Green Transition and Gender Bias: An Analysis of Renewable Energy Generation Companies in Latin America

Energy Division

Arias, Karla
López, David
Camino, Segundo
Weiss, Mariana
Walsh, Dylan
Gouvea Gomes, Livia
Carvalho Metanias Hallack, Michelle

TECHNICAL
NOTE Nº
IDB-TN-02546

July 2022

Green Transition and Gender Bias: An Analysis of Renewable Energy Generation Companies in Latin America

Arias, Karla
López, David
Camino, Segundo
Weiss, Mariana
Walsh, Dylan
Gouvea Gomes, Livia
Carvalho Metanias Hallack, Michelle

Inter-American Development Bank

July 2022

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Green transition and gender bias: an analysis of renewable energy generation companies in Latin America / Karla Arias, David López, Segundo Camino, Mariana Weiss, Dylan Walsh, Livia Gouvea Gomes, Michele Carvalho Metanias Hallack; editor, Amanda Beaujon.

p. cm. — (IDB Technical Note ; 2546)

Includes bibliographic references.

1. Renewable natural resources-Employees-Supply and demand-Latin America. 2. Women in energy development-Latin America. 3. Gender mainstreaming-Latin America. I. Arias, Karla. II. López Soto, David. III. Camino-Mogro, Segundo. IV. Weiss, Mariana. V. Dylan Walsh. VI. Gouvea, Livia. VII. Hallack, Michelle, 1983- VIII. Beaujon, Amanda. IX. Inter-American Development Bank. Energy Division. X. Series.

IDB-TN-2546

JEL Codes: N76; O13; C22; C53; Q47

http://www.iadb.org

Green Transition and Gender Bias:

An Analysis of Renewable Energy Generation Companies in Latin America

July 2022

IDB

July 2022

GREEN TRANSITION AND GENDER BIAS: AN ANALYSIS OF RENEWABLE ENERGY GENERATION COMPANIES IN LATIN AMERICA

Arias, Karla;
López, David;
Camino, Segundo;
Weiss, Mariana;
Walsh, Dylan;
Gouvea Gomes, Livia and
Carvalho Metanias Hallack,
Michelle (2022)

Executive Summary

Executive Summary

This study analyzes how the energy transition might change gender bias in power-generating industries. To this end, this paper employs a sample of 102 renewable energy generation companies from six countries in Latin America and the Caribbean: Bolivia, Chile, Costa Rica, Panama, Mexico, and Uruguay. The analysis of collected data shows that renewable generation companies with the highest relative efficiency in the labor-capital ratio are those with the highest participation of women. In addition, the results show that renewable companies are incrementing recruitment of women in energy generation. Nevertheless, in the analyzed sample, the participation of women in renewables is still lower than the sectorial average. Moreover, there is no structural change with respect to roles that women occupy, when comparing renewables companies with others generation companies. Considering the companies' size, bigger renewables companies (with higher installed generation capacity) tend to hire more women, but those women occupy mostly non-technical positions. In addition, women's participation decreases in positions requiring more technical occupations. Women represent 36% of STEM[1] employees, 39% of non-STEM employees, and 48% of non-qualified employees of the renewable generation companies surveyed. Concerning the role of women in decision-making roles within energy companies, wide gender gaps exist in executive and management positions; the proportion of females in the boardroom and in management roles for renewables generation companies was 24% and 22%, respectively. Furthermore, 68% of surveyed companies did not have a gender policy in place. This study confirms that a change in technology alone does not generate qualitative changes in the labor market from a gender perspective. Such changes would be achieved by complementing technological change with inclusion policies, encouraging women to study careers related to science and technology to fill the shortage of female professionals in these areas, and closing the knowledge gap through systematic data collection and sharing about gender in the energy workforce.

1. STEM stands for Science, Technology, Engineering, and Math, so STEM careers are those that require science, technology, engineering, and math knowledge.

Table of Contents

Introduction

1

Countries in Latin America and the rest of the world have made considerable efforts to engage in an energy transition to reduce their net greenhouse gases emissions (GHG) and align themselves with the Paris Agreement. The energy transition process not only contributes to GHG reduction, but it can also be an opportunity to create employment as part of green recovery strategies. New investments in renewable energy projects foster opportunities for employment creation, which is an important aspect that deserves to be further explored and has important policy impacts worldwide. It is expected that the energy sector will create 122 million jobs by 2050, including 43 million in renewables alone (IRENA, 2021).

The transformation of employment in the energy sector and complementary investments will transform the labor market, and this transformation is a unique opportunity to increase gender balance in the sector. There are clear indications that this process, if well structured, can be an opportunity to close the large gender gaps in the energy sector. A 2019 study developed by International Renewable Energy Agency (IRENA) reported that, of the estimated 11.5 million renewable energy jobs worldwide that year, only 32% were held by women. This is a considerably higher percentage than the 22% in the oil and gas industry worldwide, but there are still barriers for women to enter, remain in, and advance in the energy sector labor market.

According to Ravillard et al. (2021), the way in which jobs will be transformed to accompany the energy transition process depends on public policy design, knowledge of the labor market, and the business environment as these relate to the energy sector. In Latin America and the Caribbean (LAC), this relationship among labor policies, the energy transition process, and the potential to promote gender equity policies in the sector are still little known. Therefore, understanding these relationships is an important step to build better public policies to harness potential benefits of energy transition in terms of gender equity and inclusion. This is particularly relevant now, as countries are committed to decarbonization plans and quality employment generation.

This paper contributes to the literature about how the energy transition can change gender stereotypes and social norms in energy generation companies. The analysis has three components: (1) a descriptive analysis of women's participation in energy generation companies compared with the energy industry and the positions they hold in these companies; (2) the identification of variables that could generate qualitative and quantitative change in women's participation in the energy industry; and 3) an analysis of the impact that female labor might have in the labor-capital ratio in the analyzed companies. Besides the literature review, the analysis is based on data collected through a structured survey that was designed and carried out in six countries in Latin America.

This data collection was a two-year effort, starting in 2020 with Uruguay, Bolivia, and Chile; Costa Rica, Panama, and Mexico were added in 2021.[2] The information collected provides a better understanding of women's participation in the renewable energy labor market and the positions they hold, as well as existing barriers to enter, remain in, and advance in the sector, and potential solutions, all in the context of green transition. Furthermore, the survey contributes to the literature by adding a quantitative analysis. To the best of our knowledge, no other work presents a model that captures the association between energy transition change and gender bias in this industry. This paper complements existing literature about energy transition from a gender perspective.

The remainder of the paper is organized as follows. Section Two gives a global literature review about the roles of women in energy transition. Section Three presents a descriptive analysis about the current situation of women in energy generation companies compared with the rest of the industry in six LAC countries. Section Four introduces methodology used in the study and the data it yielded, as well as econometric strategies, data envelopment analysis, and empirical results. Section Five offers concluding remarks.

2. The selection of countries was associated with their proximity, resource diversity, and energy transition paths selected, as well as access to company information and the possibility to carry out fieldwork and collect survey data during a global pandemic. The project will include other LAC countries in future studies.

Women in Renewable Energy: A General Overview

2. Women in Renewable Energy: A General Overview

The energy sector is often considered one of the least gender diverse parts of countries' economies (IRENA, 2020). Changing this pattern is important to deliver a secure, affordable, and sustainable energy future for all. The development of the renewable energy industry offers an opportunity to not only produce cleaner energy, but also to foster a more inclusive energy industry. Women can garner a growing share of expanding employment in this young, burgeoning, and dynamic sector if public policy support and companies' commitment exist. This section discusses how women's roles have changed and how they exhibit the potential for change, with a regional focus on Latin America. First, this section identifies key elements identified through a literature review, and second, it focuses on evidence from Latin America.

a. Global State of the Art

The transition toward a renewable, distributed, decarbonized energy system is creating a variety of social and economic benefits, including the expansion of employment opportunities. IRENA (2021) estimates that the number of renewable energy sector jobs could increase from 12 million in 2020 to nearly 43 million in 2050. However, women have traditionally been underrepresented in the energy industry and female employment in the conventional energy sector (22%) is less than half the level of male employment (IRENA, 2019). The same appears true for renewable energy sub-sector, although it fares slightly better at 32% female employment.

