ENERGY ACCESS AND GREEN TRANSITION COLLABORATIVELY DEMONSTRATED IN URBAN AND RURAL AREAS IN AFRICA

D1.1.

Use-cases Specification

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1. PROJECT SUMMARY

The ENERGICA project is ambitiously fostering collaboration between European and African partners on energy access and sustainable energy development. The project develops innovative and tailored solutions in rural Madagascar (productive use of systems through innovative nano-grids in WP4), in peri-urban Sierra Leone (low-tech efficient biogas system, coupled with water purification demonstration in WP5) and in urban Kenya (solar powered e-mobility solution for boda-boda motorcycles in WP6). ENERGICA tackles a wide range of issues that range from energy production, local renewable value chain development to e-mobility and flexibility services to the grid; and addresses them with specific solutions through a co-creation methodology taking into consideration the different technical and socio-economic contexts as well as local stakeholders. ENERGICA aims to provide innovative business models tailored to local market uptake, and some of the solutions will rely upon local production and manufacturing, local business and workforce.

2. OBJECTIVE AND EXECUTIVE SUMMARY

The goal of this document is to describe the use cases to implement in ENERGICA. Three different use cases, each specific to one pilot, have been identified:

- Madagascar – Nano-grids for domestic and productive uses in Rural Context
- Sierra Leone – Organic waste valorisation and water purification in sub-urban and urban context
- Kenya – Battery swapping stations in Urban Context

The document is organized in three main sections:

- A description of the process of use-case definition and the methodology used
- A presentation of the demonstration sites and their specificities
- A presentation of each use-case

3. TABLE OF CONTENT

List of figures

List of notations, abbreviations and acronyms

Acronyms	Definition
AC	Alternative Current
CAPEX	Capital expenditures
CHP	Combined heat and power
CO2	Carbon dioxide
DC	Direct current
DER	Distributed Energy Resources
DSO	Distribution system operator
EMS	Energy management system
EU	European Union
EV	Electric vehicle
KPI	Key performance indicator
LV	Low voltage
MV	Medium voltage
NGO	Non-Governmental Organisations
OPEX	Operational expenditures
PV	Photovoltaic
RES	Renewable Energy sources
TEMS	Trialog Energy management system
UC	Use-Cases
UML	Unified modelling language
UV	Ultraviolet
WAN	Wide Area Network

4. INTRODUCTION

a. Scope of the document

The goal of this document is to describe the use cases to be implemented in each ENERGICA demonstration sites: northern Madagascar, Freetown (Sierra Leone) and Nairobi (Kenya).

The use cases describe what the system will achieve and how it will operate. Defined at the beginning of a project, use cases set the general orientation of the project. In order to stay relevant throughout the project, use cases might be updated to ensure their full compliance with consumer's expectations and partners considerations.

This document is publicly available, and will be used to inform the general public about the objectives of the ENERGICA project. It will also be used internally to ensure a common understanding of the use-cases of the project.

b. Approach

With ENERGICA demonstrators being located all across Africa, the systems developed in the project widely vary from what is usually seen in European projects, especially for the rural and peri-urban demonstrators. Systems are smaller and require fewer interactions between each subsystem. As such, pilot leaders are fairly independent in the development of their own solution.

The preferred approach to produce this document consisted in a series of one-on-one meetings with each pilot leader and relevant partners. These meetings were focused on the study of the existing technologies and the nature of the development envisioned by each partner. The aim is to obtain a common view for all actors involved in the sub-systems development. This should be used as a guide for future works of the project, and to ensure to always keep in mind the complete systems and their objectives. It can also be used later on as a basis to test the functional interoperability.

c. Methodology

In ENERGICA, the IEC 62559-2 standard [1] is used to describe the use-cases. It aims to set a methodology and a template for detailing a use case. It includes the description of objectives, actors, requirements (including KPI), and the relation between them. This template is designed for the definition of smart grid use cases, though it can be used as well for other energy systems such as electro-mobility or biogas production and water purification. It is therefore perfectly suitable for ENERGICA pilots use cases.

This template is divided into seven main parts, as detailed in Figure 1 below:

1. Description of the use case: defines the context and objectives
2. Diagrams of the use case
3. Technical details: including the extensive description of all the actors
4. Step by step analysis of the use case: defines the main scenarios of the use case, and details for each of them the processes and relations between actors, step by step.
5. Information exchanged
6. Requirements

7. Common terms and definitions

This methodology has been developed by Trialog to define the use-cases of several projects, such as GIFT, MAESHA, InterConnect or Sender. It enables to place the use-case as a whole in its context, describes the processes thoroughly within the scenarios, and defines each component, information or requirement, while referring to them in the whole document. It therefore drives towards a very comprehensive and detailed description of the use-case.

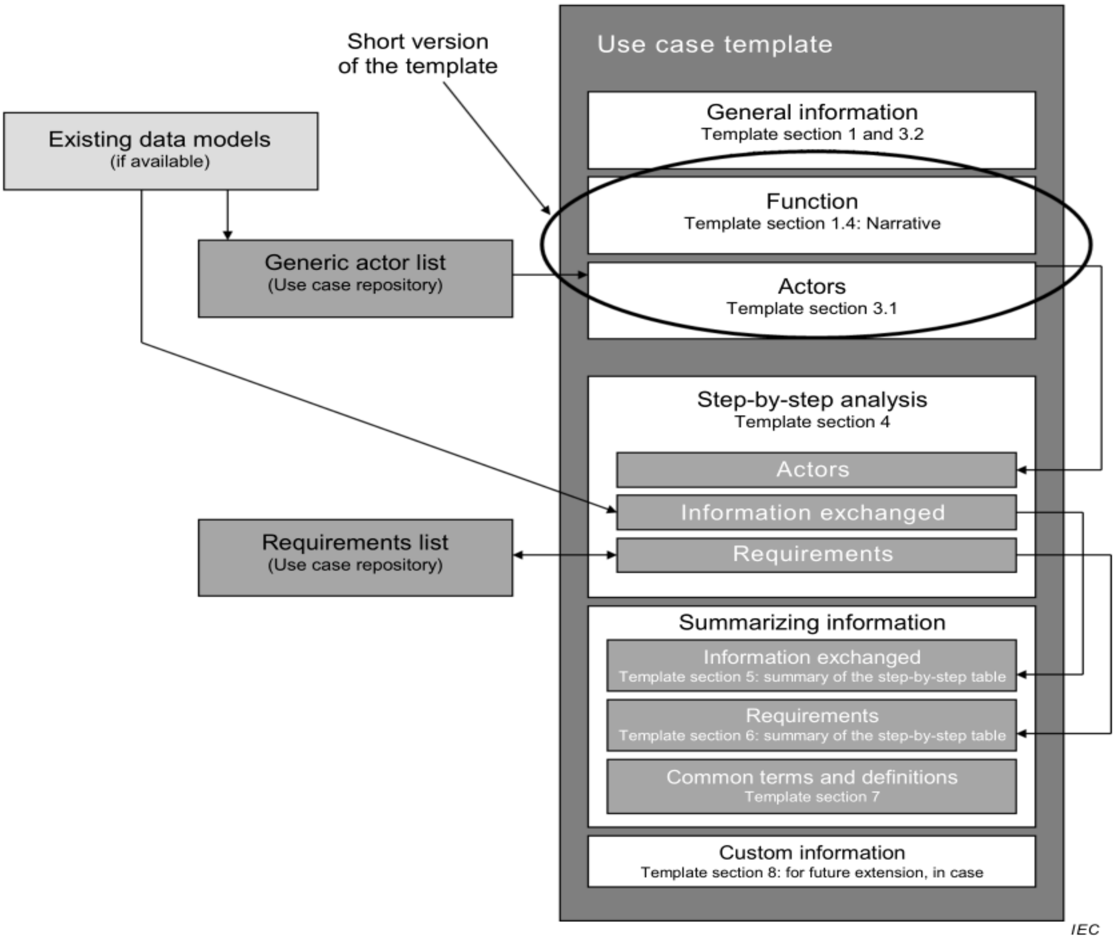

Figure 1: Overview of the IEC 62559-2 template [1]

5. DEMONSTRATION SITES

This section describes, for each of the pilots, the chosen demonstration sites, their needs and specificities.

a. Madagascar - Diana region

The Malagasy demonstrator will be performed in three rural districts of the Diana region, located in northern Madagascar: The Ambanja District, the Ambilobe District and the Diego II District. NANOE's nano-grids are already deployed in these districts, and are powering domestic uses of electricity in more than 150 villages.

