Education for an equitable energy future: lessons from Southern Brazil

Aline Cristiane Pan[1], Michele Fossati[2], Ísis Portolan Dos Santos[3], Gabriela Pereira Da Silva Maciel[1], Angela Carine Moura Figueira[1], Amanda Mendes Ferreira Gomes[2], Renata Mansuelo Alves Domingos[2], Ricardo Rüther[2], Liege Dalpra Flores[1,11], Juliana Klas[1], Bianca Neves Machado[1], Gabrielli De Carli Da Silva[4], Liane Ludwig Loder[1], Valquiria Villas Boas Gomes Missel[1], Juliane Borba Minitto[1], Thais Crestani[5], Alice Stephanie Tapia Sartori[1], Mariana Oliveira Santos Barbosa Mendes[1], Jennifer Carrion[1], Júlia Rechia Voltolini[2], Laura Da Silva de Camargo[3], Sinara Silveira Santos[6], Joice Teresinha Airoldi Costa[7], Michelle Bicalho Antunes[8], Lisandra Barreto Da Silva[9], Thais de Paiva Corrêa Picanço[10], Thieli Vicenci Wildgrube[2], Gabriela Sehnem Heck[1]

[1] Federal University of Rio Grande do Sul, Tramandaí (Brazil)

[2] Federal University of Santa Catarina, Florianópolis (Brazil)

[3] Federal University of Santa Maria, Santa Maria (Brazil)

[4] Regional Council of Engineering and Agronomy of Rio Grande do Sul, Passo Fundo (Brazil)

[5] Pontifical Catholic University of Rio Grande Do Sul, Porto Alegre (Brazil)

[6] Assis Brasil State High School, Tramandaí (Brazil)

[7] Barão de Tramandaí State Institute of Education, Tramandaí (Brazil)

[8] Vicente Farencena Municipal Elementary School, Santa Maria (Brazil)

[9] Fredolino Chimango Municipal Elementary School, Passo Fundo (Brazil)

[10] Simão José Hess Basic Education School, Florianópolis (Brazil)

[11] Prudente de Morais State Basic Education School, Osório (Brazil)

Abstract

This paper presents the project *Energizing Equity: Girls and Women Empowering the Energy Transition*, an educational initiative promoting gender equity in the energy transition through STEM-based actions in public schools in southern Brazil. Supported by CNPq, MCTI, and the Ministry of Women, the project involves 35 students and six school teachers annually across six schools, in partnership with three federal universities (UFRGS, UFSM, UFSC) and women's energy networks (MESol, Women in Biogas). Its methodology combines thematic workshops on renewable energy, energy management, gender equity, and scientific research, alongside mentorship programs connecting female professionals and students, as well as technical visits to universities, libraries, museums, and renewable energy companies. Activities integrate the UN Sustainable Development Goals (SDG 5, 7 and 10) and Brazil's National Curriculum (BNCC). First year results reveal growing engagement, strengthened scientific literacy, and expanded awareness of women's roles in energy. The project demonstrates how interdisciplinary, inclusive education can foster a more equitable and sustainable energy transition, especially in Latin America.

Keywords: gender equity, energy transition, STEM education, inclusive education, public schools.

1. Introduction

The transition to a low-carbon economy has driven the global expansion of renewable energy sources, with solar photovoltaic (PV) energy expected to play a central role in the future energy matrix (IEA, 2023). In Brazil, the PV sector has experienced rapid growth, especially in distributed generation, with an increase of

10.18086/swc.2025.09.02 Available at http://proceedings.ises.org

over 30% between 2019 and 2020 (EPE, 2021), generating more than 750,000 jobs since 2012 (ABSOLAR, 2023). However, this technological and market progress has not been accompanied by a proportional increase in women's participation in the sector. Data show that 35% of PV technology companies in Brazil have no women on their teams (Greener, 2024), and in those that do, only 7% of female professionals work in technical areas such as Project Development and Engineering (C40, 2021), with minimal representation in leadership roles.

