PRIMEIRA ESCOLA SOLAR DO BRASIL, O PROJETO PROMOÇÃO DA GERAÇÃO RENOVÁVEL DE ELETRICIDADE NA AMÉRICA DO SUL E SEUS IMPACTOS

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RESUMO

O objetivo deste estudo é analisar o impacto da implementação da primeira escola solar no Brasil, desenvolvida no âmbito do projeto Promoção da geração renovável de eletricidade na América do Sul (REGSA). Para alcançar este objetivo, a técnica de pesquisa empregada envolveu entrevistas em profundidade com questionários semiestruturados que foram aplicados em 8 pessoas as quais tiveram alguma relação

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com o projeto, ou pertencem à comunidade local. Entre os entrevistados, estão membros do governo, da comunidade, membros do REGSA na Unisul e empresas locais. Teve especificamente como objetivo analisar o impacto alcançado em três níveis: a) transferência de tecnologia; b) desenvolvimento sustentável; e c) participação na tripla hélice. Os resultados mostraram que em todas as três esferas de análise, referentes aos objetivos específicos, o projeto REGSA teve um impacto positivo.

PALAVRAS-CHAVE: Transferência de tecnologia; Desenvolvimento sustentável; Tripla Hélice; Estratégia.

1 INTRODUCTION

During the second half of the 20th century, concerns about the impact of human actions on the environment and society itself have become more frequent in international debates (KATILIUTE; DAUNORIENE, 2015, RASHID et al., 2015; BIRCANA; GENÇLER, 2015), reinforcing the need of promoting economic development in order to maintain environmental integrity and future social welfare (SACHS, 2007; ÇUBUKÇU, 2010; SIRBU et al., 2015).

With this ontology, the 1987 Brundtland Report introduced the concept of sustainable development as one that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 2014). For development to be sustainable, it is necessary to establish social, economic, and environmental welfare, aiming to improve quality of life, as well as human and environmental relations, at local, national, and international levels (BERCU, 2015; BIGGS et al., 2015; İYIGÜN, 2015; ABDULRAZAK; AHMAD, 2014.). Studies regarding the multidimensional relationship of economic, environmental, and social development have significantly increased in the past ten years (DVORAKOVA, ZBORKOVÁ, 2014; BODOSCA; DIACONESCU, 2015).

The sustainable development framework has become more widespread and applied among educational institutions, governments, the private sector, and civil society (CORNESCUA; ADAM, 2014; UNITED NATIONS CONFERENCE ON SUSTAINABLE DEVELOPMENT, 2012), promoting the growth of direct investment in sustainability worldwide (KARDOS, 2014). The interrelationship of these sectors with development is known as the triple helix. In this case, the model of the triple helix was employed to evaluate different sustainability objectives.

The triple helix is a theoretical/practical model created in the United States aiming the improvement of technological development processes involving interactions between the state, the private sector, and higher education institutions. In this model, the development and diffusion of new technologies should be based on this tripod, that is, the State as developer and promoter of scientific progress, the university as a developer of science, and the private sector (business organizations) as a processing mechanism (replication) and diffusion of new technologies (ETZKOWITZ; LEYDSDORFF, 2000; HERLIANA, 2015; MARTINI, 2012; CHANTHES, 2012).

According to Valente (2010), a sustainable technological innovation system can be achieved only if it is based on the state/university/private sector tripod in order to sustain the knowledge economy. This propeller is essentially built up by higher education institutions, enterprises (industry and service providers), and the State (government), each with its well defined institutional roles yet interact fully and cooperatively in the search of development of new technologies (STAL, 2007).

Regarding local arrangements, according to Etzkowitz and Leydsdorff the triple helix static theory applies when global and regional actions result in local development, particularly when universities, in addition to developing technologies, also act as incubators assisting small businesses and contributing to their technological development projects (ETZKOWITZ; LEYDSDORFF, 2000; HERLIANA, 2015; MARTINI, 2012; CHANTHES, 2012).