Agri-machineries, cooling devices and water pumping solutions are the most prominent needs for productive uses of energy in most rural regions of Africa. In northern Madagascar, in these three districts, over 60% of the population works in the field and almost 20% earn a living from fishing. At the moment, very inefficient and expensive Diesel-run micro rice-husking, polishing and flour milling machineries are being used by the local population. The cold chain management for sea products is still an unsolved issue leading to a very low productivity of the artisanal fishing industry. Finally, the very low rate of access to clean water is a major source of health concerns throughout the region.

Figure 2 : Madagascar demonstration area [2]

b. Sierra Leone – Freetown

The Sierra Leonean demonstrator will be based in two different sites in Freetown, the capital and largest city of Sierra Leone. Located on the coast, in the west of the country, the city is home to around 1,000,000 inhabitants. Access to reliable energy and fertilizer are the precondition to the sustainability of the local agriculture and thus the access to food security of the population.

The first demonstrator will be implemented in Waterloo, peri-urban Freetown, close to farming areas in order to test the coupling of fertilizer, cater, electricity and heat solutions with local farmers.

Building on the results of the first demonstrator, the second one will be located in downtown Freetown, where it will experiment mainly with household and commercial waste.

Figure 3 : Sierra Leone demonstration area [2]

c. Kenya – Nairobi and Kisumu

The Kenyan demonstration will be conducted in the Nairobi metropolitan area, home to around 10,000,000 people. Motorcycles are already heavily used by the local population and motorcycle taxis, known as *boda bodas*, are one of the main ways to navigate Nairobi's saturated traffic.

With around 85% of its electricity coming from renewables and an excess production of about 800 MW, Kenya is in prime position to support e-mobility. However, the region faces challenges with energy access, transport, pollution and congestion as a result of its inefficient transport systems. Nairobi's aging vehicle fleet is especially responsible for hazardous particle emissions affecting both public health and the environment.

The demonstrator will be conducted in 15 of the main motorcycle hubs in urban and sub-urban areas of Nairobi in order to gather and compare information about various parts of the city.

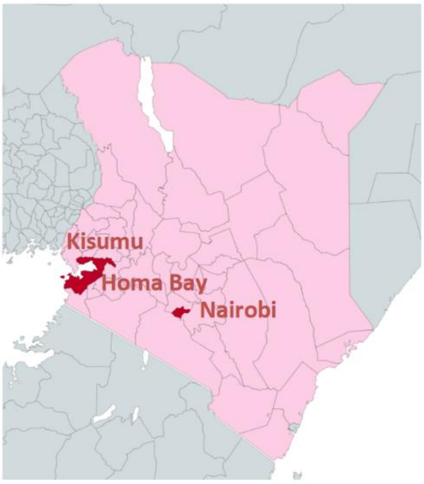

Figure 4: Kenyan demonstrating sites [2]

Using the learnings from the demonstration in Nairobi, a replication of the system will be developed in an additional 12 sites in Kisumu, Kenya's third largest city.

6. USE-CASES

This section presents three use-cases, each specific to a pilot. These provide a complete description of the narrative of the use cases, their objectives, actors, scenarios and KPIs. Each use-case also contains a UML diagram presenting the main functions performed by the demonstrator.

Note that these were defined in the early month of the project and some specific functionality might be subject to change as the project advances.

a. Madagascar – Nano-grids for domestic and productive use

This use-case describes how the demonstrator will produce renewable energy for both domestic and productive use in rural Madagascar [3].

Rural Africa faces two main energy challenges. On one side, a short-term challenge of quickly providing basic and affordable energy services in order to improve the living conditions of the largest share of its population. On the other side, a long-term challenge of developing sustainable, decentralized, decarbonized and smart powered infrastructures able to support the economic and social development of the continent. To ensure that both challenges are met, NANOE developed an innovative alternative electrification model: lateral electrification.

Lateral electrification is an agile process of progressive extension of the energy services delivered to rural end-users (from Tier 1 to Tier 4 as described in **Erreur ! Source du renvoi introuvable.**5) by quickly diffusing and aggregating basic smart units of solar power generation, storage and distribution called “Nano-grids”. These nano-grids are built and operated by franchised local rural entrepreneurs, selected in each village among the local community through written and oral tests. The entrepreneurs then enter a free 4-months training session on commercial, technical and business aspects of lateral electrification during which they have to find their first clients and build their first nano-grids. These entrepreneurs are remunerated by a 20% share of all electricity credits bought by their clients through the NANOE PAYGO mobile money platform, the remaining 80% being retained by NANOE to cover for technical assistance, components replacements, upgrades and uncertainties. This approach allows to have trained and properly incentivized solar off-grid operators with both technical and marketing skills spread across rural villages, able to ensure a high quality of service. This business model also ensures the sustainability of the project far beyond the end of grant funding.

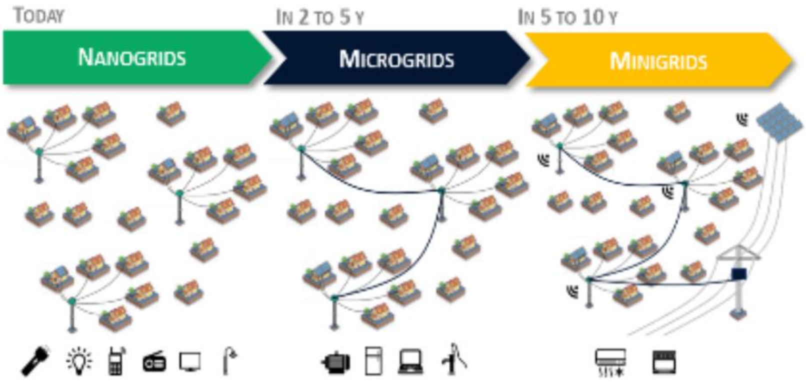

Figure 5: Expected tier evolution in rural areas [2]

In addition to this electrification model, different innovative ECOSUN solar technologies will be implemented within the project and adapted to the local contexts and needs in terms of size, power, load and connectivity to productive use appliances. Among them, the containerized solar solutions Mobil-watt, Mobil-grid and Fix-watt, that are produced by ECOSUN, have already been tested in similar environmental conditions and are foreseen to have a great potential in the Malagasy demonstration sites when tailored to the local needs.

Figure 6: ECOSUN's Mobil-watt [4]

The project aims to enable both domestic and productive use of electricity for local populations. Domestic use covers the proper functioning of a lighting system and the ability to use low voltage appliances (phone, TV, radio …). As for productive use, three different applications have been identified:

- DC rice hullers
  Madagascar is one of the largest consumers of rice per capita (ca. 150 kg/year and capita) worldwide, and its small-scale production does not supply its need, hence Madagascar is a net importer of rice (400-600 thousand tons yearly). Most families grow their own rice which, once harvested, is processed in a stationary mechanical de-husking machine (rice huller). Typically, each village has access to one such machine but also a rice mill. Currently, rice hullers are mostly fossil fuel (diesel) driven leading to higher running cost (diesel motors are less effective than electric motors) and poor working conditions (gaseous emissions, heat, and noise). Based on the needs identified with the local stakeholders, innovative designs of electric

machineries will be provided by RISE, from concept development to practical testing in field conditions to the dissemination of available technologies. Different strategies will be considered, including the retrofitting of existing machineries with adapted DC motors and implementation of DC based electric machineries available on the market.

- Cooling
  The nano-grids aim for an enhanced productive use in agricultural areas. Therefore, cooling and grids will be developed. The development will be two-fold: The adaptation of building-integrated nano-grids to power DC refrigeration systems, and the integration of all-in-one containers of cooling systems. Both types of systems will be integrated in the productive use nano-grids tests implemented in rural Madagascar. Indeed, among the local needs, ensuring a good preservation of the food provided by local agriculture is key given the climatic conditions.

- Water systems
  Water specific grids will be developed. The development will be two-fold: the adaptation of building integrated nano-grids to power DC water pumps, and the integration of all-in-one containers providing desalination solutions. Both types of systems will be integrated in the productive use nano-grids tests implemented in rural Madagascar. Since most villages located in coastal areas have little access to purified water, access to drinkable and irrigation-compatible low salt water remains a high-priority need of the local population.