Adopting a gender perspective for renewable energy development is critical to ensure that women's contributions represent an integral part of green transition. Achieving greater gender equity expands the talent pool for the renewables sector. Meanwhile, greater gender diversity also brings substantial co-benefits. Studies (Cullinan, 2018; Bear, 2011; Bowling et al., 2008) suggest that women bring new perspectives to the workplace and improve collaboration, while increasing the number of qualified women in an organization's leadership yields better performance overall. In addition, for women, accessing the energy sector, especially positions in STEM fields, allows them to improve their income and promotes a sector where there are more females by becoming role models for future generations of girls and young women (IRENA, 2019; Schomer & Hammond, 2020a).

Research on gender implications associated with energy transition is not new. IRENA published a report in 2019 on the energy transition from a gender perspective. In this study, renewable energy was found to mitigate gender imbalances. Using an online survey covering 144 countries, IRENA reported that the share of the female labor force in renewable energy is 32% (or 3.5 million jobs worldwide). Although this percentage is still low, it represents an improvement on the 22% female workforce in the oil and gas industry for the same year (IRENA, 2019).

IRENA, along with the Global Wind Energy Council (GWEC) and the Global Women's Network for Energy Transition (GWNET), also conducted a study about the wind energy industry from a gender perspective. Among other findings, this research showed that perceptions of gender roles and sociocultural norms are a major barrier to gender equity. In addition, perceived wage inequalities are lower in wind energy (40%) than in the overall economy (68%), and there is heterogeneity among countries and regions. For example, Europe and North America show the highest share of women in wind energy jobs, at 26%.

Another study conducted in Senegal, Morocco, Nepal, and India by the World Bank (2018) at several energy infrastructure projects (generation, transmission, and distribution) found similar results. The principal finding of this study was that women's direct employment created by these projects has been constrained by traditional gender roles and social norms in the local community or country, as well as lack of technical and professional skills, occupational segregation by gender, and gender-insensitive work environments and working conditions. The study's mixed-methods research approach included extensive literature and portfolio reviews, as well as critical in-country research to hear firsthand accounts of female and male stakeholders.

The International Energy Agency (IEA) (2020) developed a gender diversity initiative concerning the role of women in energy companies' decision-making roles, to produce relevant information to advise stakeholder and decision makers. Key findings of this initiative showed that women comprise only 13.9% of senior management within the energy and energy utilities composite, which is marginally lower than in the sample from non-energy industries, at 15.5%. Among energy business lines, women in senior roles are better represented in the utilities sector, at 17.1%. In addition, female inventors are increasing across different technological sectors; in the patent classes closely associated with the energy sector, women are listed as 11% of applications, including over 15% for climate change mitigation technologies.

Gender diversity by job level in energy companies can give insights into the position of women in the sector and studies show it is especially low for decision-making positions. A study analyzing 72 countries reported that women represent only 6% of ministerial positions responsible for national energy policies and programs (USAID & IUCN, 2014). The gender gap in technical and research positions can be partially explained by the low representation of female students in STEM subjects: women represent more than 50% of university degrees in OECD countries, but only 30% within science and technology (OECD, 2008).

From a regional perspective, the IEA (2020) conducted a labor force survey for the European Union showing that women's share in employment of energy sub-sectors performed poorly when compared with both the overall labor force (46%) and other industrial sub-sectors. The lowest performing sub-sector, which is also energy-related, was coal and lignite mining.

These studies provide key baseline measures and show the importance of improving gender policies in the energy sector. These policies are necessary given that the historical inequality of the sector tends to be higher than in the economy in general and to ensure that opportunities occasioned by modern technologies do not follow this trend. However, implementation of said policies is not straightforward. International studies show that there are relevant heterogeneities by countries and regions and there are few representations of LAC countries in these global reports. It is important to understand regional dynamics with respect to women's roles in energy transition. The next section presents the state of the art of the study of energy sector, energy transition, and gender diversity in LAC.

b. The State of the Art in Latin America

LAC has made important progress in gender equity. In the 1960s, only two out of ten adult women were working or actively seeking jobs; today, at least six out of ten Latin American women are participating in the workforce (Gasparini, 2015). Since 1980, more than 70 million women have entered the region's labor market. However, despite this increase, LAC women still face many barriers to entering and remaining in the labor market. For example, the labor participation gap between men and women is still 26% and women earn as much as 17% less than men. Furthermore, although women have higher educational levels, they are underrepresented in high-productivity jobs (Snyder, et al., 2018).

Women's employment is a critical factor for LAC's economic growth. It is estimated that the region's GDP would grow by US$2.5 trillion if the workforce gender gap were to be closed completely (IDB, 2018). Considering the role of women in private sector leadership, it is important to mention that women hold one out of four executive jobs in the world; typically, these consist of support positions such as human resources directors (23%) or financial directors (19%). A study conducted on 1,259 LAC companies found that women held 8.5% of board positions, 9.2% of senior manager positions, and 4.2% of executive directorships (CEO) (Luca et al., 2016). This study highlights that female representation in regional leadership positions is limited and that these numbers are below the world average.

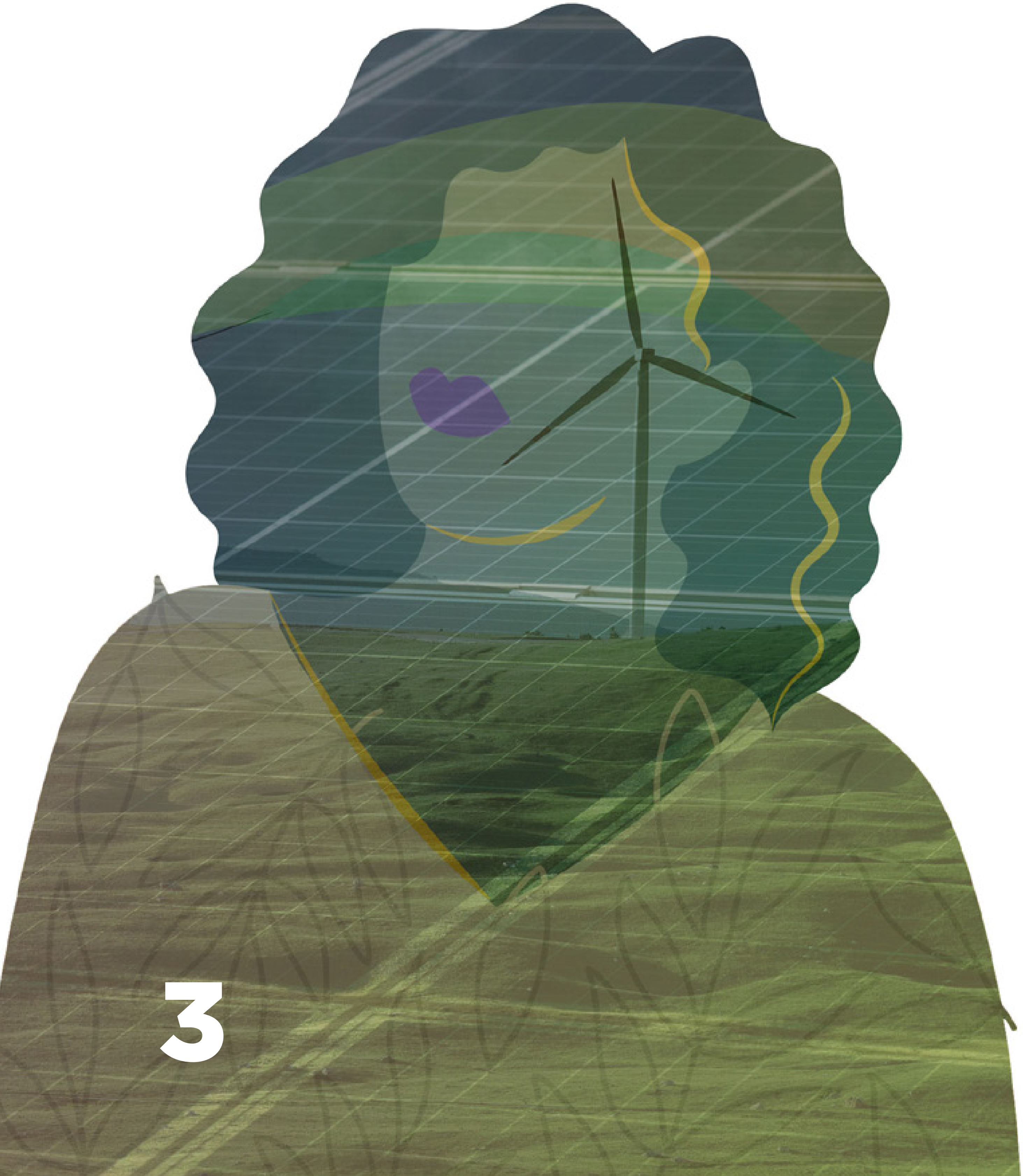
With respect to information available specifically on the LAC energy sector, a recent study reported that an average of 50 direct jobs were created for every US$1 million invested in energy projects (Brichetti et al., 2021). Considering the energy transition goal, a study developed by the International Labour Organization and Inter-American Development Bank (IDB) (Saget et al, 2020) projected a reduction of about 60,000 jobs in fossil fuel power plants, but a creation of 100,000 new jobs in renewable electricity generation, for a net gain of 40,000 jobs for LAC.

