ANALYSIS OF THE REGULATION ON RENEWABLE ENERGY, DISTRIBUTED GENERATION AND SMART GRIDS IN THE ARGENTINE ELECTRICAL INDUSTRY WITH A LOOK AT THE SUSTAINABLE DEVELOPMENT GOALS (SDGs)

Camila Aquino
Facultad de Ciencias Económicas
Universidad Nacional de Misiones
Misiones, Argentina
aquino_camila@hotmail.com

Date of Receipt: 01/07/2024 – Date of Acceptance: 15/05/2025
DOI: https://doi.org/10.36995/j.visiondefuturo.2025.29.02.006.en

ABSTRACT

The Argentine electricity industry is undergoing changes due to innovations and the appreciation of sustainability, where electricity plays a fundamental role. This also involves analyzing management, understood as the organization of the activities of all stakeholders in this industry.

In this sense, the objective of this work is to analyze the national legislation referring to the electricity industry in relation to renewable energies, distributed generation and smart grids, which contemplate the progress already developed and, with an eye on the sustainable development objectives.

Based on descriptive and qualitative research with a bibliographic review and in-depth interviews, it is concluded that regulation in renewable energy is the most developed, while in distributed generation it is less developed, and that this progress will continue depending on the vision of each national and provincial authority and the overall combination. Regulation in smart grids is still not developed.

Regarding the sustainable development goals established in the Paris Agreement, the country has committed to national targets established in regulations. It is noted that some targets have been met, while others remain to be met by 2030.

KEYWORDS: Renewable Energies, Distributed Generation; Smart Networks; Sustainable Development; Administration.

RESUMEN

La industria eléctrica argentina está sufriendo cambios por innovaciones y la valoración de la sustentabilidad en la actualidad, dónde la energía eléctrica juega un rol fundamental. Esto implica también analizar la administración, entendida como la organización de la actividad de todos los actores de esta industria.

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

En este sentido, el objetivo de este trabajo es analizar la legislación nacional referida a la industria eléctrica en lo relacionado a energías renovables, generación distribuida y redes inteligentes, que contemplan el avance ya desarrollado y, con una mirada en los objetivos de desarrollo sostenible.

En base a una investigación descriptiva y cualitativa con revisión bibliográfica y entrevistas en profundidad, se concluye que la regulación en energías renovables es la más desarrollada, en generación distribuida se encuentra desarrollada en menor medida y, continuará ese avance dependiendo de la visión de cada autoridad nacional, provincial y la combinación global. En redes inteligentes la regulación todavía no está desarrollada.

En cuanto a los objetivos de desarrollo sostenible, establecidos en el Acuerdo de Paris y, el país se ha comprometido con metas nacionales que se han establecido en la regulación. Se observa que algunas metas se cumplieron y otras, están pendientes de cumplirse hacia el año 2030.

PALABRAS CLAVE: Energías Renovables; Generación Distribuida; Redes Inteligentes; Desarrollo Sustentable; Administración.

INTRODUCTION

The Argentine electricity industry currently operates under specific characteristics and regulations that govern the activities of all stakeholders across the country. The electricity sector is capital-intensive, requiring investment and infrastructure resources, and it benefits from economies of scale. (Romo Rico D. y., 2008) The industry follows a vertically integrated structure encompassing generation, transmission, and distribution activities. (Subsecretaría de Energías Renovables y Eficiencia Energética, 2019)

Electricity transmission and distribution services are considered public services with monopolistic characteristics, while generation is regarded as an activity of general interest. (Ley 24.065, 1992)

Vives (2006) points out the following regarding electricity generation:

> Capacity constraints are significant in the generation industry, both in the medium term (construction of new power plants) and in the short term (due to availability issues or the strategic withdrawal of plants during certain periods) […] (pág. 5)

Electricity is a service characterized by the fact that its generation depends on demand or society's need for energy, as, to date, there is no possibility of storing it in large quantities. In other words, "[…] the networks lack storage capacity to cope with demand fluctuations in the very short term." (Moragues, Mayo de 2014, pág. 5). This means that electricity must be generated at the same time it is consumed. This feature—unlike in other industries—affects every stage of the electricity industry and influences the organization of power systems.

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

(Domeett, 2015) Therefore, given the need for economies of scale, the solution adopted worldwide has been to generate electricity in large quantities and transport it across all regions until it reaches the end user.

The electricity transmission service is responsible for delivering electricity to where the demand is located; that is, it connects power generation plants with the points of consumption where users are found. (Subsecretaría de Energías Renovables y Eficiencia Energética, 2019)

Las empresas distribuidoras toman energía del sistema de transporte, transforman esa energía a niveles de tensión menores y la distribuyen por sus redes a sus diferentes usuarios. (Subsecretaría de Energías Renovables y Eficiencia Energética, 2019)

In the case of transmission and distribution, these are considered natural monopolies because they require investment and infrastructure resources and rely on economies of scale. They are feasible to be produced and provided to society through a single company or institution (Torrico T., 2005) since building two separate networks would be prohibitively expensive.

Today, the electricity industry is undergoing changes that require rethinking its management due to evolving societal perspectives and technological advances. There is a growing trend toward promoting sustainable use and environmental care, particularly aimed at preserving ecosystems for future generations (Reyes-Sanchez, 2012), In the electricity market, this translates into the pursuit of cleaner, renewable energy sources, energy efficiency, and sustainable consumption.

In particular, the management of the electricity industry as it relates to regulation—taking into account renewable energy, smart grids, and distributed generation—requires attention. This is an evolving process currently underway. The importance of this analysis lies in the fact that electricity is essential to modern life; it is present in nearly all activities in today's society—for example, water supply to households, food refrigeration, and the operation of equipment in the health and industrial sectors, among others.

