

# Journal of Engineering Research

## WOMEN IN THE NUCLEAR FIELD DRIVING LATIN AMERICAN INTEGRATION

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*Nélida Lucia del Mastro*

``Centro de Tecnologia das Radiações``,  
``Instituto de Pesquisas Energéticas e  
Nucleares`` - IPEN-CNEN/SP – Universidad  
de São Paulo-IPEN/USP, Brazil  
lattes.cnpq.br/8541245790089233  
ORCID iD 0000-0001-7937-0079

*Juana Luisa Gervasoni*

Centro Atômico Bariloche, Comissão  
Nacional de Energia Atômica (CNEA),  
Argentina. Instituto Balseiro (Univ. Nac. de  
Cuyo- CNEA)  
Orcid iD 0000-0002-5472-8879

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**Abstract:** Nuclear energy is used to generate electrical energy, produce radioisotopes, desalinate seawater and produce hydrogen. Nuclear and isotopic techniques contribute to the preservation of water and soil resources and to control pests, ensure food safety and greater food security, as well as improving livestock production and health. The organization of women in the nuclear field (Women in nuclear-WiN) has as one of its functions to make the public aware of the benefits that the application of nuclear energy can bring in all possible applications. This action will help to overcome restrictions from that part of the public that is reticent about using this technology and contribute to Latin American integration. Also, data crossings of the number of related publications are presented, which help to objectively analyze the trend of this integration.

**Keywords:** WiN, nuclear energy, women, Latin American integration

## INTRODUCTION

Among the challenges that humanity currently faces is the problem of drastically reducing the consumption of fossil fuels (Kainuma et al., 2013) and proportionally increasing the use of clean energy, such as wind, solar and nuclear (SADEKIN et al, 2019) that do not emit greenhouse gases: carbon dioxide, nitrous oxide and methane (FRANCHINI et al., 2017). Nuclear energy, due to its energy density, has a higher generating potential than other sources, such as hydroelectric plants, and is independent of natural cycles (LIESNER DE SOUZA & CARNEIRO LIMA, 2019). Also, it is necessary to consider together the main problems of our time: energy generation, food, health, environmental preservation and arms control. As the only truly universal organization in the world, the United Nations (UN) has become the main forum for addressing issues

that transcend national borders and cannot be resolved by any country acting alone. In 1957, the International Atomic Energy Agency (IAEA) was founded, an organization specializing in nuclear energy, but which can also make important contributions in other areas. Nuclear energy is competitive and sustainable. An aspect rarely mentioned: of all the clean forms of electrical energy generation, the installation of a nuclear power plant occupies a minimal area compared to extensive windmill fields or photovoltaic panel installations, which cause great damage to local flora and fauna.

Latin America is the meeting point of the territory colonized by Portuguese and Spanish Europeans, initially inhabited by Indians, that is, the product of a synthesis that was made to the detriment of the indigenous element (CHAUNU, 1979), formed over the last few centuries under the imperial and colonial. "Latin America" is often used as a synonym for Ibero-America, excluding Dutch, French and English-speaking territories (RAE, 2005). Thus, "Latin America" could be defined as that part of the Americas that was once part of the Spanish, Portuguese and French empires (TORRES (2013).

The following will be analyzed: 1. the historical events regarding nuclear energy, 2. the situation of nuclear energy in Latin America, 3. the role of women scientists in Latin America, 4. the participation of women in the nuclear area, 5. the socio-historical context in which "WiN Global" emerges, 6. the process of creating WiN ARCAL, 7. public opinion on nuclear energy and finally, 8. some data on Latin American integration.

## **NUCLEAR ENERGY: HISTORICAL EVENTS**

The importance of nuclear energy lies in the fact that it does not release greenhouse gases when used to generate electrical energy, but it can also be used for the production of radioisotopes, seawater desalination and hydrogen production. Nuclear and isotopic techniques contribute to preserving water and soil resources, reducing or eliminating the bacterial load of medical and food products and controlling pests, ensuring food safety, improving livestock production and health and improving the properties of various materials.

Chmielewski (2023) very well summarizes concepts related to the application of nuclear energy in his article entitled: "Radiation Technologies: The future is here".

The historical events of the uses of nuclear energy begin with the first experiments with radioactivity carried out in the 19th century by Wilhelm Röntgen, Antoine Henri Becquerel, Marie and Pierre Curie, among others. The results of research from the following decades were used, above all, for military purposes (WNA, 2010).