This gender imbalance in Science, Technology, Engineering, and Mathematics (STEM) begins early, often in basic education, and continues throughout academic and professional trajectories. Although women are the majority in Brazilian higher education (IBGE, 2022), they remain underrepresented in Exact Sciences, Engineering, and Computing courses (UNESCO, 2021), a reality deeply connected to inequalities in early educational opportunities. Furthermore, the absence of consistent public policies that support science and the continued budget cuts to institutions such as National Council for Scientific and Technological Development (CNPq), the Coordination for the Improvement of Higher Education Personnel (CAPES), the Funding Authority for Studies and Projects (FINEP), and the National Fund for Scientific and Technological Development have weakened scientific careers, limiting opportunities for women to advance academically and professionally (Sígolo et al., 2021).

In Latin America and the Caribbean, studies indicate that women make up only about 20% of the energy sector workforce, and this number drops to 7% in leadership positions (Betti et al., 2020; Falcão et al., 2019). The lack of school infrastructure, teacher training, and adequate public support further exacerbates the exclusion of girls from STEM, particularly those in socially vulnerable contexts (Sígolo et al., 2021, 2021; Pan et al., 2022). As a result, girls are often pushed away from scientific paths early on, negatively impacting their science identity and science capital (Archer et al., 2015).

Building a just and equitable energy transition requires the active participation of women at all stages of the process, from early education to decision-making roles (Sumarsono et al., 2023; Santos et al., 2024). For this participation to be meaningful and sustainable, gender and sustainability perspectives must be integrated from the earliest levels of education, becoming foundational pillars of social and technological transformation (Fossati, 2023). Both the International Renewable Energy Agency (IRENA, 2022) and the United Nations (2015) emphasize the importance of diversity for the development of more just, inclusive, and sustainable solutions, aligned with the Sustainable Development Goals (SDGs), particularly Goals 5 (Gender Equality), 7 (Affordable and Clean Energy), and 10 (Reduced Inequalities).

In light of the challenges faced by science and education in Brazil, the public call No. 31/2023 "Girls in Exact Sciences, Engineering, and Computing," launched by CNPq in partnership with the Ministry of Science, Technology and Innovation (MCTI) and the Ministry of Women (MMulheres), aims to foster collaboration between public schools, universities, and professional networks of women in STEM fields. Selected through this call, the project *Energizing Equity: Girls and Women Empowering the Energy Transition* seeks to promote inclusion, retention, and recognition of girls and women in STEM through educational activities, thematic workshops, mentorships, technical visits, and science outreach initiatives, thereby contributing to a more inclusive energy transition.

Public investment in this initiative is strategic, as it strengthens support networks, expands educational opportunities, and promotes the democratization of scientific knowledge, especially for those in public basic education. Therefore, the objective of this work is to present the *Energizing Equity: Girls and Women Empowering the Energy Transition* project, highlighting its design, organization, and the preliminary results achieved during its first semester. Based on the activities developed in six participating public schools across the states of Rio Grande do Sul and Santa Catarina, this article analyzes the project's formative impacts, demonstrating its alignment with the SDGs and its potential to transform educational and professional trajectories.

2. Expanding Reach and Impact

The project *Energizing Equity* targets the southern region of Brazil, operating in partnership with public schools located in the states of Rio Grande do Sul (RS) and Santa Catarina (SC). In 2025, it engaged six public schools in the cities of Osório (OSR/RS), Tramandaí (TRA/RS), Santa Maria (STA/RS), Passo Fundo (PSF/RS), and Florianópolis (FLO/SC), directly impacting 35 female 9th-grade students and six female teachers annually through scholarships and capacity-building activities. Indirectly, the initiative reaches over 5,500 students and community members in these schools.