Relevant KPIs for this use-case are identified in

Key performance indicators		
ID	***Name***	***Description***
1	Number of diesel agricultural machineries replaced	Target: 20
2	Number of food storage units equipped with conservation solutions	Target: 10
3	Number of water-pumping installations deployed	Target: 10

Table 1: KPIs of use-case 1

The main actors and functions supporting the use case are depicted in the UML diagram in Figure 7.

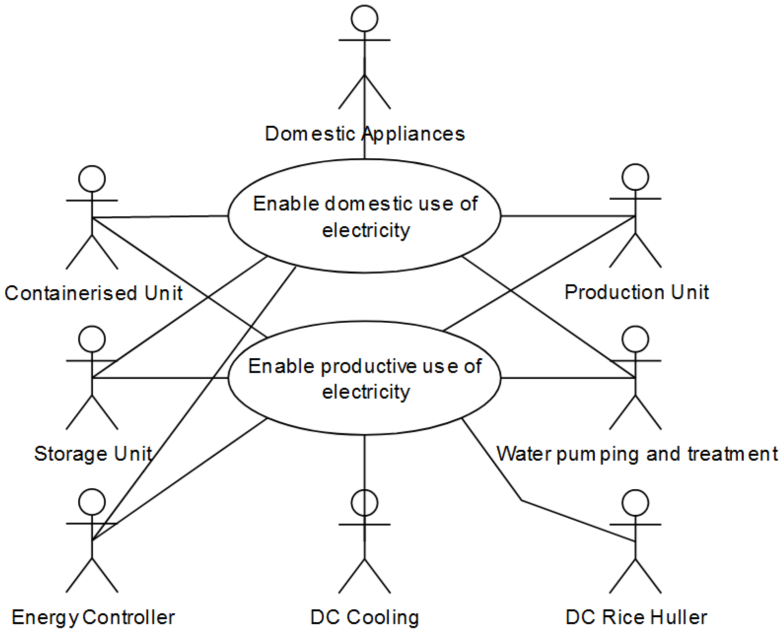

Figure 7: System Use Case Diagram

For more information concerning this use-case, and especially its scenarios, please refer to Annex A.

b. Sierra Leone - Organic waste valorisation and water purification

This use-case describes the use of the biogas digester and water purification systems in the peri-urban and urban context by the Sierra Leonean pilot. It aims to provide drinking water, organic fertilizer and electricity to the local population while studying the replicability and scalability of the system.

The demonstrator is based on two different technologies coupled together: water purification systems and biogas digesters.

The solar-based water purification technologies developed by TEK and CIEMAT use solar reactors that collect solar photons to accelerate the disinfection kinetics of microbial targets in water, solely by the use of solar light. These solar reactors will be combined with photocatalytic materials, which are known to strongly accelerate the water disinfection and boost decontamination performance by generating powerful oxidative species. This allows for the production of water that is drinkable, at low costs, while avoiding environmental damage.

The biogas digester consists of a gas tight and heated (37°C) tank where organic residues (food scraps, food processing residues or grocery store waste) are ground into a slurry. The material sits under consistent mixing for on average of 20-40 days. During this time a naturally occurring consortia of microbes breaks down the material, converting longer carbon chains to methane and carbon dioxide (biogas) while mineralizing a significant portion of the organically bound nitrogen to more immediately plant-available ammonium nitrogen. The residue, often called “digestate” contains all the nutrients of the ingoing materials and is recycled as an organic fertilizer for crop production. Depending on the hygienic quality of the ingoing material, the digestate may have to undergo some processes ensuring its hygiene (often pasteurization) to allow for safe fertilization if it is to be used on above ground crops for direct consumption. This well-established technology uniquely addresses the challenges of safe organic waste management, access to energy and access to fertilizer. In its state-of-the-art form, large, centralized facilities provide an appropriate organic waste management option, converting the waste to energy in the form of biogas (methane) and nutrient rich organic fertilizer. The methane is a versatile energy carrier that can be used as a cooking gas in its original form or converted to electricity and heat or even to vehicle fuel. The organic fertilizer contains all the nutrients of the organic waste in a mineralized form as well as the residual carbon, ideal for conserving and building soil fertility. Figure 8 summarizes the processes of the system.

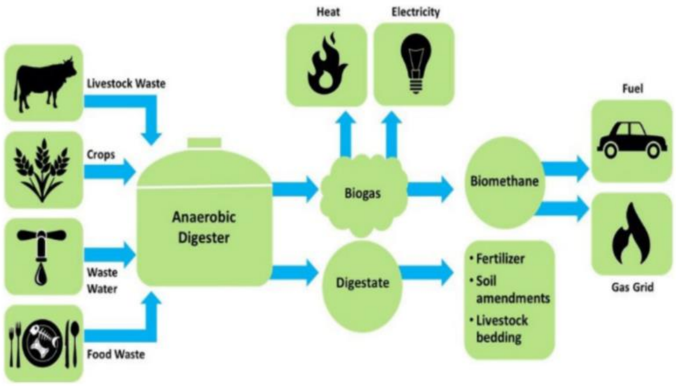

Figure 8: Principal system description for anaerobic digestion

The demonstrator aims to study the synergistic way that the two systems can compensate for each other's weaknesses. The water purification system relies on UV light to drive the process and electricity for pumps to move water through the system. In that sense, without UV light or electricity, the system will not generate disinfected water. The biogas system will ideally produce electricity evenly 24/7 as any variation in operational parameters will result in reduced energy conversion efficiency. At the same time, there is often less use of electricity during night-time, leaving a surplus of energy by night that can be used as a backup for solar systems The project will attempt an integration of the biogas system and the water purification system. For this purpose, the use of the biogas system as a form of uninterrupted power supply for the water purification system will be explored. During normal operation, the water purification system will run on its built-in Solar PV electricity supply, but in case of failure of this system or for night-time operation, the biogas system will provide a secure electricity back-up to ensure uninterrupted water disinfection operation. Another innovation that will be tested is to fit electrically powered UV lights on the back side of the transparent water purification reaction tubes. The water purification system will then be able to run on under-utilized biogas electricity during night-time, effectively doubling the operational time of the system through artificial UV lights during night to complement the natural sunlight during day.

The KPI that are relevant for the use-case 1 are identified in Table 2:

Key performance indicators		
ID	***Name***	***Description***
1	Water purification capacity per day (at the end of the project)	Target: 200-300L
2	Degradation rate	Target: 60%
3	Water quality (reduction of impurity)	Target: 80%
4	CAPEX reduction compared to existing system	Target: 20%
5	OPEX reduction compared to existing system	Target: 20%
6	Methane yield per m3 reactor volume per day with addition of ash compared to without (demo)	Target: +25%
7	Waste treatment capacity (kg/day)	Target: +20%
8	Incidence of process instability with addition of locally sourced nutrients compared to without	Target: -20%

Table 2: KPIs of use-case 2

The main actors and functions supporting the use case are depicted in the UML diagram in Figure 9.

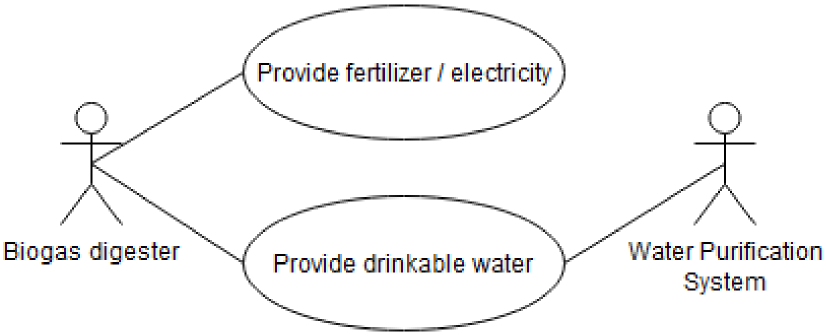

Figure 9: System Use Case Diagram

For more information concerning this use-case, and especially its scenarios, please refer to Annex B.

c. Kenya – Battery Swapping Stations

This use-case describes the use of battery swapping stations in Nairobi in order to enable electric mobility and extend energy access.

To enable a large-scale uptake of electric mobility in the two-wheeler industry, there needs to be a broadly geographically distributed network of chargers available in Nairobi, to enable agile driving patterns by the operators.

Today, electric motorcycles have been tested in Nairobi and end user demand verified for innovative services of swappable batteries and swapping stations. Therefore, the demonstrator will be focused on how swapping stations can be distributed optimally, including payment system and telemetry optimization.

