WWF

REPORT

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# ACCESS TO ENERGY FROM RENEWABLE SOURCES IN REMOTE REGIONS IN BRAZIL:

## LEARNED EDITIONS AND RECOMMENDATIONS

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# SUMMARY

# PRESENTATION

Currently, there are 237 isolated locations in Brazil. According to the National Electricity System Operator (ONS, acronym in Portuguese), most are in the North, in the states of Rondônia, Acre, Amazonas, Roraima, Amapá and Pará. Consumption in these locations is low and represents less than 1% of the country's total load. The demand for energy in these regions is mainly supplied by local diesel-fueled thermal plants. According to data from the last demographic census of the Brazilian Institute of Geography and Statistics (IBGE), the estimated population without access to energy surpassed two million Brazilians

**WHEN COMPARED TO THE TOTAL BRAZILIAN POPULATION - WHICH REACHES 207 MILLION - IT SEEMS THAT THE NUMBER OF PEOPLE WITHOUT ACCESS TO ENERGY IS INSIGNIFICANT. BUT IT IS UNACCEPTABLE THAT MORE THAN A MILLION PEOPLE STILL LIVE AS THEY DID IN THE LAST CENTURY.**

However, in the last decade, numerous connections to the network were made through the Luz para Todos Program (LpT) of the Ministry of Mines and Energy (MME) - currently, the Universal Energy Program. Although the data are dispersed and neither the distributors nor the National Electric Energy Agency (ANEEL) are sure of the exact number of people benefited by access to the energy distribution networks, it is known that, from 2011 to 2017, through the LpT program, electricity reached almost 800 thousand people (IEMA, 2019).

When compared to the total Brazilian population - which reaches 207 million - it seems that the number of people without access to energy is insignificant. But it is unacceptable that more than a million people still live as they did in the last century. These people depend on firewood and expensive fossil fuels to have just a few hours of night lighting. They are citizens who, due to the lack of electricity, do not have access to communication, quality education and improvement in their agroextractive production. In order to have electricity for a few hours a day, they emit much more greenhouse gases than a citizen connected 24 hours to the conventional grid. They are forced to travel to the place where they buy the fuel, return to their communities and use the fuel in engines. In other words, there is a triple cost. In addition, used fuel is not disposed of properly, and is usually dumped in rivers or on land close to homes.

For these people, there is no way for electricity to arrive via the traditional route of distribution lines. But it is necessary to change the extremely expensive reality of logistics and fuel purchases. It will then be necessary to invest in renewable energy sources from local and decentralized generation. Considering the high value of fuel in the North of the country, for these remote and isolated residents, the fastest and cheapest option seems to be solar photovoltaic energy.

Although the subject is very current and urgent, it is not new. For more than two decades, small projects have been developed in the Brazilian Amazon, first, to test renewable sources in the biome, and, more recently, to assess the economic sustainability of these processes.

In this sense, WWF-Brazil, alongside the Mott Foundation, conducted a survey of ten projects developed over the last decade that sought to systematize and share data and information on these off-grid renewable energy initiatives (REs) in isolated communities. The results presented in the first chapter of this publication bring optimism, but also a challenge: how can we universalize access to energy to isolated and remote populations with renewable energy so that this also becomes a good business for companies and the government?

The second chapter provides an update of information about equipment and uses of renewable energy for isolated and remote populations. The first edition, made available in 2017, has been very useful for the dissemination of technologies and for the approximation of communities that need energy services and products with the companies that operate in this segment.

Finally, based on these experiences, recommendations are made for public policies, businesses, educational and civil society engagement so that Brazil can actually achieve the goal of 100% of universal energy supply before 2030, according to objective 7 of the Sustainable Development Goals (SDGs): “Clean and accessible energy for all”. Brazil’s experience may also motivate other Amazonian countries that also face the great challenge of bringing clean and sustainable energy to all their citizens.


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# 1. IMPACT ASSESSMENT OF ENERGY ACCESS PROJECTS IN THE BRAZILIAN AMAZON


WWF Brasil/ Felipe Avino

In order to conduct this research, ten projects developed by civil society organizations and universities over the past few years were selected. Of these, nine were implemented in the Brazilian Amazon, and one in the Pantanal, which demonstrates that renewable energy technologies are perfectly adaptable to all Brazilian biomes.

## Profile of the projects

The projects focus mainly on remote populations, with no access to electricity through the distribution network. Table 1, below, presents the participating organizations, the projects and the regions covered.

***Table 1** – Description of the projects*

<table>
<tr><th>Institution</th><th>Projects</th><th>Location</th><th>Period</th><th>Investment (R$)</th></tr>
<tr><td>Advanced Studies Center for Social and Environmental Promotion – Saúde & Alegria Project</td><td>Solar Energy for Amazon River Dwellers</td><td>Santarém, West of Pará</td><td>2017 - present</td><td>996,990</td></tr>
<tr><td rowspan="3">Institute for the Development of Alternative Energy and Self Sustainability (IDEAAS)</td><td>Light in the Amazon Now</td><td>Santarém/PA</td><td rowspan="3">2010 - present</td><td rowspan="3">3 million</td></tr>
<tr><td>Bakana Solar (Fase I)</td><td>Ilhas de Belém/PA</td></tr>
<tr><td>Luz para uma Vida Melhor (Fase II)</td><td>Arquipélago do Marajó/ PA y Tefé/AM</td></tr>
<tr><td>ECOA – Ecology & Action</td><td>Pantanal Wetland – Solar Energy for Isolated Community</td><td>Campo Grande and Corumbá</td><td>2016 - present</td><td>109,000</td></tr>
<tr><td>WWF – Brazil</td><td>Resex Clean Energy Producer</td><td>Lábrea/AM</td><td>2016- present</td><td>2,152,700</td></tr>
</table>

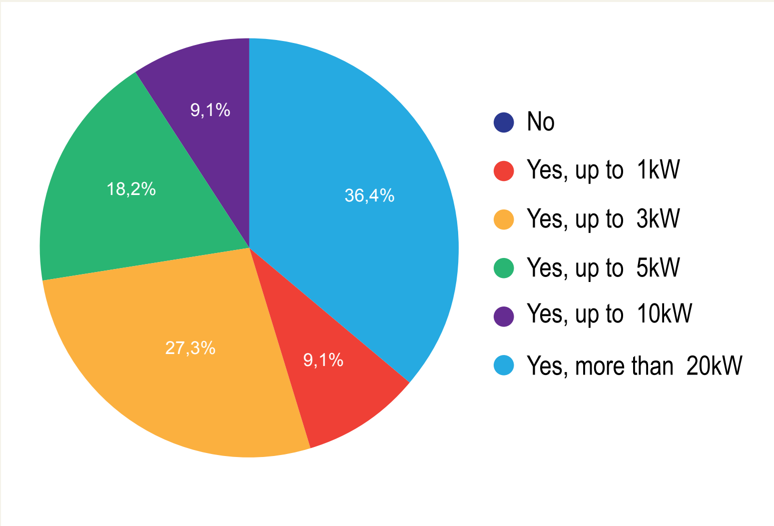
| Institution | Projects | Location | Period | Investment (R$) |
|---|---|---|---|---|
| Study Group and Development of Alternative Sources of Energy, Federal University of Pará | Sistema solar de corriente continua para el suministro de energía y el procesamiento de Asaí en las comunidades del Amazonas | Barcarena/PA | 2019 - en curso | 17,000 |
| Federal University of Amazonas | Modelo de Negócio de Energia Elétrica em Comunidades Isoladas da Amazônia | Manaus/AM | 2019 - present | 1,749,770.92 |
| Mamirauá Sustainable Development Institute | Tecnologias Sociais para Qualidade de Vida: access to water and energy by Amazonian populations | Tefé, region of Médio Solimões/AM | 1999 - present | Above 3 million |
| Instituto Socioambiental (ISA) | Xingu Solar | Mato Grosso | 2013 - present | 5 million |
| | Cruviana | Roraima | | |
| Greenpeace | Bailique Solar | Bailique, district of Macapá/AP | 2019 | 140 thousand |

Source: research data.
Exchange US$ 1 = R$ 4 Own creation.

Each project lasted between two and five years of application, and most systems, including the oldest ones, are still in operation.

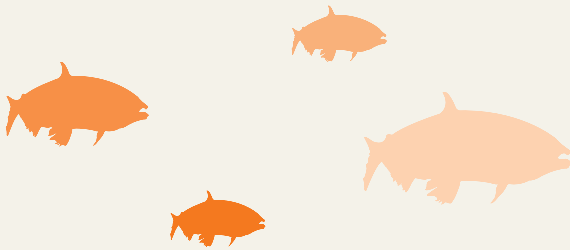
The projects installed systems of various sizes, according to the number of people benefited. Of the projects analyzed, four reported having installed more than 20 kW of solar systems, and the remainder installed less than 10 kW. The data obtained through the survey can be seen in Graph 1, below.

*Graph 1 – Is it possible to estimate how many kW are being generated with REs with the project?*




Source: research data.
Own creation.

**MOST INSTALLATIONS ARE FOR COLLECTIVE USE. UNDERSTANDING THAT THE STATE HAS AN OBLIGATION TO BRING ENERGY TO CITIZENS, ORGANIZATIONS INVESTED ON MODELS THAT SHOW THE VIABILITY OF SYSTEMS FOR PRODUCTIVE AND/OR COLLECTIVE USES. STILL, SPECIFICALLY FOR FAMILY USE, MORE THAN 150 HOME SYSTEMS HAVE BEEN INSTALLED.**



Depending on the coverage and scope of each of the projects evaluated, the number of direct beneficiaries varies, ranging from serving a single family of seven to about 6,000 people in an indigenous land. Adding all the results obtained with these initiatives, there are more than 8,900 people directly served by the projects.

