OPEN SOURCE HARDWARE TECHNOLOGY, A SUSTAINABLE SOLUTION TO ACHIEVE ENERGY FOR ALL IN THE GLOBAL SOUTH

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INTRODUCION

The global South and the lack of electricity

The "global south" could be defined as a term that extends the concept of developing countries. It usually refers to all those countries that have an interconnected history of colonialism, and a social and economic structure with great inequalities in living standards or life expectancy. Generally, in these countries, access to basic resources is scarce and this does not allow the growth and empowerment of these communities.

The world's energy needs are currently a problem and are constantly increasing, while the need to reduce carbon emissions is vital to avoid short-term climate change. In the Global South, a large part of the population still lacks access to energy, which is crucial for poverty alleviation through job creation and better health and education systems. The lack of access to these basic services continues to delay these forgotten and unequal communities. As we can see from Fig. 1, more than 95% of the population without access to electricity belongs to the global south, integrated by Sub-Saharan Africa, Asia and Latin America (Panos, 2016).

In essence, one way to overcome poverty, promote health and educational services and enhance socioeconomic development is to ensure reliable, sustainable and affordable energy for everyone. Hence, the United Nations (UN) has established ‘‘Ensuring access to affordable, reliable, sustainable and modern energy services for everyone” as one of its Sustainable Development Goals (SDGs) to be reached by 2030 (Hostettler, 2015).

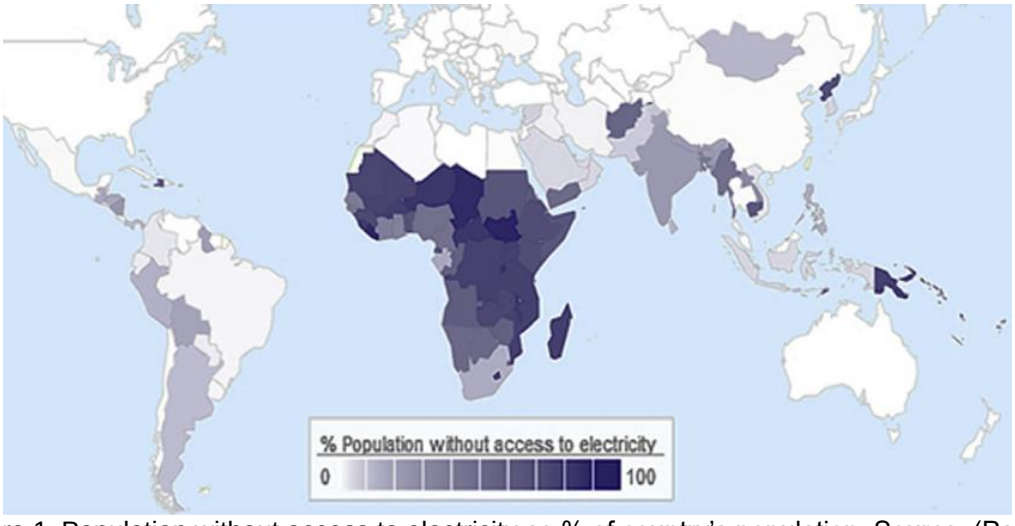

Figure 1. Population without access to electricity as % of country’s population. Source: (Panos, 2016).

In this context, the generation of energy with renewable resources using open source technology emerges as a possible solution to this problem. The open source technology is based on the philosophy of sharing knowledge, creating global communities where development is open and can be used both by end users and by other developers who enhance and make contributions to the state of the art of developed technology.

In this work, a review of different open source technologies in renewable energies at present is proposed, as well as analyzing and proposing different strategies to coordinate and integrate these developments among different interested sectors such as universities, governments and rural communities.

Finally, a case study implemented with open source technologies by the authors in the Global South will be presented, where technological and social work has been carried out providing sustainable, reliable and affordable energy for the most vulnerable people.

TRADITIONAL SOLUTIONS

Affordability

When we talk about rural electrification, we generally speak of communities with scarce resources, according to the 2018 World Bank report (World Bank, 2018), half the world population lives on less than US$5.5 a day, preventing this sector of the population from access commercial technologies.

In addition to this, 90% of the world's designers spent all of their time addressing the needs of the richest 10% of the world's customers (Polak, 2008), which is a very hopeless relationship for rural communities. Therefore, the way to develop affordable and appropriable technologies for the poorest communities is finding the cheapest and simplest tool to do the job.