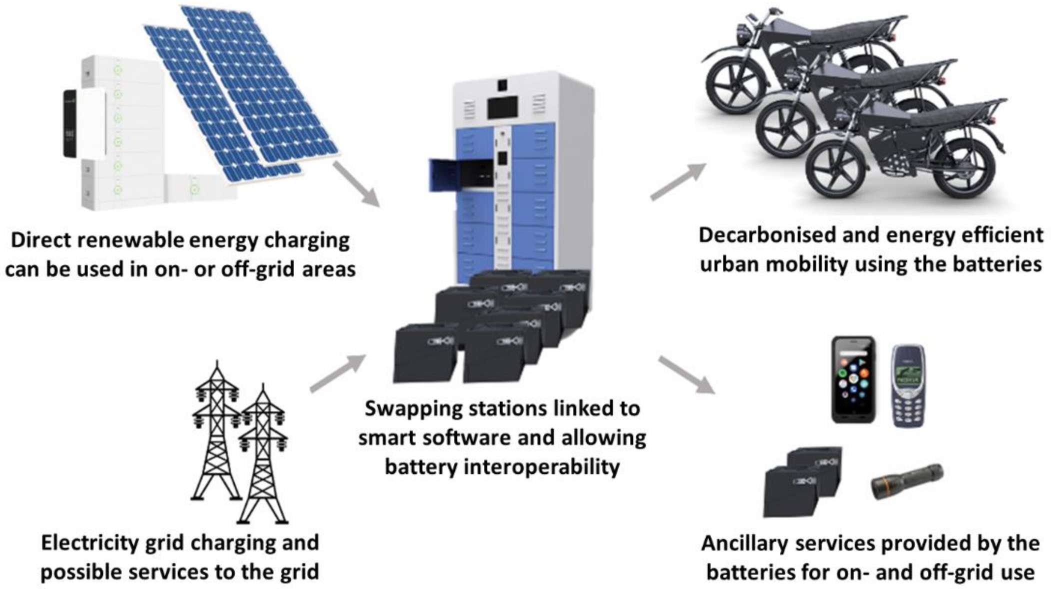

Figure 10: Eco-system for battery swapping [2]

The swapping stations are at the core of the demonstrator. The stations host 10 lithium batteries each, are interoperable with several battery voltages and chemistries, and are connected to a smart energy management software able to provide monitoring and charging optimization. Each swapping station is designed to operate on a regular three phase grid connection while being fitted with a solar system and battery storage to bring down the cost of electricity and ensure operation during electricity black outs. The solar energy systems will be connected to the smart energy management system to be able to monitor and optimize charging utilization, but also allow for easy and preventive maintenance. As part of the swapping system, the charging hubs can charge several batteries.

Finally, considering the number of actors that are launching electric motorcycles and swapping service activities in Africa, the question of interoperability is crucial. ROAM is therefore willing to enhance the standardization of batteries by opening their charging system to any other players under certain compliance conditions.

The electric motorcycles used for the Kenyan demonstrator are locally designed, developed and produced by ROAM in Nairobi. The electric motorcycles are low cost and durable, fitting the local market in terms of range, payload capacity, carrying volume, price and serviceability. Each unit includes a 2.7 kWh swappable battery giving the vehicle a range of 90km, 200kg payload, 90kph top speed and an acceleration of 6s (0-90kph). The robust motorcycle design is compatible with many local spare parts which ensure that the product is easily serviced and suitable for areas with inadequate infrastructure, therefore increasing the product lifetime and reducing cost over time.

As an additional side-benefit, these batteries can then be picked up as a motorcycle battery or a portable energy bank used for 240V or USB appliances in households or on the go. This energy distribution model can provide power for both transport services and households in large areas around one centralized charging hub without having connected every individual household to the grid. Therefore, such an ecosystem maximizes the distribution of energy access compared to traditional mobility systems (petrol-powered). This is enabled by the concept, but will not be the focus of this demonstrator.

The KPI that are relevant for this use-case are identified in Table 3:

Key performance indicators		
ID	***Name***	***Description***
1	Number of swapping stations installed during the project	Target: 15
2	Number of e-bikes made available during the project	Target: 150
3	Increased utilization of grid electricity	Target: > 200 MWh/Year
4	Number of users	
5	Total energy demands	
6	CO2 emission avoided	
7	Savings	Average savings made by an individual rider who switch to an electric motorcycle
8	Total distance travelled by electric bikes	
9	PV self-consumption	Share of local PV in the total consumption of the station (in %).

Table 3: KPIs of use-case 3

The main actors and functions supporting the use case are depicted in the UML diagram in figure 11.

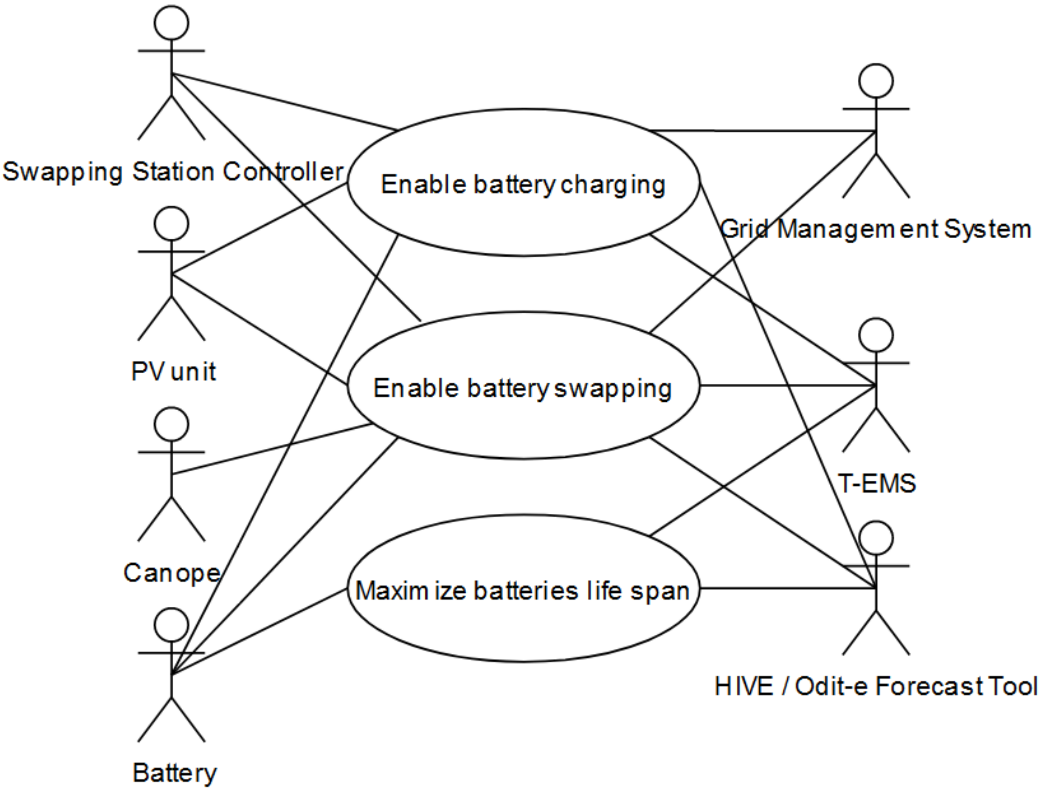

Figure 11: System Use Case Diagram

For more information concerning this use-case, and especially its scenarios, please refer to Annex C.

7. Comparison of ENERGICA use-cases

The ENERGICA use-cases are very reliant on innovative technologies. Therefore, it is interesting to compare them to previous projects in order to get perspective on the development of these use-cases. However, the European context is very different to the African context, which makes the comparison quite complicated.

The starting point of the comparison is to identify the objectives of the use-cases. These objectives are then matched with European use-cases with similar goals. The last section develops the mechanisms of the European use-cases, and the similarities and divergences with ENERGICA's use-cases.

a. Objectives of the ENERGICA use-cases

The objectives of the ENERGICA use-cases are summarized in the table below:

Objectives	**Madagascar**	**Sierra Leone**	**Kenya**
Energy access	x	x	x
Enable electric mobility			x
Renewable energy production	x	x	x
Local domestic use of electricity	x		x
Develop local productive use of electricity	x		
Provide drinkable water		x	
Provide organic fertilizer		x	

For each of these objectives, it is first assessed if it is relevant in the European context and then to which existing use-case, from the IEC 62913 standard or from an EU project, it could be mapped.