The selected schools represent diverse educational profiles and socioeconomic contexts, ranging from institutions offering technical education and evening classes to those serving rural and urban peripheries. For instance, some schools include specialized classrooms for deaf students, while others offer adult education or technical training in fields like accounting and electrotechnics. During the next two years, the project will select new cohort of schools, students and teachers through public calls, enabling intergenerational exchange and the continuous renewal of school engagement. The 9th-grade students receive Junior Scientific Initiation scholarships (ICJ/CNPq), while participating teachers receive Technical Support grants (AT/CNPq), allowing dedicated time for mentoring and coordination.

Its network implementation involves three major Brazilian federal universities, Federal University of Rio Grande do Sul (UFRGS), Federal University of Santa Maria (UFSM) and Federal University of Santa Catarina (UFSC), as well as partnerships with volunteer professional and civil society organizations, such as the Brazilian Women in Solar Energy Network (MESol), the Women in Biogas Network, and the Regional Council of Engineering and Agronomy of Rio Grande do Sul (CREA-RS). In addition to more than 60 volunteers, the project also involves four undergraduate students with Scientific Initiation scholarships (IC/CNPq), one Junior Postdoctoral fellowship (PDJ/CNPq), and one Knowledge Dissemination Support scholarship (ADC/CNPq).

By investing in the scientific education of girls and women, especially in contexts of vulnerability, *Energizing Equity's* project seeks to actively contribute to the achievement of the Sustainable Development Goals (SDGs) by 2030, promoting an energy transition that is also just, diverse, inclusive, and sustainable. The project supports the participation of girls and women in STEM through inclusive education, mentorship, and scientific engagement, supporting the advancement of gender equality and female empowerment in traditionally male-dominated fields (SDG 5). With focus on renewable energy education and the implementation of energy audits in public schools, the project encourages awareness and practical skills related to sustainable energy use (SDG 7). Together, these strategies reinforce the role of education as a driver of social transformation.

3. Methodology

The project employs a multi-layered, participatory educational methodology designed to engage woman and girls from public schools with STEM fields. With a particular emphasis on energy transition and gender equity, the methodology aims to foster inclusive, transformative learning environments that align educational pathways with a just energy transition.

3.1 Schools and Participant Selection

The selection of participating schools was based on their geographical proximity to partner universities to facilitate transportation and logistical planning for workshops and technical visits.

Both the selection of teachers and students was carried out through a public call for applications, which considered the criteria described above.

The selection of teachers awarded Technical Support (AT) scholarships considered their academic background (preferably in Science, Physics, or Mathematics), availability, leadership potential, communication with families, interest in collaborative networks, and willingness to support data production for the project. Teachers were required to dedicate at least one shift per week to project activities. From 2026 onward, they will also be responsible for monitoring project alumni as part of the long-term impact plan.

Junior Scientific Initiation (ICJ) students were selected based on academic records, school attendance, and a letter of intent outlining their motivation and expectations. Selected students were required to dedicate four hours per week to in-person meetings and project development.

3.2 Educational Structure and Activities

Activities are guided by one of four core themes: (1) Scientific Methodology, (2) Renewable Energy, (3) Energy Management and (4) Gender Equity. Each theme are organized into four workshop cycles, structured around four weekly phases: (a) literature review, (b) hands-on/practical activity, (c) technical visit, and (d) knowledge dissemination (Figure 1).

Figure 1: Educational structure and main activities of the project.

Literature Review: In the first week of each cycle, students and teachers explore the workshop theme through curated materials and literature review, such as academic articles, books and institutional reports. The goal is to develop understanding of key scientific concepts, critical reading, analytical thinking, and formulation of research questions and hypotheses. Research is guided by a central question and set of keywords, and students are encouraged to take notes and create summaries to prepare for hands-on learning.

Hands-on Activity: In the second week, a project team member leads an in-person practical session at each school. These sessions are designed to help students apply their theoretical knowledge through experiments, interactive exercises, and group challenges. This phase emphasizes contextualized, collaborative learning, linking science to students' lived experiences and fostering engagement with STEM.