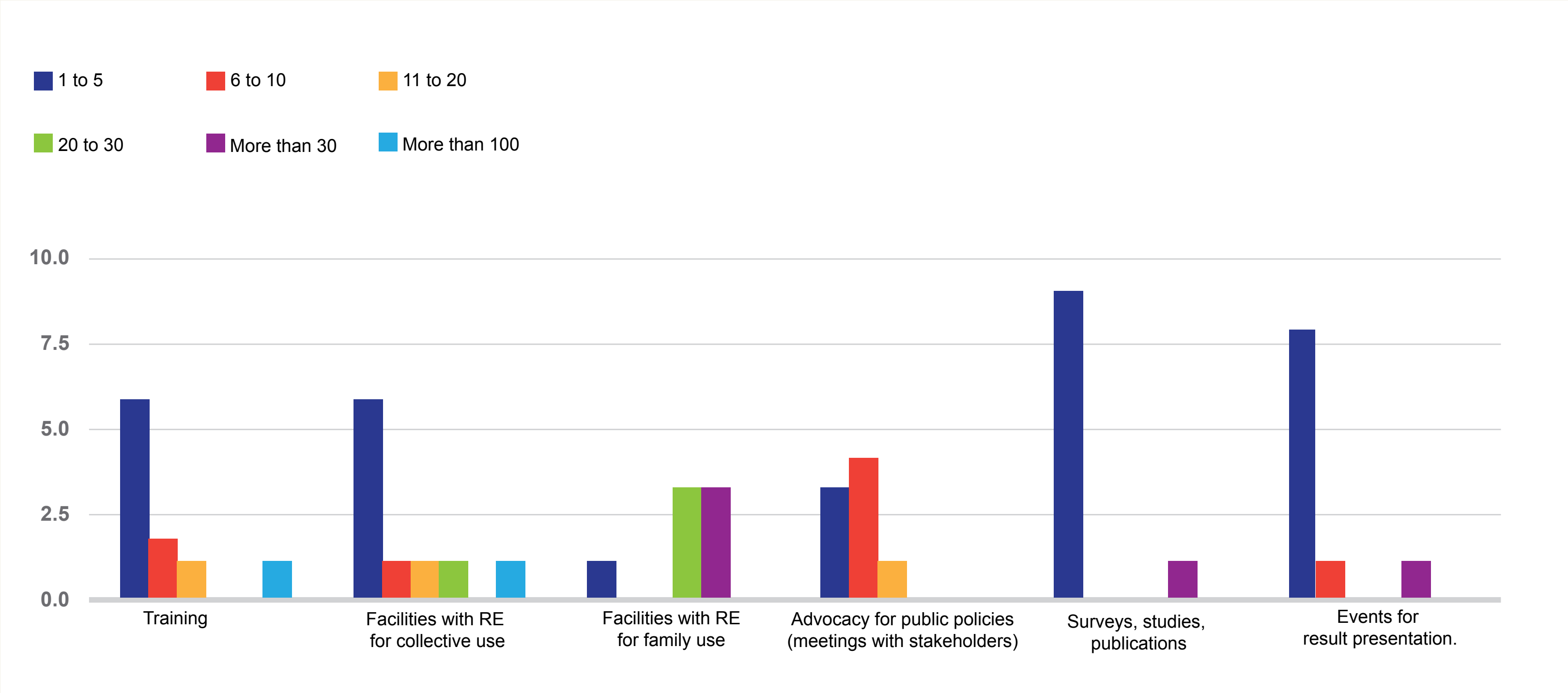
The benefits can go much further, including communities surrounding the facilities, buyers of benefited products or services that are now being provided to distant people. In this sense, these ten initiatives indirectly benefited approximately 34 thousand people.

These evaluated projects are marked by strong social involvement. They are not limited to just making the installations and leaving them to the community; they also involve training events, with guidance on energy management. After all, for communities that used to live limited to a maximum of three hours of light during the night with combustion engines, with the arrival of a source that allows the use of electricity for up to 24 hours a day, knowing how to maximize the use of energy in all their activities ensures that everyone can enjoy the technology in different ways, and that the equipment will have the expected durability if used correctly.

Most installations are for collective use. Understanding that the State has an obligation to bring energy to citizens, organizations invested on models that show the viability of systems for productive and/or collective uses. Still, specifically for family use, more than 150 home systems have been installed.

In parallel with the field actions, the projects serve as advocacy activities for public policies, through meetings with government, businesses and civil society stakeholders. Studies were also produced, the results of which were presented to the people directly involved and possible influencers of public policies. The actions performed can be seen in Graph 2.

*Graph 2 - The project developed which and how many actions?*




Source: research data.
Own creation

The projects took place through face-to-face training, with expository and practical classes, focusing on training multipliers. In order to facilitate participation, most courses took place in the communities, with instructors, printed materials, both prepared specifically for each activity, and provided by universities. A common point is that these projects did not provide distance-education courses, for an obvious reason: communities did not have energy or access to communication that would allow for this type of tool.

As these are projects that favor collective uses of energy, it was observed that those analyzed registered several benefits associated with the same installed system, as shown in Table 1.

***Table 2** – Areas benefited from the use of RE*

| Uses served by renewable energy | % of answers |
|---|---|
| School | 83% |
| Health Center | 33% |
| House | 67% |
| Water and sanitation | 67% |
| Community office | 33% |
| Monitoring of fauna and flora | 33% |
| Community center | 58% |
| Fishing | 33% |
| Crafts | 33% |
| Cassava flour production | 50% |
| Benefits to Açai | 42% |
| Ice cooling and production (food preservation) | 66% |
| Safety | 17% |
| Feed production for fish and chicken | 8,5% |
| Communication | 17% |

Note: The survey allowed for multiple benefits to be selected.
Source: research data.
Own creation.

On Table 3 we highlight the perception of those involved in regard to the benefits directly related to the use of clean energy

***Table 3*** *– Benefits connected to the use of RE*

| Situations observed after the installation of renewable energy systems | % of answers |
|---|---|
| There were changes in habits or improvements in the quality of life in the communities. | 91% |
| Improved the quality of lighting at the site. | 83% |
| The silence from the lack of a generator led to an important improvement for the communities. | 66% |
| Residents no longer need to fetch water from the river or well to drink, as the water arrives in pipes. | 42% |
| It is no longer necessary to carry water or wash clothes, dishes or bathe in the river. | 33% |
| Communities have refrigeration or more ice available. | 58% |
| Communities still use salt to preserve fish and other food. | 50% |
| There was a reduction in the number of diseases caused by water quality. | 42% |
| The energy system has given communities more time to carry out other activities. | 75% |
| There was a reduction in fuel consumption for the operation of the community generator (energy generator). | 92% |
| There was an increase in the income of the families directly involved. | 75% |
| Communities have access to communication (cell phone, radio, television, internet). | 58% |
| There was an improvement in education, with schools running at night and more students enrolled. | 50% |
| Improved protection of fauna species in the region | 25% |
| There was a reduction in disease, especially in children | 17% |

Note: The survey allowed for multiple benefits to be selected.
Source: research data.
Own creation.

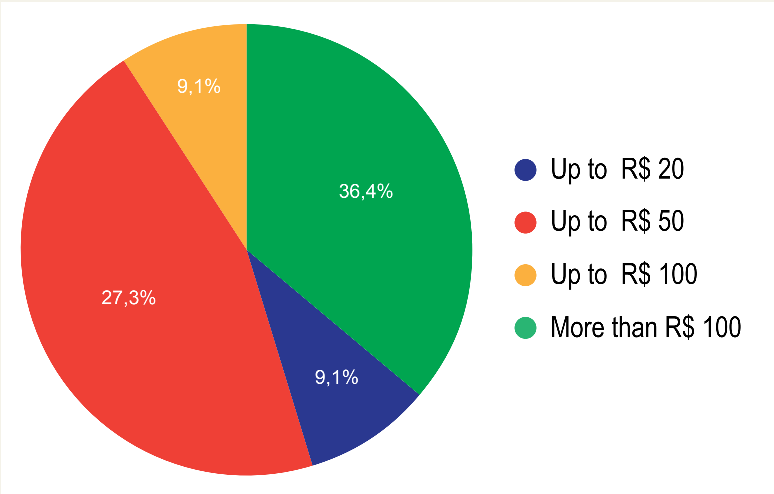
## Financial and environmental return

Improving the quality of life and the environment would alone justify the solarization of isolated communities in the Amazon. But the benefit is much greater when it comes to costs. Depending on the number of people living in each community, the region and its distance from the headquarters of the municipalities, the cost of fuel for a combustion engine can exceed R$ 7 per liter. The usual thing is for communities to make a monthly fee to buy the fuel that everyone ends up using in the community electrical installation, which is usually very precarious.

The ten projects surveyed showed that the savings are quite considerable.