Energy access

The energy access objective is not really considered in the European use-cases as the European network is quite extensive and reliable. However, the energy access is studied in the MAESHA "Energy access" use-case [5], in the quite similar context of Mayotte island.

Enabling electric mobility

The electric mobility use-case is quite similar in its mechanisms to those developed in the IEC 62913-2-4 standard [6], in the use-case "UC62913-2-4-B003 Charge an EV with demand-response", though it does not include the aspects of battery swapping. This aspect however has been studied in the Ten-t project's Slovakian pilot [7].

Renewable energy production

European innovation projects most often use existing RES or buy off-the-shelf RES solutions and integrate them in an existing electric grid: the challenge is to make the grid resilient to high levels of RES, not to install the RES itself. Therefore, no use-case specific to this objective was selected in the analysis.

Local domestic use of electricity

Corresponds to self-consumption use-cases, such as the Accept project use-case “Increase self-consumption at community level” [8].

Local productive use of electricity

The aspect of supporting the development of productive uses for electricity is not really considered in European use-cases. However, the mechanisms in ENERGICA are quite similar to those in the IEC 62913-2-1 standard [9], in the use-case “UC62913-2-1-B013: Guarantee a continuity in load service by islanding the microgrid”.

Provide organic fertilizer

Fertilizer access use-cases are not very developed in Europe because of the wide availability of fertilizers, however the use of fertilizer as a by-product of biomethane production is studied in the Incover project case study 1 [10].

Provide drinkable water

Water access use-cases are not very developed in Europe because of their wide availability, however the purification of wastewater in order to be used for field irrigation is studied in the Incover project case study 1 [10].

b. Use-cases selected and divergences towards the ENERGICA project

The first series of use-cases selected to compare the ENERGICA use-cases to the European use-cases are from the IEC 62913 standard. These use-cases are designed to be generic and fill common European problematics. However, some aspects of ENERGICA’s problematics are not covered in this standard, therefore a second series of use-cases from European projects was selected to complement them and investigate these aspects.

IEC 62913

The standard IEC 62913-2 contains a range of generic use-cases covering processes in the electricity grid in Europe. In particular, the UC62913-2-1 focusses on grid stability, and the UC62913-2-4 focusses on processes linked to the integration of electric vehicles in the electricity grid. These are particularly relevant to the ENERGICA project.

UC62913-2-1-B013

The UC62913-2-1-B013 “Guarantee a continuity in load service by islanding the microgrid” focusses on the mechanisms needed to manage a microgrid, especially in order to improve its resiliency towards blackouts in the global grid. In particular, the scenario five “maintaining the islanding” focusses on the behaviour of the microgrid when disconnected from the global grid, which is very similar to the “Local productive use of electricity” objective of the Madagascar use-cases. The process of this scenario is described in the Figure 12 below.

Figure 12: UC62913-2-1-B013 process

However, this use-case is designed for the grid-connected microgrids, and therefore includes aspects of communication with the global grid operator, and relies on the fact that the islanded microgrid will eventually get reconnected to the grid. In order for the use-case to include the ENERGICA system, it should include the case of a microgrid fully and permanently autonomous.

UC62913-2-4-B003

The UC62913-2-4-B003 “Charge an EV with demand-response” describes the processes to charge an electric vehicle with external control. This is highly similar to the Kenyan use-case in ENERGICA, in particular the charging of the motorbike’s batteries. The process of this use-case is described in the Figure 13 below.

Figure 13: UC62913-2-4-B003 process

However, this use-case does not include the battery swapping aspects, which is a very important part of the Kenyan pilot. It moreover does not include the goal of developing the network of charging stations. These are additional processes that would constitute additional use-cases.

MAESHA project use-case “Energy access”

The Mayotte pilot of the MAESHA European project focusses, among other use cases, on energy access for isolated communities. This use-case proposes to provide access to energy through a combination of local PV production and hydrogen produced in grid-connected areas that is shipped to the communities to improve reliability of electricity production, in order to support local community structures. The process of this use-case is described in Figure 14.

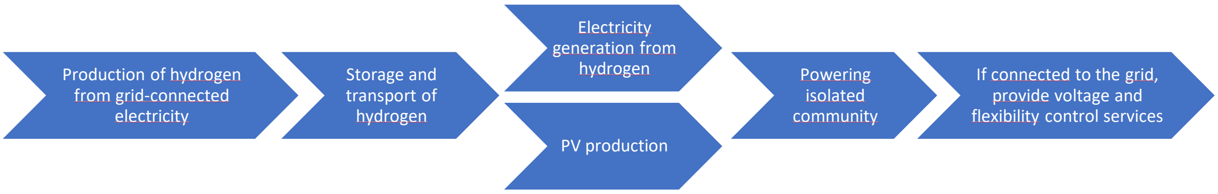

Figure 14: process of MAESHA project use-case “Energy access”

This use-case is not representative of the European grid, as the Mayotte grid is very different from it, however it encompasses the different aspects of the three pilots of ENERGICA:

- The Kenyan pilot takes advantage of energy produced through a grid and shipped to the disconnected area
- The Malagasy and Sierra Leonean pilots produces local PV energy

However, an aspect of the Sierra Leone pilot is missing: the energy access use-case not supported by a grid infrastructure is not supported. Moreover, contrarily to both the Malagasy and Sierra Leonean pilots, the electricity is only partially produced on-site and it is therefore not autonomous. Additionally, the MAESHA use-case is focussed on generating electricity, not on building a microgrid, and therefore does not include this aspect of the Malagasy pilot.

Accept project use-case "Increase self-consumption at community level"

The Accept project's use-case "Increase self-consumption at community level" is focussed on optimising locally the energy consumption in order to maximize the DER energy production. This self-consumption scheme relates to the "optimize local consumption" objective present in both the Malagasy and Kenyan use-cases. The process enabling this use-case is described in the scenario 1, and is summarized in the Figure 15 below.

Figure 15: process of Accept project use-case "Increase self-consumption at community level"

However, the process relies on the use of flexibility forecast, which is not available in either pilot. The Kenyan pilot includes features of grid observability and forecast, and there is grid metering in the Malagasy pilot, but no actual flexibility forecast. The exclusion of this feature implies that the optimization will probably be less precise.

Incover project case study 1

The Incover project aims at producing Biomethane, biofertilizer and irrigation water from wastewater. Therefore, both the "access to fertilizer" and "access to drinkable water" objectives of the Sierra Leonean use-case in ENERGICA are represented here. The technologies and mechanisms involved are moreover quite similar, with several very entangled systems. The overall process is described in the Figure 16 below.

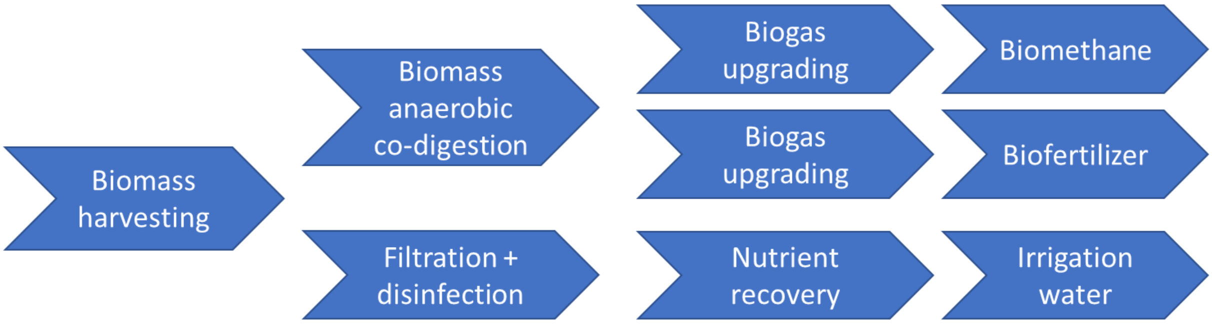

Figure 16: process of Incover project case study 1

The outcomes of Incover are quite similar to those of ENERGICA, however, the production of electricity, and its use in the water purification is missing here. Moreover, the water end-product in Incover is purified, but not actually drinkable, which is a big difference from ENERGICA, since the access to drinkable water is very important in the Sierra Leonean context.