In terms of specifics regarding gender issues for LAC's renewable energy sector, the IDB (2014) showed that the labor force was predominantly male, with the percentage of women employed not exceeding 20-24% of the total (Marcos Morezuelas, 2014). This was not significantly different for the percentage of participation in the energy sector, which was 19.7%.

The transformation of the renewables sector and gender policies in the last decade has been significant but energy sector employment gender gaps persist. That said, as demonstrated by international experiences, the investments and transformation required for energy transition has the potential to create gender balance in LAC in coming years. However, there is still a need to better understand job creation gender dynamics in the LAC energy sector.

The present study complements this discussion by analyzing job creation due to Latin America's energy transition from a gender diversity perspective. This study is a cross-country analysis that includes six countries (Bolivia, Chile, Mexico, Panama, Costa Rica, and Uruguay). This study proposes a more detailed statistical analysis of variables that can impact gender gaps within renewable energy companies. It also contributes with data about gender diversity in different sub-sectors of the renewable energy industry, comparing it with the traditional (non-renewable) energy industry.

Status of the Situation of Women in the Energy and Renewables Industry: Survey Results for Six LAC Countries



3

3. Status of the Situation of Women in the Energy and Renewables Industry: Survey Results for Six LAC Countries

This study includes different dimensions, among them, gender distribution, participation of women in decision-making positions, and determining variables for the increase in female employment. More disaggregated information on descriptive statistics for these variables is shown in Annex A. In the context of innovation, this study allows a discussion and reclassification of energy industry jobs. The status of women in the energy industry is revealed through survey results for six LAC countries. The data generating process relied on labor-oriented surveys implemented in each country where information on characteristics of the sector's workers was also collected; it is an extension of the survey used in Ravillard et al (2021)[3]. It is a cross-industry analysis of the different technologies evolved in energy transitions inspired by IEA (2020) and IRENA (2019).

With the importance of overcoming gender disparities in mind, a survey was developed that tests multiple gender metrics. It was then carried out in Bolivia, Chile, Costa Rica, Mexico, Panama, and Uruguay and yielded responses from 338 companies in the energy sector and 105[4] in energy generation, of which 102 were renewables, and three non-renewables. We chose to work with electricity generation companies to include the number of female workers by type of generation technology in the study. In addition, we considered focusing on this type of enterprise to include the variable installed capacity as an output and we have this variable just for generation companies. Of the companies surveyed, there were 55,092 employees total, of which 22% were female. In renewable energy generation companies, there were 10,691 employees, of which 11% were female. This represents a slight increase from the previous study by the IDB (2017) mentioned in Section Two for females in the energy sector; however, it is well below the world average calculated by IRENA in the Renewable Energy and Jobs Annual Report 2021, which put female employment in the renewable energy sector at 32%. This ratio provides a benchmark statistic to compare gender gaps in type of employment, educational background, and hiring trends in the energy sector. It also shows that it is important to produce information at the regional level to understand labor market dynamics of LAC's energy sector.

The survey included questions about companies' installed capacity and capital investment, needed to make estimates of employment creation. Additional questions besides the number of employees and their gender were directed at the service they perform, their training, their profile, the position they fill, their professional experience, their educational level, their type of contract, whether they were outsourced or not, companies anticipated future investment projects, and which skills these require, or which capacity they could benefit from. The survey also contained a section dedicated to report companies' costs, including salaries paid to male and female employees according to their profile. The next two sections summarize main findings in terms of distribution, employment structure, workers' qualification, diversity and inclusion initiatives, and investment forecasts.

3. The main methodology used was data survey collection through an online platform directed at the responsible human resources or financial sector person at each company. Telephone calls were also necessary for follow-up and assistance. One big part of the work consisted in identifying companies that fell within our definition of green transition sectors. These are renewable energy (generation, distribution, and transmission), energy efficiency, demand management, electromobility, hydrogen, geothermal, and storage. Traditional technologies of electricity generation, such as thermal and hydropower plants, are also surveyed, as well as transmission and distribution.

4. Within the total generation companies, we consider renewable, non-renewable, and mixed generation companies.

a. Employment at the Board of Director and Management Positions by Sex

One of the key factors to analyze about gender disparity is the participation of women on the board of directors and in management roles. In this survey, the proportion of females in the boardroom and in management roles for all surveyed companies were 22% and 29%, respectively, with no substantial differences for renewable generation companies at 24% and 22%, respectively. These values are consistent with the worldwide female participation average (Luca et al., 2016). Care is needed when making comparisons, however, as studies have different methodologies and samples (countries and number of companies). Considering just the disparities between renewables and generation companies analyzed in this study, the gender gap in the boardroom is greater than that of management and is equal to the gender gap at the general employment level. The results are displayed in Figure 4.1 below.

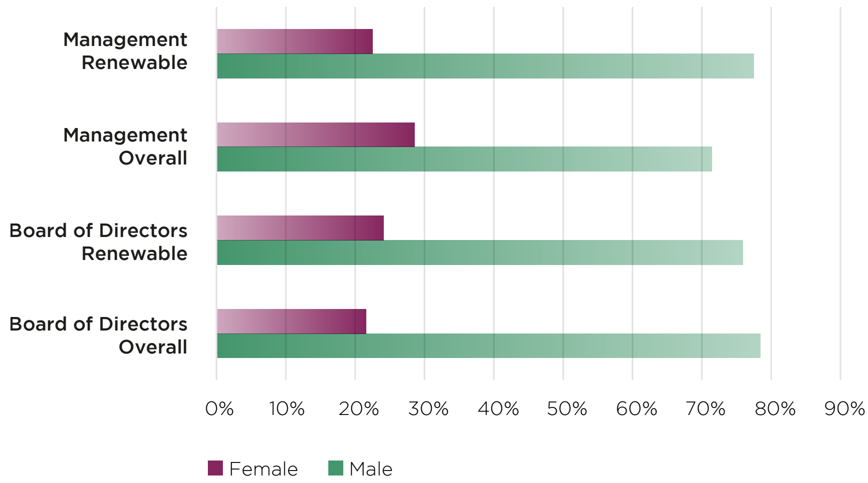


Figure 4.1: Board of Directors and Management Employment by Sex

These figures imply that employment at the top levels of generation companies in our sample varies between 20 and 32%, but with higher participation in non-renewable companies.

b Educational Background of Energy Sector Employees by Sex

Another factor that has led to gender gaps in employment outcomes in the energy sector has been education. With many jobs in the energy sector requiring STEM education, which has long been a male-dominated field of study, this leads to lower employment outcomes for females because of lower percentages of women in these fields of study (Czako, 2020).

The study addressed this factor leading to gender gaps in employment outcomes of the energy sector by examining employees' educational background. Of the employees with a STEM background, no STEM background, and not qualified, the percentage of women employed was lowest for STEM and increased as the education level decreased, at 38%, 54% and 55%, respectively. While the lowest percentage of women came from a STEM background, this figure is much higher than the general employment and executive position employment figures and could be an indicator that more women with STEM education are gaining employment in the renewable energy sector in these six Latin American countries.

This trend is the same for renewable energy generation companies. Of the employees with a STEM background, no STEM background, and not qualified, the percentage of women employed was lowest for STEM and increased as the education level decreased, at 36%, 39% and 48%, respectively. These percentages are, however, lower than the trend for all energy companies surveyed. Figure 4.2 below shows the percentages of men and women by education level for renewable energy generation companies.