In this context, the objective of this work is to analyze national legislation concerning the electricity industry with respect to renewable energy, distributed generation, and smart grids—addressing both current developments and the perspective of the Sustainable Development Goals (SDGs). This work forms part of the author's doctoral dissertation.

DEVELOPMENT

Regulation in the Argentine Electricity Industry and Its Administration

A key aspect that emerges from the concept is that administration is concerned with achieving objectives.

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

The next question that arises is: How does administration ensure that objectives are met? In this regard Arenilla Sáez (2010) emphasizes that administration involves carrying out activities, organizing, and interacting with people or institutions.

In the context of electricity industry regulation, administration refers to organizing the regulatory framework and coordinating the activities of the electricity sector, including those of all its stakeholders.

The Electricity Industry and Sustainable Development

In accordance with the provisions of the United Nations Framework Convention on Climate Change (UNFCCC), the 21st Conference of the Parties (COP21) was held in Paris in 2015, where the Paris Agreement—a legally binding international treaty on climate change—was adopted. (Res. SE 517, 2023)

The United Nations (UN) approved the 2030 Agenda, which includes 17 Sustainable Development Goals (SDGs) and 169 targets (Trejo Nieto, 2017), These goals are aimed at addressing people's needs through changes in sustainable development (Álvarez, 2016)

> Thus, in September 2015, representatives from 193 countries adopted a resolution at this global forum that established 17 Sustainable Development Goals and 169 targets to be achieved by 2030 (United Nations, 2015). (Ibujés Villacíl & Franco Crespo, 2019, pág. 38)

By ratifying the UNFCCC, Argentina committed to a series of obligations, including reporting national greenhouse gas (GHG) inventories and establishing national programs containing measures to mitigate climate change. (Subsecretaría de Energías Renovables y Eficiencia Energética, 2019)

More specifically, Article 2, Section A of the Paris Agreement established the following duty for the Parties:

> To keep the increase in the global average temperature well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change. (Res. SE 517, 2023, pág. 52)

As stated in Annex 1 of Resolution SE 517 (2023), the energy sector was responsible for 78% of global emissions in 2019. Specifically, in Argentina, the energy sector accounts for 51% of the country's emissions. "When analyzed by subsector, energy sector emissions mainly come from the transport sector, which explains 1.9% of total emissions, followed by electricity generation, whose share of total emissions amounts to 11%". (Res. SE 517 Anexo 1, 2023, pág. 4) This means, as noted in previous paragraphs, that the electricity industry plays a significant role in the problem of climate change and the greenhouse effect. Moreover, as the data show, electricity generation is crucial for contributing to the mitigation of greenhouse gas

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

emissions and the decarbonization of the country's energy matrix, and this is where non-conventional renewable energies come into play.

Considering the United Nations Sustainable Development Goals (SDGs), reflection on the electricity industry specifically involves thinking about how, within this emerging context—which includes the development of renewable energies, distributed generation, and smart grids—regulation can contribute to achieving the objectives of ensuring secure, sustainable, and modern energy; guaranteeing sustainable consumption and production patterns; and implementing urgent measures to combat climate change and its effects.

The Electricity Industry and Sustainable Development

Considering the United Nations Sustainable Development Goals (SDGs), reflection on the electricity industry specifically involves thinking about how, within this emerging context—which includes the development of renewable energies, distributed generation, and smart grids—regulation can contribute to achieving the objectives of ensuring secure, sustainable, and modern energy; guaranteeing sustainable consumption and production patterns; and implementing urgent measures to combat climate change and its effects.

Methodology

The research conducted is descriptive and cross-sectional, utilizing bibliographic and documentary reviews, along with in-depth interviews, as sources of data collection. These methods form part of the qualitative research conducted for the Doctoral Thesis in 2023. Experts from both the public and private sectors of the electricity industry in Argentina were interviewed. The interviews included open-ended questions.

Renewable Energies

Renewable energies are cleaner energy sources derived from natural origins and, as Fraguío (2021) notes, are ´in principle´ non-polluting resources. According to regulation law 27.191 (2015), renewable energy sources are defined as follows:

> Renewable non-fossil energy sources suitable for sustainable use in the short, medium, and long term include wind energy, solar thermal energy, photovoltaic solar energy, geothermal energy, tidal energy, wave energy, marine current energy, hydropower, biomass, landfill gases, sewage treatment plant gases, biogas, and biofuels, with the exception of uses specified in Law 26.093. (pág. Art. 2 inc. a)
>
> The power limit established by this law for hydroelectric power plant projects is up to fifty megawatts. (pág. Art. 2 inc. b)

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

Table 1

Regulatory Framework on Renewable Energy – Argentine Republic

Regulations on Renewable Energy Sources	Issuing Body	Year Enacted	What did it establish?
Law 27,191 (2015) National Promotion Scheme for the Use of Renewable Energy Sources for the Generation of Electric Power	Senate and Chamber of Deputies of the Argentine Nation	October 21, 2015	Objective: To promote the use of renewable energy sources for the generation of electric power. This law was introduced as a modification and expansion of Law 26,190. Article 1: The objective of this regime is to achieve a contribution from renewable energy sources representing at least eight percent (8%) of the national electric power consumption by December 31, 2017. Article 5: The objective of the second stage of the regime is to achieve a contribution from renewable energy sources representing at least twenty percent (20%) of the national electric power consumption by December 31, 2025. Chapter III: Establishes the Trust Fund for the Development of Renewable Energy (FODER). Chapter IV: Establishes the obligation of electric power users to contribute to the achievement of the objectives set forth in the Promotion Regime. A compliance schedule is established, aiming to reach twenty percent (20%) of total self-consumption of electric power by December 31, 2025. The law also provides for penalties in the event of non-compliance. Mandatory minimum targets are as follows:

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

			• By December 31, 2017: at least eight percent (8%) of total self-consumption of electric power. • By December 31, 2019: at least twelve percent (12%). • By December 31, 2021: at least sixteen percent (16%). • By December 31, 2023: at least eighteen percent (18%). • By December 31, 2025: at least twenty percent (20%). The law also establishes a set of tax incentives.
Presidential Decree No. 531 (2016)	President of the Argentine Nation	March 31, 2016	Approved the regulation of Law 26,190 as amended by Law 27, 191
Resolution 281-E (2017)	Ministry of Energy and Mining	August 22, 2017	Approved the Renewable Energy Electricity Forward Market Regime

Note: Own elaboration based on the cited sources.