In 1951, American scientists managed, for the first time, to produce electricity through nuclear fission and, three years later, Russia opened the first large-capacity reactor. In the 1960s and 1970s, nuclear energy was booming and many nuclear power plants were built around the world. The popularity of this technology as a clean and cheap alternative to fossil fuels intensified with the first oil crisis in 1973 and at the same time, critical opinions emerged that warned of the risks of accidents and radioactive waste (KRESS, 2011). Despite everything, nuclear technology continues to be an important source of energy.

There are two types of nuclear reactors: power and research. In the first, there is nuclear material to generate large amounts of

energy and be able to supply electricity to a city. In the latter, the properties of the radiation that occurs in nuclear reactions are used for research and production of radioisotopes.

According to the IAEA, 29 countries use 449 reactors that would produce 14% of the world's electricity. The share of nuclear energy in electricity production in some countries varies between 2% in China and more than 70% in France. There are countless nuclear power plants in operation, under construction and even more planned for the coming decades. Furthermore, 250 test reactors are operated in 56 countries, and 180 reactors power around 140 ships and submarines (WNA, 2011; IAEA, 2018).

## **NUCLEAR ENERGY: SITUATION IN LATIN AMERICA**

The peaceful applications of nuclear energy in Latin America are not a new activity. Argentina, Brazil and Mexico are the countries in Latin America that already have nuclear power reactors, that is, they are used to generate electrical energy. Other countries in the region only have research reactors. Countries like Chile or Venezuela aspire – or have aspired for some time – to acquire nuclear power plants. Cuba began, in 1983, to build a nuclear power plant with the help of the then Soviet Union, but had to abandon it due to financial problems in 1992. Several attempts to reopen the program with the help of different external cooperators, including the IAEA, failed (ARGÜELLO, 2009). However, in Latin America and the Caribbean there are 23 nuclear reactors for research purposes (4 in Brazil), of which 18 are operational. They are also found in Argentina, Chile, Colombia, Jamaica, Peru, Uruguay and Venezuela, and are used for nuclear energy applications in agriculture, industry, mining and medicine (ÁLVAREZ VALDÉS, 2008). In all cases, however, the use of nuclear techniques is

wide and widespread in nuclear medicine (diagnosis and therapy through the use of radioisotopes and radiation), in industry, in the preservation of the environment, as well as in all possible applications for the benefit of human beings.

In Argentina, the institution that has led nuclear policy since its creation in 1950 is the National Atomic Energy Commission (<https://www.cnea.gob.ar/es/wp-content/uploads/2016/09/Decreto-10936-50.pdf>). Brazil, in turn, enacted the law that created the National Nuclear Energy Commission (CNEN) in 1962 ([http://www.planalto.gov.br/ccivil\\_03/LEIS/L4118.htm](http://www.planalto.gov.br/ccivil_03/LEIS/L4118.htm)). In Mexico, the National Institute of Nuclear Research (ININ), a Mexican state institution, was founded in 1956 under the name of the National Nuclear Energy Commission ([https://www.inin.gob.mx/\\_acercade/historia.cfm](https://www.inin.gob.mx/_acercade/historia.cfm)).

Argentina currently has three nuclear power reactors, the first put into operation in 1974. It is the Atucha I Nuclear Power Plant, located northwest of Buenos Aires. The second is in the Córdoba region, called El Embalse and put into operation in 1984; and finally, Atucha II, which is also located northwest of the Argentine capital and was commissioned in 2014. The three reactors, which use high-pressure heavy water as a neutron moderator, generate around 6.2% of the energy supplied to the country (<https://latinamericanpost.com/es/29112-america-latina-tambien-tiene-reactores-nucleares>). Brazil was the second country to activate its nuclear power reactors. They were Angra I, activated in 1982, and the second Angra II, in 2000. A third reactor is under construction and will also be located in Angra-dos-Reis, in Rio de Janeiro. The two active plants generate around 3% of the country's energy and the active plants have an electrical capacity of 1,990 megawatts (MW), the new plant will have an additional 1,405 MW.

Mexico currently has a nuclear plant, in Laguna Verde, which has two generators, which were opened in 1989 and 1994 and are located in the state of Veracruz. By 2018 and according to the Nuclear Forum, it produces around 5% of total energy and has a capacity of 1,552 MW.

To promote research in Latin America, the Regional Cooperation Agreement for the Promotion of Nuclear Science and Technology in America was adopted in Vienna in 1998 (signed by Brazil on August 4, 1999, decree no. 5,885 of September 5, 2006). Latin America and the Caribbean (ARCAL), which initially had 12-member states and has numerous projects underway to this day.