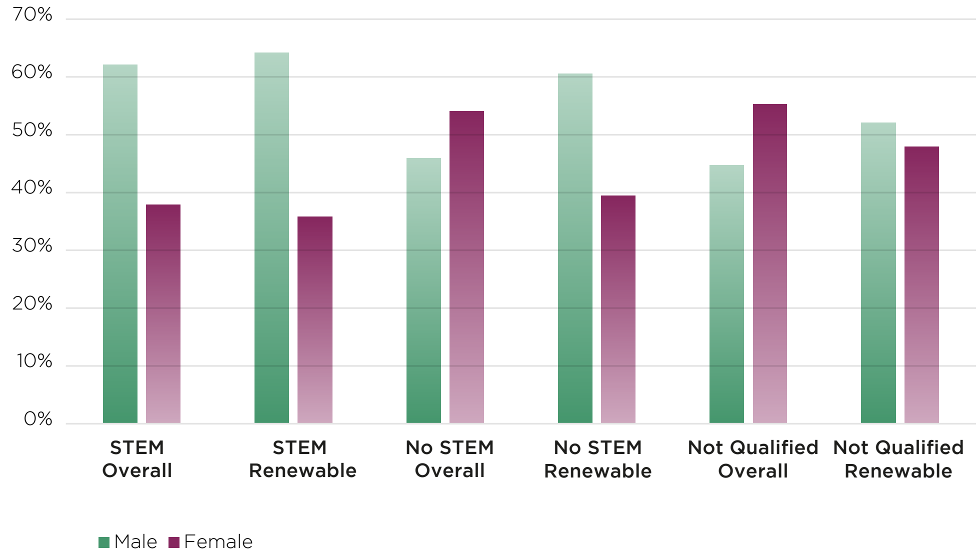


Figure 4.2: Educational Background of Employees by Sex

The survey also asked which of these companies had a gender policy to address such disparities in employment outcomes. Given gender gaps in STEM education, boardroom and management employment, and overall employment, gender policies in the workplace could help overcome such disparities. Of the 101 companies that responded to this question, 22% did have a policy in place and that figure increased to 35% when looking at renewable energy generation companies.

c. COVID-19 Impact on Hiring Practices by Sex

The COVID-19 pandemic wreaked havoc on the global economy for 2020 and much of 2021. The ILO (2021) estimated that 125 million full-time jobs were lost because of the COVID-19 pandemic and that great disparities were emerging in the global recovery between developed and developing nations. As a result, the survey tested the number of employees being hired and how many of those were female to see how regional hiring practices were affecting the employment gender gap in the energy sector.

Specifically, the survey asked how many people had been hired since March 2020, the economic onset of the COVID-19 pandemic. Of the 2,634 employees hired, 876 were female, corresponding to 71% male and 29% female. For renewable energy generation companies, of the 543 employees hired, 174 were female, corresponding to 68% male and 32% female, slightly above the average for female, as noted above.

The survey also asked for the number of people who had been fired in the same time frame. The results were 1,573 people fired; of those, 442 were female. Of the employees let go during the COVID-19 pandemic, 72% were male and 28% were female, which is above the current employment levels of these companies. For renewable energy generation companies, 223 people were fired and of those, 27 were female, corresponding to 88% male and 12% female, a figure that is a 16 percentage point difference with all energy companies surveyed.

These figures provide a snapshot of current hiring practices of energy sector companies in these six Latin American countries. Key takeaways are that it is promising to see the proportion of female new hires above the current employment ratio, but women being let go is also above the current ratio of overall employment. That said, the proportion of women being hired is greater than that of those being fired and suggests that the net trend could lead to a narrowing of the employment gender gap in the energy sector (Figure 4.3).

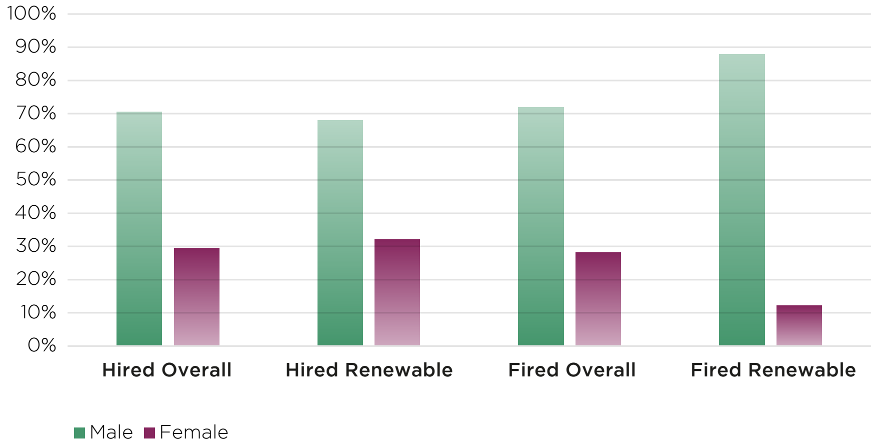


Figure 4.3: Job turnover during the COVID-19 Pandemic

To complement the information presented in Figure 4.3; Figure 4.4 presents the percentage of women hired in 2020 in relation to the total number of women in the companies (0.93%), and the percentage of women dismissed in the same year in relation to the total number of women (2.34%). For this sample of renewable companies, the proportion of women being hired of all the women workers is greater than the proportion of men being hired of all the men workers; however, the ratio of women fired over all women workers is also higher than men. Given that the turnover of women is higher than that of men in this sample of companies, it is important to carry out a more in-depth analysis of the possible causes. Literature about gender differences and gender turnover (Weisberg & Kirschenbaum, 1993; Arokiasamy, 2013; Metin Camgoz et al., 2016) suggests that turnover rates for women in the industry overall are significantly higher than those rates for men, and that no differences were found in the intent to leave. Both groups perceived their work environment similarly. Therefore, it is assumed that gender turnover is associated with existing gender gaps (Lee, 2012) and with the type of jobs these workers are performing (Xu, 2008).

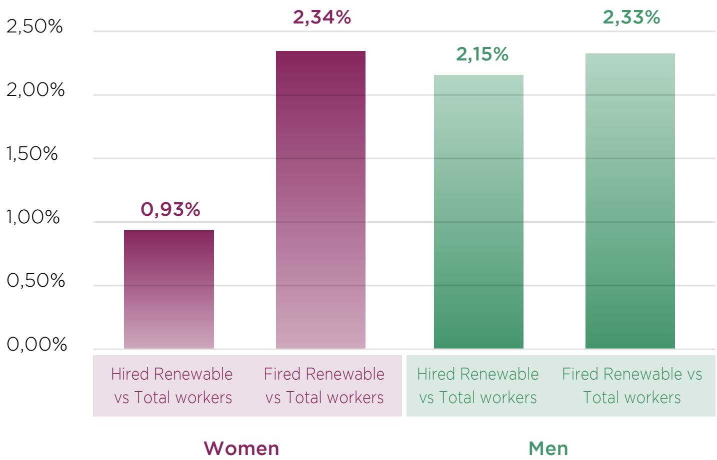


Figure 4.4: Relative Job Turnover during the COVID-19 Pandemic

Descriptive statistics provide important information about gender disparities and gaps in the energy sector in the six analyzed countries. However, this study aims to go a step further and use survey data to identify critical variables that impact the energy sector's variation of the female employment rate. To this end, the methodological strategy that was applied in this study is described below.

Methods and Data

4

4. Methods and Data

The studies discussed in the literature review applied mixed methods, descriptive, and perceptual analyses to obtain answers about women in the energy industry. This paper seeks to complement and add to previous studies by applying analytical methods to identify critical variables that contribute to the increase in the number of women hired in the industry. The data analysis applied an econometric strategy to identify variables that have a significant impact on female job creation. In addition, this study applied Data Envelopment Analysis (DEA) to study not only job creation, but also the impact on gender diversity on each decision-making unit (DMU) as well, based on the surveyed information.

DEA´s non-parametric methodology allows us to study quantitative and qualitative data as well as information presented in different units. Each methodology has its limitations and by using complementary methodologies, this model's limits can be partially overcome.

This analysis aims to bring evidence about whether decarbonization of the energy sector might have a positive effect on reducing gender gaps in energy sector. In methodological terms, this work aims to contribute to the literature by using parametric and non-parametric methods to determine which type of firms have better gender outputs and which variables influence the reduction of the energy sector's gender gap. This section first summarizes key elements of the use of the DEA, to justify the methodological choice. The second subsection describes the econometric strategy and the following subsection describes the non-parametrical model.

a. Revision of the Methodology Strategy: Data Envelopment Analysis

The DEA model is a performance measurement technique that assesses the relative efficiency of decision-making units (DMUs) in a scenario with multiple possible inputs and outputs. The DEA model, CCR developed by Charnes, Cooper and Rhodes (1978), was a generalization of the framework of Farrell (1957) on the measurement of productive efficiency, which assumes constants return to scale. Then, a study by Banker et al. (1984) analyzed a new scenario in which they assumed variables return to scale (DEA BCC).