Compatibility

Another point to keep in mind is that the electrical microgrids are not standard and compatible, they depend on numerous factors such as the natural resources of the location, the voltage and frequency of the country and therefore the available electronics, the technical level of operation of the community, among others. It is for the above, that on repeated occasions, rural electrification projects implemented have failed due to their high cost, lack of maintenance or lack of (compatible) spare parts, among others.

In addition, small and large organizations often work independently in tackling complex and global problems, disconnected from potential collaborators with complementary skills and ideas. This entrepreneurial mindset, characterized by competition and driven by the maximization of self-interest, is one of the main contributors to this pattern.

However, when the challenges are global and urgent, such as rural electrification or climate change, these challenges require more than incremental new advances. They require paradigm shifts driven by our creative and collective intelligence. This collective intelligence is powered by decentralized and distributed Internet networks, open source hardware and software, and communities that open collaboration across disciplines, continents, and languages.

OPEN SOURCE HARDWARE TECHNOLOGY

Philosophy

The OSH philosophy is that different people, from technical experts, designers or even end users, can help find a common solution to a problem for the further development of an idea. Community power can offer different points of view that add value to the proposed solution and these proposals are shared even more openly so that the idea can continue to improve and evolve. It means that while a traditional company-led

research and development effort would require very large human, financial, and technical resources, in an OSH development methodology, most of these resources come from the community.

One of the most important reasons is that it opens up many more opportunities to find technical solutions from many more actors. Although possibly previously only public and private research laboratories or companies could offer a service or product to solve different problems related to emergency aid, health, energy, food, housing, education or economic development, there is now a growing army of manufacturers, designers, engineers who are already very passionate about learning, sharing, and using digital manufacturing technologies who can also participate in creating innovative solutions.

Another very important characteristic of OSH developments is that from the communities, different types of tools are developed to train the use of end users, as well as their installation and maintenance. In the case of rural electrification applications, these activities are carried out by the developers themselves or by non-governmental organizations that are responsible for the implementation of the project.

The ultimate goal is that beneficiaries can actively participate in the process, for example, assembling kits to create sustainable energy systems or for drinking water. Open innovation and design transfer more power to drive change to the end user, promote decentralized problem solving, and make beneficiaries responsible actors by promoting creativity.

Another important advantage of OSH development is that many of the resources needed to create a new product or solution are shared, and therefore less funding is needed compared to traditional R&D funding, which often requires large investments of capital to guarantee patents and intellectual rights. even for small innovations. Having a lower development cost and being open means that those financial savings can also be passed on to the end user, hopefully by offering high-quality products at a much lower cost.

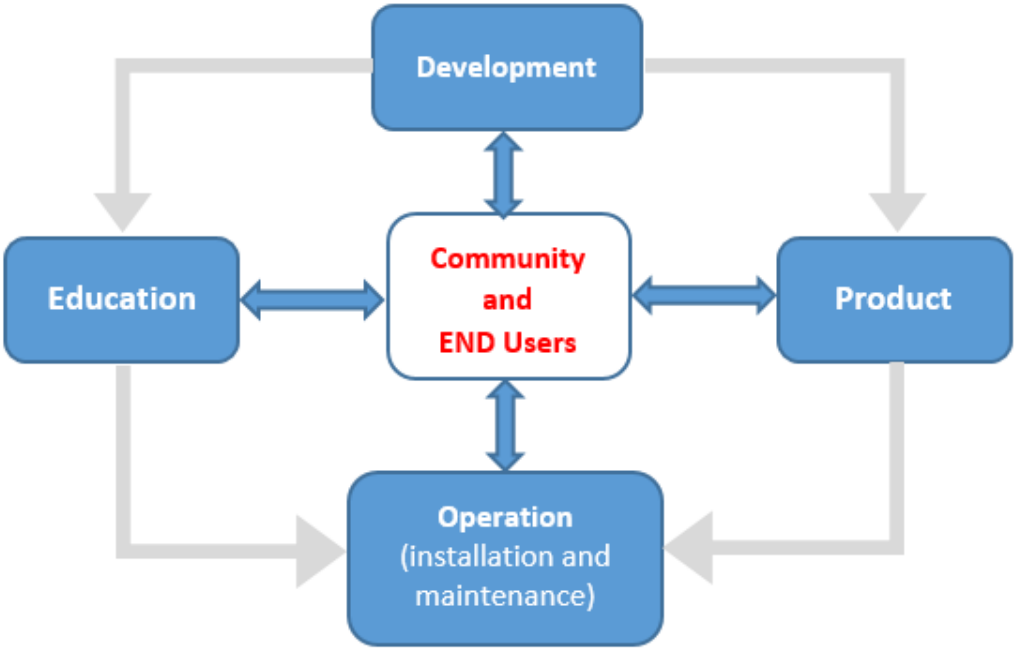

Figure 2. Open Source Hardware philosophy.