Technical Visit: During the third week, students participate in a visit to an institution related to the workshop theme, such as a university, energy company, research center, lab, or museum. These visits are regionally coordinated and aim to expose students to real-life professional environments.

Knowledge Dissemination: In the final week, students collaboratively produce and present materials that synthesize their learning. These outputs are tailored to be shared with their colleagues and the school community and may include posters, banners, slideshows, oral presentations, pamphlets, videos, models, artwork, or written texts.

3.3 Additional Program Components

Beyond the workshop cycles, the project includes the following components to deepen its educational impact:

School Engagement and Planning: Collaborative school teams work alongside administrators to align project activities with institutional goals and routines, fostering long-term cultural change toward inclusive STEM practices.

Workshops Aligned with the SDGs and BNCC: All workshops are co-designed to meet both the needs of students and the guidelines of the National Common Curricular Base (Brasil, 2018), with a clear alignment to SDGs.

Mentorship Program: Female volunteer professionals from the energy sector mentor students and teachers, helping them define academic and personal goals through structured sessions (online), fostering leadership, identity formation, and professional aspiration.

Participation in Academic Events: Students conduct research projects based on workshop content, preparing for regional and national science fairs and competitions such as the National Energy Efficiency Olympiad (ONEE). These projects involve hypothesis testing, data analysis, and public presentation, supported by the project team.

Network Strengthening: Annual in-person events at participating universities provide space for evaluation, professional development, and community-building among schools, universities, and partner organizations.

Gender and Energy Performance Indicators: A set of qualitative and quantitative indicators is being developed collaboratively to assess school-level progress in gender equity and energy awareness.

4. Results

During 2025, the first year of the project, it progressed in several key areas outlined in its implementation plan. Following approval and initial planning, selection processes were carried out for assembling school teams, including teachers and 9th-grade students, as well as undergraduate students and Junior Postdoctoral Researcher, in accordance with CNPq guidelines.

With teams established, the first semester focused on developing theoretical and practical materials to support the thematic workshops. This included the creation of educational content, didactic activities, and educational games, alongside the logistical and pedagogical planning of technical visits linked to each workshop theme. Workshop implementation began in April 2025, following the project timeline. During the first seven month of the project, the four workshop were developed:

4.1.Scientific Methodology Workshop

This workshop introduced students to essential concepts of the scientific method, such as research question formulation, hypothesis development, methodological planning, and data analysis. Through participatory dynamics and collaborative knowledge construction, students were prepared to design research projects for scientific fairs and exhibitions.

The associated technical visits included experiences with university research groups, academic libraries, and science museums, helping students visualize scientific work in practice, illustrated at Figure 2.

(A) TRA and OSR at the Museum of Natural Sciences (MUCIN/CECLIMAR/UFRGS)

(B) FLO at the Central Library of UFSC

Figure 2: School visits to different educational spaces.

4.2 Renewable Energy Workshop

The Renewable Energy workshop aimed to introduce students to different types of renewable energy sources and their environmental and social benefits. Emphasis was placed on solar, wind, hydroelectric, green hydrogen, wave, tidal, biomass, and geothermal energy, framing each within the context of a just energy transition.

Students engaged in experiments and played an educational game titled “Energy Profile,” produced by the project and available at the project webpage. Technical visits were conducted at solar plants, universities, or clean energy demonstration centers (Figure 3).

(A) TRA and OSR at Photovoltaic Solar Power Plant /UFRGS | (B) PSF at BE8 Renewable Energy. | (C) STA at Technical Industrial School of Santa Maria/UFSM | (D) FLO at Fotovoltaica/UFSC

Figure 3: School visits to institutions dedicated to renewable energy research and production.

