh gCO_2/kWh$

Both indices are examples that significant changes can be achieved to achieve a transition to a green economy, however, financial and technological mechanisms must continue to be implemented so that the impact can be greater.

2.6 ANALYSIS OF INNOVATIVE FINANCIAL MECHANISMS FOR THE TRANSITION TO A GREEN ECONOMY

Sustainable finance aims to align with financial markets and integrate environmental, social and governance criteria into investment decision-making. This implies carrying out a transition process, where economically sustainable environmental technologies and practices are adopted, based on redirecting funds towards low-carbon models and ensuring that investments generate positive impacts for the environment and communities (Mealy and Teyteboym, 2022).

Therefore, the following section will analyze the key mechanisms for mobilizing capital towards the transition to a green economy. The mechanisms analyzed will be: green bonds, blended *finance*, multilateral financing and green policies.

2.7 GREEN BONDS AS SUSTAINABLE FINANCING INSTRUMENTS

Green bonds are financing options for private companies and public entities that need to support their investments in the climate and environment. It should be noted that the World Bank (WB) and the International Finance Corporation (IFC) were pioneers in the development of the green bond market, since in 2008 the first green bond was issued by the WB, while in 2013 the IFC was in charge of issuing the first global green bond (World Bank Group, 2017).

Green bonds are debt instruments where the issuer commits to use the proceeds to finance or refinance projects that benefit the environment and mitigate the effects of climate change. These bonuses are divided into labeled and unlabeled. The former refer to those explicitly issued as green to finance environmental projects, while the latter are those that finance sustainable initiatives without formally declaring themselves green (Forest, 2023).

In order to ensure that these instruments meet the environmental objectives they promise, it is necessary to establish clear definitions of what constitutes a *green* asset and implement robust verification and monitoring systems, avoiding practices such as *greenwashing*, in order to ensure transparency in the market (ECLAC, 2018).

According to IRENA data (2023), the green bond market exceeds 500 billion dollars in cumulative issuances, with a growth rate of 50%, reflecting a growing dynamic of awareness about climate change and the need to align financial flows. Finally, the bond market is becoming a fundamental pillar for the transition to low-carbon economies.

2.8 BLENDED FINANCE, THE COMBINATION OF PUBLIC AND PRIVATE RESOURCES

Blended finance is the combined use of grants, concessional instruments, and reimbursable financing from public and private sources, which seek to provide greater financial viability and sustainability to projects with an impact on sustainable development (CAF, 2021). This mechanism allows for greater mobilization of resources to sectors that traditionally suffer due to structural market barriers. In addition, according to data from Concergece (2024), blended finance has mobilized approximately $249 billion for sustainable development, and around 6800 financial commitments have been identified for these blended finance transitions.

It should be noted that blended finance allows you to structure your investments through layers of financing and mechanisms to transmit returns and risks, allowing private investors to participate in market-like conditions (González and Sánchez, 2024).

In recent years, the Development Bank of Latin America (CAF) has mobilized highly concessional resources through blended finance programs in collaboration with strategic partners in order to support projects or common areas. A successful example was the approval of financing from the Climate Action and Solar Energy Development Program in Chile. With a total amount of 79 million dollars, combining resources from CAF, the Green Climate Fund and the private sector (CAF, 2021).

However, *blended finance* faces certain challenges including structuring investments, the complexity of deals that may affect its implementation and scalability, measuring its performance in emerging markets, and mobilizing private finance in developing countries. Therefore, more research is needed on the impact mechanisms of sustainable investing.

2.9 MULTILATERAL FINANCING: ESSENTIAL SUPPORT FOR EMERGING ECONOMIES

Multilateral financing is an important key to the transition to green economies, mainly in developing countries that face both financial and technological constraints. There are various mechanisms that allow the channeling of resources to support sustainable projects. These multilateral investments are usually channeled by financial institutions such as the World Bank, the Green Climate Fund, and the Inter-American Development Bank (IDB) (Sunguryan, 2023).