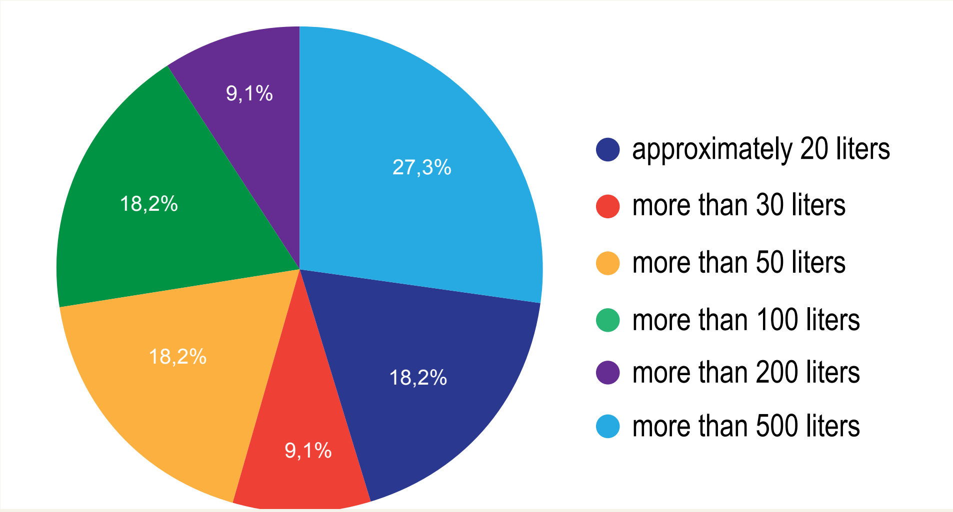
Adding the total amount that was spent on fuel by the communities before they benefited from the projects, we can see the positive impact that off-grid systems bring to the environment and the budget.

***Graph 3** – How much, on average, is each household directly impacted by not having to spend a monthly amount on fuel for electricity?*




Source: research data.
Own creation.

***Graph 4-*** *How many liters of fuel are no longer used monthly to generate local electricity (adding all directly impacted communities)?*




Fuente: datos de la investigación
Elaboración propia

THE USUAL THING IS FOR COMMUNITIES TO MAKE A MONTHLY FEE TO BUY THE FUEL THAT EVERYONE ENDS UP USING IN THE COMMUNITY ELECTRICAL INSTALLATION, WHICH IS USUALLY VERY PRECARIOUS.

***Table 3*** *- CO2 emissions by communities before the installation of projects*

| Fuel per liter | Kg of CO2 emissions |
|---|---|
| Pure gasoline | 2.28 |
| Diesel | 2.779 |

Source: research data.
Own creation.

If the fuel used for electricity in the analyzed projects was only gasoline (which has lower emissions of $CO_2$ than diesel), we can infer that after the projects are in place, around 2,070 liters of fuel would no longer be used monthly, which would be equivalent to 4,719.6 kg of $CO_2$. It is as if 70 trees are planted annually and they reach their maturity. After all, the best way to offset greenhouse gas (GHG) emissions is to keep the forest standing. Each tree is capable of offsetting up to a ton of GHG during its entire life.

In summary:

| Beneficiaries | Fuel not used for electricity/year | Kg of CO2 not used |
|---|---|---|
| 8.900 | 24,840 liters | 69,552 = 70 trees |

## How are families using the money they used to spend on "light fuel"?

The responses to the survey show changes in daily life, more comfort in community and family life, as well as great savings for public coffers.

In one of the projects, for example, a municipal school has been saving R$ 35,000 per year because it no longer needs to use diesel oil in the generator. In this case, the Public Power reverted the saved resource to the community itself, which allowed the improvement of school meals.

Another community now uses fuel that was previously used for lighting to transport students and the immediate needs of all residents.

Still with regard to collective improvements, there are benefits for the community's food and the increase in local production. With the savings of money that was previously spent on fuel for lighting plus the use of solar energy available 24 hours for refrigeration, residents now depend less on ultra-processed foods - such as canned meat and sausages - and have returned to consuming chilled fish, without the need to use salt for conservation.

In the case of açaí and pulps of other fruits, typical products of the region, the fact of being able to rely on the ice supply avoids losses and helps in organizing the collection, also ensuring a better price negotiation for the sale.

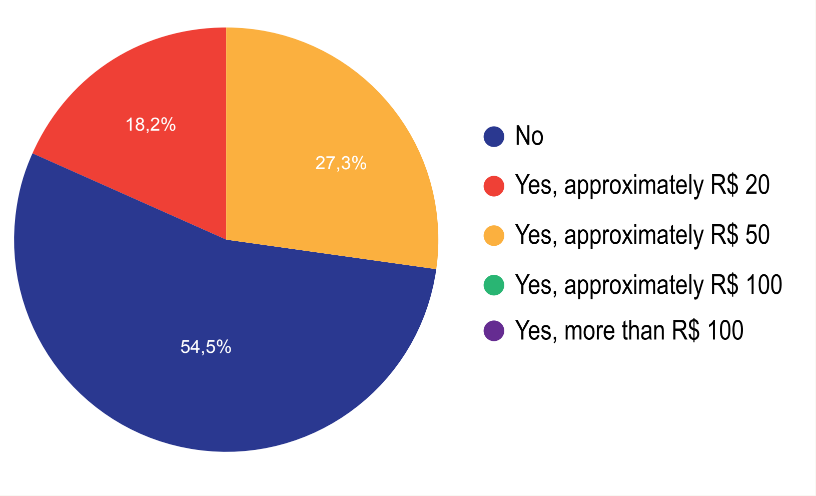
In households, the change is more significant. There is an increase in income, both due to the savings in energy expenses and the increase in revenue resulting from the sale of better-quality extractive products. The houses now have electronics and appliances, such as a washing machine, television, satellite dish, refrigerator, in addition to night lighting, which allows activities such as studies, meetings and the production of handicrafts. Residents also highlight night lighting as a factor that provides more security for families, both in personal relationships and with regard to the presence of venomous animals.

In the older projects, it was noticed that the communities took over and incorporated the systems management (maintenance) and, with that, the presence of the organization responsible for the project is no longer necessary.

Even so, as in the supply of energy in cities, there is also a price for maintaining the service in off-grid systems. And this is part of the community's energy management, which needs to organize itself as to not only deal with possible technical problems on a daily basis, but also to prepare for the replacement of key parts. This is the case for battery banks, which have an average cost of 1/3 of the system. It is also worth noting that not all the projects analyzed were able to supply 100% of the communities' energy demands, and it is still necessary to cover costs. In any case, the information on how much, on average, each family still needs to pay monthly to have electricity is very relevant. Most respondents said they did not have to pay anything else, while others said the costs were much lower, on average between R$ 20 and R$ 50 per month.

**IN ONE OF THE PROJECTS, FOR EXAMPLE, A MUNICIPAL SCHOOL HAS BEEN SAVING R$ 35,000 PER YEAR BECAUSE IT NO LONGER NEEDS TO USE DIESEL OIL IN THE GENERATOR. IN THIS CASE, THE PUBLIC POWER REVERTED THE SAVED RESOURCE TO THE COMMUNITY ITSELF, WHICH ALLOWED THE IMPROVEMENT OF SCHOOL MEALS.**

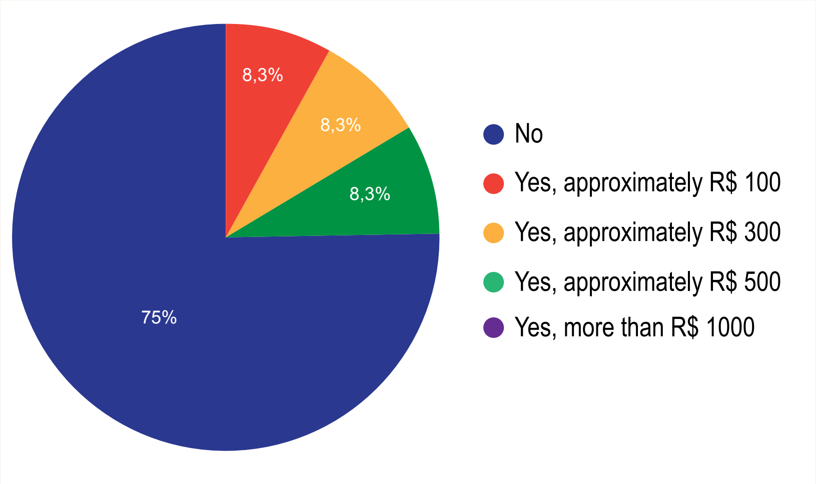
***Graph 5** – Do families still need to pay for fuel to have electricity in their homes and communities?*




Source: research data.
Own creation.

Trust in the system and maintenance savings were also highlighted in the projects analyzed. In 75% of them, during the execution and evaluation time, it was not necessary to spend anything for maintenance. And in those that required maintenance, this was due to the time of the project, the depreciation of the equipment. Still, costs well below what would be needed with fuels.

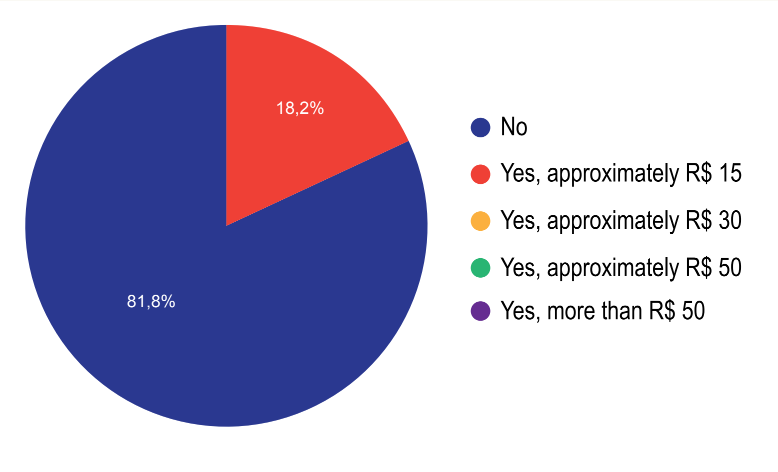
***Graph 6** - Was it necessary to spend any unforeseen amount to maintain the community's clean energy system?*




Source: research data.
Own creation.