4.3 Energy Management Workshop

This workshop focused on energy literacy and consumption awareness. Students conducted weekly monitoring of school electricity usage using an "energy dashboard." They learned how to interpret consumption data, identify inefficiencies, and propose local solutions for improved energy management at school building. In addition, students were able to play the game "*Investigative Stories*," available at the project webpage, featuring riddles about energy management (Figure 4).

(A) OSR playing Investigative Stories | (B) PSF measuring the school's weekly energy consumption

Figure 4: Energy Management activities.

An experiment using lemons to generate electricity illustrated key concepts in a hands-on format (Figure 5). Technical visits included trips to energy distribution companies and energy-efficient buildings, offering insights into energy production, distribution, and pricing.

(A) PSF | (B) FLO | (C) TRA | (D) OSO

Figure 5: Experiment on energy transformation with a lemon.

4.4. The Gender Equity Workshop

The last workshop aimed to foster critical reflections on gender inequalities in education, science, and the labor market. Through group discussions, reflections, group and individual activities, and educational materials, students explored gender norms, identified structural barriers, and engaged with inspiring stories of women in STEM. The workshop also included interviews conducted by the students with women from their communities who work in fields with greater gender inequality, providing role models and opportunities for dialogue. As a practical activity, all participants watched a play about women in science careers and their difficulties, that took place at the Scientific Fair *Mostra Científica do Litoral Norte Gaúcho* (MOSCLING) (Figure 6).

Figure 6: Participants at MOSCLIN watching the play.

4.5 Supporting Materials

In addition to the workshops, the project has produced a variety of supporting materials designed to be accessible and fun, and to be used by other students across the country. These include theoretical guides, activity handbooks, scientific games, and dissemination resources such videos and Instagram posts. The creation of two educational games on the themes of renewable energy and energy management are highlighted:

Renewable Energy Profile: the Renewable Energy Profile game was designed with the goal of guessing which renewable energy source is being described, using the fewest clues possible. To play, the students were divided into two teams. The teacher picks a card and reads one clue at a time. After each clue, every team has the chance to make a guess (Figure 7).

Each team is allowed only one guess per round. If a team guesses correctly, the round ends and points are awarded based on which clue the correct answer was given. If no team guesses the word after all clues have been read, no points are awarded.

Figure 7: Example of cards from Renewable Energy Profile game.

Investigative Stories: For the Energy Management workshop, a customized set of mystery-solving storytelling cards was developed, combining compelling visuals with cryptic clues inspired by real-life energy use scenarios. Participants engage in investigative inquiry by asking questions that can only be answered with "yes," "no," or "not relevant," encouraging active deduction and problem-solving.

Every storyline addresses key energy efficiency issues such as the use of outdated appliances, mismatched system sizing, battery overheating caused by improper configurations, and energy-wasting behaviors. Example: The Car That Wouldn't Start. The family car wouldn't start, even though the battery was new, why? The interior lights had been left on all night, draining the battery. The family started checking to make sure everything was turned off before leaving the car. They also learned that electric car batteries are rechargeable and more cost-effective in the long run (Figure 8).