## **ROLE OF WOMEN SCIENTISTS IN LATIN AMERICA**

In terms of the role of women scientists in the Latin American region and according to the United Nations Educational, Scientific and Cultural Organization (UNESCO), an adjunct body to the UN, Latin America exceeds the world average of women researchers/researchers (<https://www.aa.com.tr/es/pol%C3%ADtica/unesco-am%C3%A9rica-latina-supera-la-media-mundial-de-mujeres-investigadoras/1731331>). In the region, 45% of researchers are women, a number that far exceeds the global rate of 28%. However, worldwide, only 35% of students enrolled in careers linked to science, technology, engineering and mathematics are women. Today, a growing number of women are becoming aware of the beauty of science and technology and their potential to improve the well-being of our societies.

## **WOMEN'S PARTICIPATION IN THE NUCLEAR AREA**

The work carried out by women in the nuclear area is characterized within science, technology and innovation activities, corresponding to different categories according to the type of activity, but there is still a low number of women in this area. As an illustration of this evidence, we will mention institutional data from the National Nuclear Energy Commission (CNEN) of Brazil from 2020, which are probably similar to those of other Latin American countries with similar development in nuclear activities, such as Argentina or Mexico. Of the total number of CNEN workers (1,664), 13% were scientists, 30% technologists, 11% analysts, 23% technicians, 21% assistants; performing all these activities, 29% of workers were women. 50% of them have a university degree, compared to 31% of men. But when we look at the distribution of power positions, we see that there are the following discrepancies in the male/female ratio: directors 7/1, general coordinators 7/3, division heads 21/12 and service heads 69/19.

Also, the objective of the work by Santos et al. (2022) was to evaluate female participation in a nuclear research institute (an institution linked to the state of São Paulo and the Brazilian federal government). The authors verified how the women working in this unit are distributed, what their area of activity is and their position in career levels. The research was carried out using an online form, answered voluntarily, which contained questions to profile these women. The result showed that the majority profile is white women, postgraduate students aged up to 41, from the Southeast region, predominantly from São Paulo, who are/were guided by men, who are not aware of the Women in Nuclear association. Research like this survey and dissemination of events about women

is something that needs to be done more frequently to emphasize the importance of the female presence in science.

Women in the nuclear area enter the job market after rigorous selection and often through a public competition. Therefore, in principle they do not suffer discrimination, although they have less representation in management and leadership positions as mentioned above. This gender disparity was verified in relation to Mathematics, Computing and Natural Sciences with a Latin American approach (MONTEZ & DAWSON, 2019) and in particular Argentine women who work at the National Atomic Energy Commission (GERVASONI & PAHISSA, 2020).

## **SOCIO-HISTORIC CONTEXT IN WHICH "WIN GLOBAL" ARISES**

The organization "Women in the nuclear field - WiN Global" is completing 30 years, as it had its first constitutional meeting in 1993 (<https://win-global.org/about/history>) with women representing Canada, Germany, France, Switzerland, Sweden, Netherlands, Finland and USA, coming from different organizations: Canadian Nuclear Association, Inforum Germany, French Alternative Energy and Atomic Energy Commission (CEA), Verband Schweizerischer Elektrizitätsunternehmen (VSE), Ringhals NPP, IVO Finland, ECN Netherlands and USCEA.

The central idea for creating WiN was to oppose the perception that the nuclear industry was a purely male world (IAEA, 2018) and this way, offer a valuable role model for young women, with two main objectives:

- i) support and encourage women working in nuclear sciences and technologies.
- ii) encourage the promotion of understanding and knowledge of the benefits of the peaceful use of nuclear

energy by the public, through active networks at national, regional and international level. WiN Global currently has members, predominantly women, from 129 different countries, belonging to chapters or individually. Currently, 47 countries have their own chapters and there are also regional chapters such as WiN Europe and WiN Africa and international chapters such as WiN IAEA (includes women working at IAEA).

From 2021 onwards, there will be a new international chapter: WiN Global Young Generation, which aims to centralize and promote activities aimed at the new generation, made up of young people from chapters in different countries such as France, Japan, Taiwan, Indonesia, Ukraine, United Kingdom, Hungary, which also has 2 young people linked to the nuclear sector in Argentina, 2 from Brazil and 1 from Mexico.

## **WIN IN LATIN AMERICA AND THE CREATION PROCESS OF WIN ARCAL**

Several countries have locally created their respective national chapters of WiN Global in recent decades. WiN Argentina and WiN Brazil were the first chapters created in the Latin American region, organizations focused on women working in the various areas of nuclear energy and radiation applications.