The main advantage of this type of financing is to offer favorable conditions in interest rates and longer terms, which makes it easier to facilitate investments. In addition, some institutions usually provide technical assistance and some knowledge transfer to strengthen capacities (IFC, 2022).

Key challenges and constraints include geographic concentration, as funding tends to be concentrated in middle-income countries and neglects lower-income countries. It is also necessary to be able to have an adequate regulatory framework and certain mechanisms that increase investor confidence and thus be able to guarantee the effectiveness of financing (Kim and Lee, 2021; Nepal *et al*., 2024; Wang *et al*., 2024)

2.10 GREEN FISCAL POLICIES AS AN EFFECTIVE MOBILIZATION FROM THE PUBLIC SECTOR

Green fiscal policies are government strategies that use taxes, subsidies, and other fiscal instruments to promote sustainable practices and reduce the impact of the environmental crisis. Its main objective is the alignment between economic growth and

sustainability, to achieve this it seeks to encourage the transition to clean technologies, its main tool being carbon taxes (IMF, 2019).

This type of policy seeks to internalize environmental costs, through taxes on carbon or polluting products, in order to promote the adoption of greener alternatives. The aim is for the revenues generated to be used to finance sustainable infrastructure, as well as to the conservation of natural resources and innovations in green technologies. These types of measures, in addition to promoting economic development, seek to ensure environmental protection and are essential to face climate challenges (UNEP, 2021).

However, and according to ECLAC (2018), green fiscal policies face multiple challenges for their effective implementation, including political and social resistance, mainly from sectors dependent on polluting practices and from citizens who perceive environmental taxes negatively. Therefore, it is key to have coherence so that its impact is not limited, in addition to multisectoral collaboration and comprehensive policy designs that can balance environmental, economic and social objectives.

3 TECHNOLOGICAL INNOVATIONS FOR A GREEN TRANSITION

3.1 THE ROLE OF TECHNOLOGICAL INNOVATION IN THE GREEN TRANSITION

This section analyzes how innovation is found in financial and technological mechanisms; In addition, where the way in which capital is mobilised for sustainable projects is being revolutionised, contributing to greater efficiency, transparency and scalability of investments aimed at the global green transition.

The analysis is carried out in a context where the adoption of various disruptive technologies such as *blockchain,* AI, IoT, and *big data* have paved the way for the development of digital platforms that aim to monitor investments and verify environmental and social impacts (OECD, 2020; PwC, 2023).

Different authors have highlighted the importance of this technological transformation since it not only allows for the reduction of operating and transaction costs, but also allows for the monitoring with great precision of the environmental and social impacts that derive from green investments, which facilitates a more transparent and effective management of financial resources (Agrawal *et al.,* 2021; OECD, 2020).

3.2 BLOCKCHAIN AS A TOOL FOR FINANCIAL TRANSPARENCY AND TRACEABILITY

Blockchain technology became popular due to cryptocurrencies, but it has revolutionized the transparency and traceability of green financing. This technology is based on providing a distributed and cryptographically secure database, which records sustainable financial transactions in an immutable way that is also verifiable by any actor involved (WEF, 2021). As a result, the risks of fraud, corruption and so-called *greenwashing* in projects that are financed through green bonds or *blended finance are significantly reduced* (Wang *et al., 2021).*

Specific examples could include platforms such as *Energy Web Foundation* and *Power Ledger*, which employ *blockchain* to manage digital green certificates, ensuring traceability of renewable green energy generated and sold in international markets (*Energy Web Foundation,* 2023). Thus, this technology generates confidence among institutional and private investors, facilitating a greater flow of capital towards sustainable projects.

However, the use of *blockchain* in sustainable finance also presents technological and regulatory challenges, this is due to high energy costs in certain *blockchain* protocols and the need to have international regulatory frameworks that facilitate its application on a global scale (Lacity *et al.,* 2021).