A point of attention that these demonstration projects bring is the organization in energy management and its maintenance cost over time. It is common, in the first years of the project, excited by the benefits, that the community does not organize itself for future expenses that, it is known, will arrive, after all, energy is not free. The research showed that in almost 82% of the projects, families paid absolutely nothing for this future provisioning, while the other 18% claim to make a minimum reserve of up to R $ 15.00 per month, which is insufficient for a change of batteries in a horizon of four years, for example.

***Graph 7-*** *How are families paying any amount to maintain the installed RE systems?*




Source: research data.
Own creation.

Off-grid projects with renewable energy will only be economically viable if there is also the involvement of public authorities in inclusive energy policies. Of those evaluated, 75% had the interaction of government agents (in the three spheres), while 25% were initiatives by civil society organizations and universities directly with the communities involved.

However, this involvement with government entities has not yet translated into local influence on government decisions. Few brought real gains. In Tefé, Amazonas, an action is underway between the City Hall, the Sanitary Department of Indigenous Health and the Ministry of Health involving the use of clean energy in promoting basic health actions in the municipality and dimensioning community systems with renewable energy. Also inspired by the projects of the Mamirauá Institute, the municipality of Fonte Boa / AM has invested in systems for capturing water from the river with distribution to households. In the Pantanal, on the basis of an initiative by the non-governmental organization Alcoa, the municipality of Corumbá / MS is preparing the installation of two solar photovoltaic systems for two other isolated schools in the region.

The involvement of the government in promoting clean energy, in addition to enhancing current projects, will show energy component and service companies that this can be a very promising market. What this research has shown is that the considerable positive impacts on communities have not yet been enough to create a chain of clean energy goods and services locally.

Of the projects analyzed, 58% indicate that the host cities do not have equipment and training in the area. But, timidly, in the regions where larger projects were implemented, some stores are already investing on solar-powered water pumping systems (simple and cheaper), few portable solar equipment (such as flashlights and chargers) and some already have complete systems for sale and technical assistance, with modules, inverters, controllers and batteries. Which leads to the conclusion that, when demand is generated, "word of mouth" arouses the interest of neighbors, who seek technological solutions.

A similar situation occurs due to professional activities related to clean energy. Of the municipalities that received the projects, 63% registered an increase in the number of technicians in installation and maintenance of solar systems, as well as more electricians.

## Challenges

During the execution of each of the analyzed projects, it is noticed that most of the problems and challenges are the same, as detailed below.

1. **Distances** from remote communities: this makes logistics more expensive to take equipment to communities, as it is also a major complicating factor for training, exchange of experiences and possible maintenance more elaborated by specialized technicians from pole cities.

2. Difficulty **accessing consistent information** to scale systems in communities: the cheapest option is not always the most recommended. There was a complaint about the low quality and high cost of batteries. This quality can be questionable, as it is highly dependable on the use of energy locally. Due to the lack of information, it is common for residents to use it beyond the capacity for which the system was designed. So, there is a distrust of clean technology. Getting rid of fuel dependency for electricity is the big challenge, because although it is expensive,

noisy and polluting, communities trust that fuel provides electricity..

3. Difficulty in **financing** for the acquisition of equipment, in the development of local productive arrangements, training activities and the introduction of technical progress: it is not enough to take the energy to the isolated community; monitoring of energy management is required, both for use and provisioning for future needs. And, depending on the distances, this monitoring is also an expensive process that, as a rule, is not included in the costs of energy universalization projects.

4. **Water quality:** just pumping the water does not guarantee the supply according to the sanitary recommendations. It is necessary to develop treatment systems according to the region.

5. Little interest by the **Public Power** in developing energy actions that actually contribute to sustainable development in the interior: what was seen in the projects is that there is an acceptance of the initiatives, but this does not translate into local replication actions, led by the Public Power.

6. Difficulty for **women to participate** in decision-making: the presence of women in decisions should be observed more, since they are the biggest beneficiaries, as their daily work becomes much lighter and more productive after the arrival of clean energy.

7. Total **absence of suppliers** of photovoltaic equipment: the population must have direct access to products in small municipalities.

8. Lack of staff (both community and government and non-government officials) with **technical knowledge**: the implementation of preventive and corrective installations and maintenance depends on specialized professionals.

The way to overcome such problems necessarily involves appropriate public policies. A lot has already been done, but as long as a family lives in Brazil without access to clean energy, the work needs to continue, whether by civil society, as noted in the projects analyzed, but mainly by the State and its obligation to provide adequate infrastructure. for the full development of citizenship. We will see later that technology is no longer a problem to break this barrier.

# 2. USE OF ENERGY SYSTEMS FOR ISOLATED COMMUNITIES

WWF Brasil/ Felipe Avino

In 2017, we published the first edition of the booklet **Uses of energy systems with renewable sources in isolated regions**. At that time, the publication made an important contribution in the Brazilian context, as the then Luz para Todos Program was scheduled to end in December 2018 and there were still more than one million people, especially in the Amazon, without access to energy. There were two years of extensive discussions and interactions between civil society organizations, governments and companies that deal with the subject of electrification, through seminars, fairs and many meetings.

We are aligned with the United Nations (UN) Sustainable Development Goals (SDGs), in particular with Goal 7 - Accessible and clean energy for all. In order to achieve the Brazilian goals, our intention is to show that betting on clean sources, even in the context of isolated and remote systems, will be the best path, both for those who need the energy to live, develop, generate income, education and more health , as for companies that have not yet seen an important public of clean energy services and goods in this region.

The following are the most viable alternatives for using renewable energy systems aimed at productive uses and adding value, which guarantee the improvement of the quality of life of remote communities and, consequently, strongly assist in the maintenance of forests. The list of solutions presented here is not finite but represents a set of alternatives tested in the field and which have shown value for traditional populations in the North of the country.

## Energy services and their income generating value

From the widely known renewable energy sources (hydroelectric, wind, solar thermal, solar photovoltaic, biomass), and with regard to the context of isolated communities, we will focus on solar thermal and solar photovoltaic. In the background we will also bring some uses of biomass, in particular the use of biogas. The reason for this choice is simple: the solar systems are modular, their application is fast, and the operational costs are reduced, in addition to being easy to apply throughout the national territory. Bio-digestion is a rarely used process, but it has great energy potential for cooking, processing and energy generation.

Table 2, below, presents examples of various energy services and their income generating value that are more feasible for remote communities. In this context, we can say that we are talking about productive uses of renewable energy adopting the following definition: "agricultural, commercial and industrial activities depending on energy services as a direct input for the production of goods or provision of services" (OLK; MUNDT, 2016).

The productive use of renewable energy "promotes socioeconomic development by allowing and/or increasing income generation. Renewable energy can be differentiated in the form of 'individual consumption', that is, the use of energy services, such as home lighting, cooking and private entertainment, and the use of energy for community services, such as health and education "(OLK ; MUNDT, 2016).

Considering the study on the man's ability to perform work, and comparing the power data of the man/woman with the work performed by solar photovoltaic energy, for example, the following analogy can be made:

- A woman can take up to 6 hours (between collection and transport) to transport 500 liters of water in a bucket for a family.
- Solar pumping - considering a 1 kW pump - allows you to

**THE REASON FOR THIS CHOICE IS SIMPLE: THE SOLAR SYSTEMS ARE MODULAR, THEIR APPLICATION IS FAST, AND THE OPERATIONAL COSTS ARE REDUCED, IN ADDITION TO BEING EASY TO APPLY THROUGHOUT THE NATIONAL TERRITORY. BIO-DIGESTION IS A LITTLE USED PROCESS, BUT IT HAS GREAT ENERGY POTENTIAL FOR COOKING, PROCESSING AND ENERGY GENERATION.**

***Chart 2*** – Examples of energy services and their income-generating value

| Energy services | Income-generating value | Renewable energy services |
|---|---|---|
| Water supply and irrigation | Improvement in quality of life, higher productivity, higher value-added crops, greater reliability, production during periods when market prices are higher | Wind, solar PV, biomass, biodigesters, micro-hydraulic |
| Lighting | Reading, extending the hours of operation of establishments and working hours | Wind, solar PV, biomass, biodigesters, micro-hydraulic |
| Crushing, grinding, peeling | Value-added products generated from fresh agricultural products | Wind, solar PV, biomass, biodigesters, micro-hydraulic |
| Drying, smoking (preserve with process heat) | Value-added products, preservation of the product to allow sales in higher value markets | Biomass, biodigesters and solar thermal |
| Pressing | Allows production of oil extracted from seeds | Biomass, biodigesters and solar thermal |
| Transportation | Enables you to reach markets and transport people | Biomass (biodiesel) |
| TV, radio, computer, internet, phone | Allows entertainment, education, access to market news, coordination with suppliers and distributors. | Wind, solar PV, biomass, biodigesters, micro-hydraulic |
| Battery charging | Enables a wide range of services for end users (for example, cell phone charging business) | Wind, solar PV, biomass, biodigesters, micro-hydraulic |
| Cooling | Allows the sale of refrigerated products, increasing the durability of products, preserving vaccines, etc. | Wind, solar PV, biomass, biodigesters, micro-hydraulic |

Own creation.

