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Photovoltaic energy in the enhancement of indigenous education in the Brazilian Amazon

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ABSTRACT

Within the context of electricity supply in indigenous communities in Brazil, this work presents the experience of the Kalapalo ethnic group, living in the Aiha village (Xingu indigenous land), with photovoltaic energy in the scholar environment. Besides being the most adequate resource for a sustainable energy supply in the village, it is in tune with the social and cultural aspects of its people, being a desired alternative by the community. The natives themselves chose the Aiha Central Indigenous State School to house a pilot project, which brought clear improvements in working conditions, teaching and learning. The main purpose of the present work was to evaluate the contributions that the photovoltaic energy brought to the educational actions in the village. To that end, the indigenous teachers participated in the definition of the content to be measured, allowing the methodology used (and its appropriate statistical treatment) to prioritize the perceptions and expectations of the students and the community. The arrival of electricity had an overall positive impact, allowing indigenous people to associate scholar activities with fishing and agriculture, to conserve food and have audiovisual resources available for the classroom and the community.

1. Introduction

According to the Energy Research Company (EPE), in 2017, the share of renewable sources in the Brazilian energy matrix remained among the largest in the world (42.9%). Sugarcane biomass, hydropower and firewood accounted together for 37% of this supply, while 5.7% were related to other renewable sources, including solar energy (0.4%). Despite its relatively small percentage within the Brazilian energetic context, the solar energy supply had a substantial increase of 875.6% from 2016 to 2017. This is in line with a global trend of photovoltaic energy growth, made possible due to improvements in materials and technology, market introduction programs and government incentives (Zahedi, 2006).

Since 1999, governmental programs for rural electrification provided electricity access to millions of rural inhabitants in Brazil. Nevertheless, in 2015, approximately 155.000 rural houses remained without electricity in the Amazon region, as the expansion of the existing network couldn't reach isolated communities. For instance, the legal Amazon area has great potential for the implementation of renewable energy routes, however, the supply via special projects is challenging. (Sánchez et al., 2015).

Restricting the analyses universe to the Brazilian indigenous communities, several indigenous people, due to the growing contact with the urban environment, are exposing their energetic needs. These needs are comparable with their own concepts of development, as reported by Gallois (2005) on a previous analysis on development and sustainability in indigenous communities. The current lack of assistance in this regard intensifies the exodus of young indigenous, which subsequently impairs the preservation of their cultures. In that way, a detailed study on the electricity demand in indigenous communities is fundamental, as such traditional cultures pass through processes of broader dimensions. (Bartolomé, 1991).

On the specific case of the Aiha village, the population already shows an interest by the photovoltaic solution for two reasons. The first one refers to the great experience with a former photovoltaic project for the water supply in the residences. Accordingly, the community has a well water pumping system available and supplied by solar panels, which extinguished the traditional way of water collection, *i.e.* by carrying pots from the closest lagoon, a tiring activity performed by the women. The second reason, cited by Bartolomé (1991), concerns the sun, a symbolic reference that bases the solar energy technology and denotes power and fullness for the community. Agricultural cycles practiced by peasants have the same idea over the sun. It is believed that, due to its empirical experience, the symbolism related to the sun is recognized universally, and this leads to a positive influence on the comprehension and acceptance of solar energy by such communities.

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The photovoltaic option is also the most promising when considering the large distances that impair the energy supply through diesel fuel or the conventional electrical grid.

1.1. Audiovisual resources in the indigenous education as a factor of local development

Costa and Barbosa (2013), after living among the Xavantes community, reported that the use of communication means, specially videos, contributes significantly for the preservation of oral memory and perpetuation of the knowledge and values of indigenous culture.

Jesus (2014), on the other hand, emphasizes that audiovisual resources are very similar to orality, which is a strong characteristic of indigenous populations. Furthermore, teachers need more efficient methods to comply with the indigenous reality, with actions compatible with the construction of a distinctive indigenous school. On her camp of observation (a Terena school), the researcher highlights that the indigenous education is based on perception and senses, and the singing, dances, sonorities, body paints, conversations and stories together confirm this affirmation. It is, thus, comprehensible that these populations can easily absorb audiovisual content, as their dialogues are mainly oral. In this context, didactic books and blackboards are not sufficient to excite their perception. The author also points out that the teachers in Terena use audiovisual content as a didactic support in the classroom. During her research, several videos were observed with the following content: stories narratives by the elders, women singing, typical foods, medicinal herbs and moments of political militancy in the village. This pathway assisted the buildup of methodologic processes and specific teaching references, as well as reinforced the mandatory content in the school, allowing the maintenance of the indigenous identity and ancestral memories.