A question that is often asked about OSH technology is whether it is sustainable in time and even in the case of startups with this philosophy if their business model is possible, in (Li, 2019) from various surveys and analyzes it is concluded that an OSH strategy can

have an economic sense. By opening hardware design, a company can naturally develop a community, which is a key element for the success of the company. Using the community to increase the perceived value of customers, reduce costs, shorten product development and accumulated knowledge and experience can compensate for the risks involved in the process of OSH.

Successful Cases

In **Electronics**, OSH projects like Raspberry Pi and Arduino are excellent examples of a true revolution around the world, impacting certain sectors such as digital culture, programming, education, and even entrepreneurship and innovation.

These platforms have become the base on which many engineering students, fans of the world of electronics can develop their projects in a self-taught way supported by large working communities.

Although Raspberry Pi and Arduino are among the best known projects, the reality is that there are many freer hardware projects that are supported by powerful user communities and even by companies. Among the most widespread we can mention "Open Compute Project" by Facebbok, Uzebox, ubieboard, VIA OpenBook and RepRap widely disseminated among 3D printing communities.

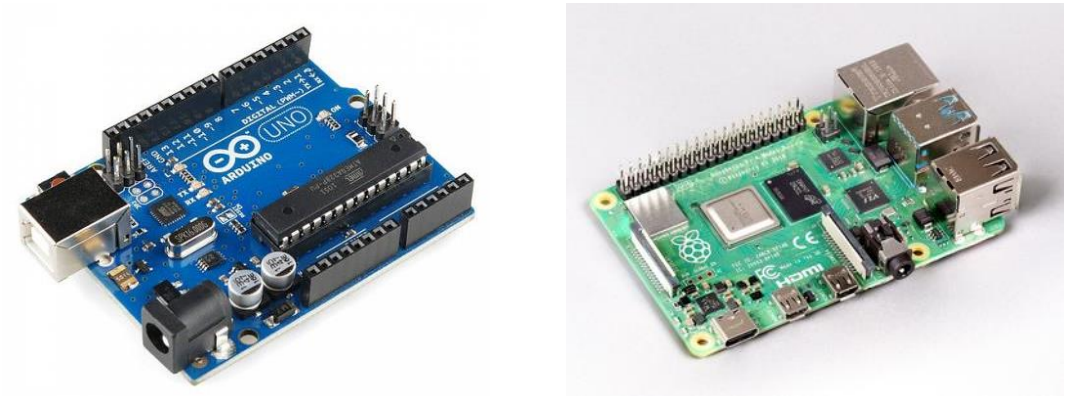

Figure 3. Arduino and Raspberry PI

In **microgrids**, there are numerous research laboratories and companies dedicated to OSH projects, whose objectives are to develop collaborative communities, the democratization of energy and climate change, among others (Yale OpenLab, 2018) (OpenEnergyMonitor, 2011).

In the specific case of **isolated microgrids** for rural communities, which do not have access to the electricity grid, they are generally made up of a generation source, which can be renewables like wind, solar, biodigester. Also a storage device such as batteries and power converters that adapt signals and voltage and current levels.

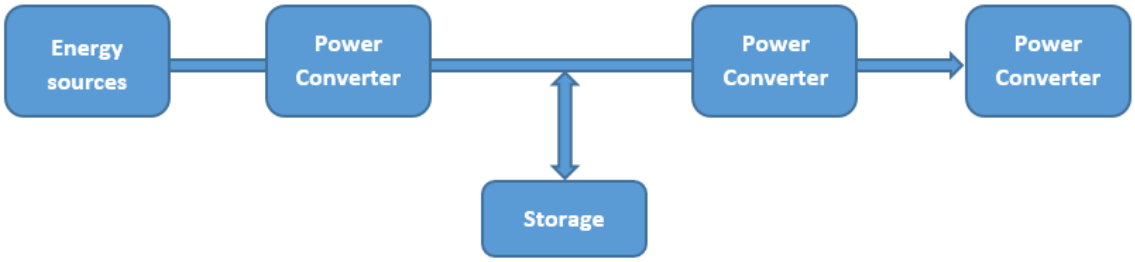

Figure 4. Structure of isolated microgrid

In the generation systems we can find the Piggott wind turbine, diffused and perfected for more than 30 years and different communities that spread it, capture it and implement it around the world (Wind Empowerment, 2011). In the field of biodigesters, there are

numerous communities that disseminate and train the construction technology of small biodigesters (Redbiolab, 2007).