3.3 ARTIFICIAL INTELLIGENCE AND BIG DATA FOR SUSTAINABLE IMPACT ASSESSMENT

Along the same lines, Artificial Intelligence (AI) together with advanced data analysis (*big data*) have become the main tools for assessing the environmental and social impact generated by green investments with high precision and efficiency. In this sense, these new technologies make it possible to analyse large amounts of environmental, economic and social data in real time, which substantially improves decision-making and optimises the allocation of financial resources towards projects with greater potential for positive impact (PwC, 2023).

Specifically, AI algorithms applied to green investments can accurately predict the future outcomes of sustainable projects, from emissions reductions to renewable energy generation, improving the profitability and effectiveness of these investments (Agrawal *et al.,* 2021). To mention one case, technology platforms such as Arabesque S-Ray and MSCI Research use AI and *big data* to comprehensively evaluate companies and projects based on environmental, social, and governance (ESG) criteria. Despite the above, the adoption of

these technologies still faces barriers related to the quality of reliable environmental data, ethical and regulatory challenges regarding the responsible and equitable use of sensitive information (OECD, 2020).

3.4 INTERNET OF THINGS (IOT) IN GREEN INFRASTRUCTURE OPTIMIZATION

In the same way, the Internet of Things (IoT) has an important role in the operational and economic optimization of sustainable infrastructures, especially in sectors such as renewable energy, transport and smart cities. The IoT allows sensors and devices to continuously monitor the operation and performance of green infrastructure, significantly increasing its efficiency and reducing costs (PWC, 2023).

To illustrate, the IoT makes it possible to optimize smart *grids*, facilitating efficient management of electricity consumption and a better integration of different renewable energies in real time, thus reducing energy losses and operating costs (WEF, 2021). Similarly, in sustainable transport, the IoT makes it possible to monitor and optimise the energy performance of electric vehicles and public transport, directly contributing to the effective reduction of urban pollutant emissions (IRENA, 2023).

3.5 HYBRID AND INNOVATIVE FINANCIAL INSTRUMENTS

The emergence of hybrid instruments, for example, social impact bonds and sustainable ones that are linked to environmental performance indicators, are an important step forward. These instruments make it possible to create a combination of financial returns with metrics in social and environmental areas. This is the case of Social *Impact Bonds,* which incorporate performance clauses that depend on the achievement of the Sustainable Development Goals (SDGs), such as improving access to education or reducing poverty (Rizello and Kabli, 2020).

One case could be that of Latin America, where various renewable energy projects have been financed through co-financing between public and private organizations. According to data from OMFIF (2024), these strategies have made it possible to mobilize more than 3000 million dollars in the last three years. The key to this model lies in the use of public guarantees and concessional financing that reduce perceived risk, encouraging the participation of institutional investors.