In this sense, it is important to mention the project *Vídeo nas Aldeias* (VNA) which, according to Nunes (2016), started in 1987 with the aim to promote access to technology and encourage the protagonism of indigenous on the elaboration of their images and narratives. This media openness has as consequence the bigger exchange of perspectives between indigenous and non-indigenous worlds. Through this project, around 100 movies (involving several indigenous ethnicities) were produced, a result of the audiovisual training workshops provided. Being considered a successful experience, the project was developed by the NGO *Centro de Trabalho Indigenista* (CTI), formed by anthropologists, professors and scholars, whom elaborated projects to attend the necessities of each village.

1.2. Vision of local development

The thoughts of Silva Filho (2008) amplify the borders of audiovisual resources at indigenous communities. For this researcher, who worked in the Burity village (Terena community located at Mato Grosso do Sul state), the audiovisual constitutes a tool to manipulate concepts and ideas, and can increment local development. He observed during his own experience (training indigenous people for the use of audiovisual resources) that the content of their messages frequently referred to intangible elements, religious expressions, social organization, respect to the environment and endogenous capacity to search for solutions to the community' issues. Besides, the use of such instrument for the intercultural communication between indigenous and non-indigenous was emphasized. The search for identity reaffirmation and the defense of their rights, present in these visual and sound records, open a way for communication to be stablish with the indigenous vision. In this way, the points of view from an indigenous perspective can be spread not only within the community itself, but also externally.

Gallois (2005) also related the concepts of development and sustainability to actions that, indeed, meet indigenous aspirations and demands. To the author, the lifestyle and way of thinking of these populations must be preserved by their own guidelines, managed from their world perspective and not by public policies. Thus, these populations can and must receive external contributions, however, the base for supporting knowledge and experiences that become quality of life need to have an endogenous character.

According to Ávila (2003), the aforementioned definitions become more relevant to the extent in which the protagonism of local societies increase in the processes of development management. The idea of local development, to this author, relates to actions created by internal or external agents, having the maintenance and management of own potentials as main objectives, and seeking as well the answers to problems that hinder the growth and excellence on the domain of competencies and abilities. This idea reinforces the hypothesis of Silva Filho (2008) regarding the impact of the audiovisual resources on local development.

Azanha (2002), in addition, uses the concept of etnodevelopment, describing it as the development capable of maintaining the socio-cultural differential of each society (*i.e.* ethnicity). In this sense, the measurement of development stands apart from the usual indicators of social progress (*e.g.* PIB and *per capita income*), while cultural autonomy and developmentalist protagonism become elements of great importance on the assessment of quality of life within indigenous populations. This confirms the need that every action taking place passes through analyses of historical and cultural experiences on such communities.

The main objective of the present work is to demonstrate the contributions from the implementation of photovoltaic energy on the educational actions at the Aiha village. A pilot project was carried in the community, which chose the Aiha Central Indigenous State School to receive the energy supply. The results show an overall positive outcome experienced by the educators with the advent of electricity. Furthermore, it suggests improvements on the public policy as a way to provide technical training and tax exemption on the acquisition of photovoltaic components by indigenous communities, facilitating the development of similar projects.

2. Materials and methods

2.1. Materials

2.1.1. Aiha Central Indigenous State School

The geographical coordinates of the Aiha village are 12°09′46,35″ South and 53°15′20,41″ West. It is the biggest community of the Kalapalo ethnicity, located in the center of Xingu indigenous lands. The village was comprised of 22 huts in April of 2016, totalizing 245 indigenous residents. Around half of the population (*i.e.* 112 people) have activities either in primary or high school. The Aiha Central Indigenous State School (see Fig. 1) is comprised of 4 classrooms, as well as one room intended for management, where all materials and records are kept.