Data Envelopment Analysis (DEA) has been used in few applications, in terms of gender diversity and company performance specifically (Adeabah et al., 2019; Bowlin & Renner, 2008). Adeabah et al. (2019) applied DEA to analyze the efficiency of banks with respect to gender diversity and examined determinants of bank efficiency. Meanwhile, Bowlin and Renner (2008) used DEA to study gender pay equity in top management team positions in medium and small companies in the United States. Most gender diversity studies use regression analysis. As far as we know, there is only one study that applied DEA to analyze gender and energy transition in Tibetan pastoral areas of China; that study was developed by Ding et al. (2019). The results of their study showed a significant increase of total household energy consumption and energy efficiency and decrease of the disease rate due to the use of renewable energy and clean devices.

Based on our literature review, we found that DEA has several characteristics that make it an interesting methodology for this study. First, the use of DEA helps unravel issues in the regression stage because efficiency scores derived are not founded on residuals obtained from econometric techniques. The advantage of the DEA approach is that we do not have to consider the appropriate functional form of the model a priori compared to stochastic frontier analysis (Adeabah et al., 2019). Second, DEA focuses on optimizing individual observations in contrast to regression, which focuses on averages and parameter estimates for classes of entities. Thus, DEA results are entity (observation) specific and do not imply an average entity or class of entities (Bowlin et al., 2003). This characteristic is particularly important for the present study since it considers different firms with different activities from different countries and the level of data heterogeneity is high. Finally, DEA handles multiple output and multiple input variables simultaneously. Consequently, DEA readily recognizes the substitutability of different inputs and outputs. For this study, this characteristic allowed us to evaluate the relative efficiency of DMU relationship between labor (L) and capital (K).

As it was a cross-country study of different types of companies in the energy sector, it was necessary to have a methodology that allowed working with these differences without significantly impacting results. Therefore, due to the characteristics mentioned before, DEA was selected to complement the econometric strategy and obtain more solid results. To the best of our knowledge, no other study has used DEA to address gender diversity and energy transition in companies. The literature shows that DEA is a useful tool to complement the results found with other quantitative and qualitative methodologies.

b. Econometric Strategy

To obtain evidence on how the energy transition might change the labor gender gap in power generating industries, the model proposed captures the association between energy transition change and the labor gender gap in this industry, as follows:

$$Y_{i,c}=\beta X'_{i,c}+\gamma_c+\varepsilon_{i,c} \quad (1)$$

where the dependent variable $Y_{(i,c)}$ is a set of different outcomes that capture the gender gap in this industry in firm i at country c. Specifically, six outcomes of women's labor force participation are included. The first outcome is the ratio of the total number of female workers over the total number of workers (wemp). This ratio shows the representation of women in the company's labor force. The second outcome is the ratio of the total number of female workers hired over the total number of workers hired since March 2020 (hwemp). This ratio shows the participation in new hired contracts of women in the company's labor force during the Covid-19 pandemic. The third outcome is the ratio of the total number of female workers on the board of directors over the total number of workers on the board of directors (wboardroom). This ratio represents the weight of women on the board of directors. Our fourth outcome is the ratio of the total number of STEM female workers over the total number of STEM workers (wstem). This variable shows the weight of women in STEM positions at the company. The fifth outcome is the ratio of the total number of non-STEM female workers over the total number of non-STEM workers (wnostem). This variable shows the weight of women in non-STEM positions at the company. Finally, our sixth outcome is the ratio of the total number of female workers in managerial positions over the total number of workers in managerial positions (wmanagers).

The variable X is a vector of explanatory variables, γ_c is a country-specific effect, and $\varepsilon_{(i,c)}$ is an idiosyncratic error. The baseline specification includes three key explanatory variables within the X vector.

The first explanatory variable tested is the carbon footprint certification (Carbon foot), from which the dummy variable takes the value of one when the firm reports to have the certification, and zero otherwise. The hypothesis tested was the carbon footprint certification is associated with a higher labor participation of women. This could happen because firms that are environmentally friendly tend to be more socially responsible, which can be related to a greater number of women in these firms.

The second key explanatory variable is ownership nationality. More precisely, the analysis focused on the multinational firm (multinational), from which the dummy variable is constructed taking the value of one if more than 25% of the ownership of the firm belongs to an international holding, and zero otherwise. The hypothesis tested was the multinational firm is associated with a higher women's labor participation because they could have better governance. Consequently, it could bring more inclusive policies, such as career plans without discrimination.

The third explanatory variable is a dummy variable that captures whether a firm operates in the renewable industry. The hypothesis tested was the renewable industry is more gender diverse, based on the findings of the studies considered in the literature review.

An important issue here might be an endogeneity problem. Endogeneity might arise from two sources: unobservable variables or reverse causality. To solve the first source, country fixed effects were included. Regarding the second source, a propensity score matching (PSM) technique to weight was applied to increase the comparability of the dataset.

To test the first hypothesis, the magnitude of the effect of having a carbon footprint certification on reducing the gender gap was obtained by estimating the following equation:

$$PSM_{ATT}=E[Y_{i,c}(1) \mid \rho,D=1]-E[Y_{i,c}(0) \mid \rho,D=0] \qquad (2)$$

where $Y_{(i,c)}$ is a set of six different outcomes that capture gender bias in this industry in company i at country c, mentioned above. ρ is the propensity score of having a carbon footprint certification based on the given company characteristics X, which, in our case, refers to a multinational company, a company that operates in the solar industry, and country dummies. ρ is also used to find matched treated (having a carbon footprint certification) and untreated (not having a carbon footprint certification) companies, allowing like-for-like comparison. D is a dummy equal to one if the company has a carbon footprint certification, while it takes the value zero otherwise. Finally, PSM_{-ATT} is the magnitude of the difference between the total number of female workers over the total number of workers in a company with a carbon footprint certification, and those not having a carbon footprint certification. The equation (2) was regressed by matching companies with a carbon footprint certification and their counterparts. The average treatment effect on the treated (ATT) was estimated for the total number of female workers over the total number of workers ($Y_{i,c}$). It allowed comparison of the total number of female workers over the total number of workers of carbon footprint certification and their counterpart companies in similar industries, countries, etc. Furthermore, in the PSM estimation, a logit regression was applied, in which a dummy for a carbon footprint certification was used as dependent variable, and company characteristics were used as independent variables. Finally, to obtain average effects of having a carbon footprint certification, the nearest-neighbor matching (k) with k=2 was implemented.
To analyze potential technology and knowledge spillovers from green energy technologies and how can they create employment, we proposed a model that captured the effect of efficiency (proxy of technology and knowledge) on employment creation. Here, we first estimated the efficiency measure using the data envelopment analysis (DEA) approach.

c. Econometric Results

In general, the results showed that carbon footprint certification has a significant but negative relationship with female labor in the analyzed companies (see Annex 1). Specifically, our results show that a company with a carbon footprint certification is associated with a decrease of 0.093 percentage points (pp) in female labor participation, a decrease of 0.110 pp in the total number of female workers hired over the total number of workers hired since March 2020, compared to a company that does not have this certification. Our results are statistically significant at the 10% level in these two outcomes; nevertheless, in the rest of the outcomes, evidence is not statistically significant at standard levels. This means that the hypothesis we established at the beginning -- that having a carbon footprint certificate would be associated with a higher women's labor force participation -- was not met. This implies that the fact that a company is environmentally responsible does not imply that it promotes gender equity[5].

5. An attempt was made to deepen the analysis to obtain a broader explanation by controlling for company size. However, it was not possible to do so, and these results were not significant. This result points to to new research questions that could be answered in future studies.

The results of the second hypothesis discussed above, being a multinational company, were only significant when we use the hwemp outcome. Our results suggest that being a multinational company is associated with an increase of 0.128 pp in the total number of female workers hired over the total number of workers hired since March 2020.

The results related to the third hypothesis showed that renewables explain the tendency of increasing women's participation in the market, even if only slightly. Moreover, we find that being a company operating in the renewable energy industry is associated with an increase in female labor participation in all outcomes studied. This result confirms and complements the findings made in the descriptive section of this study and in previous descriptive studies such as IRENA (2019), where it is indicated that the percentage of women working in renewable energy companies is higher than the percentage of women working in traditional industries.