4 KEY INDICATORS FOR ASSESSING THE RESULTS OF THE ENERGY TRANSITION

Similarly, analysing the effectiveness of the efforts made in the energy transition towards a green economy is necessary to determine whether financial and technological mechanisms are delivering results.
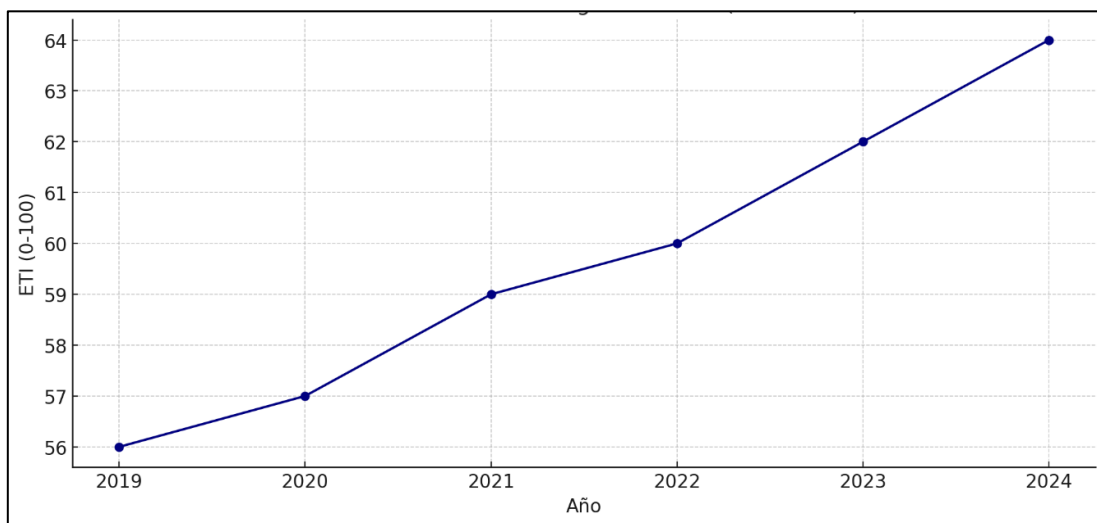
4.1 ENERGY TRANSITION INDEX (ETI)

The World Economic Forum develops the Energy Transition Index and has managed to consolidate it as an indicator of global scope with robustness and wide acceptance. The ETI comprehensively assesses the ability of countries to transform their energy systems towards more sustainable and economically viable systems. The ETI is made up of three dimensions: performance of the current energy system, energy security and access, environmental sustainability and economic growth; preparation for transit (stability in regulations, infrastructure, investment, human capital and innovation); long-term sustainability, energy diversification, energy efficiency and effective emission reduction.

Thus, in 2024, the ETI reached a value of 64 out of 100, showing progress compared to previous years (WEF, 2024).

This indicator shows both important achievements and challenges to be faced, allowing us to assess how various financial and technological mechanisms directly influence progress towards a green economy.

Figure 1

Energy Transition Index (ETI), 2019-2024

Source: adapted from World Economic Forum (2019-2024). Retrieved from
https://www.weforum.org/publications/fostering-effective-energy-transition-2024/

4.2 GLOBAL CARBON INTENSITY

Global carbon intensity is another important indicator that allows us to assess the impact of the energy transition on the reduction of greenhouse gas emissions (Ember Climate, 2024). Thus, this indicator shows the proportion of fossil fuels compared to renewable energies within global energy generation, which allows for an immediate assessment of the real results of climate policies and sustainable financing.

According to Ember Climate (2024), carbon intensity showed a reduction from 475 gCO2/kQh in 2019 to 421 gCO2/kQh in 2024. In other words, the decline shows a notable increase in the global share of renewable energy, driven by public policies and innovative mechanisms such as green bonds, even if they are only a small part (IEA, 2024). However, the current rate of decline is not enough to meet international climate goals, which highlight the importance of intensifying the adoption of clean energy.