The Energisa group, which controls the electricity distribution in

Fig. 1. Aiha central indigenous state school.

Table 1
Desired electric energy for the Aiha school per day.

Quantity	Equipment	Power (W)	Use/day (h)	Energy/day (Wh)
01	Lamp	15	4	60
01	Computer	60	4	240
01	TV	180	4	720
01	Freezer	240	10	2400
Total				**3420**

Mato Grosso state, informed that the two closest grids to the Aiha village (34.5 kV of voltage) are located 75 km away from the village.

The indigenous community itself was consulted and has chosen the school to house the pilot project. This choice had three main reasons: *i)* the need of audiovisual resources in the school; *ii)* the fact that the school is a communitarian space within the village; *iii)* avoiding any dissatisfaction among the people, which could happen in case of having only one or two huts with electricity.

The idea was to create a night class for high school, enabling that people with daily activities related to fishing and agriculture could study. In addition, the use of a freezer could solve the problem of food conservation, allowing also the conservation of some medicines of the health center of the village, as well as the expected use of audiovisual resources to increment both teaching and learning experiences.

2.1.2. Pilot project

To satisfy the goals of the project, the priorities identified for the energy supply where: 01 television (TV), 01 freezer, 01 portable computer and 01 lamp (see Table 1).

Villalva (2015), studying a similar system, proposed sizing the battery bank to have energy for two days. The criteria were based on the condition of not having essential appliances, reducing not only the comfort but also the system costs, as a lower number of batteries is necessary. It is also indicated the use of stationary lead acid batteries of 12V, with maximum discharge of 50%, aiming for a better trade-off between durability and cost. This planning took into consideration that for most periods of the year, under favorable sunlight conditions, the batteries' energy will be necessary only for daily use. Therefore, the discharge capacity will be predominantly of 25%, and 50% only in cases where there is lack of sunlight for two consecutive days.

$$Ea = Ed * D \tag{1}$$

Where:*Ea* is the stored energy;*Ed* is the daily demand of energy;*D* represents the days without sun.

The stored energy can be calculated with Equation (1).

The capacity can be obtained with Equation (2):

$$Cap = (Ea/Vs)/Pd \tag{2}$$

Where:*Cap* is the capacity of the battery bank; *Ea* is the stored energy;*Vs* is the systems' voltage;*Pd* is the maximum depth of discharge.

Following, the total amount of modules, according to Equation (3), will be the daily demand of energy divided by the daily produced energy:

$$Nm = Ed/Ep \tag{3}$$

Where.*Ed* is the daily demand of energy;*Ep* is the energy produced by the module.

With these basic equations it is possible to scale an autonomous photovoltaic system. The specialized company Solstício Energia, collaborator of the project, used the calculated data of daily energy to size the equipments accordingly, *i.e.* for an electricity availability of two days.

From the initial calculations aforementioned, the concept of building a system with redundant components emerged, aiming for a higher operational reliability. Furthermore, the system allows for future expansion through a new set of panels. Thinking on the indigenous context, load controllers and inverters with backups reduce the possibility of operational discontinuity, as the defective parts can be easily replaced in case of technical problems. Finally, the selected system consisted of: *i)* 03 photovoltaic panels of 270 Wp; *ii)* 04 batteries of 240 Ah and 12 V; *iii)* 02 load controllers of 24 V and 40 A (with MPPT capability); *iv)* 02 inverters of 24 VCC, 220 VCA and 2 kW (pure sine wave).

2.2. Method to assess the contributions of electricity in the educational actions

In the present research, the defined methodology is quantitative, although the starting point is the perception of each individual. To achieve that, questionnaires where used for data collection. For instance, questionnaires are widely used in research areas in which it is needed to evaluate opinions, preferences and behaviors. According to Matthiensen (2011), a questionnaire, if well design and applied, metrifies the process quality and reach reliable conclusions by using statistical techniques. To a series of questions, numerical values can be added for each answer, and the formed scales, besides serving as measurement tools, define the prognostic variables for objective models (Bland and Altman, 1997). Importantly, the items that compose such structure must be closely related with each other.