# Water supply and irrigation

Water is an essential natural resource for human life, because, in addition to meeting our physiological and health needs, it is used in food production. This resource is extracted from surface and underground sources. However, several factors can complicate the water supply in the Amazon region. In that case, some technologies can help provide drinking water without using fossil fuels, including:

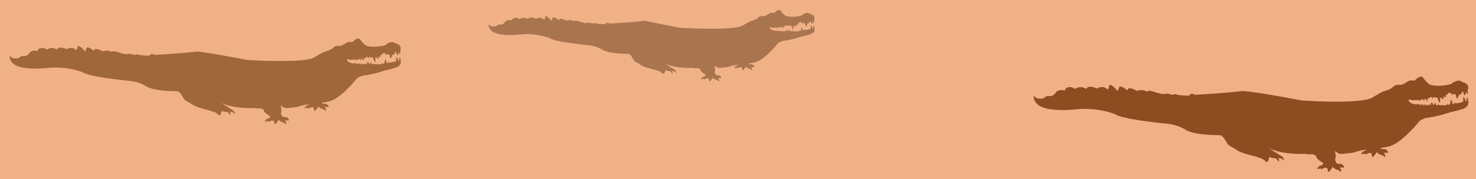
- rainwater collection systems and
- photovoltaic water pumping systems.

Below, we present some of the easiest alternatives to apply. It is important to note that, when the water is destined for use in irrigation, it is recommended to use micro-irrigation systems (drip, micro-sprinkler, etc.) to optimize water consumption.

## Rainwater collection systems

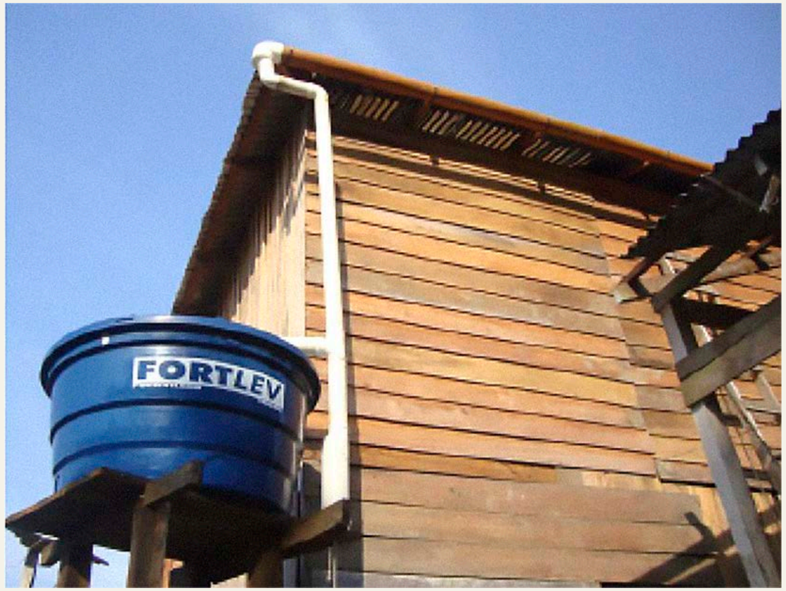
Rainwater collection systems are usually made with low-cost components found in building supply stores, although there are more complex and sophisticated systems. The simplicity of current systems makes this way of capturing water easily accessible to traditional populations.

Rainwater can be captured by taking advantage of the tiles in the homes. With few exceptions, like straw roofs, most roofs can be used for this purpose. The water descends through gutters, which must have a certain inclination to avoid the accumulation of water in certain points, which would favor the proliferation of mosquitoes. For collective uses, the systems can store more water, therefore depending on a larger roof area (rain collector). To store the water, masonry or plastic tanks with UV protection can be used.



*Picture 1* – Rainwater collection

*Source:* IDSM (2016).




Additionally, it is suggested to install a separator of leaves and other debris that accumulates on the roof before the collected water reaches the tank. Various waste separation systems are available on the internet and can be made using recycled material (PET bottles), for example. It is recommended to "discard two liters of water for each square meter of roof area used for capture, which corresponds to the first two millimeters of precipitation" (IPT, 2015).

Figure 1 and Photo 2 present an example of the various models available on the internet with the possibility of "do it yourself" from tutorials and videos on Youtube.

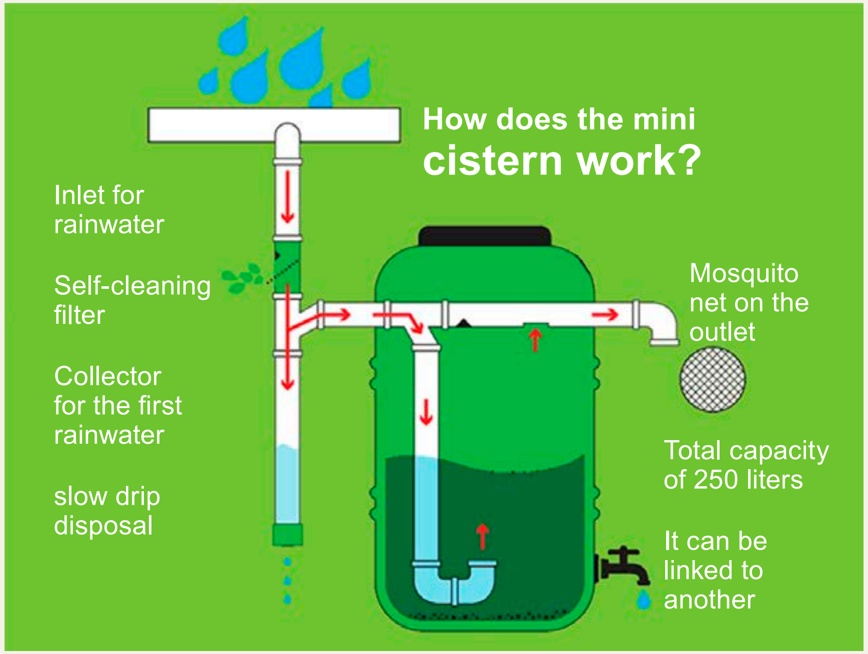
The use depends on the final quality of the collected water. In urban regions, rainwater may contain particulate material that prevents its use for human consumption. In addition, proper cleaning of roofs and cisterns is necessary to avoid water contamination due to animal waste and the presence of algae.

Thus, in general, rainwater is unfit for human consumption, requiring filtration, treatment or boiling. In many cases, the treatment is done with sodium hypochlorite (NaClO), widely used to disinfect water in many rural communities.

***Figure 1*** – Simplified layout of rainwater cistern with plastic drum

***Picture 2*** – Cistern and finished water separator

***Source:*** ecycle.com.br




## Photovoltaic water pumping systems

Photovoltaic pumping systems can be used to take advantage of water potential in rivers, lakes, streams and wells.

The difference between home photovoltaic systems and pumping systems is that they do not need batteries, since water can be stored in elevated reservoirs for later consumption. Depending on the flows and heights necessary to raise the water, it is possible to use small systems in direct current (DC) with working voltages at 12 V or 24 V. In the case of deeper wells, the systems usually work in alternating current (AC) .

In the case of systems for surface sources (rivers, lakes, and streams), the system is usually installed on dry land with the submerged pump or motor-pump set. But due to the variation in the water level of the rivers during the year, the photovoltaic system can be installed on a floating base as shown in Photo 3. It is important to point out that a surface water problem is the propensity for contamination by physical, chemical or other agents. which would make its use for human consumption unfeasible. In such cases, the use of filters is recommended, if it is necessary to use this water for human consumption.

Photovoltaic water pumping systems for underground sources tend to be more complex and generally work in alternating current. These systems are generally sold in kits that include a centrifugal or positive displacement motor pump, a control system and the photovoltaic generator. Smaller systems do not even need the control component, as shown in the photos below.[1] [2]

***Picture 3*** – Artesian well solar pumping equipment.

Source: Shurflo (2016).

***Picture 4 – Surface solar pumping equipment.***

***Source: Shurflo (2016).***

1 Direct current is the current produced in batteries, cells, etc. Alternating current is the current present in the household sockets.

2 The difference is that in DC the flow of energy follows a single direction, and in AC, the flow of energy constantly alternates its direction

Pumping systems are sold in several sizes. What determines the ideal size of the system is the required daily water volume. Whether for human consumption or irrigation, the calculation procedure is the same.

In possession of water consumption, dimensioning tables are consulted based on flow (per hour or per day) and total head (maximum height the water will be raised).

***Table 4*** – Typical setups of pumping systems

| Item | Pump | Solar panel | Maximum Manometric Height (m) | Daily Flow Rate (lts/day) | Type |
|---|---|---|---|---|---|
| 1 | Shurflo 8000 | 90 Wp | 14 | 2,115 to 2,450 | Surface or floating |
| 2 | | 140 Wp | 42 | 1,700 to 2,450 | Surface or floating |
| 5 | Shurflo 9325 | 180 Wp | 70 | 1,500 to 2,100 | Well and reservoir |
| 6 | Grundfos SQF 2.5-2 | 600 Wp | 120 | 3,700 to 30,300 | Well and reservoir |
| 7 | Grundfos SQF 2.5-2 | 2.100 Wp | 115 | 9,000 to 31,700 | Well and reservoir |
| 8 | Bomba AC común | 2.000Wp | 60 | 7,000 to 20,000 | Well and reservoir |

Own creation.

Therefore, the first step is to define water consumption and then choose the equipment that meets this demand. It is important to note that the pumping systems have a defined capacity depending on the amount of water that will be pumped and the height that the water will be pumped. Choosing the ideal pump for higher flow rates requires consultation with a professional. Smaller systems, as seen in photos 3 and 4 can be purchased over the internet and installed easily. Larger systems, as in photos 5 and 6 below, demand greater knowledge about equipment sizing and characteristics.

***Picture 5*** – Solar pumping in the Tapajós-Arapiuns Extractive Reserve

***Source:*** PSA (2016).


***Picture 6*** – Surface pumping system in the Mamirauá Sustainable Development Reserve

***Source:*** Usinazul (2015)

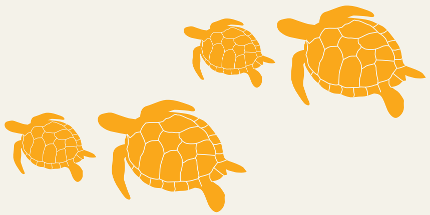
Table 5 below shows typical pump sizes and flow rates for different pumping heights (manometric height).