The triple helix theory has another model called the "laissez-faire model" (Sabato triangle), which also has the presence of the same three institutional spheres as the static model. However, in this model there is no interaction or integration between the actors, that is to say that the State, industry, and universities operate separately in technological and innovation production (ARBIX; CONSONI, 2011).

Finally, there is the third model of the triple helix called hybrid, in which the government, universities, and industries overlap in the production of technological innovations, forming a framework in which each of the actors perform the role of another, i.e. all interact without a distinctively defined role in the production of technological innovations (ETZKOWITZ; LEYDSDORFF, 2000).

Technological innovations can be essential for environmental preservation and sustainable development (BIRCANA; GENÇLER, 2015; KARDOS, 2012). However, the initial investment in green technologies is often high and may not result in immediate returns. Therefore, the need for international cooperation for sustainability

is emphasized (D'AVIGNON; CARUSO, 2011; UNITED NATIONS ENVIRONMENT PROGRAMME, 2011; UNITED NATIONS ENVIRONMENT PROGRAMME, 1972; UNITED NATIONS, 2014; BRAZIL, 1995; UNITED NATIONS, 2002; UNITED NATIONS CONFERENCE ON SUSTAINABLE DEVELOPMENT, 2012; STIGLITZ, 2007).

This article examines the first solar school in Brazil (located in Rancho Queimado, Santa Catarina), using the triple helix hybrid model to analyze the interaction between actors. Unlike in the static model, this case was driven by a project initially formulated at a university, with the State as a receiving partner of this pilot project. In this case, the State and the private sector were the recipients of innovations promoted by academia.

Rancho Queimado is a city in the southern region of Brazil. The municipality, which has an HDI of 0.753 (higher than the national average, equivalent to 0.744), has 2,748 inhabitants spread over an area of 286.288 km² (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2015; UNITED NATIONS DEVELOPMENT PROGRAMME, 2013).

Evident questions concerning how technology relates to the innovation process are incorporated into the objectives of this study, in this way, both can be linked to the development of renewable energy, other sustainable technologies, and technology transfer. In this framework, the authors use the definition of Peters (2000) to conceptualize technology transfer: "this is the process by which an existing technology is applied to a new use or a new user."

Innovation can result in economic dynamism, both from a micro and macro perspective (CAMPANÁRIO, 2002). At the micro level, innovation generate new technological paradigms that can ultimately require local organizations to adapt to the new production standards, since innovation processes can impose it over the economy in order to improve competitiveness. This dynamism can produce macroeconomic outcomes that, when unfolded can achieve local, regional, national, and global impacts (COVERS; NIJKAMP, 2004; FAGERBERG, 1994).

Innovation is an important factor for the socioeconomic development and technology transfer process is a key role that is played by companies, universities, and governments (JONES-EVANS; KLOFSTEN, 1999; KUHLMANN; EDLER, 2003; COVERS; NIJKAMP, 2004; LACERDA, VAN DEN BERGH, 2014).

Thus, the idea of technology transfer explained throughout this theoretical framework is consistent with what has been argued by Peters (2000) and Rogers (2003) and, for this study, technology transfer took place along a previously existing technological basis, which applied to a new use (by the school unit) and users (the first solar school in Brazil).

In order to promote the adoption of sustainable practices and environmentally friendly technologies, such as encouraging local energy efficiency and renewable energy use, the REGSA Project (Promoting Renewable Electricity Generation in South America) aimed to increase the share of renewable energy production in Bolivia, Brazil, and Chile. The project, led by Germany, lasted for 4 years and received funding from the European Union.

The REGSA project resulted in three pilot modules in Bolivia, Brazil, and Chile, as well as two International Conferences and a large number of articles and books. In Brazil, the local direction of the project decided for the development of the first school generating solar energy in the country that was later selected for the analysis in this paper.

The REGSA project implemented energy efficiency practices at the school through the implementation of solar power generation. Throughout the project, reforms were applied in four classrooms and the library in order to increase illumination. The process consisted of the replacement of 48 lights, 192 lamps, and painting of the walls and ceiling in order to illuminate the environment and provide greater lighting for the students, which helped improving their performance and concentration.