Ten-t project battery swapping pilot

The ten-t project, though its use-cases were not available, enables to showcase the mechanism of battery swapping in Europe. The project has developed two energy hubs for light freight vehicles, combining a battery swap station and a fast-charger in Slovakia. The stations are supported by a smart back-end system, which enables central dispatch, monitoring and statistic collection, and remote adjustments. This is very similar to the system of swapping stations developed in ENERGICA's Kenyan pilot, which features similar functions, even though they are scaled for motorcycles batteries.

Moreover, the project has supervised the development and installation of the stations, with the acquisition and adaptation of batteries. This is relatable to the development of stations in Kenya, though on a smaller scale, as the Kenyan pilot aims at ending up with a minimum of 15 swapping stations by the end of the project. The conditions for the location of the charging stations are moreover quite similar in both projects: convenient access, availability of grid supply and reasonable costs for instance.

8. CONCLUSION AND NEXT STEPS

These use cases pave the way for the development of each demonstrator. They provide a first look on what the system aims to achieve and how it will proceed. It should be used by pilots to ensure a common understanding of the functions and objectives of the systems they are developing.

Here are the three use-cases designed:

1. Madagascar: Nano-grids for domestic and productive use
2. Sierra Leone: Organic waste valorisation and water purification
3. Kenya: Battery Swapping Stations

The following steps comprise the definition of each demonstrator architecture in the deliverable D1.2 to further specify their mode of operation. Additionally, the cybersecurity and privacy, as well as the telecom requirements will be further detailed in the task T1.4, based on this study.

Moreover, we can see that the use-cases in ENERGICA and in European projects can have quite similar processes in many areas, even though the context is quite different. In particular, the presence in Europe of an electricity grid that is fully developed induces massive differences with the Malagasy and Sierra Leonean pilots, which focusses on bringing energy in areas that do not have access to an electricity grid.

The results of this analysis aim to study the potential replicability and adaptability of European use-cases in the African context, and vice-versa. The dissemination of the ENERGICA use-cases will be achieved by sharing the ENERGICA use-cases through the BRIDGE use-case repository, and in the cluster of energy projects with Africa. The ENERGICA use-cases will additionally be considered in the BRIDGE Reference Framework (in particular its Generic Business Processes) in order to broaden its scope.

9. REFERENCES

[1] IEC, “62559-2: Use case methodology - Part 2: Definition of the templates for use cases, actor list and requirements list.,” 2015.

[2] ENERGICA project Grant Agreement ID 0103742, “GRANT AGREEMENT NUMBER 101037428 — ENERGICA,” 2020.

[3] Nanoe, “Electrification latérale – Vers un nouveau modèle d’électrification pour l’Afrique”.

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[5] MAESHA European project (Grant Agreement ID 957843), “D1.1 Use cases, Requirements and KPIs,” 2021.

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[7] GreenWay, “Commercial deployment of inter-urban EV freight logistics infrastructure,,” 2015.

[8] Accept European project, Grant Agreement n°957781, “D2.1 – ACCEPT business scenarios, use cases & requirements,” 2021.

[9] IEC, “IEC 62913 Generic smart grid requirements - Part 2-1: Grid related domains,” 17 5 2019. [Online]. Available: https://webstore.iec.ch/publication/32407.

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10. ANNEXES

a. Malagasy demonstrator

1. Description of the use case

1.1 Name of the use-case

Use case identification		
ID	***Area/Domain/Zone(s)***	***Name of the use case***
UC1	Area: Energy Systems Domains: DER, Customer Premises Zones: Process, Field	Madagascar – Nano-grids for domestic and productive uses in Rural Context

1.2 Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
0.1.	01/02/2022	Hadrien Lafforgue - TRIALOG	Draft	
1.0.	08/07/2022	Hadrien Lafforgue - TRIALOG	Scenarios description added	

1.3 Scope and objective of use case

Scope and objectives of the use case	
Scope	This use-case is limited to the study of renewable energy production for domestic and productive use in rural Madagascar.
Objective(s)	• Produce electricity through renewables. • Allow for a local domestic use of electricity. • Develop local productive use of electricity.
Related business case(s)	

1.4 Narrative of use case

Narrative of use case
Short description
The Malagasy demonstrator will be performed in three rural districts of the Diana region in northern Madagascar (Ambanja District, Ambilobe District and Diego II District) where NANOE's solar nano-grids are already powering domestic and other non-productive users in more than 150 villages (typically counting 100-200 households and limited economic activities). Agri-machineries, cooling devices and water pumping solutions are the most prominent needs for productive uses in these Districts as well as in most rural regions of Africa. Indeed, over 60% of the population works in the field and almost 20% live from fishing and sea products. Very inefficient and expensive diesel-run micro rice-husking, polishing and flour milling machineries are present in almost all rural villages of these districts. The cold chain management for sea products is still an unsolved issue leading to a very low productivity of this artisanal industry and the very low rate of access to clean water is a major source of health concerns throughout the region (for babies and children in particular).

Figure 17 : Madagascar demonstration area

Complete description

This use-case describes how the demonstrator will produce renewable energy for both domestic and productive use in rural Madagascar.

Rural Africa faces two main energy challenges. On one side, a short-term challenge of quickly providing basic and affordable energy services in order to improve the living conditions of the largest share of its population. On the other side, a long-term challenge of developing sustainable, decentralised, decarbonised and smart powered infrastructures able to support the economic and social development of the continent. To ensure that both challenges are met, NANOE developed an innovative alternative electrification model: lateral electrification.

Lateral electrification is an agile process of progressive extension of the energy services delivered to rural end-users (from Tier 1 to Tier 4 as described in **Erreur ! Source du renvoi introuvable.**3) by quickly diffusing and aggregating basic smart units of solar power generation, storage and distribution called “Nano-grids”. These nano-grids are built and operated by franchised local rural entrepreneurs, selected in each village among the local community through written and oral tests. The entrepreneurs then enter a free 4-months training session on commercial, technical and business aspects of lateral electrification during which they have to find their first clients and build their first nano-grids. These entrepreneurs are remunerated by a 20% share of all electricity credits bought by their clients through NANOE PAYGO mobile money platform, the remaining 80% being retained by NANOE to cover for technical assistance, components replacements, upgrades and uncertainties. This approach allows to have trained and properly incentivised solar off-grid operators with both technical and marketing skills spread across rural villages, able to ensure an incomparable quality of service. This business model also ensures the sustainability of the project far beyond the end of grant funding.

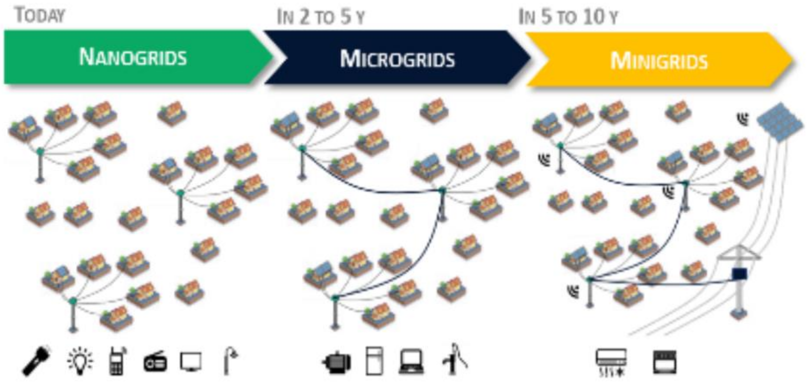


Figure 2: Expected tier evolution in rural areas [2]

In addition to this electrification model, different innovative ECOSUN solar technologies will be implemented within the project and adapted to the local contexts and needs in terms of size, power, load and connectivity to productive use appliances. Among them, the containerised solar solutions Mobil-watt, Mobil-grid and Fix-watt have already been tested in similar environmental conditions and are foreseen to have a great potential in the Malagasy demonstration sites when tailored to the local needs.

Figure 3: ECOSUN's Mobil-watt [4]

The project aims to enable both domestic and productive use of electricity for local populations. Domestic use covers the proper functioning of a lighting system and the ability to use low voltage appliances (phone, TV, radio …). As for productive use, three different applications have been identified:

- DC rice hullers
  Madagascar is one of the largest consumers of rice per capita (ca. 150 kg/year andcapita), and its small-scale production do not supply its need, hence Madagascar is a net importer of rice (400-600 thousand tons yearly 8). Most families grow their own rice which, once harvested, is processed in a stationary mechanical de-husking machine (rice huller). Typically, each village has access to one such machine but also a rice mill. Currently, rice hullers are mostly fossil fuel (diesel) driven leading to higher running cost (diesel motor are less effective than electric motors) and poor working conditions (gaseous emissions, heat, and noise). Based on the needs identified with the local stakeholders, innovative designs of electric machineries will be provided by RISE from concept development to practical testing in field condition and dissemination of available technologies. Different strategies will be considered, including the retrofitting of existing machineries with adapted DC motors and implementation of DC based electric machineries available on the market.

