ENergy VAO (ENVAO)

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Kukula, H4O

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In the world, there are 759 million people (IEA, 2020) that live with no electricity, three-quarters of which are in Sub-Saharan Africa. With a population that is going to almost double by 2050, all African countries need to find ways to meet the rising energy demand without falling into non-renewable schemes, which would prove to be non-sustainable in the long run. This is, for example, the case of Madagascar, where 26,9 % of the population only has access to electricity, with 79,5% of the urban population and just 7,7% of the rural population (World Bank, 2019). The purpose of the project is to design an electrification system for the rural island of Gran Mitsio in Madagascar. The research was pursued in collaboration with Kukula and H4O, two NGOs that have been operating in the area for several years. After the study of the state of the art, the social analysis of the context and the definition of the energy demand profile, the team proposed a set of strategies for the implementation of a renewable energy system. Four plausible strategies were ideated to provide energy to both public (school, hospital, public lighting) and private places (households, shared kitchens, local activities), and were categorized based on the energy generation system: centralized generator, or multiple decentralized generators. The two most promising strategies are the ones utilizing a hybrid approach to the energy generation system (e.g. the use of individual generators for public facilities and a single central generator for households). The two (“Light Trail” and “Energy Hub”) can be actually merged into a single two-step plan to construct a solid, comprehensive and inclusive system.

Key words

rural, electrification, madagascar, sustainability, renewable

Fig. 1 Project’s set of strategies

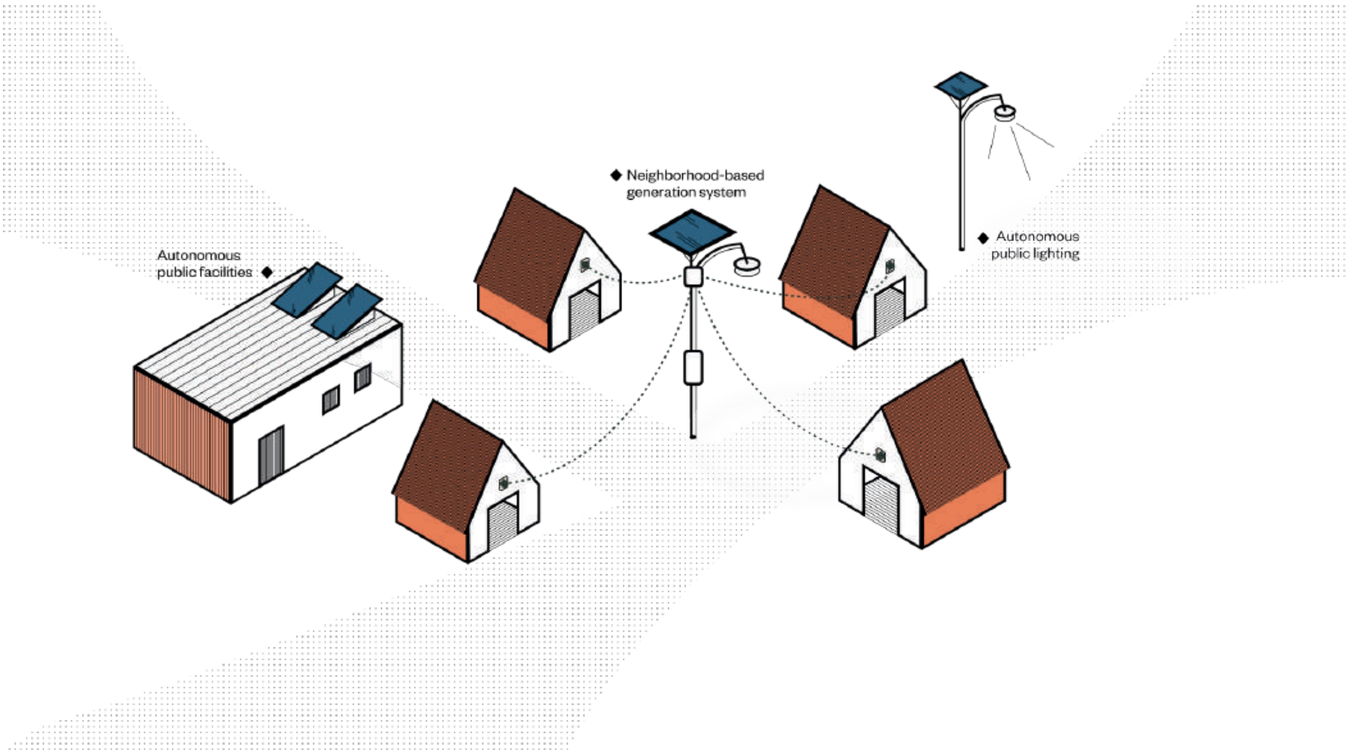

Fig.2 Strategy “Light Trail”