The installation of 27 solar panels with an annual electricity generation capacity of 8,784 kWh allowed Roberto Schütz Basic Education School to be self-sufficient in electrical consumption, and generate surplus power that can be distributed throughout the electric grid. The school's solar water heater also contributed to the welfare of students and school staff by providing hot water, a necessity due to the harsh winter in the region.

The project directly influenced 150 students at the school through its approach to issues related to sustainability and environmental conservation while involving the community, city officials, state government departments, and the energy utility in a partnership for the diffusion of sustainable technologies. The expectation is that over time, and with the introduction of new students, the project will expose greater numbers of youth to issues related to sustainability by showing that technologies such as solar

panels, solar water heaters, and energy efficient light bulbs exist and are accessible, inspiring later adults that are more conscious and sustainable-like minded.

The expectation of the project is that the innovations applied here can be used in the future as a basis for the construction of new school units. It is believed that in the medium or long term, the continuous depletion of non-renewable natural resources will become uneconomical, necessitating the newly constructed buildings to be built on similar models to the Rancho Queimado school.

Before this demand can be fully determined, it is necessary to assess the project's impact on the specific context in which it was developed, in order to understand qualitatively if the perception of the actors involved has changed regarding sustainability issues and innovative technologies. Was the project successful in involving the community, state, the university, and companies? Thus, the subsequent paragraph will present the methodology of this study.

2 METHODS

This research project commences with a qualitative and phenomenological methodology, on an exploratory basis, in the form of a case study, with cross time frame. All stages of the research are supported by previous literature review. It studies the REGSA pilot module project at the Roberto Schütz School, in Rancho Queimado, Brazil. The school was chosen due to its proximity to the University of Southern Santa Catarina (UNISUL), located 90.7 kilometers away from the state capital of Santa Catarina and 76.8 km from the main campus of UNISUL.

The first stage of the research was carried out through a literature review on the topics related to the pilot module's objectives. This step sought sources that had recognized and brought relevant understandings on the subjects addressed as well as contemporary authors in order to evaluate what was currently the "State of the Art" in the chosen area.

The second stage of the research was carried out via personal interviews and email questionnaires. A trip to Rancho Queimado, aiming to conduct personal interviews for the development of this article, proceeded featuring a structured script in the workplace and/or conviviality of the interviewees, conducted by two different researchers, which were later transcribed. The equipment used for the recording of the interviews was a Motorola Moto G. The recording included the capture of audio and

video in MP4 format using the FFTranscriber 1.0 software, with audio files extracted in the WAV format. The website <https: //transcribe.wreally.com/> was used in the creation of transcripts. Interviews were also conducted via e-mail, using the same structured questionnaires, which were answered and returned to the researchers via email.

This third stage of the study had as its main objective to analyze the impact of the REGSA pilot module in different segments of Rancho Queimado referring to three main aspects: technology transfer, sustainable development, and the triple helix involvement. Interviews conducted with local representatives of the executive and legislative powers, as well as a representative of the local community not directly involved in the project, the current and the former directors of the pilot school, a member of the parents and teachers association, a local businessman, and the UNISUL representative of REGSA project were analyzed and tabulated. The sample was chosen by convenience and judgment.

Tables 01 and 02 demonstrates the interview results both personal and via email, carried out with the same set of questions.

Table 01 - Sample characterization and their social function (interview via e-mail)

Cods	Interviewees	Filiation	Day of Interview	Occupation
E1	Jamile Beatriz S. Beretta	City hall of Rancho Queimado	27/07/2015	Secretary of Education of Rancho Queimado.
E2	Flavia Alfen Kaifer	Community	27/07/2015	Former teacher and civil servant.
E3	Aldo Lins Kumm	Chamber of Councilors of Rancho Queimado	27/07/2015	City councilman and Vice president of the city council.
E4	Luciane Schütz Sell	Roberto Schütz.Basic School	27/07/2015	Teacher and former director of Roberto Schütz Basic School.
E5	Marcelo Schütz	Community	27/07/2015	Restaurant owner.
E6	Adriana Sagaz	Association of Parents and Teachers	27/07/2015	Member of the Association of Parents and Teachers and mother of 2 students.