The first law to declare wind and solar energy generation as a matter of national interest throughout the entire national territory was Law 25.019 (1998, pág. Art. 1), which established tax incentives for wind and solar generation activities intended for public service provision.

Law 26.190 (2007), known as the National Promotion Regime for the Use of Renewable Energy Sources for Electricity Production, was promoted in 2006. This law declared electricity generation from renewable energy sources as a matter of national interest and also established tax benefits. Law 26.190 (2007) further set a target of 8% participation of renewable energies in the country's energy matrix within a period of ten (10) years.

Finally, in 2015, Law 27.191 was enacted, establishing a promotion regime for renewable energies intended for electricity production, which modifies and expands Law 26.190.

In addition to defining renewable energy sources already mentioned in Law 26.190 — including wind, solar thermal, photovoltaic solar, geothermal, tidal, hydropower, biomass, landfill gases, sewage treatment plant gases, and biogas, with the exception of uses specified in Law 26.093 (2007, pág. Art. 4 inc. a), — Law 27.191 (2015, pág. art. 2) adds wave energy, marine current energy, and biofuels as renewable sources. Furthermore, the aforementioned law increased the hydroelectric power plant project capacity limit from 30 MW, as established by Law 26.190 (2007, Art. 4, clause b), to 50 MW.

La ley 27.191 (2015, pág. art. 2) además de definir como fuentes de energías renovables las ya mencionadas por la ley 26.190 - energía eólica, solar térmica, solar fotovoltaica,

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

geotérmica, mareomotriz, hidráulica, biomasa, gases de vertedero, gases de plantas de depuración, biogás, con excepción de los usos previstos en la ley 26.093 - (2007, pág. Art. 4 inc. a), agrega como fuentes de energías renovables la undimotriz, de las corrientes marinas y los biocombustibles. Asimismo, la mencionada ley amplió el límite de potencia de 30 MW que estableció la ley 26.190 (2007, pág. Art. 4 inc. b) para los proyectos de centrales hidroeléctricas a 50 MW.

Law 27.191 (2015) set as its initial target achieving an 8% contribution of renewable energy sources to the national electricity consumption by December 31, 2017 (pág. Art. 1). According to annual reports by CAMMESA, the evolution of the electricity generation supply achieved the following participation:

Table 1

Annual Energy Generation Supply by Year

% Participation in the Total Supply	2018	2019	2020	2021	2022
Thermal	63,8%	61,8%	60,5%	59,1%	58,9%
Hydraulic	29,1%	27,2%	25,8%	25,2%	25,2%
Nuclear	4,7%	4,4%	4,2%	4,1%	4,1%
Renewables(*)	2,4%	6,5%	9,5%	11,6%	11,8%

Note: Elaboración propia en base a datos CAMMESA Informe Anual 2018 (2019) CAMMESA Informe Anual 2019 (2020), CAMMESA Informe Anual 2020 (2022), CAMMESA Informe Anual 2021 (2023) y CAMMESA Informe Anual 2022 (2024).
(*) Las energías renovables incluyen biodiesel, biomasa, biogás, eólico, solar e hidro renovable.

Analyzing the evolution of the total electricity generation supply according to CAMMESA data, it can be observed that the initial target set by Law 27.191 was achieved in 2020.

For Large Users of the Wholesale Electricity Market — defined as major consumers who are clients of distributors with power demands equal to or greater than three hundred kilowatts (300 kW) — Law 27.191 (2015) mandates their contribution to fulfilling the objectives of the Promotion Regime. For these Large Users (with power demands equal to or exceeding 300 kW), a compliance schedule is established, aiming to reach 20% of their total self-consumption of electricity by December 31, 2025. The law also provides for penalties in case of non-compliance. The Renewable Energy Sources Electricity Term Market Regime (MATER) (Decreto PEN 531, 2016) allows these users to self-supply their demand or purchase renewable energy from private parties to meet their obligations under Article 8. (Resolución SE 517 Anexo 1, 2023)

Based on CAMMESA's annual reports from 2017 (CAMMESA, 2018), 2020 (CAMMESA, 2022), 2021 (CAMMESA, 2023) and 2022 (CAMMESA, 2024) the generation of electricity from renewable sources was distributed as follows from 2012 to 2022:

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

Table 2

Renewable Energy Sources 2012-2022

ENERGY SOURCE	YEAR 2012	YEAR 2013	YEAR 2014	YEAR 2015	YEAR 2016	YEAR 2017	YEAR 2018	YEAR 2019	YEAR 2020	YEAR 2021	YEAR 2022
Biodiesel	8%	0%	0%	0%	0%	0%	0%	0%	0%	-	-
Biomass	6%	7%	5%	6%	7%	9%	7%	4%	3%	1,4%	1,4%
Wind	16%	23%	27%	24%	21%	23%	43%	64%	74%	66%	65%
Renewable Hydro	68%	64%	63%	66%	69%	64%	42%	19%	10%	10%	10,4 %
Solar	0%	1%	1%	1%	1%	1%	3%	10%	11%	21%	21%
Biogas	2%	5%	4%	3%	2%	2%	4%	3%	2%	1,4%	1,4%
Total GWh	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note: Elaboración propia en base a datos CAMMESA Informe Anual 2017 (CAMMESA, 2018), CAMMESA Informe Anual 2020 (2022), CAMMESA Informe Anual 2021 (2023) CAMMESA Informe Anual 2022 (2024).