***Table 7*** – Examples of pumping systems found on the market

| | Photovoltaic water pumping systems for surface sources | | Photovoltaic water pumping systems for submersible sources | |
|---|---|---|---|---|
| | **Model 1** | Model 2 | Model 3 | Model 4 |
| Typical powers of photovoltaic generators (Watts-peak) | 100 - 200 | 100 - 180 | 1200 | 1500 |
| Typical manometric heights (m) | Up to 100 | Up to 40 | Up to 50 | Up to 50 |
| Typical daily volumes (m3/h) | 0,1 - 0,3 | 1,2 - 4 | 3 | Up to 3 |
| Typical prices(R$) | 2.000 | 3.500 | 15.000 | 10.000 |

Own creation.

It is important to note that pumping systems can be scaled to any size, according to the daily water demand. Even being applied in parallel to increase water supply.



***Picture 7*** – Surface water filtration system (river)

***Source:*** Usinazul (2015).

## Preserving food and other products

The North region is in the equatorial zone, with high temperatures and humidity, which promotes the proliferation of microorganisms that accelerate the degradation of food. In this sense, the use of energy systems for the generation of cold is one of the most desired technologies for food conservation in the Amazon, as well as commercial refrigerators or those adapted to work directly with photovoltaic solar energy.

Another form of processing, the dehydration of food, increases the shelf life of several extractive products, such as fruits, vegetables, herbs and even fish, whenever there is thermal energy available in the place: firewood, gas and sun.

### Solar dryers

The drying of food consists of reducing the amount of water contained in the food through the passage of heated hot air using a thermal source (sun, firewood, fossil fuels, etc.). The use of the sun for drying means a reduction in costs associated with the use of fuel or electricity. Although it is possible to dry the products in the open air, it is recommended to use solar dryers to speed up the process, avoiding contamination of the products by dust, insects, rodents and birds and, in some cases, to reduce product damage caused by direct exposure in the sun.

For this reason, the choice of the most suitable model of solar dryer depends on the characteristics of the environment and the product, the amount of water to be removed and the desired drying speed.

Direct dryers are recommended for products that are not damaged by direct sunlight. In their simplest version, they consist of a triangular structure covered by a plastic film in the form of a tent that allows the passage of solar radiation. A small opening at the bottom and top allows air to enter and exit.

***Picture 8*** – Low temperature solar dryer

Indirect dryers are more sophisticated. The air is previously heated in a solar collector and then passed through the product, which is stored in a cabinet with several trays. It is also possible to speed up the drying process with the use of special fans and forced drying. In this case, a small photovoltaic generation system with batteries is required.

## Commercial solar cooling

Photovoltaic systems can be sized to specifically supply refrigerators or freezers. This type of system needs a battery bank for use outside the solar hours. The energy consumption of any refrigerator depends on the room's ambient temperature, efficiency, the amount of food stored and the number of times the door is opened. The greater the consumption, the greater the investment in batteries. For this reason, the use of high-efficiency refrigerators is recommended to reduce the costs associated with battery storage.

An alternative is the use of refrigerators dedicated to photovoltaic applications. This type of refrigerator usually works in direct current and has an efficiency higher than the average of commercial refrigerators. However, its price can be much higher.

Picture 9 below shows types of solar cooler with a capacity of 270 liters. The differences between this appliance and a conventional refrigerator are basically two: use of direct current energy and better thermal insulation (80 mm thick). In summary, the reinforced thermal insulation keeps the interior of the refrigerator cooler for longer, minimizing energy loss. And, because it works with direct current, there is no need to install a DC-AC inverter.

***Picture 9*** – Commercial photovoltaic refrigerators

Picture 10 below shows a photovoltaic freezer with a capacity of 240 liters. Like the previous refrigerator, this freezer has reinforced thermal insulation and works with direct current, without the need for an AC-DC inverter. Both systems require batteries for daily operation; however, low energy consumption is an important factor that makes this equipment very suitable for applications in remote and isolated areas of the Amazon. This technology is still not widespread in rural and isolated regions due to the costs, which are higher than those of ordinary freezers.

WWF-Brasil and ICMBio installed a refrigeration system in a small community in the Ituxi Extractive Reserve, in southern Amazonas. The return of the residents could not be better. With only one freezer unit, the more than 70 residents do not buy more ice, they reduced the salting of fish and started to work in a chain that they could not before: the açaí. Now, in the community itself, they harvest, pulp and refrigerate the fruit pulp. They achieved better prices and increased ties with other communities, by offering ice and space for processing and cooling products.

***Picture 10*** – Solar freezer in Volta do Bucho community, Ituxi Extractive Reserve, Lábrea/AM

Source: WWF (2019).

## Solar ice machine

The first version of the solar ice machine arrived in the state of Amazonas in 2015, with funding from Google, as part of the Social Impact Award received by the Mamirauá Sustainable Development Institute (IDSM), in partnership with the Photovoltaic Systems Laboratory (LSV) of the Institute of Energy and Environment (IEE) of the University of São Paulo (USP)[1] and Usinazul.[2]

Developed to produce an average of 27 kg of ice per day, considering a daily solar radiation above 5.5 kWh/m2 (sunny day), the ice machine is made up of a solar panel, cold chamber with good thermal insulation and electronic circuit of conversion and control. It has an automatic activation that allows you to turn on when the sun rises, and turn off when it sets, without the need for batteries.

This machine, developed in the laboratory, associated with the social technology of organization and community participation, carried out by local non-governmental organizations, allowed the development of a project that is a watershed for populations living in isolated regions. During the process of implanting the machines, a community management model of technology is discussed and approved by everyone. It is a model that can be replicated in the future in several communities in other developing countries, considering cultural and socioeconomic specificities. It is not yet manufactured industrially and continues to be researched at USP.

The results of use in remote communities of the ice machine and direct current refrigerators range from the application of solar energy to generate income, subsidizing the conservation of family production in

1 The solar ice machine (MGS) of the Photovoltaic Systems Laboratory (LSF/IEE/USP) was developed between 2007 and 2009 by researcher Carlos Driemeier, under the guidance of prof. Roberto Zilles, and had funding from the São Paulo State Research Support Foundation (Fapesp).

2 Project information can be found at: https://desafiosocial.withgoogle.com/brazil2014/charity/instituto-mamiraua

***Picture 11*** – Solar ice machines installed in the Amazon.

Source: Usinazul (2015).

rural communities, to the increase in well-being and quality of life, associated with environmental benefits, with the reduction of carbon emissions into the atmosphere by burning fossil fuels.

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## Cooking and food processing

### Improved stoves and ovens (eco stoves and ovens)

Most artisanal wood stoves consume a lot of firewood and emit harmful gases during combustion. An improved stove expels smoke better, reduces firewood consumption and improves cooking time. This is because an efficient stove has several elements that improve the burning of fuel and the transfer of heat produced.

In addition, many improved stoves have chimneys that release gases outside the home, reducing health problems associated with inhaling smoke and particulate matter.

In the same way, it is possible to use improved ovens for the production of manioc flour. They work with the same principle as stoves, with a combustion chamber to reduce the consumption of firewood and a chimney to correctly eliminate combustion gases.

***Picture 12*** – Efficient eco stoves

***Source:*** Mamirauá Sustainable Development Institute

***Picture 13*** – Efficient ovens

***Source:*** Mamirauá Sustainable Development Institute

Another cooking technology is the solar cooker. It is not very common in Brazil, but it is already being researched in the Northeast of the country and in arid regions such as the Argentine desert. This oven transforms solar radiation into heat using a satellite dish, which creates a “greenhouse effect” to heat water, dry, bake or cook food. It is usually built with low-cost products, such as scrap and mirrors. But there are already commercial versions as well. This type of technology works well in good solar conditions: open time, between 9 am and 2 pm. It also requires important care, such as the use of sunglasses, so that the light does not reflect in the eyes, and thermal gloves.

***Pictures 14 and 15* –**
Solar ovens

Public domain images.

## Biodigesters

A biodigester is a system designed for the processing and use of organic material to generate methane gas and fertilizers. The working principle is simple: inside a closed chamber, bacteria digest organic material in the absence of oxygen, releasing methane and solid material that can be used as fertilizer.

The organic material used must be a mixture of animal and vegetable waste, in an adequate proportion to provide water, carbon, nitrogen and mineral salts that will be consumed by the bacteria. In this way, animal and human excreta, food scraps and agricultural residues can be used without pesticides.

***Picture 16*** – Canvas biodigester

Source: Sansuy

With the proper piping of the gas, it can be used for cooking food or heating water or houses. Solid waste can be used as fertilizer.

In the context of a conservation unit, where there are few animals raised in captivity, the collection of animal waste is not easy or even feasible, and biodigesters may not work properly. For this reason, details of the characteristics of this equipment will not be presented here. The potential for using biogas for productive uses is high, always when there is decomposing organic matter in considerable volume. The International Center for Renewable Energies-Biogas (CIBiogás), a non-profit entity based on the Itaipu Technological Park (PTI) in Foz do Iguaçu / PR, produced a very interesting book on biogas and its applications entitled **Biogás: a energia invisível** (BLEY JUNIOR, 2015).

## Power generation: lighting, production, leisure, others

The supply of energy for lighting, communication, entertainment, among other end uses can be done through specific systems for this purpose or with autonomous photovoltaic systems with power generation in isolated systems. Basically, energy can be produced by any energy source, but in this publication, the emphasis is on the generation of solar photovoltaic energy, due to its modular nature and the ability to supply small energy.