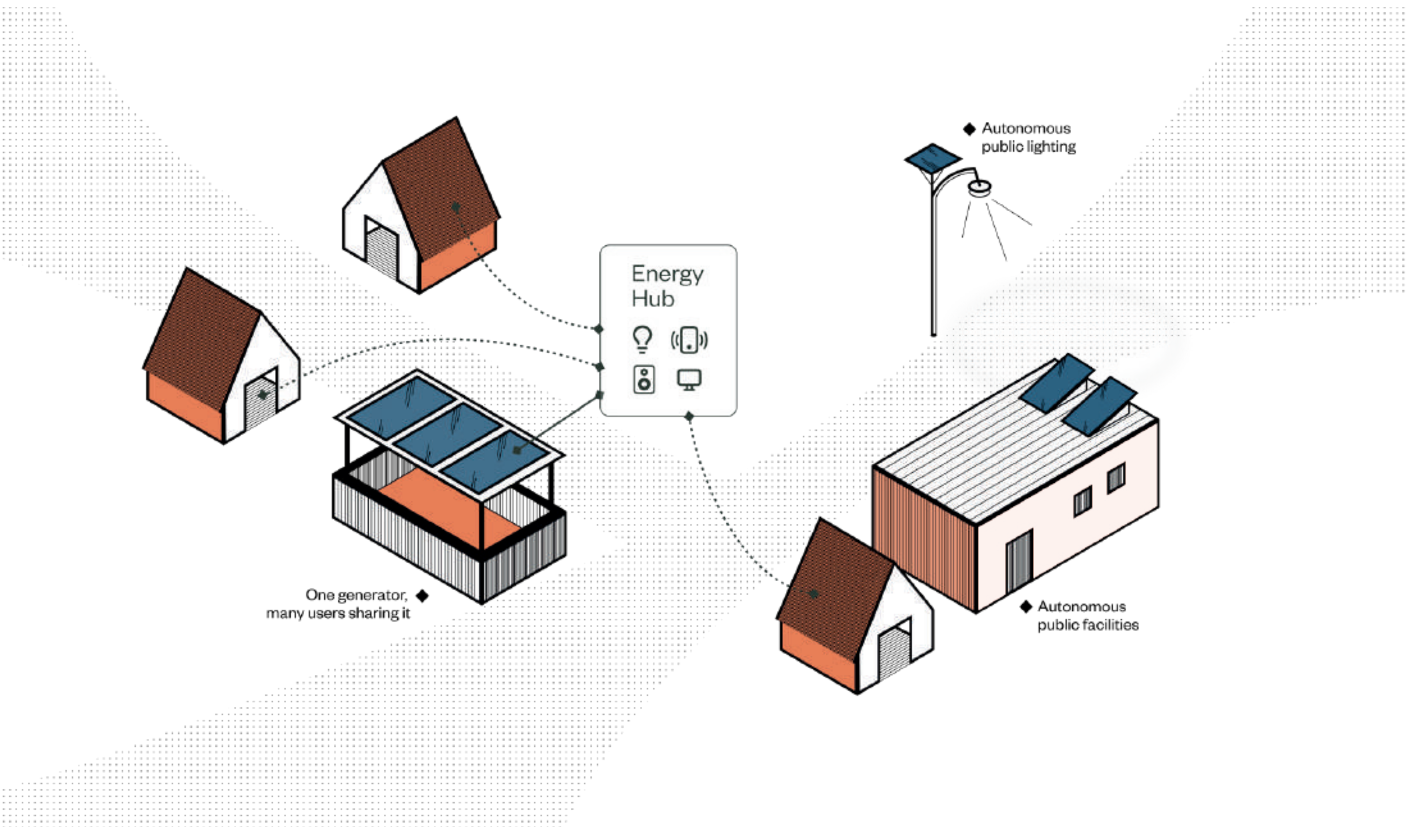

Fig.3 Strategy “Energy Hub”