Sources: Elaborate by the authors, 2015.

Table 02 - Sample characterization and their social function (personal interview)

Cods	Interviewees	Filiation	Day of Interview	Occupation

E7	Cristiane Hamm Schütz	Roberto Schütz.Basic School	27/07/2015	Director of Roberto Schütz Basic School.
E8	Norma Beatriz Camisão Schwinden	University of Southern Santa Catarina	27/07/2015	Researcher of REGSA project.

Sources: Elaborate by the authors, 2015.

The third stage of the study presents the results from the qualitative content analysis, which seeks to clarify the impact of the experience of the pilot module of the REGSA project and examine whether the REGSA project has succeeded in transferring some of the new technologies tested in its pilot module to multiple stakeholders (community, business, university, and government). It then analyzes whether the installation of the pilot module was able to demonstrate the applicability of sustainable development to different actors. Finally, the authors evaluated the level of involvement of the above actors in order to clarify whether this project could be located in one of the three potential triple helix models proposed by Etzkowitz and Leydsdorff (2000).

3 RESULTS AND DISCUSSION

The first objective of this paper focused on obtaining data demonstrating the nature and the level of technology transfer involved in REGSA project, focusing on how the technologies incorporated in the pilot module could affect the wider community.

Three researchers conducted separate content analysis then compiled together all data in the following table, which indicates the different technologies mentioned by the interviewees that could later be potentially adopted by the wider community.

Of the eight respondents, 6 could effectively present examples of a technology that was used in the pilot module and later applied in other school units or segments of society in which the pilot module was conducted.

Interviewees E1, E4 and E6 said that many condominiums that are now being built in Rancho Queimado have incorporated solar panels in their building plans, enabling new residents to benefit from solar generated energy.

Efficient lamps were cited by respondents E1 and E8 as being used in the city´s municipal schools. Interviewee E2 stated that, based on their professional experience

from the school unit, they decided to replace all of the lights in their home with LED lamps. Interviewee E6 stated that after the experience acquired from the REGSA project, more energy efficient lamps are now being used in Rancho Queimado homes. In turn, interviewee E5 said they had replaced incandescent bulbs with more efficient lamps in both their home and restaurant.

A relevant observation can also be made through interviewee E5. They decided not to use LED lamps due to the high cost of acquisition in comparison to traditional ones. The same said, *"In my case, I've replaced incandescent lamps a long time ago, I'm currently using the cold lamps. I intend to use the LED type futurally, for their durability and saving potential. LED lamps are still a little expensive in my opinion, but they are getting cheaper".*

Interviewee E1, pointed out the replacement of all the old electrical wiring of another school unit in "Mato Francês", located in the same city as the pilot module intending to reduce energy consumption, this school also obtained efficient lightning.

The complete list of the technologies mentioned during the interviews, and their intended applications can be seen in Table No. 3.

Table 03: Technologies and their applications

E1		**E2**		**E4**	
Technology	**Use**	**Technology**	**Use**	**Technology**	**Use**
Solar panels	Condominiums	Led Lamps	Interviewee home	Solar panels	Condominiums
Efficient Lamps	Public Schools				
New Wiring	"Mato Francês" School				
E5		**E6**		**E8**	
Technology	**Use**	**Technology**	**Use**	**Technology**	**Use**
Efficient Lamps	Interviewee home and restaurant	Efficient Lamps	Local Houses	Water heating	Local Houses
		Solar panels	Local Houses	Single lever faucets with aerator	Local Houses
				Efficient fixtures	Projects for new public buildings

Sources: Elaborate by the authors, 2015.