There are two fundamental aspects for scheming an adequate questionnaire, *i.e.* its validity and reliability. As stated by Richardson (1989), if a measurement tool is valid, it measures what is desired, that is, if the degree in which the items are related is respecting criteria, formulated definitions, objectives, etc. This concept is directly linked to accuracy. With respect to reliability, Hayes (1998) defined it as the degree in which the measured result reflects the truth. In other words, it means verifying the extent in which a measurement is free from the variance of random errors. Such concept is related to the consistency. Construct, on the other hand, is defined as a theoretical concept, in which the researcher cannot take direct measurements and use indicators instead (Anderson et al., 2005). A common example of this case refers to the attitude of a person (*i.e.* construct) with respect to a product, as it can never be measured in a precise, free of uncertainties way. However, when answering several questions (*i.e.* indicators), the attitude of this person can be evaluated in many aspects. The combined answers provide a reasonable measurement of construct (in this example, attitude).

The Cronbach alpha (α) coefficient is an adequate parameter to evaluate the reliability of a group of construct indicators (Bland and Altman, 1997). Accordingly, α values can vary between 0 and 1,0, and the closest to 1, the more reliable is the result. Streiner (2003) suggests to limit the α value to 0,9, as higher values are normally related to redundant items. This parameter was consolidated along the years due to the following reasons: *i)* in a single test, a reasonable measure of reliability is provided; *ii)* its formulation allows the application to multiple choice questionnaires of polytomic variables; *iii)* its calculation is based on basic and straightforward statistics principles.

In a didactic way, Hora et al. (2010) highlights that the value of a measurement x is composed by two variables, *i.e.* the real v value with an added error e. For the observation value to be as close as possible to the real one, a population sample is evaluated. In a quantitative analysis of variability, the variance (S^2) is defined as the dispersion of a dataset. Thus, S^2x represents the sum of the variances of both real and error values, see Equation (4).

$$S^2x = S^2v + S^2e \tag{4}$$

Clearly, when the variance associated to the error decreases, the x value will be closer to v, resulting in a higher reliability of the instrument used for data collection. The α coefficient is calculated from the sum of the variances related to each individual item, as well as the variance of the sum of each evaluator, see Equation (5).

$$\alpha = \left[\frac{k}{k-1}\right].\left[1 - \frac{\sum S^2 i}{S^2 t}\right] \tag{5}$$

where: k corresponds to the number of items in the questionnaire; S^2i corresponds to the variance of each item; S^2t corresponds to the total variance of the questionnaire (*i.e.* the variance of the evaluators' scores).

There are important prerequisites for the application of the Cronbach alpha (α). First, the questionnaire must be grouped in dimensions (approaching the same aspect) and applied in a significant population sample. In addition, the applied scale must be validated, that is, the measurement tool must be really measuring what is supposed to (Hora et al., 2010). The fields of health, social sciences and economics use this coefficient extensively, however, its potential encompasses other knowledge areas as well.

With respect to field work, the basic guideline is to assess the impacts that the arrival of electricity brought to the educational actions it the school. Therefore, the questionnaire was divided in four groups, indicating the existence of four different aspects to be addressed: work conditions, learning and teaching, use of audiovisual resources in the classroom and impacts in the life of the community. At first, the questionnaires were applied to primary and secondary school teachers, proceeding with the identification and data collection regarding training and teaching time. It is important to highlight that the questionnaires' content (see Appendix 1) were consolidated with the participation of six indigenous teachers, two non-indigenous, the schools' director and the pedagogical coordinator. Thus, the topics were discussed and built, in essence, by them. The questions were of multiple choice, having sometimes fields for complementary information. The sampling of teachers was of 100%, *i.e.* all teachers within the community were consulted. Important to mention, the language barrier and the fact that part of the indigenous students are very young hindered an extensive evaluation by them. Therefore, the results here disclosed come from the educators' perspective.