Table 6 shows a list of productive applications and their typical energy consumption based on experiences collected in different rural development projects.

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Professionals of Mamirauá Sustainable Development Institute

***Table 6*** – Productive applications of photovoltaic systems in agriculture

| Productive Application | Typical power range (kWp) |
|---|---|
| Irrigation | 1 - 3 |
| Water for drinking fountains | 0.5 - 1 |
| Electric fence | 0.02 - 0,1 |
| Electrification of farms (lighting, security) | 0.05 - 0.5 |
| Forced drying | 0.1 - 1 |
| Lighting of corrals, farms and fields | 0.2 - 3 |
| Pumping water for fish | 0.5 - 3 |
| Aeration - fish | 0.2 - 1 |
| Insect light traps (per lamp) | 0.01- 0.02 |
| Refrigeration of livestock vaccines | 0.05- 0.1 |
| Refrigeration of agricultural products | 0.5 - 10+ |
| Ice machines | 2 - 10 |
| Telecommunications | 0.2 - 0.3 |

Source: Modified from Weingart (2003

***Picture 17*** – Household appliances present in Amazonian communities

***Source:*** LSF/IEE/USP (2011).

Picture 17 shows typical equipment of a riverside home in the interior of the Amazon. It is good to be aware of the use of equipment with less energy consumption to reduce investment in the power generation system. Flat-screen TVs, for example, consume less energy than tubular TVs, like the one shown in the photo.

Information on the energy consumption of equipment is present on the National Energy Conservation Label (ENCE), issued by the National Metrology Institute (Inmetro), which presents the main characteristics of household appliances, especially energy consumption, which is the data that interests us in the design of an energy system.

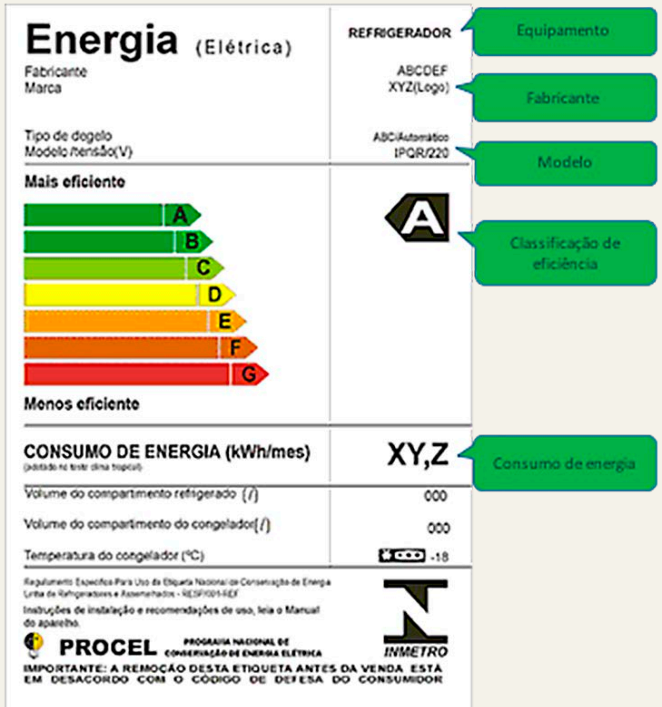



***Figure 2*** – Energy Conservation Label

Source: Inmetro.

Whenever possible, consumers should opt for "Class A" equipment, which has the lowest energy consumption when compared to other equipment..

## Solar Peak / Pico PV

Pico PV systems, which include solar lamps, are small photovoltaic systems sold in the form of kits to supply energy for small loads, typically lamps. Recently, these systems have been used for charging cell phones, using USB ports already present in solar kits.

Usually, this type of system consists of a photovoltaic module of up to or 10 W, a lithium battery and one or two LED lamps. Peak systems have several advantages due to their low cost, ease of transport, modularity and practicality.

The cost of the kits varies according to the number of lamps, the autonomy of the system and the additional functions included (cell phone charging, built-in radio, etc.).

***Picture 18*** – Solar peak



***Picture 19*** – Solar flashlight and photovoltaic kit for lighting and charging

## Individual and collective autonomous photovoltaic systems

An autonomous photovoltaic system is capable of supplying energy for different purposes (lighting, leisure and productive activities). There are several configurations of autonomous systems that allow service in direct, alternating current or in both types. The amount of energy that the system can deliver depends on the climatic characteristics of the location, the power of the photovoltaic generator and the capacity of the battery bank.

Basically, there are two types of autonomous systems: individual or collective. The collective systems can be assembled in the form of mini-networks, serving different loads in different locations, relatively close to each other. The difference between these two types of systems is that, in the first case, each residence is served with an individual system, while in the second, the generation is shared by several residences or other consumers of energy (cooperative, productive uses, etc.). Individual systems are best suited for communities where there is a large dispersion between households. On the other hand, a mini-network, despite its complexity, is recommended for cases where several residences are located close together.

Individual systems are typically composed of a photovoltaic generator, battery bank, charge controller and off-grid inverter. Mini-networks can be hybrid, with energy generated by more than one source (photovoltaic, diesel, wind or biomass).

***Picture 20** – Detail of residential solar system*


***Picture 21** – Individual residential solar system*

*Source: LSF/IEE/USP*

There is a special class of autonomous photovoltaic systems (individual or collective), framed by Aneel Normative Resolution 83/2004 - SIGFI: Individual System of Electricity Generation by Intermittent Energy Sources, developed for rural energy service, which serves as a reference for energy concessionaires in the implementation of the Luz para Todos Program, of the Ministry of Mines and Energy (MME), as defined by the Universal Electricity Service Law in Brazil (Law 10.438 / 2002). These systems installed by the energy utilities guarantee the availability of supply of a specific amount of monthly energy. In 2012, RN 83/2004 was updated by RN 493/2012. Table 7 shows the classes of systems regulated by the amount of minimum monthly energy to be served and the possible uses of the energy.

***Table 7 – Autonomous systems regulated by Aneel Resolution No. 493/2012 – SIGFI***

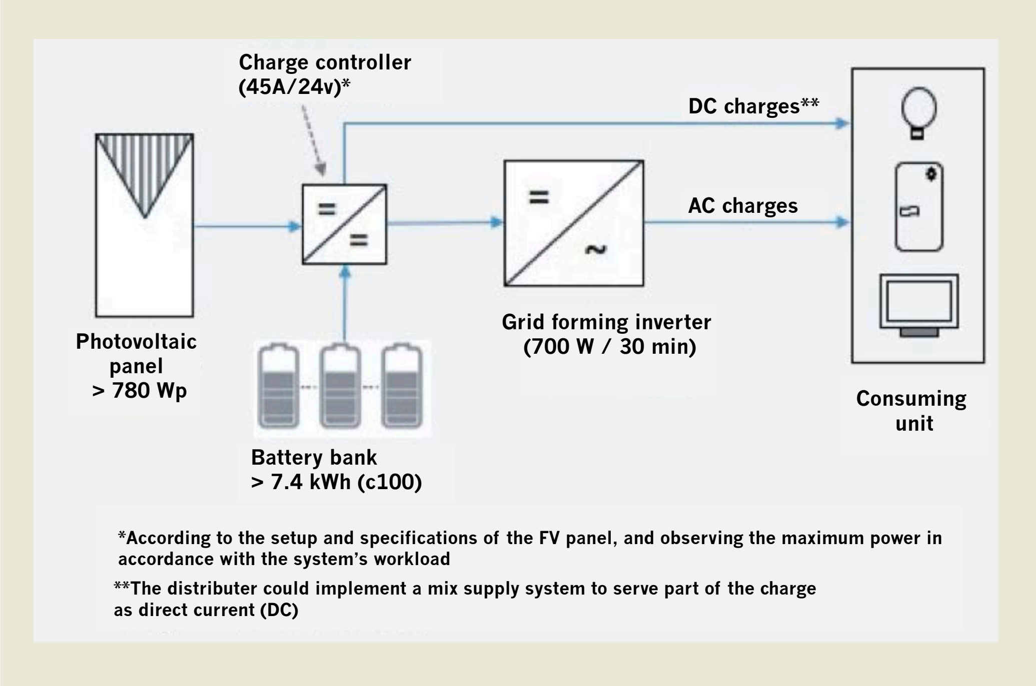
| Model | Monthly energy available (kWh/ month) | Solar panel | Minimum inverter power | End uses |
|---|---|---|---|---|
| **SIGFI 30** | 30 | 580 Wp | 500 | Lighting and leisure |
| **SIGFI 45** | 45 | 1,160 Wp | 1,000 | Lighting, leisure and cooling |
| **SIGFI 60** | 60 | 1,500 Wp | 700 | Lighting, leisure, cooling and small productive activities |
| **SIGFI 80** | 80 | 2,320 Wp | 1,000 | Lighting, leisure, cooling and small productive activities |
| **SIGFI 180** | 180 | 4,640 Wp | 1,250 | Lighting, leisure, cooling and small productive activities |

Own creation.

The aforementioned solar systems are composed of the following items, varying the quantity and technical specification according to the power to be installed: photovoltaic modules, charge controllers, batteries and inverters. The following diagram shows a connection diagram of the main components of a solar photovoltaic system for SIGFI 45. The correct dimensioning and the proper installation are important to obtain the expected result of the system.

***Figure 3** – SIGFI 45 diagram*

*Source: Usinazul (2019).*




INDIVIDUAL SYSTEMS ARE MORE SUITABLE IN COMMUNITIES WHERE THERE IS A BIG SPACE BETWEEN THE RESIDENCES.