The goal of the REGSA project was to facilitate the adoption of new technologies and promote their penetration into the wider market. Interviewees indicated that this

objective was, albeit in a limited way, achieved, confirming the same results presented by Peters (2000) and Rogers (2003).

The second aim of this paper was to expand understanding of how the community internalized the sustainable development principles from the solar energy REGSA project in Brazil.

To achieve this goal, interviewees were questioned about their perceptions of this issue before and after the pilot module deployment. The content analysis was performed using a qualitative approach, produced by a single researcher, with greater involvement in the project.

This analysis sought to list conversation fragments that presented archetypal and relevant information about the contribution that REGSA pilot module had in that community. To do so, the table below was developed presenting some fragments of each surveyed interviewees' comments.

Table 4: Fragments of interview (Sustainable Development)

Interviewee	Interviewees familiarity with sustainable development after the implementation of the pilot module
E1	*"This project inspired teachers' self-esteem, they felt honored with the implementation of REGSA project in Roberto Schüts school, this project was a boost to all teachers, to all employees, to the administration, students and community". "Students participated in all the process of the project implementation, and inspired their enthusiasm for scientific study, having a positive impact on the community." "The implementation of project in the school contributed widely to sustainable development".*
E2	*"The REGSA project contributed to sustainable development by encouraging students' ecological awareness and this is really important for their future".*
E3	*"I ... do not say it [the solar electricity generation] lowers atmospheric pollution, but it contributes decreasing the amount of water used to generate energy somewhere else".*
E4	*"When the project REGSA was implemented in the school, the concern about environmental preservation was energized, encouraging people to look for another way of development".*
E5	*"The REGSA project contributed to sustainable development in our community by introducing this technology [solar panels]".*
E6	*"As a result of the project, many people were interested to use these energy technologies".*
E7	*"A present discussion in school [sustainable practices] is that the project enabled us to put into practice. So it is omething palpable".*
E8	*"The application of electricity generation from photovoltaic solar panels and solar heating of water by means of vacuum tube heaters, allowed the implementation of sustainability initiatives. Although the installation of single lever faucets with aerator, minimizing consumption and the use of hot water from the sun into the kitchen and bathrooms".*

Sources: Elaborate by the authors, 2015.

The development of these interviews made it possible to determine the beneficial impact of the installation of photovoltaic panels for the promotion of sustainable development through energy efficiency measures.

According to E1, E2, E4, E5, E6 and E7, the introduction of the pilot module allowed students and the community to have more contact with clean and renewable energy technologies, demonstrating its feasibility and tangibility. Interviewee E2 believes that REGSA project contributed to sustainable development by inspiring children through their experience with the project and renewable energy.

Asked about the school's position on sustainable development before the pilot module development, E4 states that "the school has had a big involvement with the issue of environment, Roberto Schütz school always had," however its implementation "revived what the school had been working," showing that clean technologies exist and are tangible. E6 agrees with this perception and adds that "people, as I said, did not know, I did not even know that there was this possibility. What we see much was wind energy, solar energy as something very distant. "

Survey fragments demonstrate that the school was not involved in sustainability concepts before the development of the project, so the implementation of the pilot module brought opportunities to educate about sustainability. This allowed a case study on the available technologies and their potential benefits, contributing to local development.

Thus, it can be noticed that the pilot module was successful in its aims to demonstrate the feasibility of a development project linked to sustainability, without losing sight of the predicates of economic efficiency. This efficiency is considered in a broader context, taking into account the life cycle of products and the commitment to future generations.

Regarding the third objective, respondents were asked in different parts of the structured interview about the involvement of different actors (university, government and other organizations) for the purposes of REGSA project. We conducted a qualitative content analysis of three different researchers, who collaborated in developing this article.

These researchers analyzed the content of the interviews separately, and consolidated their perceptions on a table on the level of involvement each participant played in the REGSA design, using the following scale: "-1", "0" and "1" The number -

1 stands for low or non-involvement; the number 0 features a partial involvement; and the number 1 means a great involvement.