When it comes to power converters, this is where most developments and communities meet, OwnTech is a project created for the electronic development of low-cost and reliable and modular microgrids (OwnTech, 2018).

Another project dedicated to the development of converters in solar applications is LibreSolar, specializing in different versions of charge controllers (PWM and MPPT) and battery management systems (LibreSolar, 2015). LibreSolar is part of Open Energy Access Alliance, established by a small group of organizations, sharing the belief that access to energy is fundamental for human and economic development and that decentralized approaches to energy provision are vital for achieving universal energy access (OEAA, 2017).

As mentioned above, numerous initiatives around the world share a passion for OSH technology development, with the aim of facilitating access to affordable, reliable, sustainable and modern energy sources, in line with the UN's Sustainable Development Goal 7.

In Fig. 5 there is another example of an OSH development, a PWM wind regulator developed by the Automatic Control Laboratory (LCA-INTEQUI) in collaboration with the NGO 500RPM in Argentina, low cost, open and with excellent performance (Catuogno, 2020).

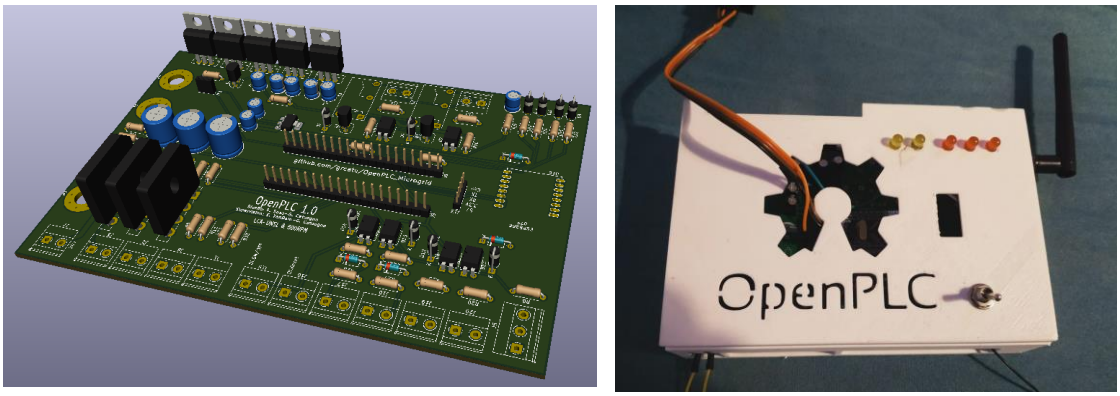

Figure 5. OpenPLC for wind turbines

STUDY CASE

The case study consists of a project implemented during the year 2019, financed by IEEE Humanitarian Activities Committee (HAC), which consisted of building and installing a small wind turbine (Piggott) with an electric-electronic water pumping system in the Municipal Agroecological Demonstration Unit of Esquel-INTA in the Province of Chubut, Argentina.

The objective of spreading OSH technology and training local users, promoting an active role for the community and providing an affordable solution to the most widespread problem of rural inhabitants of the Patagonian steppe: access to water (Catuogno, 2019). In Fig. 6 a simple diagram of the water pumping system is presented.