***Table 8** – Summary of renewable energy technologies for remote areas*

| Item | Energy services | Technology | End uses | Typical costs** |
|---|---|---|---|---|
| 1 | Water supply and irrigation | Rainwater collection systems* | Human water supply and productive uses (cleaning and processing of extractive products) | - 500 liters: R$ 900<br>- 1000 liters: R$ 1,500<br>- 5,000 liters: R$ 6,000<br>- 10,000 liters: R$ 12,000 |
| 1 | Water supply and irrigation | Photovoltaic water pumping systems* | Human water supply and productive uses (irrigation, product washing, cooking, etc.), hygiene, health, comfort, etc. | Well (40 m deep):<br>- Up to 2,500 l/day: R$ 2800<br>- Up to 30,000 l/ day: R$ 16,000<br>Surface:<br>- Up to 2,500 l/ day: R$ 2,800<br>- Up to 30,000 l/ day: R$ 25,000 |
| 2 | Preserving food and other products | Solar dryer | Drying food | |
| 2 | Preserving food and other products | Fridges / Freezer | Preservation of food, vaccines, etc. | Solar refrigerator (CC): R $ 4,500 to R$ 5,500<br>Freezer 150L (CC): R$ 4,500 to R$ 6,000<br>Freezer 240L (CC): $ 7,500 to R$ 9,000 |
| 2 | Preserving food and other products | Solar Ice Machine* | Production and ice for preservation of food, vaccines, etc. | R$ 25,000 to R$ 30,000 (product tested by the academy in the field, but not available for commercialization) |

| Item | Energy services | Technology | End uses | Typical costs** |
|---|---|---|---|---|
| 3 | Cooking and food processing | Improved stoves and ovens (eco stoves and ovens)* | Flour production and several types of process that require cooking | Efficient stove: R$ 600 to R$ 1,000<br>Efficient oven: R$ 1,500 to R$ 2,500<br>Portable solar cooker: R$ 1,500 to R$ 4,000 |
| | | Biodigesters | Treatment of organic waste, with production of biogas for cooking, energy production and biofertilizer production | R$ 5,000 to R$ 10,000 |
| 4 | Generación de energía: iluminación, productiva, ocio y otros | Pico PV (flashlight) | Lighting | R$ 100 - 500 |
| | | SIGFI 30 | Electric power generation for various residential uses | R$ 7,000 to R$ 9,000 |
| | | SIGFI 45 | Electric power generation for various residential and community uses | R$ 10,000 to R$ 15,000 |
| | | SIGFI 60 | Electric power generation for various residential and community uses | R$ 16,000 to R$ 20,000 |
| | | SIGFI 80 | Electric power generation for various community uses | R$ 30,000 to R$ 35,000 |
| | | SIGFI 180 | Electric power generation for various community uses | R$ 45,000 to R$ 50,000 |

Notes:
* Values defined based on similar projects implemented by the Mamirauá Sustainable Development Institute (IDSM).
** Installation and freight costs are not included for the locations.
Own creation.

# 3. RECOMMENDATIONS

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There have been government projects and civil society initiatives with clean energy in the Amazon for over two decades. In that time, the technology has also evolved considerably, bringing more durability and considerable reduction in prices. However, the energy reality of the remote regions remains with the fossil energy of the past, even in the face of demonstrative projects already showing social, environmental and economic viability.

The experiences analyzed for this publication, as well as those of public knowledge, bring to light the following practical recommendations:

1. Refrigeration solutions that require little storage are the most viable. Lighting and cooling systems at 12 and 24 volts are more sustainable. In the Amazonian heat, the inverters heat up a lot and have a short useful life.

2. Usually the Amazonian reality imposes local adjustments to the projects. Between the study, the dimensioning, the training, the installation and the maintenance, there are always problems that need to be corrected at the moment, from a part that broke on the way, from the structure prepared for the assembly that was not adequate, to the excessive expense of electricity.

3. It is necessary to involve communities in the entire process, from consultation to understand their demands to monitoring the functioning of the system. The best ideas come from communities. Focusing on promoting community organization can guarantee local energy sustainability. All the time invested in community planning and agreements reverts favorably to results.

4. In projects in which this part of strengthening social organization has been simplified, it was found that maintenance for the preservation of systems was not always carried out as directed by manufacturers. And when the problems come, there is a complaint about the technology. Hence, once again, the fundamental need to build local capacity and permanent technical support. In general, everyone is very happy when they see the equipment working well, without noise and without fuel. They make plans with the money to be saved and want to expand the systems for their families.

5. People who live remotely lack information. They are productive and want to improve their living conditions but are wary of possible promises. Many are still waiting for the Universalization Program (such as Luz para Todos). And many who have already benefited from the program complain about the constant lack of energy. At the same time, remote populations require low powers, even for local productive uses. An interesting bet for this intermittence in the supply by network would be portable home kits, which can be leveraged from local productive arrangements, valuing the solidarity and circular economy in each municipality.

**IN GENERAL, EVERYONE IS VERY HAPPY WHEN THEY SEE THE EQUIPMENT WORKING WELL, WITHOUT NOISE AND WITHOUT FUEL. THEY MAKE PLANS WITH THE MONEY TO BE SAVED AND WANT TO EXPAND THE SYSTEMS FOR THEIR FAMILIES.**

6. Methodologies need to guide, understanding that there is no single model for community management of technologies. Therefore, betting on the development of management and maintenance workshops with tools that include the participation of illiterate people and mainly women and young people, is very promising. It is necessary to consider the existing social organization and carry out the project according to these characteristics (such as number of houses, family relationship, community association, distance from cities, among others).

7. It is possible to implement business models on a sustainable basis and with renewable energy without subsidy for their maintenance. For this, it is essential that the use of energy be prioritized initially to generate employment and income, and later for other purposes. First, income is generated, then another account is taken for families to pay. In addition, the participation of a private agent (entrepreneur) in the business model is important to ensure that activities are

maintained. This involvement must occur in the context of a contract with deadlines and goals to be achieved.

8. Only with the development of a social culture related to energy management and its product use added to the availability of simple solar products such as plug and play can the necessary scalability be reached. For that, it is necessary to establish a network of photovoltaic energy services and products in the interior, integrating small community traders and the city market.

9. Renewable sources of energy in rural areas increase productivity, and consequently, the competitiveness and resilience of traditional populations living in remote and isolated rural communities, as they support the improvement of quality of life, production and income generation. For this reason, programs to encourage this source should not be restricted to the Ministry of Mines and Energy, but also to the Ministries of Agriculture, Citizenship and others that promote local productive arrangements. Overcoming energy exclusion in the Amazon is a huge and complex challenge that depends on the articulation of different actors.

10. The multi-annual rural electrification goals of the energy distribution concessionaires must be submitted to public consultation in the states and municipalities before their approval by the National Electric Energy Agency, in order to provide more transparency to the schedule and inclusion criteria and also to receive updated information about the communities that need to be included in the concessionaire’s goals.

11. The Energy Universalization program and the distribution concessionaires must also include in their objectives and goals the attendance to the productive demand of the communities. For this, the normative regulation needs to be adjusted in order to guarantee the tariff benefits and contemplate the ways of social organization of the communities in meeting the productive loads. In a complementary way, the articulation of rural electrification programs with other government programs and policies and the expansion of financing programs adapted to the reality of communities are also important, with a view to


fostering productive chains and local development plans.

12. The expansion of service in remote regions must be accompanied by a robust training and capacity building program for the management of electricity generation systems. Thus, it is also opportune to carry out studies and consultations on the feasibility of operation and maintenance of energy generation systems by communities or their associations.

13. Given the high costs of fossil fuels in Brazil, the subsidies for diesel in the Amazon and the Brazilian commitment to reduce emissions, it is believed that with cheaper products, with improved storage solutions and access to credit solutions, Brazil will be able to meet its goal of universal energy supply by 2030, in accordance with the Sustainable Development Goal 7. It is worth mentioning that access to energy also presupposes its use for productive, educational and recreational activities, and not only basic access to energy.

14. The SDGs exist and are being guided by a political guideline. However, little is measured about social, structural and economic impact and change. In this sense, it is necessary that governmental bodies, science and technology institutions and organized civil society structure macro-structural action plans and evaluate scenarios for reaching the goals. And that there is a financial allocation for the execution of the action plans.

## AN INTERESTING BET FOR THIS INTERMITTENCE IN THE SUPPLY BY NETWORK WOULD BE PORTABLE HOME KITS, WHICH CAN BE LEVERAGED FROM LOCAL PRODUCTIVE ARRANGEMENTS, VALUING THE SOLIDARITY AND CIRCULAR ECONOMY IN EACH MUNICIPALITY.

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# ACCESS TO ENERGY FROM RENEWABLE SOURCES IN REMOTE REGIONS IN BRAZIL: LEARNED EDITIONS AND RECOMMENDATIONS

100% RECYCLED PAPER

## 1

A tree is able to compensate up to one ton of GHG during all its life. The best way to compensate greenhouse gases (GHG) emissions is maintaining the standing forest.

## SDG 7

Access to clean energy also presumes its use for productive, educational and recreational activities, and not just daily basic access.

## 24 HOURS OF CLEAN ENERGY PER DAY

brings more health to isolated communities. With refrigeration, people were less dependent on ultra-processed foods - such as meat and canned sausages- and have returned to consume chilled fish, without the need of using salt for its conservation.

## 21ST CENTURY

And millions of people keep using the old fossil energy even with demo projects that already showed social, environmental and economic viability.

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Stop the degradation of the environment on the planet and build a future in which human beings live in harmony with nature

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