On a single occasion, concerning the level of participation of "other organizations" in REGSA project, according the perception of interviewee E4, the three involved researchers, when analyzing the interview content assigned three different concepts to it, for this reason, the decision to transcribe to the table the average concept 0 was made.

For the final table, the values of the obtained concepts were added by each of the actors and in the end the university totaled six points from a possible total of 8 and a minimum of -8, representing this way a high level of commitment and participation of this actor in REGSA project.

These figures show that it was evident for most respondents that the university represented the greater leadership among all actors involved in the acquisition and implementation of new technologies. The Government and other organizations also played a positive role in their level of involvement with this project.

Thus, the numbers transcribed in the table below confirmed Etzkowitz and Leydsdorff (2000) proposals on the model of the triple helix hybrid, noting that all organizations had an important role in the development of the pilot module.

Table 5: Stakeholder Involvement: Model of the Triple Helix Hybrid[20]

Interviewee	E1	E2	E3	E4	E5	E6	E7	E8	Results
University	0	0	1	1	1	1	1	1	**6**
Government	1	1	-1	0	-1	1	0	1	**2**
Other Organizations	1	-1	-1	0	1	1	0	1	**2**

Sources: Elaborate by the authors, 2015.

The final considerations will be presented below, highlighting the main objectives of this project, as well as the limitations found throughout the research and the theoretical contributions of this study.

4 CONCLUSIONS

[20] Stakeholder's involvement in the perception of respondents: number -1 is low or null level of involvement, number 0 features a partial involvement and number 1 represents a greater involvement. The final number represents the balance of the scores awarded by the interviewees regarding the involvement of each actor in the pilot module.

The REGSA project did not create new technologies, however, the technology transfer can be perceived through its application for a new use or a new user. Thus, it can be said that the study achieved its specific objective when assessing the project's impact on the technology transfer level, meeting Peters (2000) and Rogers (2003) definitions on transfer of technology and innovation.

The REGSA project pilot module also has succeeded in improving the attentiveness of the local community in the promotion of sustainable development, yet the majority of interviewees could not answer what was the level of involvement of the school in projects related to sustainability prior to REGSA. All respondents called into question regarding what happened afterwards, mentioned transforming elements that promoted greater sensitivity to environmental issues. Thus, it was noticeable the benefits provided by the project in the implementation elements of transformation in the society in which it was incorporated, fulfilling the second objective of this research.

The study could evaluate the involvement of the various actors and stakeholders in the design of the REGSA pilot module, framing this perception to the hybrid triple helix model of Etzkowitz and Leydsdorff, (2000), achieving the last of the three objectives proposed in this paper.

Finally, to meet the three objectives mentioned above, the authors understand that this article succeeded in analyzing the influence of the pilot module in the first solar school in Brazil. Using qualitative research techniques, significant data were extracted for understanding what happened upon the foundation of REGSA pilot module in the community of Rancho Queimado.

The authors believe that the positive impacts obtained by REGSA project can serve as an inspiration and model for replication of its pilot module, enabling a deeper evaluation of the social impact of such strategy, in order to guide development in more sustainable directions.

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FIRST SOLAR SCHOOL IN BRAZIL, THE RENEWABLE ELECTRICITY GENERATION IN SOUTH AMERICA PROJECT AND ITS IMPACTS

ABSTRACT

The objective of this study was to analyze the extent of the impact of implementing REGSA project pilot module: the 1st solar school in Brazil, for local development, from the perspective of the actors and stakeholders involved in this process. To achieve this goal the research technique employed involved in-depth interviews with semi-structured questionnaires applied to the different actors involved in this process (government, community, universities consortium and companies), specifically aimed to analyze the impact achieved on three levels: a) technology transfer; b) sustainable development and c) involvement in the triple helix. The results showed that all spheres were analyzed according to the perception of respondents have a positive impact on local development to deployment from the REGSA project in the community of Rancho Queimado, Santa Catarina, Brazil.

KEYWORDS: Technology transfer; Sustainable Development; Triple Helix; Strategy.

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