Figure 2

Global Carbon Intensity (gCO2/kWh), 2019-2024
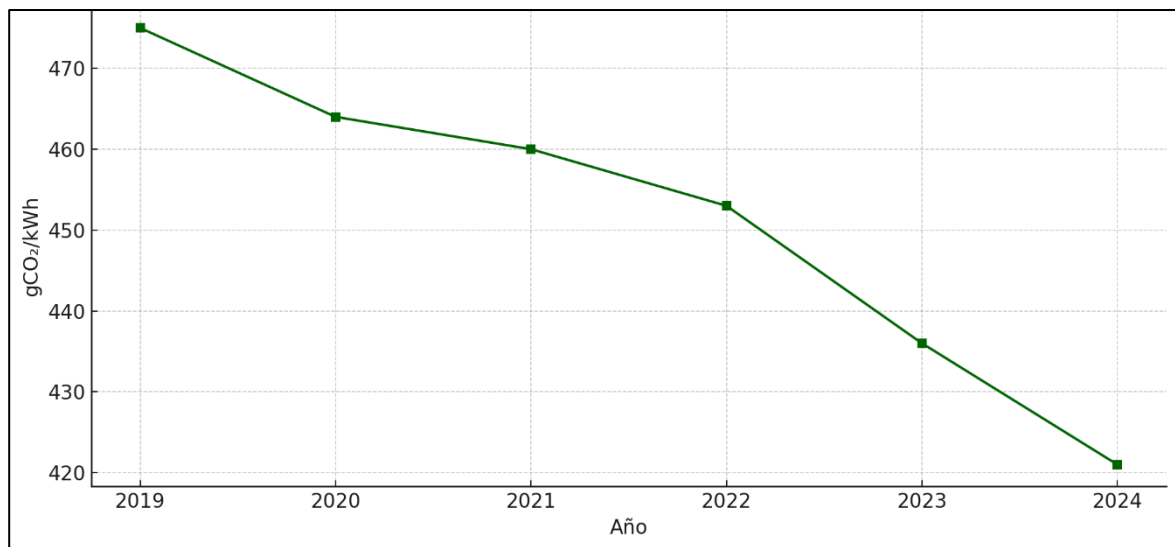
Source: adapted from Ember Climate. (2024). Global Electricity Review 2019-2024. Retrieved from: https://ember-climate.org

4.3 GLOBAL SHARE OF RENEWABLE ENERGY

Along the same lines, the share of renewable energies in global energy consumption is another important indicator that is used by different international organizations, such as the International Renewable Energy Agency (IRENA). The objective of this indicator clearly shows the share of clean energy (solar, wind, hydro, geothermal, biomass) in the total global primary energy consumption (IRENA, 2023).

In 2023, this indicator shows a 30% share of total energy consumption, showing a growth compared to the 20% recorded in 2015 (IRENA, 2023). Therefore, this increase reflects the effectiveness of financial mechanisms and global public policies focused on the energy transition. However, participation is not sufficient compared to the 50% recommended by experts by 2030, indicating the need to accelerate the adoption of these renewable energies, particularly in emerging and developing economies (IEA, 2024).

Figure 3

Global Share of Renewable Energy in Percentages, 2019-2024
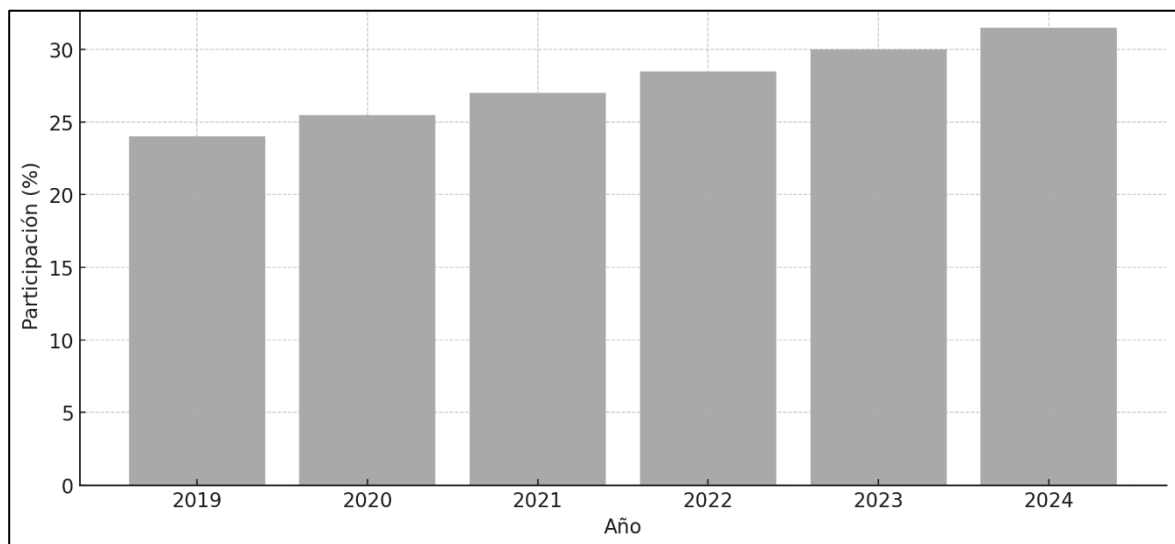
Source: adapted from International Renewable Energy Agency (IRENA). (2019-2024). Renewable Energy Statistics 2023. Retrieved from: https://www.irena.org