- Cooling
  The nano-grids aim for an enhanced productive use in agricultural areas. Therefore, cooling and grids will be developed. The development will be two-fold: the refurbishment and adaptability to fixed nano-grids of traditional or AC refrigeration, and the integration of all-in-one containers of cooling systems. Both types of systems will be integrated in the productive use nano-grids tests implemented in rural Madagascar. Indeed, among the local needs, ensuring a good preservation of the food provided by local agriculture is key given the climatic conditions.

- Water systems
  Water specific grids will be developed. The development will be two-fold: the adaptation of building integrated nano-grids to power DC water pumps, and the integration of all-in-one containers providing desalination solutions. Both types of systems will be integrated in the productive use nano-grids tests implemented in rural Madagascar. Indeed, most villages being in coastal areas with little access to purified water, access to drinkable and irrigation-compatible low salt water is necessary for a proper impact on the local population.

1.5 Key performance indicators

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Number of diesel agricultural machineries replaced	Target: 20	Develop local productive use of electricity.
2	Number of food storage units equipped with conservation solutions	Target: 10	Develop local productive use of electricity.
3	Number of water-pumping installations deployed	Target: 10	Develop local productive use of electricity.

1.6 Use case conditions

Use case conditions
Assumptions
• Industrial consumers will be interested in switching to electric machinery
Prerequisites
• Identify hardware supplier • Identify implementation sites with the help of local NGO

1.7 Further information to the use case for classification/mapping

Classification information
Relation to the other use cases
Level of depth
Generic
Prioritization
Obligatory
Generic, regional or national relation
Regional
Nature of the use case
Technical and business UC
Further keywords for classification
Distributed Energy Resource (DER), Agri-machinery, Cooling device, Water pump

1.8 General remarks

General remarks
The Malagasy regulation for installations under 10kW is flexible but subject to frequent change. It is thus susceptible to change before the on-site implementation. Weather constraints make it impossible to work on-site from January to March.

2 Diagrams of use case

Diagram(s) of use case

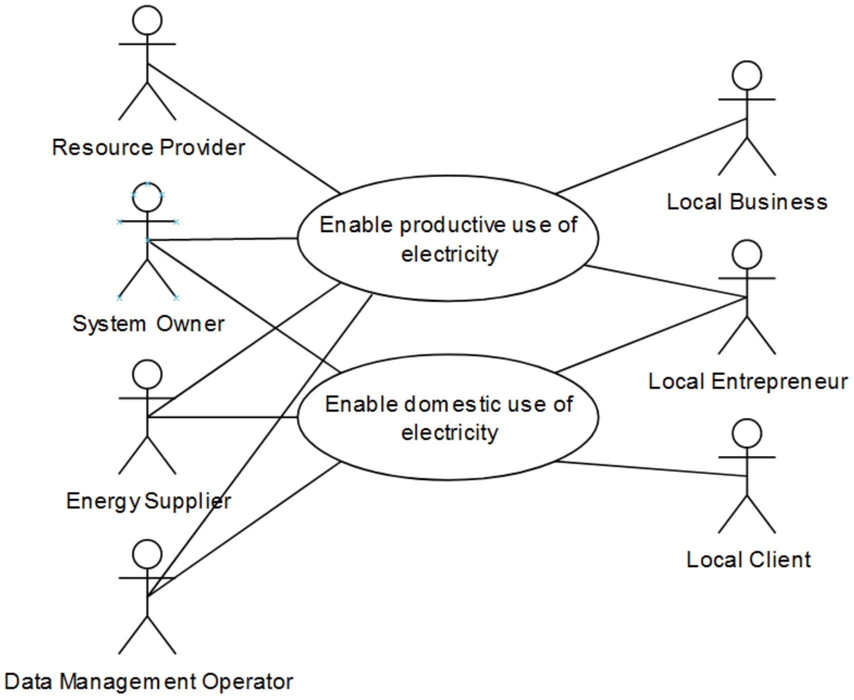


Figure 18 : Business Use Case Diagram

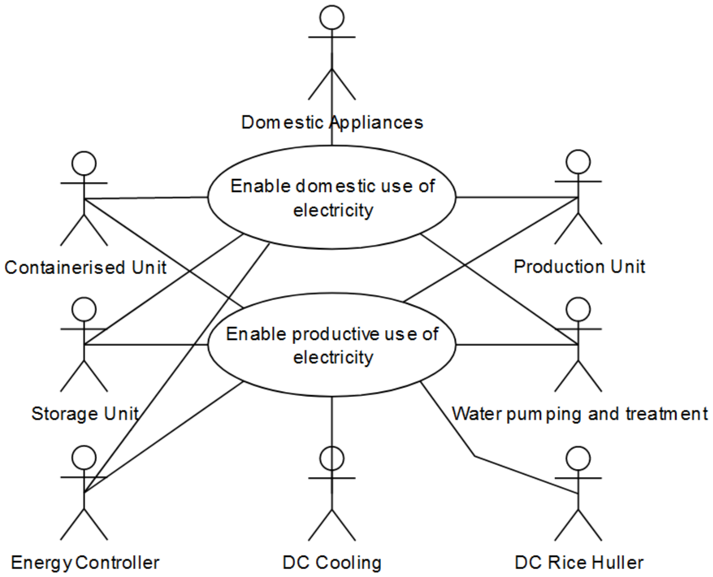


Figure 19 : System Use Case Diagram

3 Technical details

3.1 Actors

Actors			
Grouping		***Group Description***	
Business Actor		Physical or legal person that has his own interests, defined as “Business Goals”	
Operator		Business Actor that operates a system	
Logical Actor		Technical entity that takes part in the execution of a use case. A logical actor can be mapped to a physical component	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***

Business Actor			
System Owner	Business Actor	Designs and operates the nano-grids	Nanoe
Energy Supplier	Business Actor	Provides plug-and-play containerized solutions	Ecosun
Resource Provider	Business Actor	Provides electric agri-machinery.	RISE (Research Institute of Sweden)
Data Management Operator	Business Actor	Provide software-based solution for the monitoring of technical parameters	Odit-e
Local Business (Client)	Business Actor	Local business (fisheries, grocery shop …) in need of refrigeration solutions.	
Local Community (Client)	Business Actor	Local community in need of drinking water and rice.	
Operator			
Local entrepreneur	Operator	Franchised local entrepreneurs who build and operate the nano-grid. They are remunerated by a 20% share of all electricity credits bought by their client.	Ref 1
Logical Actor			
Production Unit	Logical Actor	The production unit of the nano-grids consists of one or more photovoltaic panels mounted on structures firmly anchored on the roof of one of the connected households. The installed production capacity varies from 100 Wp to 10 kWp depending on the number of users connected to the nano-grid and their energy needs.	Ref 1
Containerized Unit	Logical Actor	Mobile/semi-mobile/fixed solar power plant delivered in a pre-assembled container.	Ref 1
Storage Unit	Logical Actor	The storage unit is made up of batteries located in a dedicated, ventilated and sealed box, installed in one of the connected users' homes; it is designed to be able to store at least 3 days of consumption in order to ensure a maximum availability rate of the service under local conditions.	Ref 1
Energy Controller	Logical Actor	Independently monitors and controls the energy supply of all consumers. Stores consumption data (load curves for each user, battery charge level curves, power overruns, short circuits, time of credit recharges)	Ref 1
Common Interface	Logical Actor	Common interface to all consumers connected to the Energy Controller. Allow for the entry of credit codes giving access to a fixed amount of energy and display remaining prepaid energy credit to each consumer.	Ref 1
Large Consumer Controller	Logical Actor	Combines the functions of controller, interconnection modules and DC/AC conversion for large non-domestic consumers whose main usage would be in AC.	Ref 1
Nanoe Platform	Logical Actor	Stores data about each nano-grid (client, energy use, …). Centralizes and secures payments. Allows for the monitoring of maintenance efforts. Allows for the accounting monitoring of each entrepreneur.	Ref 1
Domestic Appliances	Logical Actor	LED lamps / electric sockets allowing for the connection of a phone battery, television, radio, …	Ref 1
DC Rice Huller	Logical Actor	Process harvested rice.	Ref 2
DC cooling	Logical Actor	Refrigerator / Ice block producer.	Ref 2
Water Pumping and Treatment	Logical Actor	Produces drinking water.	Ref 2