From the table above, it can be observed that between 2012 and 2018, renewable hydroelectric, wind, and biomass energy accounted for the largest share within renewable energy sources. Over the last four years, there has been notable growth in the participation of wind energy as well as an increase in the share of solar energy.

Distributed Generation

For regulatory purposes, distributed generation is defined as follows:

> […] the generation of electricity from renewable sources by users of the distribution network for their own consumption, with the possible injection of surplus energy into the grid, and the obligation of public distribution service providers to facilitate such injection, ensuring free access to the distribution network, without prejudice to the powers of the provinces. (Ley 27.424, 2017, pág. Art. 1)

Table 4

Regulatory Framework on Distributed Generation – Argentine Republic

Regulations on Distributed Generation	Issuing Body	Year Enacted	What did it Establish?
Law 27,424 (2017) Promotion Regime for Distributed Generation of Renewable Energy Connected to	Senate and Chamber of Deputies of the Argentine Nation	December 27, 2017	What It Establishes: • Objective: Establishes policies and legal and contractual conditions for the generation of renewable electric energy by distribution network users for self-consumption, with the possibility of injecting surplus energy into the grid, and mandates that public

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

the Public Electric Grid			distribution service providers facilitate such injection. (Article 1) • Large users or self-generators in the wholesale electric market are excluded. (Article, Point j) • All user-generators must meet the technical requirements established by the regulations. (Article 5) • Requires that user-generators obtain prior authorization from the distributor, including a technical and safety evaluation of the distributed generation equipment. • Establishes a promotional benefits regime and creates the FODIS (Trust Fund for the Development of Distributed Generation from Renewable Sources).
Presidential Decree No. 986 (2018)	President of the Argentine Nation	November 2, 2018	The decree aims to achieve the installation of a total of 1,000 MW of distributed generation capacity from renewable sources within twelve years from the date the decree comes into effect, that is, by the year 2030. (Article 2)
Resolution S.G.E. 314 (2018)	Secretariat of Energy Government	December 21, 2018	Created the National Registry of Renewable Energy User-Generators (RENUGER). (Article 4)
Presidental Decree No.471	President of the Argentine Nation	September 6, 2023	Replaces Article 25 of the Annex of Decree 986/2018. It establishes that the granting of promotional benefits will be available to User-Generators from jurisdictions that have fully or partially adhered to the regime established by Law 27,424 and its amendments.

Note: Own elaboration based on the cited sources.

According to Law 27.424 (2017), distributed generation is considered for self-consumption with the possible injection of surplus energy into the grid. This means that large users or self-generators in the wholesale electricity market are not included under this definition.

Law 27.424 (2017)) introduces the figure of the Prosumer (user-generator), referring to a user who has the ability to meet part of their electricity demand through their own renewable energy generation via distributed generation.

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

> The installation of a renewable distributed generation system enables the user to cover part of their electricity demand without relying on the grid supply, resulting in economic savings due to self-consumption. Furthermore, if there is surplus electricity generated by the renewable source, the user-generator may receive financial compensation for injecting the surplus into the grid. (Subsecretaría de Energías Renovables y Eficiencia Energética, 2019, pág. 8).

Distributed generation represents a fundamental change for users adopting this system, as they transition from being solely consumers to becoming user-producers—that is, they can generate energy for self-consumption while also consuming electricity from the grid. This concept of a User-Producer did not previously exist in the Argentine electricity industry.

Another important regulatory aspect related to renewable energies and distributed generation is that Resolution 507 (2023) by the Secretariat of Energy approves the High Voltage Electricity Transmission System Expansion Plan, aiming to increase the integration of renewable sources. This responds to the challenge that the high-voltage transmission capacity is saturated or near saturation.

Smart Grids

Smart grids, or the digitalization of electricity distribution networks—also known as smart grids—are a concept that emerged several years ago in the electricity industry. Smart grids can be viewed as a disruptive technology because their adoption will inevitably modify certain aspects of the industry as it currently stands.

What are Smart Grids?

According to Medina (2013):

> This concept is based on incorporating electronic devices such as meters, sensors, or controllers into the traditional electrical grid; linked through various communication technologies, enabling the centralization and use of information for the benefit of all actors involved; optimizing the operation of the electrical system. (pág. 1)

As can be derived from Medina's (2013) concept of smart grids, there is a direct link to the Industry 4.0 concept (Díaz Martínez, Cruz-Méndez y Ruiz-Domiguez, 2018) — that is, how the introduction of digital and communication technologies in the industry enables devices and systems to collaborate with each other, achieving the concentration and use of information for the benefit of all stakeholders.

Regarding the regulation of smart grids, it is still under development.

Energy Transition

Currently, non-conventional renewable energies, distributed generation, and smart grids can be encompassed within the concept of the energy transition, alongside other evolving industry variables.

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

Resolution 517 of the Secretariat of Energy (2023) sets forth a national energy transition plan for the Argentine Republic, serving as a coordinating instrument for various initiatives from the National Congress, the Secretariat of Energy, and other agencies. This resolution includes an analysis of the relevant national regulatory framework.

Presented below is the regulatory framework through which Argentina ratified the United Nations Framework Convention on Climate Change, the Kyoto Protocol, the Paris Agreement, and the implementation of the 2030 Agenda for Sustainable Development.

Table 3

Regulatory framework on energy transition

Regulations on Energy Transition	Issuing Body	Year Enacted	What does it establish?
Law 24.295 (1993)	Argentine National Congress	1993	Approved the United Nations Framework Convention on Climate Change.
Law 25.438 (2001)	Argentine National Congress	2001	Approved the Kyoto Protocol to the United Nations Framework Convention on Climate Change, adopted in Kyoto, Japan, on December 11, 1997.
Law 27.270 (2016)	Argentine National Congress	2016	Approved the Paris Agreement, made in Paris, France, on December 12, 2015.
Decree No. 499 (2017)	Office of the President of the Nation	2017	Implemented the 2030 Agenda for Sustainable Development.