Project description written by the Principal Academic Tutor

As Westerners with enough energy to appreciate Nosy Mitsio (GMI) beauty, from our comfortable sofa, we contemplate the incontaminated life of its inhabitants as beautiful and "pristine". Living without any electricity is extremely difficult, though, and much an obstacle to improve their human development index. ENVAO had the simple, yet challenging aim of designing sustainable ways to immediately satisfy the still latent energy needs of island's inhabitants. Despite COVID enormous limitations, thanks to NGOs on board of ENVAO, the team entered also in contact with locals and understood their energy needs. The team performed an extensive review of innovative socio-technical solutions recently adopted in similar settings to bring energy where there is none. Wind, solar, biomass, waves, biophotovoltaics: each team member has lead exploration of one tech and made possible for the group to analyze best options. Confronting step after steps findings with onboard NGOs, the team has (i) investigated the peculiar problems of GMI's inhabitants, (ii) trasformed them into requirements for designing consequent solution(s), (iii) prepared a set of verifiable indicators to assess ENVAO impacts, outcomes and outputs. After having mapped GMI territory (that was not mapped yet), the team quantified energy demands of each user category in the village (e.g. household, school and hospital) and partitioned them over daytime. With a peak of power demand of around 1.5kW, the target of using but solar energy seemed quite reacheable and feasible to implement. ENVAO developed various "business-models" to offer sustainable community energy services to all, and analyzed major PROs and CONs of each model. The construction of a community "light trail" with few photovoltaic panels shared between neighborhoods seemed the best candidate to "turn lights on" in GMI. We say seemed and not was, because such a transformative solution cannot result from deskjob (remember COVID limitations). Engagement of the local community is key and the team would love to keep working it out with NGOs. Costs are at reach (a few thousand euros) and the team willingness to act is very strong. Who knows if the team would find energies to walk with H40 and Kukula the one last mile left to light the first bulbs in GMI.

Team description by skill

Diego Reitano is currently an Experience Designer (UX) at Publicis Sapient based in Milan. He previously worked for a four-month period at EcoG in Munich as UX designer and at PARIPARI GmbH, for seven months, as a graphic designer. He obtained his Bachelor degree in Communication Design at Politecnico di Milano (PoliMI). He then continued his Masters' degree in Product Service System at PoliMI. Furthermore, he participated to the Master of European Design, which led him to join several university across Europe, namely, the International School of Design in Köln and the prestigious Aalto University in Finland. Finally, he joined the ASP program in 2019.

Emilio Pulli is aMSc Energy Engineering student at Politecnico di Milano. He obtained his Bachelor degree in Energy Engineering at Politecnico di Torino, where he also joined the highly selective "Young talents program". During the three years, he also participated in the Erasmus+ Program where he had the opportunity to study in Barcelona for the Autumn Semester of his third year at the Universitat Politècnica de Catalunya (UPC). He finally joined the ASP program in 2019.

Emanuele Sciuva is currently a Msc student in Architecture Construction City at Politecnico di Torino (PoliTO). He obtained his Bachelor degree in Architecture at PoliTO, during the three years he also participated in the Erasmus+ Program where he had the opportunity to study in Germany at the Bauhaus-Univeristät. During the last year of his Masters', he spent three months at the Urban Morphology and Complex System Institute for the development of his thesis. He has worked as teaching assistant in several courses treating Economics and Urban Planning. He also worked for a six-month period at Balance Architettura in Turin. Finally, he joined ASP in 2019.

Teresa Bonserio is an Environmental Engineering Master Student at Politecnico di Milano. She obtained her Bachelor degree in Civil Engineering at Politecnico di Bari. She also worked for a three-month period at Ecoacque, in Giovinazzo, within the framework of an interniship. FInally, she joined the ASP program in 2019.

Goal

In a remote and virgin context such as Grand Mitsio Island (GMI), where one can take advantage of te powers of sun, wind and sea, there were all the conditions to realise a sustainable, clean and non-invasive technology.

The purpose of our project is the selection and design of an electrification system for GMI. We aimed at providing a development model in which electricity represents one of the means for achieving progress. To realise an innovative energy system, community-centered and user friendly, born from a new way of thinking and collaborating, which aligned to principles of equity and equality. We expected to supply energy using a cross-cutting approach that will kick-start the local development by providing lighting for houses and the school, pumping water for irrigation and preserving sanitary products.

It was essential to rethink the concept of development in terms of sustainability, which should not be seen as a result but as a pre-commencement condition. In this context, GMI could become a participatory laboratory and an inspiration-hub for the creation of a replicable and scalable development model, capable of converting the potential available energy into an opportunity for growth of the entire community.