As there are questions for each aspect, the definition of scales is necessary. Matthiensen (2011) indicates the Likert scale, which refers to a type of scale of psychometric responses widely used in opinion polling questionnaires. To evaluate the aspects of working conditions and learning/teaching in the classroom, the following scale consisting of five levels was adopted: improved a lot (value of 1.0), improved (value of 0.75), didn't change (value of 0.5), got worse (value of 0.25) and got much worse (value of 0). For the use of audiovisual resources in the classroom, another scale consisting of five levels was used: fully agree (value of 1.0), partially agree (value of 0.75), neutral (value of 0.5), partially disagree (value of 0.25) and fully disagree (value of 0). For the impact on the life of the community, the following scale was adopted: very positive (valor 1,0), positive (value of 0.75), neutral (value of 0.5), negative (value of 0.25) and very negative (value of 0). For the treatment of blank responses, a methodological criterion should be adopted, which can be a replacement of the answer with a zero value, the rejection of all respondents' answers or the answer replacement with the average of values answered in the specific item (Hora et al., 2010). In the present study, no blank responses were observed, and for each group of teachers (*i.e.* primary school and high school) a matrix of responses was acquired. From the calculation of average values and variances from the matrices, the Cronbach α was obtained. In addition, the intensity of the correlation between the items (*i.e.* reliability) can be tested through the elimination of questions from the questionnaire, a procedure called scale purification. If an item removal leads to the increase of α in a significant way, it is suggested that this item is not so related with the others. If, on the contrary, α decreases, the item is strongly correlated with the others. Hence, the variation of α shows how each item interfere on its reliability. When applying the scale purification, a new matrix must be validated and the process for reliability evaluation must be repeated until it stabilizes or reaches the desired level (Hora et al. 2010).

Fig. 2. Power central.

3. Results and discussion

The photovoltaic system installation was very challenging due to the difficult access of the Aiha village. For instance, the system had to be transported for 2800 km by paved road, then for 300 km on trails within the indigenous territory (only accessible in the dry season). Subsequently, a 4-h transfer along the Kuluene River was necessary with the help of an indigenous guide. A boat able to carry approximately 700 kg (materials, luggage, fuel and people) was provided by the community.

The system provided 2,8–3,7 kWh/day during the week subsequent to the installation, which is compatible with the estimative used for its design (*vide supra*). Fig. 2 shows the complete power central. It is important to highlight the industrial plugs, protection screens and semi-hermetic features used to ensure safety during operation. After the first six months, the energy meters accounted for 496 kWh of energy consumed, *i.e.* about 2.75 kWh/day.

After six months of operation in the school, a system evaluation was performed together with the teachers. The sampling corresponds to both indigenous and non-indigenous teachers, as well as the director and pedagogical coordinator of the school. There are currently 87 students in the primary school and 25 in high school. To achieve the desired operational continuity, some natives received technical training to properly manage and do the maintenance of the photovoltaic system.

3.1. Application of questionnaires in the school

The questionnaire presented in Appendix 1 was applied to the teachers, addressing the arrival of electrical energy in the school from the following perspectives: work conditions, teaching and learning, audiovisual resources and impact on the life of the community. The planning of the questionnaire together with the teachers was very important. It not only delimited the content, but also contributed for a better understanding from the teachers' side.

Fig. 3 shows the average impact (*i.e.* average of answers) for the primary teachers, in a scale ranging from 0 to 1. By analyzing the items included within work conditions, it was observed that there were no

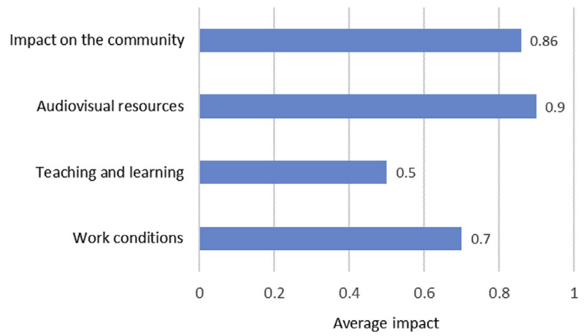

Fig. 3. Average impacts for the primary teachers.

impressions on the change of schedule and thermal comfort, as the school doesn't have ventilators. However, regarding lighting, food conservation and other uses (*e.g.* mobile phones), benefits are shown, totalizing an average impact of 0.7.