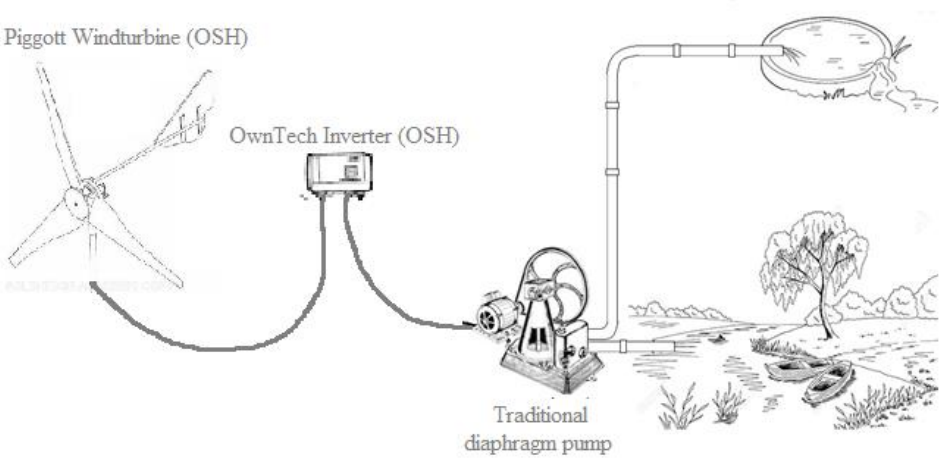

Figure 6. Block diagram of wind water pumping system

As previously mentioned, the Piggott wind turbine, a successful case and OSH technology, is a horizontal axis, three blades, with 500 W nominal power (Fig. 7a).

The advantage of this wind turbine is its simplicity of design, construction, robustness and low maintenance. This allows it to be built by high school students from Esquel, Chubut (Fig. 7b), through training from the NGO 500RPM, a member of the Wind Empowerment community. Some of its characteristics are,

- Blades: Made with cedar wood, with Clark-Y aerodynamic profile.
- Structure: Steel protected with anti-rust paint.
- Generator: 24V, 500W. Axial flow, with operation between 300 and 600 RPM.
- Tail: Plywood.

Figure 7. Piggott wind turbine and construction

The other OSH component of this system is the power inverter and the control board, the choice was the development carried out by the LAAS laboratory at the University of Toulouse (OwnTech), which also are active members of Wind Empowerment.

The inverter board is configured to operate with a power of up to 1 kW and in conditions where the climate is a factor to consider for its design and manufacture, so it was sent to be manufactured by companies specialized in the field and having enough technology to provide a quality PCB, due to the power it must withstand, track widths, being double-sided and containing other specific construction features, it becomes difficult to make a quality and robust board using traditional methods of PCB manufacturing.

In this context, the LCA-UNSL and 500RPM decided to adopt the developed OSH technology and adapt it to the requirements of the motor pump to be used and the

adaptation of the voltage levels and sensors, making a contribution to the existing development.

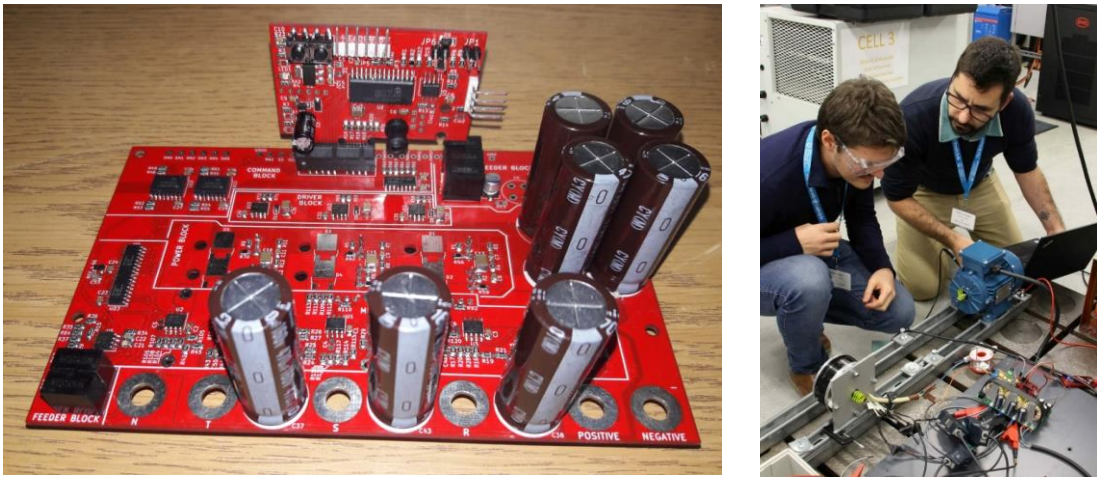

Figure 8. three phase inverter designed by OwnTech

Figure 9. OSH wind pumping project in Argentine Patagonia

CONCLUSIONS

In this work the electrification problem in the global south is raised, and the need to develop an affordable technology that fights poverty and promotes health, education and socioeconomic development.

In addition, an attempt is made to give an overview of Open Source Hardware technologies, and their impact on the democratization of energy, and whose vision is to attack the problem globally through multidisciplinary work communities and reach a faster and more affordable solution for the people of the south global.

Finally, a successful case study is presented that uses two open source hardware technologies in Argentine Patagonia whose purpose is to disseminate and replicate among the original communities.

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