Note: Own elaboration based on a (Resolución SE 517 Anexo 1, 2023)

In-Depth Interview Analysis

The in-depth interviews aimed to gather the perspectives of experts from the Argentine electricity industry regarding the development of non-conventional renewable energies, distributed generation, and smart grids—that is, insights into how these changes or new conditions are shaping the Argentine electricity industry. The following analysis emerges from their responses.

Results

When asked about the progress of non-conventional renewable energies in achieving a cleaner energy system, all interviewees agreed that this area is the most advanced and developed to date. Regarding the pace of progress, the responses indicated that the advancement has been slow compared to developed countries, with notable progress mainly observed from 2016 to the present.

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

Analyzing future development perspectives, the interviewees also indicated that the growth of non-conventional renewable energies in the country's energy matrix will partly depend on the development of natural gas, which is an abundant resource in Argentina.

From both the bibliographic research and the interview responses, it is evident that Argentina's regulation has incorporated obligations it committed to upon ratifying the United Nations Framework Convention on Climate Change (UNFCCC). Linked to the Sustainable Development Goals and the Paris Agreement, each country committed to achieving national targets aligned with the global goals. In this regard, Argentina established among its objectives a significant increase in the proportion of renewable energy within its overall energy sources by 2030 (Ley 27.191, 2015). The interview responses reflected diverse opinions—ranging from those who believe Argentina is close to fulfilling its commitments to others who consider the country still far from achieving the proposed goals.

When asked about the greatest potential for non-conventional renewable energies in Argentina, respondents identified wind, solar, and biomass energy as the most promising sources.

The interviewees also pointed out challenges that hinder further growth in the share of non-conventional renewable energies within the country's energy matrix. There was consensus in identifying the national transmission system as a bottleneck, since some renewable generation projects could not be carried out due to the transmission network lacking sufficient capacity to incorporate the new generation.

Regarding the development and progress of distributed generation in Argentina, the interviewees agreed that advancement has been minimal or insignificant.

Additionally, responses indicated that this progress varies widely across provinces. Some provinces had already established their own regulatory frameworks promoting distributed generation prior to the enactment of the national law, and the greatest progress is observed in these pioneering jurisdictions. The rest of the provinces remain highly dependent on national funding.

The lack of development credits was identified as a major obstacle to the continued advancement of distributed generation in the country.

When exploring future development prospects in Argentina, responses indicated that significant progress or development is necessarily linked to state incentives. Existing regulations, which remain incipient, need to be advanced; many provinces have implemented such regulations with positive results. Regulatory frameworks could be further developed to simplify and facilitate the effective integration of distributed generation. Additionally, respondents highlighted that the current energy transition context favors the advancement and development of distributed generation. Another point raised is that currently, only generation

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

for self-consumption is accepted, but in the coming years, there should be substantial facilitation for generating energy beyond self-consumption.

Regarding smart grids or the digitalization of networks in Argentina, this variable is the least developed among those analyzed. Interviewees' opinions ranged from those perceiving no significant progress to those observing no development at all.

Delving deeper into the current status of smart grid deployment in Argentina, the responses indicate that at the high-voltage level, the country already operates smart grids, with the major challenge being their extension to distribution networks. One observation was that worldwide, there are few examples of countries that have fully solved network digitalization for large cities.

The difficulties perceived for the advancement of smart grids in Argentina are mainly related to the required investment.

One key takeaway from the interviews is that, regarding smart grid regulation, the country is still in an analytical phase with much work remaining, as well as the need for economic incentives.

Regarding future development prospects, responses suggested that the advancement and implementation of smart grids will require 8 to 10 years.

Another noteworthy point from the responses is that the digitalization of networks will inevitably alter the current balance between generation, transmission, and distribution, reducing (though not completely eliminating) the role of transmission.

Interviewees were also asked about the aspects that must be addressed to achieve a robust and flexible energy system, especially considering common critiques of non-conventional renewables related to their intermittency.

A primary conclusion from this question is the country's need to secure energy supply at all times—i.e., to solve the intermittency issues of renewable generation. Despite past criticisms regarding intermittency, the responses suggest this is no longer the central focus of analysis; the criticism phase has been overcome. The current attention is on how to feasibly integrate renewable energy into the national energy matrix considering all relevant factors.

Analyzing the current situation, it is clear that the capacity of high-voltage transmission lines is presently a bottleneck for incorporating available capacity, and therefore a barrier to increasing the share of non-conventional renewables in the national energy matrix.

Looking ahead, the interviews indicated optimism toward a mixed expansion strategy, including the integration of battery storage packs working in conjunction with photovoltaic generation to ensure renewable energy supply remains constant. Achieving a robust energy system involves recognizing that it cannot be 100% renewable and must incorporate thermal, hydroelectric, or gas generation. Currently, gas is the cheapest energy source in the country—raising the question: how do we reconcile this with sustainable development goals?

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

When analyzing key factors for achieving energy efficiency in Argentina, and considering its growing global relevance, the interviews concluded that given energy scarcity and high costs, efficient practices will increasingly become mandatory, and new products leveraging advances in optimal energy use with minimal losses will continue to be developed.

First, analyzing efficiency in electricity generation, current perspectives highlight, on one hand, a lack of capital investment, and on the other, progress toward commissioning efficient power plants and decommissioning inefficient ones. Related to the goal of achieving efficiency in electricity generation is the issue of the current capacity of high-voltage electricity transmission; in other words, where there is potential for more efficient generation, there is no means to transport that energy.