In addition, no significant changes regarding learning and teaching were detected, as the school didn't have a TV and a portable computer available for use in primary school classes. Training is lacking for them to master the use of such resources. Nevertheless, in the teachers' opinion, the use of audiovisual resources will be very positive (average impact of 0.9). Regarding the impact on the community, the response was also positive (*i.e.* 0.86). The school cinema and stimulation for the use of solar energy were well accepted in the opinion of the primary school teachers.

With respect to the high school teachers (see Fig. 4), improvements in all groups of questions are clear. Furthermore, the start of night classes prevented the overlap between agricultural and fishing activities and classes.

Despite the lack of equipment in the school, the high school teachers could borrow a TV and, together with their personal computers, used the resources (in a limited way) during the classes. From the average impact measured, improvements were detected in teaching and learning. Naturally, the familiarity with the use of these resources were decisive for such positive results, which strenghtes the importance of proper training (when needed) for such initiatives to be successful.

High school teachers reported the ease of understanding of various subjects with the use of the audiovisual resource, *e.g.* subjects related to ecology and environment, solar systems, maps and subjects related to the indigenous culture. They also indicated geography, sciences and indigenous culture as the most favored disciplines. Importantly, the audiovisuals in which the indigenous are the protagonists aroused a greater interest by the students. These results are in line with the observations reported by Jesus (2014).

Regarding the impacts on the community, non-indigenous teachers could not identify the perceptions of the women and the elderly in the community, however, they incorporated observations about the importance of the cinema in the schoolyard. According to them, some protagonists of Kalapalo productions, after being watched by the community, showed great satisfaction and resourcefulness when talking about the facts, contrasting with a certain daily shyness (especially for the women). The indigenous inhabitant responsible for recording the videos was stimulated by the communitarian experiences, which led to the creation of new images and scripts. He currently waits for an adequate computer to edit the productions. The overall positive repercussion of the cinema on the high school students, from their comments and expressions, was also pointed by the teachers.

The approval of the community and its participation in the schoolyard cinema sections ratified previous experiences such as that of Silva Filho (2008) with the Terena people, and the project *Vídeo nas Aldeias*, cited by Nunes (2016). These experiences have the following common points: reaffirmation of identity, indigenous protagonism and a greater exchange between indigenous and non-indigenous worlds. The stimulus to own productions leads to the transmission of content from an indigenous point of view to the environment outside the village.

The director and the pedagogical coordinator point out the need for more modern resources to serve as a bridge to the further development of these skills. They also answered the questionnaires that were applied to the high school teachers, as they are aware of the transformations and new demands of the Aiha village school. The strong interest of the community in expanding the use of photovoltaic energy to the domestic environment was emphasized. For instance, after only six months of the school project, 20% of the residences had initiatives related to photovoltaic systems.

Fig. 5 shows a comparison between the average impact of the two studied groups, *i.e.* primary school teachers and high school teachers.

Overall, high school teachers reported more significant impacts. This result is related to the practical effect of applying audiovisual resources. The results observed under such modest conditions show the great initiative and motivation of the indigenous teachers. Accordingly, it is expected that a proper expansion accompanied by technical trainings and the efficient use of audiovisual resources leads to even higher benefits.

As aforementioned, primary school teachers are not yet familiar with the proposed technologies. It is also worth noting the high importance given to audiovisual resources, and that this vision is shared by the community. The director of the school reported, in the field of observations of the questionnaire, the clear excitement and greater interest of high school students in the activities in which the audiovisual resource is used. The pedagogical coordinator shared a similar opinion, emphasizing the new possibilities in learning, which can lead a path to more comprehensive teaching. According to him, the students of the school, corresponding to 45% of the population of the village, can already think about a future with internet. Figs. 6 and 7 show, respectively, the classroom equipped with audiovisual resources and the cinema in the courtyard of the central school Aiha.

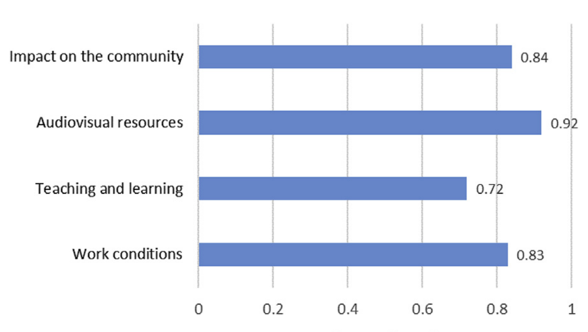

Fig. 4. Average impacts for the high school teachers.