5 CONCLUSIONS

The conclusions we reach in this chapter are that the transition to a green economy is due to an urgent response to the climate crisis, loss of biodiversity and, not least, growing socio-economic inequalities. This paper confirms the idea that this transition not only presents environmental challenges, but also a profound economic and social transformation, which requires an effective integration of different mechanisms to materialize successfully.

First, the documentary analysis shows how the mobilization of capital directed towards sustainable projects has grown significantly, particularly through innovative instruments such as green bonds, *blended finance,* and multilateral financing. However, current investments, although with a growing trend, are still not enough in the face of global climate goals, as they need to increase to 4.5 trillion dollars per year by 2030 (IEA, 2024). Thus, the urgency of

strengthening these financial mechanisms, improving their transparency, scalability and global standardization is highlighted.

Therefore, the strategic importance of innovation to strengthen and optimize financial mechanisms is shown. Technologies such as *blockchain*, artificial intelligence, *big data, and* the Internet of Things have improved the efficiency, transparency, and traceability of sustainable finance, facilitating a more effective and reliable allocation of available financial resources. However, these technological advances still face barriers related to regulatory frameworks, a digital infrastructure with inequalities, data quality and ethical aspects, which partially limits their adoption and scalability in different economic and geographical contexts.

In the same vein, the use of international indicators has made it possible to accurately assess the impact of global energy transition efforts. On a one-off basis, indicators such as the TSI, global carbon intensity and the share of renewable energies reflect real progress that shows how financial and technological mechanisms are managing to significantly reduce emissions and increase the global share of clean energy. On the other hand, the analysis also reveals that the current pace is insufficient to meet the international goals of the Paris Agreement, which emphasizes the need to accelerate and deepen these global actions.

In summary, the information analyzed confirms the idea raised, financial and technological innovation is crucial to accelerate the transition to a global green economy. These mechanisms, together with clear public policies and public-private partnerships, represent a historic opportunity to confront the current climate crisis while building a more just, equitable, and sustainable global economy in the long term.

Although this paper offers a comprehensive and multidimensional analysis of innovative and technological financial mechanisms in the transition to a green economy, it is important to recognize the limitations that arose in their development, which open opportunities for future research.

The analysis of the mechanisms was mainly based on secondary sources from institutional reports, academic literature and official databases. Although these sources are recognized and reliable, there were no primary data that would allow us to delve into the perceptions and experiences of key actors involved in the implementation of these mechanisms.

Due to the global scope of the study, the national or local specificities in the use and impact of financial and technological mechanisms are not addressed in detail. Political, regulatory, and socioeconomic dynamics in each country or region may influence the

effectiveness of these instruments, suggesting the need for studies of greater territorial scale and contextual depth.

Finally, the interdisciplinary nature of the topic implies that some economic, technological, social, and political aspects could only be addressed synthetically within the framework of the study, leaving pending a more in-depth and sectorized analysis of the interactions between these elements.

Based on the various limitations that were identified, priority lines for future research are proposed. Investigate mechanisms in depth in specific national and local contexts, including analyses of success stories and challenges unique to each region, especially in developing or underdeveloped countries. Likewise, to carry out empirical research that quantifies the real impact of financial and technological mechanisms.

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