In the residential sector, responses indicate the need for continued user education and training, as well as the necessity to align costs transparently to incentivize efficiency. In the industrial sector, it was noted that energy efficiency measures are already being implemented.

Finally, regarding energy efficiency measures and the regulatory framework, responses emphasized the need to update existing regulations.

From the analysis of regulations on non-conventional renewable energies, distributed generation, and smart grids, and considering whether new regulations are required beyond the existing ones, an initial reflection from the interviews is that the regulation of the electricity market in general must address current problems and anticipate future markets. In this regard, regulatory updates are ongoing but lag behind.

Regulation of renewable energies is relatively well developed, and a renewable energy futures market has been established, making renewable energies an integral part of investment decisions. Generally, the framework is regulated, and perhaps only improvements are needed.

Concerning the regulation of distributed generation, there has been progress, although to a lesser extent than with renewable energies. Coordination with the overall system is necessary, and the pace of advancement depends on both national and provincial visions, as well as on creating mechanisms to access investments and improve the economic context.

Regulation of smart grids, however, remains undeveloped. Interviewees highlighted the necessity of regulation concerning smart grids for distribution companies, as well as accessible incentives for all stakeholders. Responses also suggest that smart grid regulation will emerge as a complement to the country's development of distributed generation.

In general terms, regarding the regulation of these three variables analyzed in this research, it appears essential to start with existing regulations and update them.

Finally, responses indicate that the future vision of electricity industry regulation can be divided into two broad paths or perspectives: one involving continued strong state regulation, and the other promoting free competition or, driven by the number of autonomous users and

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

generators, liberalizing at least generation costs. In the latter scenario, regulation would differ from the current framework, but state regulation would remain necessary given the crucial role of energy in societal life.

CONCLUSION

The objective of this study was to analyze the national legislation related to the electricity industry concerning renewable energies, distributed generation, and smart grids, taking into account the progress already achieved and framed within the Sustainable Development Goals (SDGs).

Analyzing the national regulatory framework with regard to renewable energies, distributed generation, and smart grids involves examining whether new forms of management will be required, understanding management as the normative ordering and organization of the industry's activities and all its stakeholders.

The update of the national regulatory framework is ongoing, considering that it must anticipate changes in the environment, as observed from the literature review, the regulation itself, and the interviews. The research indicates that regulation should begin with the existing framework and focus on updating it.

It is concluded from the literature review and interviews that regulation of non-conventional renewable energies is the most developed in the country.

Argentina has adhered to the United Nations Framework Convention on Climate Change, the Kyoto Protocol, and the Paris Agreement, and has implemented the 2030 Agenda for Sustainable Development. In this regard, a comprehensive regulatory framework and goals have been established. Some of these goals were already achieved in 2020, such as the first objective of Law 27.191 (2015) to reach an 8% contribution of renewable energy sources to national electricity consumption (pág. Art. 1). The upcoming challenge is to meet the second objective of Law 27.191 (2015), which is to achieve, by December 31, 2025, a 20% contribution from renewable energy sources to national electricity consumption (pág. Art. 5). The research suggests that the future advancement of non-conventional renewable energies in the country's energy matrix will partly depend on the development of natural gas, an abundant resource in Argentina. Electricity transmission currently poses another challenge for increasing the share of renewable energies in the country's energy matrix. Although it is not yet feasible to envision a fully renewable matrix, progress will depend on the context and the expansion of transmission capacity or lines.

From the literature review and interviews, it also emerges that progress in distributed generation regulation varies by province, with some advances observed. Future perspectives are necessarily tied to state incentives. Regulation could be improved to simplify the integration

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

of user-generators. Regulation of smart grids remains undeveloped and will require gradual updates.

Analyzing the national legislation related to the electricity industry in terms of renewable energies, distributed generation, and smart grids allowed, on the one hand, to highlight their significant contribution to fulfilling the Sustainable Development Goals, and on the other hand, to reflect on how regulation, understood as sector management, can support these ongoing changes. Future research may continue to study regulatory evolution as well as analyze progress toward the Sustainable Development Goals in the energy sector.

BIBLIOGRAPHIC REFERENCES

Álvarez, A. (2016). Retos de América Latina: Agenda para el desarrollo sostenible y negociaciones del siglo XXI. *Problemas del desarrollo, 47*(186), 9-30. doi:https://www.probdes.iiec.unam.mx/index.php/pde/article/view/55886

Arenilla Sáez, M. (2010). *La administración pública entre dos siglos.* Madrid: Instituto Nacional de Administración Pública. Recuperado el 2 de 12 de 2023, de https://www.euskadi.eus/gobierno-vasco/contenidos/informacion/bibl_digital/es_documen/adjuntos/siglos.pdf

Ballesteros-Ballesteros, V. A., & Gallego-Torres, A. (2019). Modelo de educación en energías renovables desde el compromiso público y la actitud energética. *Revista Facultad de Ingeniería, 28*(52), 27-42. doi:https://doi.org/10.19053/01211129.v28.n52.2019.9652

CAMMESA. (27 de junio de 2018). *CAMMESA - Compañía Administradora del Mercado Mayorista Eléctrico Sociedad Anónima.* Recuperado el 28 de junio de 2024, de CAMMESA - Compañía Administradora del Mercado Mayorista Eléctrico Sociedad Anónima: https://cammesaweb.cammesa.com/informe-anual/?doing_wp_cron=1719574191.2821960449218750000000#

CAMMESA. (10 de julio de 2019). *Compañía Administradora del Mercado Eléctrico Sociedad Anónima.* Recuperado el 28 de junio de 2024, de Compañía Administradora del Mercado Eléctrico Sociedad Anónima: https://cammesaweb.cammesa.com/informe-anual/?doing_wp_cron=1719574191.2821960449218750000000#