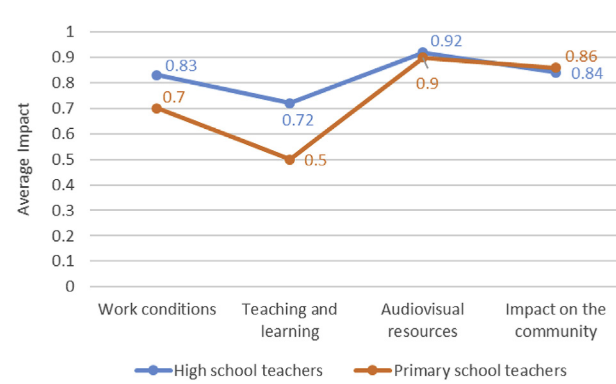

Fig. 5. Comparison of the average impact from each studied group.

Fig. 6. Classroom equipped with audiovisual resources.

Fig. 7. Cinema at the schoolyard.

3.2. Cronbach alpha (α) coefficient

Despite the extensive use of questionnaires for quality and behavior assessment, it is important to evaluate the consistency of such instruments. The α Cronbach coefficient is a common tool used for this purpose. In the present case, following the methodology, this index was calculated and interpreted for each studied group. Table 2 shows the answers from primary school teachers.

$$\alpha = [16/15] \text{ x } [1 - 0{,}24375/1{,}110417] = 0{,}83 \quad (6)$$

In Table 3, α values higher than 0,9 are considered questionable, as they indicate the redundancy of items measuring the same element of a construct. In this case, according to the classification in Table 3, an excellent internal consistency is observed. Table 4 shows the responses of the high school teachers to the questionnaires. Through the same treatment given to the previous dataset, the Cronbach's alpha coefficient was calculated in order to evaluate the internal consistency of the questionnaires in this case.

$\alpha = [16/15] \text{ x } [1 - 0{,}3020083/1{,}083333] = 0{,}77$ (7)

In this case, according to the limits showed in Table 3, a good internal consistency was achieved. It should be noted that, in this analysis, the data needed to evaluate the reliability are the answers of the teachers for each question. These data meet the prerequisites for the application of Cronbach's alpha coefficient, *i.e.* they deal with a common subject, have a valid scale and have a significant sample size. The obtained indexes that prove the reliability of the survey are 0.83 and 0.77, respectively. That is, the correlations between the items in the questionnaire increase the alpha value. As these correlations are greater when the items measure the same construct, it is concluded that the questionnaire has internal consistency.

Table 3
Internal consistency of the questionnaires, according to the Cronbach α (Streiner, 2003).

α value	Consistency
Higher than 0,90	Questionable
0,90 - 0,81	Excellent
0,80 - 0,71	Good
0,70	Acceptable
Lower than 0,70	**Poor**

4. Conclusions

Photovoltaic systems are considered a good alternative for the sustainable energy supply of rural areas, which in the Brazilian context include certain indigenous communities. In order to provide electricity to the Aiha village, located in the Brazilian Amazon, a photovoltaic pilot project was designed and installed at the village's school. After six months of continuous operation, the (primary and high school) teachers' input on the advent of electricity in the scholar environment was accessed via questionnaires. The results were very promising, as there were significant improvements on teaching conditions, as well as positive responses regarding the use of audiovisual resources and acceptance by the community. Accordingly, the measured average impacts were of 0,90 to 0,92 and 0,84 to 0,86 for primary school and high school teachers, respectively (in a scale ranging from 0 to 1). With respect to teaching and learning, the high school group achieved remarkable results, as it was possible to properly use the audiovisual resources due to the technology domain. In order to ascertain the internal consistency of the questionnaires, the Cronbach alpha coefficient was used. With the aid of an adequate scale, it was possible to transform the qualitative dataset into a quantitative one, which was statistically treated. The calculated coefficients of 0.83 and 0.77 confirmed the reliability of the obtained results.