As mentioned previously, ARCAL is today a network of 22 countries in the region, which puts nuclear technology at the service of the lives of our people. ARCAL constitutes a solid cooperation mechanism that supports coordinated projects, courses, human resources training, establishes information networks and databases, harmonizes standards, protocols and procedures, and relies on technical cooperation funds from the IAEA. The IAEA itself is the intergovernmental organization created in

1957 with the aim of promoting the safe and peaceful use of nuclear energy and ensuring, through a system of safeguards, that nuclear activities and materials are not diverted to non-peaceful uses, as prescribed in the Non-Proliferation Treaty. The following states are part of ARCAL: Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Chile, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Jamaica, Panama, Paraguay, Peru, Uruguay and Venezuela.

Currently, the regional chapter Women in the Nuclear Area ARCAL (WiN ARCAL) has been created and is already operational.

## **PUBLIC OPINION ABOUT NUCLEAR ENERGY**

Any technology can be well accepted by public opinion or the opposite can happen, depending on how this knowledge arrives. The public received its first information about nuclear energy through the atomic bomb explosions that ended World War II. Thus, the issue of nuclear energy to this day arouses suspicions, which only correct information can dispel, as what poses a risk to society is the lack of information. In this sense, activities for public acceptance of nuclear energy must be carried out to achieve maximum effectiveness and satisfy the nation's "right to know" (FERNANDES DE ALMEIDA et al, 2019). Mulder (2012) highlights in his analysis that nuclear energy, like any other important issue for society, is linked to the way in which the respective governments conduct the discussion. The national chapters of WiN Global have as one of their main objectives to bring to the public the various benefits of nuclear energy as there is a great lack of knowledge in this area on the part of the public. Massarani & Castro Moreira (2016) carried out research on communication science activities in Brazil since the 19th

century, and recognize the great progress that has been made, but equally, there is still a long way to go to provide quality communication in science and technology for Brazilian society.

There are good examples in the literature of the socio-economic and other factors that contribute to the acceptance of nuclear energy in different countries. In 2007, Rodriguez & Diaz already proposed that information about nuclear energy must be promoted through modes of communication that involve the direct experience of citizens (NGUYEN & YIM, 2018). Han, Kim & Choi (2014) published research on how education changed social acceptance of the use of nuclear energy. Tantitaechochart, Paoprasert & Silva (2020) concluded that the way to gain acceptance of this technology, for the construction of a nuclear power plant in a given location, is by providing information to the population, to inspire confidence and perception of the benefits. Espluga Trenc et al. (2017) presented a theoretical framework that integrates contributions from different traditions on risk perception. In general terms, while promoters and regulators tend to emphasize health/environmental dimensions and economic dimensions (valuing the wealth they can bring to the territory), opposition groups also include sociocultural and political/institutional dimensions (FERREIRA & SOARES, 2012; HANSEN & MACHADO, 2018). Wang & Kim (2018) conducted a comparative modeling analysis on public attitudes towards nuclear energy covering 27 European countries. The individual perception of the benefits that nuclear energy can bring explains the greatest variation in acceptance, followed by the perception of risk and trust in authorities and technology. At a contextual level, electricity production, environmentalism and ideology itself influence the acceptance of new technologies. Furthermore, and no less important, the

acceptance of nuclear energy depends on the educational, institutional and sociocultural context of the public.

## **LATIN AMERICAN INTEGRATION**

In the opinion of Osterhammel (2014), the birth of international relations, as we know them today, was the result of the transformation of the world, dominated by the West in the 19th century. González Molina (2015) maintains that Latin America was characterized, in the nineties and the first years of this century, by the euphoria of implementing an “open regionalism” with the creation of: 1) Mercosur, signed in 1991 by Argentina, Brazil, Paraguay and Uruguay and, 2) the North American Free Trade Agreement (NAFTA), signed by Canada, the United States and Mexico in 1994.

It was of enormous importance, for Latin American society and an example for the rest of the world, the creation by Brazil and Argentina of the Brazil-Argentina Agency for Accounting and Control of Nuclear Materials (ABACC), to verify the commitment assumed to use the nuclear energy only for peaceful purposes, thus renouncing explosive devices (DO CANTO, 2016; TRINDADE, 2017). Thus, the two Latin American countries with the most advanced technology ended the rivalry, reinforcing peace and cooperation structures in the region, such as UNASUR, CELAC and others.

An objective way to see the evolution of international relations in Latin America over time is to analyze the number of articles published on related topics. For this purpose, the Scielo Citation Index database was used. This database provides academic literature articles in the areas of science, social sciences, arts and humanities from the main open access publications in Latin America, Portugal, Spain and South Africa, published in Spanish, English or Portuguese since 2002.