CAMMESA. (12 de junio de 2020). *Compañía Administradora del Mercado Eléctrico Sociedad Anónima.* Recuperado el 28 de junio de 2024, de Compañía Administradora del Mercado Eléctrico Sociedad Anónima: https://cammesaweb.cammesa.com/informe-anual/?doing_wp_cron=1719574191.2821960449218750000000#

CAMMESA. (20 de mayo de 2022). *Informe Anual 2020.* Recuperado el 19 de febrero de 2024, de Compañía Administradora del Mercado Eléctrico Sociedad Anónima: https://cammesaweb.cammesa.com/informe-anual/

CAMMESA. (09 de mayo de 2023). *Informe Anual 2021.* Recuperado el 19 de febrero de 2024, de Compañía Administradora del Mercado Mayorista Eléctrico Sociedad Anónima: https://microfe.cammesa.com/static-content/CammesaWeb/download-manager-files/Informe%20Anual/2022/Inf%20Anual%202021.pdf

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

CAMMESA. (06 de junio de 2024). *Informe Anual 2022.* Recuperado el 19 de febrero de 2024, de Compañía Administradora del Mercado Mayorista Eléctrico Sociedad Anónima: https://cammesaweb.cammesa.com/informe-anual/

Decreto PEN 499. (13 de julio de 2017). "Agenda 2030 para el Desarrollo Sostenible". Objetivos. *(33665)*. Argentina. Recuperado el 12 de febrero de 2024, de https://servicios.infoleg.gob.ar/infolegInternet/anexos/275000-279999/276820/norma.htm

Decreto PEN 531. (31 de marzo de 2016). Régimen de Fomento Nacional para el Uso de Fuentes Renovables de Energía destinada a la Producción de Energía Eléctrica. Reglamentación. Argentina. Recuperado el 13 de febrero de 2024, de https://www.boletinoficial.gob.ar/detalleAviso/primera/142860/20160331?busqueda=1

Decreto PEN 986. (2 de noviembre de 2018). Presidencia de la Nación. Argentina. Recuperado el 14 de febrero de 2024, de https://www.boletinoficial.gob.ar/detalleAviso/primera/195080/20181102?busqueda=1

Díaz Martínez, Cruz-Méndez y Ruiz-Domiguez. (2018). Instrumento de diagnóstico y autoevaluación para medir las condiciones organizacionales hacia la nueva revolución industrial 4.0. *RIIIT Revista internacional de investigación e innovación tecnológica, 6*(35), 1-14. Recuperado el 31 de agosto de 2020, de http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-97532018000500002&lng=es&tlng=es

Domeett, G. (2015). Análisis de los determinantes del cambio de la demanda. *Ciencias Administrativas*(6), 17-31. Recuperado el 20 de octubre de 2023, de https://www.redalyc.org/articulo.oa?id=511651382003

Fraguío, M. P. (2021). Retos jurídicos ante la transformación del paradigma energético. . *Revista Internacional CONSINTER de Direito - Publicação Oficial do Conselho Internacional de Estudos Contemporâneos em Pós-Graduação*(12), 321-342. doi:https://doi.org/10.19135/revista.consinter.00012.15

Ibujés Villacíl, J. M., & Franco Crespo, A. A. (2019). Uso de las TIC y relación con los Objetivos de Desarrollo Sostenible en Ecuador. *RETOS Revista de Ciencias de la Administración y Economía, 9*(17), 37-53. doi:https://dx.doi.org/10.17163/ret.n17.2019.03

Iturralde Durán, C. (2019). Los paradigmas del desarrollo y su evolución: Del enfoque económico al multidisciplinario. *RETOS Revista de Ciencias de la Administración y Economía, 9*(17), 7-23. doi:https://doi.org/10.17163/ret.n17.2019.01

Iturralde Durán, C. (2019). Los paradigmas del desarrollo y su evolución: Del enfoque económico al multidisciplinario. *RETOS. Revista de Ciencias de la Administración y Economía, 9*(17), 723. doi:https://doi.org/10.17163/ret.n17.2019.01

Ley 24.065. (16 de enero de 1992). Régimen de la Energía Eléctrica. Argentina. Recuperado el 20 de junio de 2024, de http://servicios.infoleg.gob.ar/infolegInternet/anexos/0-4999/464/texact.htm

Ley 24.295. (1993). Ley 24.295 Honorable Congreso de la Nación Argentina. *Convención Marco de las Naciones Unidas - Cambio Climático(27805)*. Argentina. Recuperado el 3 de febrero de 2024, de https://servicios.infoleg.gob.ar/infolegInternet/anexos/0-4999/699/norma.htm

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

Ley 25.019. (26 de octubre de 1998). Régimen Nacional de Energía Eólica y Solar. *(29008)*. Argentina. Recuperado el 26 de junio de 2024, de http://servicios.infoleg.gob.ar/infolegInternet/anexos/50000-54999/53790/texact.htm

Ley 25.438. (2001). *Protocolo de Kyoto sobre cambio climático(29692)*. Argentina. Recuperado el 3 de febrero de 2024, de https://servicios.infoleg.gob.ar/infolegInternet/anexos/65000-69999/67901/norma.htm

Ley 26.190. (02 de enero de 2007). Régimen de Fomento Nacional para el uso de fuentes renovables de energía destinada a la producción de energía eléctrica. *(31064)*. Argentina. Recuperado el 26 de junio de 2024, de http://servicios.infoleg.gob.ar/infolegInternet/anexos/120000-124999/123565/texact.htm

Ley 27.191. (21 de octubre de 2015). Régimen de Fomento Nacional para el uso de Fuentes Renovables de Energía destinada a la Producción de Energía Eléctrica. Modificación. Argentina. Recuperado el 23 de junio de 2024, de http://servicios.infoleg.gob.ar/infolegInternet/anexos/250000-254999/253626/texact.htm