Furthermore, the community's initiative on using the audiovisual resources for cinema sessions was extremely important, as it encourages the indigenous protagonism in the elaboration of their own images and narratives, promotes a greater exchange of perspectives between the indigenous and non-indigenous worlds, and may constitute a tool to share concepts and ideas, increasing the local development. Therefore,

Table 2
Primary school teachers (A-F) answers to the questions 1–16 of the questionnaire.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	0,5	0,75	0,75	0,5	0,5	1	0,5	0,5	1	1	1	1	0,75	0,75	0,75	1
B	0,5	1	1	0,5	1	1	0,5	0,5	1	1	1	1	1	1	1	1
C	0,5	0,75	0,75	0,5	0,5	0,75	0,5	0,5	1	1	0,75	0,75	0,75	0,75	0,75	0,75
D	0,5	0,75	1	0,5	0,5	0,75	0,5	0,5	1	1	1	0,75	0,75	0,75	0,75	0,75
E	0,5	0,75	1	0,5	0,5	1	0,5	0,5	1	0,75	0,75	1	1	1	1	1
F	0,5	0,75	1	0,5	0,5	0,75	0,5	0,5	0,75	0,75	0,5	0,75	0,75	0,75	1	1
Avg	0,5	0,791	0,916	0,5	0,583	0,875	0,5	0,5	0,958	0,916	0,833	0,875	0,833	0,833	0,875	0,916
Var	0	0,01	0,016	0	0,041	0,018	0	0	0,01	0,016	0,041	0,018	0,016	0,016	0,018	0,016

According to the table, the sum of the answers' variances equals to 0,24375. On the other hand, the variance of the sum of scores of each evaluator equals to 1,110417. Therefore, following the presented methodology.

Table 4
High school teachers (A-D) answers to the questions 1–16 of the questionnaire.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	0,5	0,75	1	1	0,75	1	0,75	0,75	1	1	0,75	1	0,5	0,5	1	1
B	0,5	0,75	1	1	0,75	1	0,5	0,75	1	0,75	0,75	0,75	0,5	0,5	1	0,75
C	0,5	0,75	1	1	1	1	0,75	0,75	1	1	1	1	1	1	1	1
D	0,	0,75	1	0,75	0,75	1	0,75	0,75	1	0,75	1	1	1	1	0,75	1
Med	0,5	0,75	1	0,937	0,812	1	0,687	0,75	1	0,875	0,875	0,937	0,75	0,75	0,937	0,937
Var	0	0	0	0,015	0,015	0	0,015	0	0	0,02	0,02	0,015	0,083	0,083	0,015	0,015

Applying the same calculations as previously, the sum of the answers' variances equals to 0,302083, and the variance of the sum of scores of each evaluator equals to 1,083333. Thus.

it can be concluded that the electricity generated by the implemented photovoltaic system had an overall positive impact on the educational actions in the Aiha village, being those not restricted to the classrooms, as the entire Kalapalo community benefited.

The indigenous experience with handling the photovoltaic system and further expanding it for domestic uses indicate their capacity of managing their own potential. In this way, a policy focused on training and covering the efficient, rational and safe use of energy is valuable. Recently, there have been important governmental initiatives to introduce photovoltaic energy and provide training in indigenous communities in Brazil. A notable example is the Xingu Solar Project, which took solar energy generation systems to 52 schools, 22 health centers and other community centers located in different ethnic groups within the Xingu indigenous territory (ISA, 2019).

Tax exemption for indigenous people to acquire and set up their own photovoltaic systems would also lead to a relevant development of such communities. An interesting example is the decree number 46296 of Minas Gerais state in Brazil, which provides fiscal incentives to projects related to renewable energy. In detail, for micro photovoltaic geration, this legislation exempts from taxes all equipment, spare parts and components (ALMG, 2018). Such policy incentives are of utmost importance for the expansion of photovoltaic systems in the context of indigenous communities. Nonetheless, due to the particularitites of the different ethnic groups, further studies are necessary to provide tailored energetic solutions. In this way, the vision of development of each community can be prioritized and respected.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.enpol.2019.05.037.

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