The econometric strategy shows that the fact that a company is international has a positive impact on the participation of women in renewable generation companies.

d. Non-parametric Model

The DEA analysis, as mentioned by Fall et al. (2018), does not need previously estimated parameters, in contrast to the Stochastic Frontier Analysis (SFA), which requires specification of functional form and assumptions regarding distribution of the error term. In this study, the non-parametric input-oriented DEA model was employed with variable returns to scale (VRS) where the objective of the DMUs is to minimize inputs, given a level of outputs. To perform the efficiency[6] analysis with the DEA model, we solved the following linear program:

$$\min_{\theta,\lambda}\theta$$

$$s.t.:$$

$$\theta_{xj} - X\lambda \geq 0$$

$$Y\lambda \geq y_j$$

$$\lambda \geq 0$$

where λ is a semi-positive vector in $\mathbb{R}^k$ and θ is a real variable. In this model, θ represents the efficiency score of a given company, and has values from 0 to 1. $\mathbf{x}_j$ is a vector of the company inputs, and $\mathbf{y}_j$ a vector that contain the outputs. The minimization problem is subject to the constraint that no DMU can function beyond the production possibility curve and that there cannot be negative weights.

We used the VRS technical efficiency score[7] for X-efficiency and for scale efficiency the division of the constant returns to scale (CRS) efficiency score by the VRS efficiency score (SE=CRS/VRS). In the case of inputs, we used the ratio of the total number of female workers over the total number of workers (wemp) and the total number of workers. For output, we considered installed capacity (k)[8]. After the estimation of the efficiency score (DEA), we used this variable as the main explanatory variable, as follows:

$$Y_{i,c} = \beta X'_{i,c} + \alpha \mathrm{DEA} + \gamma_c + \varepsilon_{i,c} \qquad (3)$$

6. Efficiency is defined as a weighted sum of outputs divided by a weighted sum of inputs, where all efficiencies are restricted to rest between zero and one (Cichowicz et al., 2021).

7. The VRS efficiency score is defined as a ratio of the weighted sum of outputs to the weighted sum of inputs. It is based on a non-parametric linear programming technique which identifies an efficiency frontier on which only the efficient DMUs are placed (Mardani, 2017).

8. In this study, the installed capacity is expressed in MW.

where the dependent variable $Y_{i,c}$ is a set of six different outcomes that capture gender bias in this industry in company i at country c, mentioned above. The variable X is a vector of explanatory variables, γ_c is a country-specific effect, and $\varepsilon_{i,c}$ is an idiosyncratic error. The main variable of interest is DEA, which captures the effect of technology and knowledge spillovers from green energy technologies to employment creation. Two DEA measures are used: xeff, which is managerial efficiency (X-efficiency), and seff, which is scale efficiency. If the efficiency variables showed a positive sign and were significant, then the efficiency hypothesis would be confirmed. It was expected to find a positive effect of efficiency on employment since companies operating in the technological frontier need higher labor inputs and higher quality of employees. Nevertheless, if the efficiency variables showed a negative sign and were significant, the efficiency hypothesis would not be confirmed. The last might be because companies operating in the technological frontier do not need higher labor inputs and might need higher quality technology to expand their production.

e. Non-parametric Results

The results of equation 3 (shown in Annex 2) show that our baseline results were robust to the inclusion of the DEA variables. Furthermore, the main explanatory variables (seff and xeff) are not statistically significant at standard levels, with the exception for the association with the ratio of the total number of STEM female workers over the total number of STEM workers (wstem) and with the ratio of the total number of non-STEM female workers over the total number of non-STEM workers (wnostem). More specifically, results showed that there was a positive association between an increase of scale efficiency and the increase of the participation of women in non-STEM positions by 0.255 pp. On the other hand, we find that there is a negative association between an increase of scale efficiency and the increase of the participation of women in STEM positions by -0.013 pp.

This means that our hypothesis is confirmed for women in non-STEM positions and rejected for women working in STEM positions. In other words, it was found that those companies that have a higher number of women in non-STEM positions are the ones that are better positioned with respect to the others. This is partly explained by the results of the descriptive analysis, which show that although renewable energy companies hire a greater number of women, most of them occupy non-STEM positions. This result does need to be further explored because women's participation in STEM positions needs to consider different biases, some of them related to the energy sector, and some of them more generally associated with social norms. It is important to highlight that women's participation and efficiency does not have a causal effect, but there is a relationship.

Concluding Remarks

5. Concluding Remarks

The energy transition will disrupt the energy sector's labor market. It will demand new labor skills, especially due to the development of new technologies, but it will also shake off long-standing labor structures. This paper employed surveyed data from six Latin American and Caribbean countries (Mexico, Chile, Bolivia, Uruguay, Costa Rica, and Panama), and contributes to the extant literature in two ways: (1) It shows the potential employment impacts of decarbonization in the LAC region by focusing on gender diversity in energy firms; and (2) It presents an analytical strategy that aims to assess the current situation of companies in the energy generation sector in terms of gender equity and to corroborate whether renewable energy companies are indeed hiring more women.

The econometric strategy shows that the fact that a company is international has a positive implication with respect to the participation of women in renewable generation companies.

Overall, the DEA results demonstrate that renewable generation companies with the highest relative efficiency in the labor-capital ratio are those with the highest participation of women. However, these women occupy non-STEM positions. DEA results also establish that although renewable companies are increasing the number of women hired, there is no structural change with respect to the roles that women occupy in those companies. These results confirm and complement the information found in the previous studies presented in the first section of this document. The companies categorized as renewable with higher installed generation capacity hire more women, but these women occupy mostly non-STEM positions.

These results can be explained to a large extent by education gaps in STEM areas. The energy sector demands professionals with STEM training and the results of the descriptive analysis show that the percentage of women employed was lowest for STEM and increased as the education level decreased, at 38%, 54% and 55% respectively. This trend is the same for renewable energy generation companies, with 26% for STEM, 44% for non-STEM, and 48% for not qualified, respectively.

Concerning the roles of women in energy companies and technology spillover, wide gender gaps exist in executive and management positions; the proportion of females in the boardroom and in management roles for renewables generation companies were 24% and 22%, respectively. For non-renewable energy generation companies, those figures were 20% and 32%, respectively, which is higher than the overall trend and ten percentage points higher than renewables. Gender disparity in the boardroom is greater than that of management and is equal to gender disparity at the general employment level. These percentages are higher than those found in the IEA study (2020) and higher than those presented in the study by Luca et al. (2016), and this may be due to the sample size. The overall results show that employment trends and gender gaps are persistent, from overall employment to executive positions. In addition, the results show that 68% of the companies surveyed did not have gender policies in place.

This study confirms that a change in technology alone does not generate qualitative changes in the labor market from a gender perspective. Considering findings from the literature review, these changes would be achieved by complementing technological change with inclusion policies, encouraging women to study careers related to science and technology (STEM) to fill the shortage of female professionals in these areas, and closing the knowledge gap through systematic data collection and sharing with respect to gender in the energy workforce.

6. References

Abadie, A., & Imbens, G. W. (2006). Large sample properties of matching estimators for average treatment effects. Econometrica, 74(1), 235-267. https://economics.mit.edu/files/11867

Abadie, A., & Imbens, G. W. (2011). Bias-corrected matching estimators for average treatment effects. Journal of Business & Economic Statistics, 29(1), 1-11. https://economics.mit.edu/files/11861

Abadie, A., & Imbens, G. W. (2016). Matching on the estimated propensity score. Econometrica, 84(2), 781-807. https://www.jstor.org/stable/43866448

Adeabah, D., Gyeke-Dako, A., & Andoh, C. (2019). Board gender diversity, corporate governance and bank efficiency in Ghana: A two-stage Data Envelope Analysis (DEA) approach. The International Journal of Business in Society. http://197.255.68.205/bitstream/handle/123456789/30378/Board%20gender%20diversity%2C%20corporate%20governance%20and%20bank%20efficiency%20in%20Ghana%20a%20two%20stage%20data%20envelope%20analysis%20%2-8DEA%29%20approach.pdf?sequence=1&isAllowed=y

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30(9), 1078-1092.

Bear, J. B., & Woolley, A. W. (2011). The role of gender in team collaboration and performance. Interdisciplinary Science Reviews, 36(2), 146-153. . http://www.jstor.org/stable/2631725.