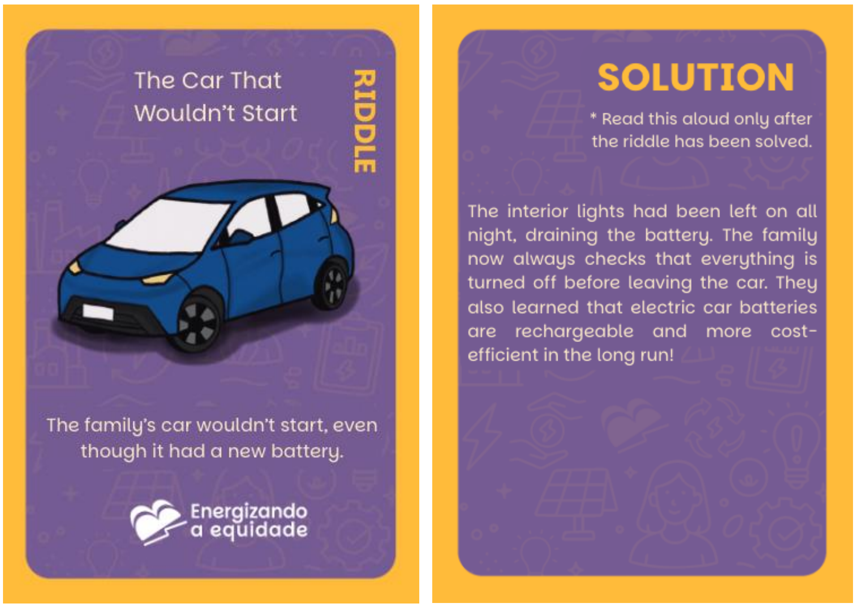

Figure 8: Example of cards used at Investigative Stories game.

4.6 Scientific Fair

In 2025, all participating students and teachers developed research projects and wrote extended abstracts to submit to the Scientific Fair *Mostra Científica do Litoral Norte Gaúcho* (MOSCLIN/UFRGS). A total of 12 abstracts were submitted, of which 8 were accepted for presentation.

The projects covered a wide range of themes related to renewable energy and sustainability, including:

- construction of a solar stove/oven,
- development of a biodigester,
- evaluation of voltage variation in a 1:25 scale model of a solar-powered house,
- comparison of energy efficiency among incandescent, LED, and fluorescent lamps,
- creation of an educational game on renewable energy for early childhood education,
- design of a sustainable streetlight for flood-prone areas in southern Brazil,
- assembly of a solar-powered car to understand its efficiency.

These projects reflect the students' interest and engagement with the themes the workshop, fostering critical thinking, teamwork, and scientific literacy. The group that conducted the irradiation evaluation using a scale model received an Honorable Mention Award at MOSCLIN 2025, in recognition of study's methodological complexity. The experiment involved the use of a multimeter to measure variations in solar irradiance under both clear and cloudy sky conditions.

5. Discussion and Final Remarks

The project exemplifies the importance of university–school partnerships in addressing gender inequalities in

STEM and promoting a just and inclusive energy transition. The thematic workshops increased the engagement of students, teachers, and the wider school community in scientific and environmental discussions. This engagement translated into active participation in investigative activities, including the development of student-led research projects and initiatives within the schools.

Despite the positive outcomes, the implementation of the project revealed several structural and logistical challenges. Some schools lacked appropriate spaces for after-school activities, requiring adjustments in both schedule and methodology. Transportation difficulties affected participation in technical visits and inter-school exchanges. Bureaucratic issues related to the formalization of the scholarships also delayed student and teachers access to research systems, due to platform limitations and banking constraints for underage participants. Additionally, with over 90% of the public funding allocated to scholarships, only a small portion remained for essential pedagogical resources, transportation and daily allowances, impacting Scientific fair participation.

Furthermore, during the activities, the importance of teacher and undergraduate research student engagement became evident. In schools where teachers and IC students were well-aligned and motivated, the 9th year girls appears significantly more enthusiastic about the project. Some challenges arose in cases where teachers and undergraduate's participants require greater support and of coordination team. As a result, new schools, teachers and IC students will be selected for participation in second and third years of the project, while maintaining the possibility of continuing for the same schools that demonstrated strong engagement.

Even so, the evaluation of the first year confirms that the project is progressing toward its objectives. The workshops fostered scientific and energy literacy and encouraged critical thinking on gender justice and climate issues. Students began to express new interests in science and technology fields, even in Engineers carriers. For the next years, key goals include strengthening mentoring with women in the energy sector, implementing gender and energy equity indicators in schools, expanding partnerships, and publishing the project's results, reinforcing education as a strategic pillar for sustainable futures.