Ley 27.270. (19 de septiembre de 2016). *Acuerdo de París(33464)*. Argentina. Recuperado el 3 de febrero de 2024, de https://servicios.infoleg.gob.ar/infolegInternet/anexos/265000-269999/265554/norma.htm

Ley 27.424. (27 de diciembre de 2017). Régimen de Fomento a la Generación Distribuida de Energía Renovable integrada a la Red Eléctrica Pública. *(3379)*. Argentina. Recuperado el 26 de junio de 2024, de http://servicios.infoleg.gob.ar/infolegInternet/anexos/305000-309999/305179/texact.htm

Medina, O. (2013). *Redes inteligentes ¿Realidad, utopía o futuro?* Secretaría de Energía. Recuperado el 27 de junio de 2024, de http://www.energia.gob.ar/contenidos/archivos/Reorganizacion/contenidos_didacticos/publicaciones/redes_inteligentes.pdf

Moragues, J. (Mayo de 2014). *Núcleo socio-productivo estratégico. Almacenamiento de energía.* Ministerio de Ciencia, Tecnología e Innovación Productiva. Argentina Innovadora 2020 Plan Nacional de Ciencia, Tecnología e Innovación Productiva. Recuperado el 15 de agosto de 2023, de https://www.argentina.gob.ar/sites/default/files/almacenamiento_energia_2016_arg_innovadora_2020.pdf

Morejón Santistevan, M. E. (2016). La teoría organizacional: un análisis de su enfoque en una administración pública y su diferencia en una administración privada. *Revista Enfoques: Ciencia Política y Administración Pública, XIV*(25), 127-143. Obtenido de https://www.redalyc.org/pdf/960/96049292007.pdf

Res. MEyM 281-E. (22 de agosto de 2017). Régimen de Mercado a Término de Energía Eléctrica de Fuentes Renovables. Aprobación. Argentina. Recuperado el 13 de febrero de 2024, de https://www.boletinoficial.gob.ar/detalleAviso/primera/169410/20170822?busqueda=1

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

Res. SE 507. (12 de junio de 2023). Resolución Secretaría de Energía. Argentina. Recuperado el 17 de febrero de 2024, de https://www.boletinoficial.gob.ar/detalleAviso/primera/288063/20230612?busqueda=1

Res. SE 517. (7 de julio de 2023). Resolución Secretaría de Energía 517. Argentina. Recuperado el 23 de junio de 2024, de https://www.boletinoficial.gob.ar/detalleAviso/primera/289826/20230707?busqueda=1

Res. SE 517 Anexo 1. (7 de julio de 2023). Anexo 1 Resolución 517 Secretaría de Energía de la Nación. *Plan Nacional de Transición Energética a 2030*. Argentina. Recuperado el 3 de febrero de 2024, de https://www.boletinoficial.gob.ar/detalleAviso/primera/289826/20230707?busqueda=1

Res. SGE 314. (21 de diciembre de 2018). Resolución Secretaría de Gobierno de Energía. Argentina. Recuperado el 14 de febrero de 2024, de https://www.boletinoficial.gob.ar/detalleAviso/primera/198581/20181221?busqueda=1

Resolución SE 517 Anexo 1. (17 de julio de 2023). Secretaría de Energía de la Nación. *Plan Nacional de Transición Energética a 2030*. Argentina. Recuperado el 3 de febrero de 2024, de https://www.boletinoficial.gob.ar/detalleAviso/primera/289826/20230707?busqueda=1

Reyes-Sanchez, L. (2012). Aporte de la química verde a la construcción de una ciencia socialmente responsable. *Educación química, 23*(2), 222-229. doi:https://doi.org/10.1016/S0187-893X(17)30113-1

Romo Rico, D. y. (2008). El futuro de los energéticos en la globalización. *Análisis Económico, XXIII*(54), 305-327. Obtenido de https://www.redalyc.org/articulo.oa?id=41311483015

Romo Rico, D., & Galina Hidalgo, S. (2008). El futuro de los energéticos en la globalización. *Análisis Económico, XXIII*(54), 306-327. Obtenido de https://www.redalyc.org/pdf/413/41311483015.pdf

Secretaría de Energía. (Noviembre 2019). *Escenarios Energéticos 2030.* Recuperado el 15 de septiembre de 2023, de http://www.energia.gob.ar/contenidos/archivos/Reorganizacion/planeamiento/2019-11-14_SsPE-SGE_Documento_Escenarios_Energeticos_2030_ed2019_pub.pdf

Subsecretaría de Energías Renovables y Eficiencia Energética. (2019). *Introducción a la Generación Distribuida de Energías Renovables.* ISBN 978-987-47110-3-8. Recuperado el 26 de junio de 2024, de https://www.argentina.gob.ar/sites/default/files/introduccion-a-la-generacion-distribuida-de-er.pdf

Torrico T., S. (2005). El discreto encanto del monopolio. Monopolios y derechos de propiedad. *Perspectivas, 8*(2), 25-31. Recuperado el 21 de junio de 2024, de https://www.redalyc.org/pdf/4259/425942412003.pdf

Trejo Nieto, A. (2017). Crecimiento económico e industrialización en la Agenda 2030: perspectivas para México. *Problemas del desarrollo, 48*(188), 83--111. doi:https://doi.org/10.1016/j.rpd.2017.01.005

Vives, X. (2006). El reto de la competencia en el sector eléctrico. *IESE Ocasional Paper, 6*(13), 1-13. Recuperado el 27 de 11 de 2023, de

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina

https://blog.iese.edu/xvives/files/2012/01/OP-06-13-El-reto-de-la-competencia-en-el-sector-el%C3%A9ctrico.pdf

BIBLIOGRAPHICAL ABSTRACT

Please refer to articles Spanish Biographical abstract.

Los trabajos publicados en esta revista están bajo la licencia Creative Commons Atribución-NoComercial 2.5 Argentina