Blanco, M. I., & Rodrigues, G. (2009). Direct employment in the wind energy sector: An EU study. Energy Policy, 37(8), 2847-2857. doi: 10.1016/j.enpol.2009.02.049

Bowlin, W. F., & Renner, C. J. (2008). Assessing gender and top-management-team pay in the S&P mid-cap and small-cap companies using data envelopment analysis. European Journal of Operational Research, 430–437. doi: 10.1016/j.ejor.2007.04.022

Brichetti, J., Mastronardi, L., Rivas Amiassorho, M., Serebrisky, T. & Solís, B. (2021). La brecha de infraestructura en América Latina y el Caribe: estimación de las necesidades de inversión hasta 2030 para progresar hacia el cumplimiento de los Objetivos de Desarrollo Sostenible. I. Inter-American Development Bank. Infrastructure and Energy Sector. VII. Serie. IDB-MG-962. https://publications.iadb.org/publications/spanish/document/La-brecha-de-infraestructura-en-America-Latina-y-el-Caribe-estimacion-de-las-necesidades-de-inversion-hasta-2030-para-progresar-hacia-el-cumplimiento-de-los-Objetivos-de-Desarrollo-Sostenible.pdf

Cichowicz, E., Rollnik-Sadowska, E., Dędys, M., & Ekes, M. (2021). The DEA method and its application possibilities for measuring efficiency in the public sector—The case of local public employment services. Economies, 9(2), 80. doi: 10.3390/economies9020080

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 2(6), 429-444. doi: 10.1016/0377-2217(78)90138-8

Cooper, W., Kingyens, A. T., & Paradi, J. C. (2014). Two-stage financial risk tolerance assessment using data envelopment analysis. European Journal of Operational Research, 273–280. doi:10.1016/j.ejor.2013.08.030

Cullinan, R., (2018). In collaborative work cultures, women carry more of the weight. Harvard Business Review.
https://hbr.org/2018/07/in-collaborative-work-cultures-women-carry-more-of-the-weight

Fall, F., Akim, A. M., & Wassongma, H. (2018). DEA and SFA research on the efficiency of microfinance institutions: A meta-analysis. World Development, 107, 176-188.

Farrell, M. J. (1957). The measurement of productive efficiency. Journal of the Royal Statistical Society: Series A (General), 120(3), 253-281. doi: 10.1016/j.worlddev.2018.02.032

Flabbi, L., Piras, C., & Abrahams, S. (2016). Female corporate leadership in Latin America and the Caribbean region: Representation and firm-level outcomes. IDB Working Paper Series; 655. https://publications.iadb.org/publications/english/document/Female-Corporate-Leadership-in-Latin-America-and-the-Caribbean-Region-Representation-and-Firm-Level-Outcomes.pdf

Gasparini, L., & Marchioni, M. 2015. Bridging gender gaps. La Plata: Universidad Nacional de La Plata. http://labor-al.org/participacionfemenina/wp-content/uploads/2016/01/Bridging-gender-gaps_full-book.pdf

IDB. (2017). Documento de Marco Sectorial de Género y Diversidad. https://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=EZSHARE-1024040741-39

IDB. (2018). Women at the forefront of economic prosperity in the 21st century. https://publications.iadb.org/en/women-forefront-economic-prosperity-21st-century

IEA (2020), Gender diversity in energy: what we know and what we don't know, IEA, Paris https://www.iea.org/commentaries/gender-diversity-in-energy-what-we-know-and-what-we-dont-know

ILO. (2021, October 27). : Employment impact of the pandemic worse than expected. https://www.ilo.org/global/about-the ilo/newsroom/news/WCMS_824098/lang--en/index.htm.

IRENA. (2019). Energías renovables: Una perspectiva de género. International Renewable Energy Agency.https://www.irena.org/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019_ES_Summary.pdf?la=en&hash=C6894D6EFCE7650E7456F7AC1A6ACD026A720FE9

IRENA. (2020). Wind energy: A gender perspective. International Energy Renewable Agency. https://www.irena.org/publications/2020/Jan/Wind-energy-A-gender-perspective

IRENA and ILO, 2021. Renewable Energy and Jobs- Annual Review 2021. International Renewable Energy Agency, International Labour Organization, Abu Dhabi, Geneva. https://www.irena.org/publications/2021/Oct/Renewable-Energy-and-Jobs-Annual-Review-2021

Ji, Y. B., & Lee, C. (2010). Data envelopment analysis. The Stata Journal, 10(2), 267-280. https://journals.sagepub.com/doi/pdf/10.1177/1536867X1001000207

Marcos Morezuelas, P. (2014). Género y energías renovables. Energía eólica, solar, geotérmica e hidroeléctrica. Interamerican Development Bank. https://publications.iadb.org/es/genero-y-energias-renovables-energia-eolica-solar-geotermica-e-hidroelectrica

Ravillard, P., Ortega, B., Paramo, A., Chueca, E., Weiss, M., & Hallack, M. (2021). Implications of the Energy Transition on Employment. https://publications.iadb.org/publications/english/document/Implications-of-the-Energy-Transition-on-Employment-Todays-Results-Tomorrows-Needs.pdf

Saget, C., Vogt-Schilb, A. & Luu, T. (2020). Jobs in a net-zero emissions future in Latin America and the Caribbean. Inter-American Development Bank and International Labour Organization, Washington D.C. and Geneva.
http://dx.doi.org/10.18235/0002509

Schomer, I., & Hammond, A. (2020). Stepping up women's STEM careers in infrastructure: An overview of promising approaches. ESMAP Paper. Washington, D.C.: World Bank. https://openknowledge.worldbank.org/handle/10986/34787

Simas, M., & Pacca, S. (2014). Assessing employment in renewable energy technologies: A case study for wind power in Brazil. Renewable and Sustainable Energy Reviews, 83-90. doi: 10.1016/j.rser.2013.11.046

Snyder, V., Hallack, M., & Larrea, S. (2018). Gender and energy: A balance of power. Inter-American Development Bank. https://publications.iadb.org/publications/english/document/Gender_and_Energy_the_balance_of_power_en.pdf

Soto, D., Hallack, M., & Johnson, O. (2021). La transición energética, una oportunidad para desarrollar políticas de género. Inter-American Development Bank. https://blogs.iadb.org/energia/es/la-transicion-energetica-una-oportunidad-para-desarrollar-politicas-de-genero/

UNESCO Institute for Statistics. (2019). Data Centre. Accessed 2019. http://www.uis.unesco.org/DataCentre/Pages/default.aspx

Vogt-Schilb, A. (2021). Stronger sustainable growth. In Eduardo Cavallo and Andrew Powell, Coordinators, "Opportunities for Stronger and Sustainable Post-pandemic Growth." Inter-American Development Bank. Accessed at https://publications.iadb.org/publications/english/document/2021-Latin-American-and-Caribbean-Macroeconomic-Report-Opportunities-for-Stronger-and-Sustainable-Postpandemic-Growth.pdf.

Whitford, A. B., Wilkins, V. M., & Ball, M. G. (2007). Descriptive representation and policymaking authority: Evidence from women in cabinets and bureaucracies. Governance, 20(4), 559-580. doi: /10.1111/j.1468-0491.2007.00372.x

7. ANNEX

7.1 ANNEX A – Descriptive Statistics

Variables	Mean	Observations
National property (%)	95	4900
International property	0	31
Installed capacity (MW)	1123	33586
Carbon footprint	1	27
Energy consumption	0	5

Workers by age	Mean	Observations
Workers between (men) 15 and 25	27	65
Workers between (men) 26 and 35	204	721
Workers between (men) 36 and 45	371	1181
Workers between (men) 46 and 55	283	716
Workers between (men) 56 and 65	143	353
Workers between (men) 66 and 75	2	4
Workers between (men) more than 75	1	1
Workers between (women) 15 and 25	2	6
Workers between (women) 26 and 35	50	170
Workers between (women) 36 and 45	73	220
Workers between (women) 46 and 55	39	108
Workers between (women) 56 and 65	14	31
Workers between (women) 66 and 75	0	0
Workers between (women) more than 75	0	0

Job Turnover	Mean	Observations
Hired workers (women)	34	2526
Hired workers (women)	1	25
Fired workers (women)	5	223
Fired workers (women)	1	27