6. Acknowledgments

The authors would like to thank the National Council for Scientific and Technological Development (CNPq), the Ministry of Science, Technology, and Innovation (MCTI), and the Ministry of Women for funding the project "Energizing Equity: Girls and Women Empowering the Energy Transition" (CNPq nº 440587/2024-7), in progress and approved by the National Council for Scientific and Technological Development (CNPq) within the scope of the Girls in Science 2023/2024 Call. We would like to thank the partner networks (MESol, Mulheres do Biogás, and CREA-RS), the researchers and faculty at federal universities (UFRGS, UFSM, and UFSC – Fotovoltaica/UFSC), and the schools involved for their support in developing the activities.

7. References

ABSOLAR. Brasil já criou mais de 30 mil empregos no setor solar em 2023. In: A**ssociação Brasileira de Energia Solar Fotovoltaica**, 2023.

Archer, L., E. Dawson, J. DeWitt, A. Seakins, and B. Wong., 2015. "Science Capital: A Conceptual, Methodological, and Empirical Argument for Extending Bourdieusian Notions of Capital Beyond the Arts." Journal of Research in Science Teaching 52 (7): 922–948.

Betti, P., and L. Boing., 2020. Análise de Gênero do Solário Carioca. C40 Cities Climate Leadership Group. Deutsche Gesellschaft für InternationaleZusammenarbeit (GIZ) GmbH.

Brasil. Ministério da Educação., 2018. Base Nacional Comum Curricular. Brasília: MEC.

C40., 2021. Energia Solar no Brasil: Quais São as Barreiras e as Oportunidades para as Profissionais Mulheres no Setor? C40 CitiesFinanceFacility.

EPE (Empresa de Pesquisa Energética)., 2021. Anuário Estatístico de Energia Elétrica 2021. Brasil: EPE.

Falcão, J., A. Strapasson, K. M. Costa, N. W. N. Masulino, and M. Barbosa.,2019. Energy & Gender: An Assessment on Gender Equality in the Energy Sector in Brazil. Brasília: British Embassy.

Fossati, M., 2023. Sustentabilidade é Coisa de Criança: Abordagem da Sustentabilidade em Escolas de Ensino Fundamental. Projeto de Extensão. Universidade Federal de Santa Catarina.

Greener., 2024. Estudo Estratégico Geração Distribuída Mercado Fotovoltaico.

IBGE (Instituto Brasileiro de Geografia e Estatística)., 2022. Censo Demográfico 2022. Brasil: IBGE.

IEA (International Energy Agency)., 2023. World Energy Outlook 2023. Paris: IEA.

IRENA (International Renewable Energy Agency)., 2022. Renewable Energy and Jobs: Annual Review 2022.

Pan, A. C., A. Kirsten, K. Schneider, N. Chaves, and I. Zanesco., 2022. "Perspectivas de Resiliência de Gênero: Ações da Rede Brasileira de Mulheres na Energia Solar." In IX Congresso Brasileiro de Energia Solar, Florianópolis. Anais […]. Florianópolis: Associação Brasileira de Energia Solar.

Santos, Í. P., B. G. H. Teixeira, M. J. Napoli, J. I. Rodrigues, and J. G. Daltrozo., 2022. Mulheres e as Profissões das Áreas da Ciência, Tecnologia, Engenharia, Arte e Matemática. Santa Maria: UFSM. (Cartilha de atividades para crianças).

Sígolo, V. M., T. Gava, and S. Unbehaum., 2021. "Equidade de Gênero na Educação e nas Ciências: Novos Desafios no Brasil Atual." Cadernos Pagu, no. 63 (Campinas).

Sumarsono, N., R. Kasali, and T. E. Balqiah., 2023. "Circular Business Model, Technology Innovation and Performance: A Strategic-Based Theoretical Framework in the Indonesian Energy Transition." Renewable Energy Focus 45: 259–270.

UNESCO., 2021. Mulheres Representam Apenas 28% dos Graduados em Engenharia. Organização das Nações Unidas para a Educação, a Ciência e a Cultura.