For this survey, the keywords were crossed: foreign policy + Latin America (LA); international relations+AL and sociology+AL in the periods 2002-2010 and 2002-2020. Furthermore, the number of articles published in these intervals was recorded when the keywords were Latin America Integration and in parallel Latin American Integration (Integration of Latin America) (Fig. 1). The survey shows a clear increase in interest in demonstrations in the areas of Foreign Policy, International Relations and Latin American Integration in the last decade compared to the previous decade. Both the number of publications on Latin American Integration written in Spanish and English (4 times higher) show the same trend.

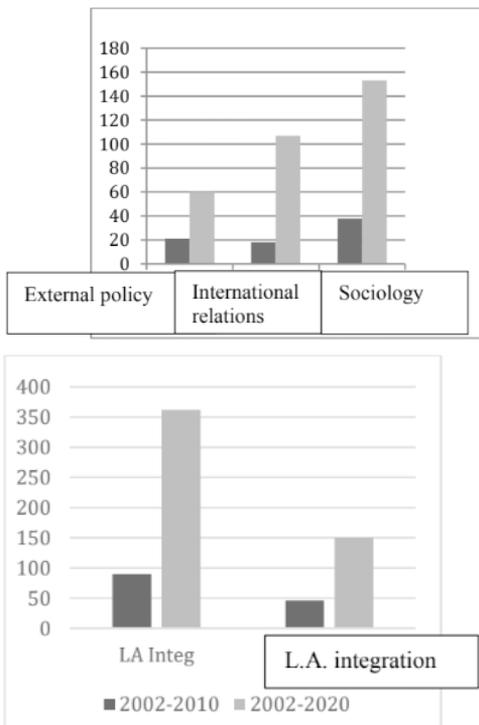


Figure 1. Left) Number of articles published using the crossing of words: foreign policy+AL; international relations+AL and sociology+AL in the periods 2002-2010 (dark gray) and 2002-2020 (light gray); Right) Number of articles published using key words: Latin America Integration and in parallel Latin American Integration in the same periods.

The mention and evolution of nuclear activities and women's participation in them, over time, are represented in Figure 2, which shows the number of articles published in two periods: from 2002 to 2010 and from 2002 to 2020, using the crossover of keywords: Women+Nuclear Energy or Nuclear Technology and on the other hand: Women+Nuclear Energy or Nuclear Technology in the periods 2002-2010 (dark gray) and 2002-2020 (light gray).

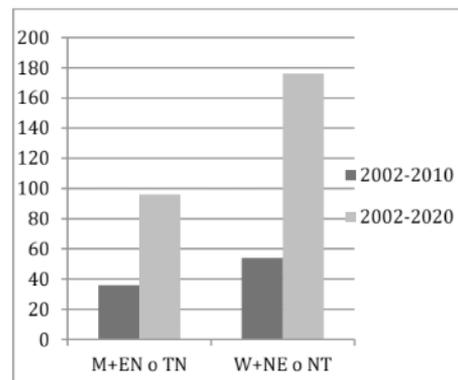


Figure 2. Number of articles published using the crossing of key words: Women+Nuclear Energy or Nuclear Technology and on the other hand: Women+Nuclear Energy or Nuclear Technology in the periods 2002-2010 (dark gray) and 2002-2020 (light gray).

There is an increase in published works that mention women, in conjunction with nuclear energy or nuclear technology, whether these works are published in English or Spanish.

## FINAL CONSIDERATIONS

The objective of this article was to make known what women's organizations are in the nuclear area: WiN Global and the national chapters, such as WiN Argentina or WiN Brazil, and the regional chapter WiN ARCAL, within the context of the development of nuclear energy in the countries Latin Americans. Nuclear energy depends, for its development, on training and investments in science, technology and innovation (STI). A

workforce that better incorporates society's diversity, including representation of women, also helps build society's trust in cutting-edge technologies, such as nuclear technologies. The WIN chapters, like other organizations and networks of scientific and technical women in the region, carry out activities to raise awareness about the gender inequalities that still persist in the CTI.

The promotion of equity in female and male representation in STI is necessary not only for reasons of justice and human dignity, but also because it is more efficient in economic terms,

improves the quality of research and the performance of systems and, consequently, is a opportunity to move correctly towards sustainable development. It is urgent to try to combat climate change with clean, efficient and stable energy, such as nuclear energy. Latin American integration cannot do without promoting fields of knowledge where there are already important initiatives and confluences of interests, such as nuclear energy. Women from the Latin American region are called to make their contribution.

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