Level of worker's education	Mean	Observations
Without formal education (women)	1	11
Primary education (women)	47	741
Secondary education (women)	47	1143
Associate degree (women)	61	440
Bachelor's degree (women)	81	992
Master's degree (women)	30	158
Doctorate's degree (women)	1	2
Without formal education (women)	0	0
Primary education (women)	2	77
Secondary education (women)	5	162
Associate degree (women)	6	38
Bachelor's degree (women)	27	321
Master's degree (women)	13	64
Doctorate degree (women)	0	0

Types of jobs	Mean	Observations
STEM workers (overall)	29	1026
STEM workers (women)	9	367
Non-STEM workers (women)	11	380
Without qualification (women)	13	956
STEM workers from directory board (women)	5	237
Non-STEM workers from board of directors (women)	6	236
Without qualification workers from board of directors (women)	2	53

Company costs	Mean	Observations
Administrative costs	2359963	25454071
Production costs	22116836	71593689
Indirect costs	118631	3228247
Funding costs	56905	3201101
Energy costs	600469	5883335

Wage gap	Mean	Observations
Wages for STEM workers (men)	161362	14746279
Wages for STEM workers (women)	20845	1315851
Wages for non-STEM workers (men)	1142588	62199001
Wages for non-STEM workers (women)	8635	516421
Wages for non-qualified workers (men)	30982	2743092
Wages for non-qualified workers (women)	18346	812720

Number of workers	Mean	Observations
Workers (overall)	1222	10691
Workers (men)	73	1161

7.2 ANNEX B – Results of econometric strategy

In Table 1, we show the main results by estimating the equation (1).

Table 1. Certification in carbon footprint and women's labor force participation

Variables	(1) rwemp	(2) hwemp	(3) wboardroom	(4) wstem	(5) wnostem	(6) wmanagers
Carbon footprint	-0.093**	-0.110*	-0.064	-0.033	0.005	0.005
	(0.039)	(0.056)	(0.058)	(0.055)	(0.060)	(0.058)
Multinational	-0.024	0.128*	-0.099*	-0.085*	-0.047	-0.043
	(0.048)	(0.070)	(0.052)	(0.044)	(0.062)	(0.064)
renewable_energy	0.154*	0.016	0.133*	0.058	-0.270	-0.188
	(0.079)	(0.109)	(0.077)	(0.058)	(0.431)	(0.153)
Chile	0.053	-0.051	-0.027	0.141***	0.201***	-0.076
	(0.068)	(0.137)	(0.064)	(0.032)	(0.044)	(0.083)
Costa Rica	-0.080	-0.058	-0.160*	-0.007	0.063	-0.056
	(0.080)	(0.144)	(0.083)	(0.046)	(0.068)	(0.181)
Mexico	0.009	-0.133	0.314	0.177	0.231	0.288
	(0.089)	(0.143)	(0.247)	(0.114)	(0.222)	(0.269)
Panama	0.070	0.040	0.029	0.183**	0.136*	-0.043
	(0.081)	(0.154)	(0.129)	(0.078)	(0.072)	(0.111)
Uruguay	0.045	0.008	-0.066	0.124**	0.275***	-0.036
	(0.075)	(0.142)	(0.073)	(0.061)	(0.080)	(0.108)
Constant	0.058	0.162	0.093	0.010	0.299	0.410**
	(0.093)	(0.166)	(0.086)	(0.048)	(0.430)	(0.165)
Observations	102	102	102	102	102	102
R-squared	0.071	0.088	0.112	0.058	0.072	0.072

Notes: Robust standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

In Table 2, we present our robustness check by estimating equation (2). Our results are similar to the findings reported in Table 1. We show that there is a negative, statistically significant difference between having a carbon footprint certification or not when analyzing the ratio of the total number of female workers over the total number of workers (wemp), and the ratio of the total number of female workers hired over the total number of workers hired since March 2020 (hwemp).

Variables	**(1) rwemp**	**(2) hwemp**	**(3) wboardroom**	**(4) wstem**	**(5) wnostem**	**(6) wmanagers**
Carbon footprint (1 vs 0)	-0.070* (0.037)	-0.106** (0.051)	-0.052 (0.055)	-0.016 (0.052)	-0.030 (0.059)	-0.006 (0.057)
Observations	102	102	102	102	102	102

Notes: Bootstraps standard errors in parentheses. We implement the matching approach as proposed by Abadie and Imbens (2006, 2011, 2016) using the teffects psmatch command in STATA. * p<0.10, ** p<0.05, *** p<0.01.

7.3 ANNEX C
Results of non-parametric model

Table 3. Efficiency and employment

Variables	Rwemp		hwemp		wboardroom	
	(1)	(2)	(1)	(2)	(1)	(2)
Seff	0.051 (0.064)		-0.030 (0.079)		-0.133 (0.155)	
Xeff		-0.007 (0.007)		-0.005 (0.009)		-0.005 (0.006)
Carbon foot	-0.083** (0.041)	-0.096** (0.040)	-0.086 (0.055)	-0.112* (0.059)	-0.039 (0.066)	-0.070 (0.064)
Multinational	-0.031 (0.043)	-0.004 (0.049)	0.144** (0.068)	0.151** (0.075)	-0.062 (0.059)	-0.091* (0.055)
renewable_energy	0.145** (0.071)	0.158** (0.079)	-0.048 (0.107)	0.020 (0.110)	0.058 (0.071)	0.136* (0.079)
Chile	0.041 (0.073)	0.073 (0.071)	-0.095 (0.139)	-0.031 (0.139)	-0.064 (0.086)	-0.019 (0.068)
Costa Rica	-0.084 (0.076)	-0.019 (0.088)	0.004 (0.154)	-0.012 (0.156)	-0.229** (0.095)	-0.120 (0.096)
Mexico	0.013 (0.100)	0.022 (0.094)	-0.128 (0.143)	-0.121 (0.147)	0.317 (0.243)	0.321 (0.251)
Panama	0.124 (0.086)	0.105 (0.084)	0.072 (0.162)	0.088 (0.160)	0.078 (0.169)	0.051 (0.148)
Uruguay	0.051 (0.080)	0.078 (0.073)	-0.016 (0.144)	0.034 (0.143)	-0.088 (0.117)	-0.046 (0.082)
Constant	0.044 (0.102)	0.041 (0.094)	0.221 (0.181)	0.144 (0.169)	0.198 (0.131)	0.088 (0.090)
Observations	87	96	87	96	87	96
R-squared	0.093	0.083	0.126	0.111	0.136	0.109

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

CONT.

Variables	wstem		wnostem		wmanagers	
	(1)	(2)	(1)	(2)	(1)	(2)
Seff	-0.059		0.255*		0.027	
	(0.089)		(0.146)		(0.127)	
Xeff		-0.013*		-0.006		-0.017
		(0.007)		(0.009)		(0.011)
Carbon foot	-0.007	-0.039	-0.012	0.009	0.012	-0.002
	(0.064)	(0.059)	(0.069)	(0.064)	(0.069)	(0.065)
Multinational	-0.051	-0.071	-0.063	-0.029	-0.012	-0.028
	(0.046)	(0.046)	(0.061)	(0.066)	(0.071)	(0.066)
renewable_energy	0.005	0.061	-0.241	-0.265	-0.226	-0.185
	(0.060)	(0.060)	(0.398)	(0.434)	(0.156)	(0.150)
Chile	0.122***	0.156***	0.202**	0.220***	-0.092	-0.059
	(0.032)	(0.031)	(0.087)	(0.046)	(0.088)	(0.089)
Costa Rica	0.027	0.089	0.100	0.119	0.058	0.067
	(0.064)	(0.056)	(0.098)	(0.092)	(0.249)	(0.236)
Mexico	0.187	0.191	0.252	0.243	0.305	0.305
	(0.113)	(0.115)	(0.262)	(0.226)	(0.283)	(0.275)
Panama	0.210**	0.209**	0.154	0.155*	-0.010	-0.018
	(0.098)	(0.088)	(0.106)	(0.081)	(0.127)	(0.124)
Uruguay	0.131**	0.164**	0.354***	0.308***	0.002	0.012
	(0.064)	(0.070)	(0.118)	(0.088)	(0.125)	(0.119)
Constant	0.059	-0.000	0.167	0.282	0.411**	0.399**
	(0.076)	(0.049)	(0.400)	(0.433)	(0.191)	(0.165)
Observations	87	96	87	96	87	96
R-squared	0.048	0.070	0.119	0.071	0.097	0.081

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1


IDB