Given the nature of the project, based on a demand-pull requirement, the team, in accordance with the stakeholders involved, set as final objective the development of a number of strategies or "scenarios" which were to represent a "portfolio" of possibilities, from which the NGOs will be able to choose and evaluate the best possible direction for the future actual development of the electrification project.

Understanding the problem

The first priorities identified by GMI people were to access clean water and education. Once water was supplied and the school were built (2018), the priorities turned into fighting malnutrition and developing domestic spaces. Each and all those needs require energy, though.

The analysis carried out within the time of this project, in the form of problems and objectives' trees, confirmed the first observations of the NGOs and expanded on further latent needs and issues that are experienced daily by the local population. The lack of electricity, in its different forms was categorised according to the use:

The lack of electricity for lighting, at present, impacts many different aspects of daily life. Firstly, the possibility to carry out any activity, either for productive purposes or for domestic needs, is significantly hindered after dark. Incidents and safety issues have been rising over the last years due to the lack of light. Moreover, a secondary aspect is the use of battery or oil-based devices to cope with the lack of lighting which is causing environmental issues.

The lack of electricity for devices, limits the community to utilise PCs, printers, cell phones and radios. Besides their ludic aspect, these devices were also seen as a potential source of information and educational development for the local population. Furthermore, the lack of a radio station to communicate with the mainland exposes the locals to safety issues, as there is no communication extra-island in case of an event.

The lack of electricity for appliances is mostly connected to the impossibility to have refrigerators of any kind or any sort of system to cook safely. Locals, at the moment, do not have the possibility to store food or medicines and cooking is mostly carried out by burning wood.

Finally, the lack of electricity for pumping water is mostly limiting agricultural practices and the availability of drinkable water for the entire population, even though the development of appropriate strategies in these terms was not viable, as data on the actual water availability (and drinkability) were not available.

Fig.4 Lack of drinkable water in GMI

Fig.5 Lack of lighting in the school of GMI

Exploring the opportunities

A large number of case studies from similar contexts all over the world, clustered by renewable source type: bio-photovoltaic, biomass, wind energy, and solar energy.

Considering the bio-photovoltaic, despite the high level of innovation, the state of the art of these technologies still deals with lab-scale prototypes capable of producing only a few watts of power and their correct implementation requires the creation of the appropriate chemical environment where the microbial batteries can grow.

The biomass solution requires the adoption of separate crop cultures, to be entirely devoted to energy production, in order to avoid food competition. Moreover, the energy generation system presents high initial investment costs, not economically sustainable in a rural context such as the one of this project.

Wind energy was considered to be a potential candidate for introducing a new way of producing electricity while involving the population during the construction and maintenance phase. However, the low wind speeds and the design of an efficient aerodynamic structure under limited wind conditions impose a challenging task.

In conclusion, photovoltaic technologies turned out to be the best-fitting candidate for starting a sustainable electrification process in Gran Mitsio Island. The modularity of the photovoltaic panels allows the design of different electrification strategies in terms of power generation centralization or fractionation.

Generating a solution

A set of strategies for the implementation of a renewable energy system. Four plausible strategies were ideated to provide energy to both public (school, hospital, public lighting) and private places (households, shared kitchens, local activities), and were categorized based on the energy generation system: centralized generator, or multiple decentralized generators. The two most promising strategies are the ones utilizing a hybrid approach to the energy generation system (e.g. the use of individual generators for public facilities and a single central generator for households). The two ("Light Trail" and "Energy Hub") can be actually merged into a single two-step plan to construct a solid, comprehensive and inclusive system.

"Energy Hub" uses a single generation system for all private applications and a series of distributed generation systems for public facilities. The goal is to create a solar-powered hub, where inhabitants can rent or share electricity-powered products and services, based on the temporary tasks and needs that they need to satisfy. For instance, they can rent task lights for work, solar lanterns for ambient lighting and community, radios for communication or stereos for celebrations. Community members involved in the hub collaborate with the NGOs to manage it. Public facilities, such as the school, the hospital and the street lights are powered by independent generation systems, all using solar panels.

"Light Trail" features a partially distributed generation method for private users, while the generation for public facilities and public lighting remains unchanged. It is a neighbourhood-based generation system, which can provide energy access to each household in the village, by exploiting a distributed generation system installed on public lighting poles. The ones close enough to a cluster of four to five households will include an upgraded solar panel and battery, able to give lighting to each family, as well as power outlets for free use. Each cluster will be responsible for its upkeep.

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