3.2 References

Version management						
No.	***Reference type***	***Reference***	***Status***	***Impact on use case***	***Originator/organization***	***Link***
1	Study	Electrification latérale – Vers un nouveau modèle d'électrification pour l'Afrique			Nanoe	
2	Contract	Grant Agreement - ENERGICA			European Commission	

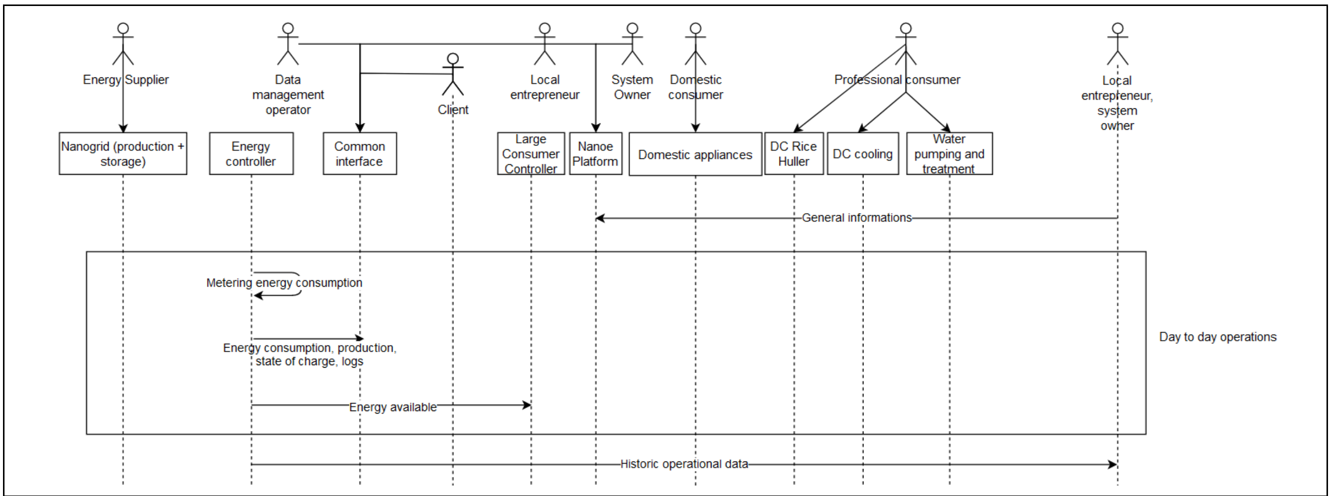
4 Step by step analysis of use case

4.1 Overview of scenarios

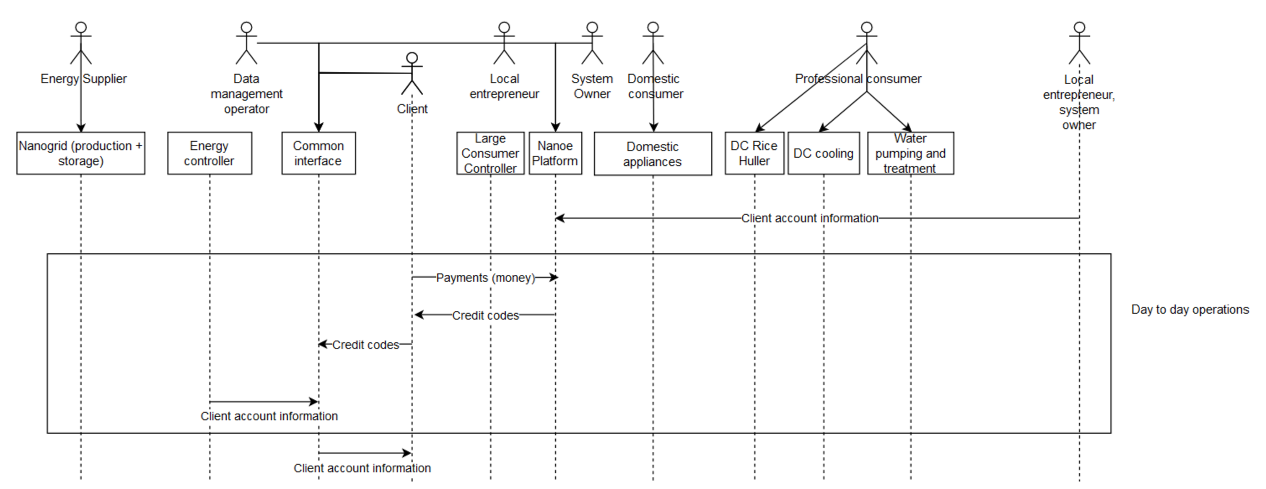
Version management						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Metering data management	How metering data is handled during the nano-grid's operations.	Energy controller	Nano-grid installation		
2	Client Data management	How data account and financial information is managed during the nano-grid's operations.	Client	Nano-grid installation		
3	Nominal operation	How the nano-grid operates in nominal conditions.	Nano-grid	Nano-grid installation		
4	Energy constrained operation	How the nano-grid operates under energy stress.	Large consumer controller	The system's energy storage and production cannot support its consumption	The system is under energy stress.	The system no longer is under energy stress.

4.2 Steps – Scenarios

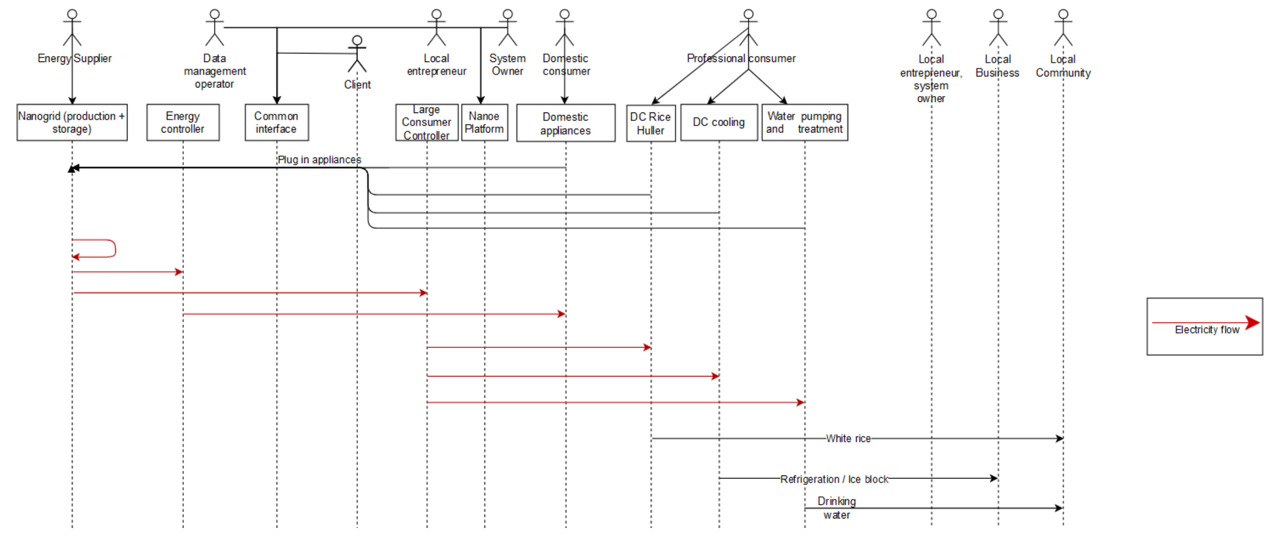
Scenario							
Scenario name	Metering data management						
Step No.	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information exchanged (IDs)***	***Requirements, R-IDs***
1	Nano-grid installed	General information report	The local entrepreneur reports general information about the nano-grid to the nanoe platform.	REPORT	Local entrepreneur	Inf1	R2, 3, 4-10, 12, 13, 14, 16, 18-24
2	Nano-grid operational	Metering energy consumption	The energy controller monitors the energy consumption of the nano-grid.	CREATE	Energy controller	Inf2	R2, 3, 4-10, 11, 12, 13, 14, 15, 17, 18-24
3	Metering on going	Metering data report	The energy controller reports metering data to the Common Interface.	REPORT	Energy controller	Inf2	R2, 3, 4-10, 11, 12, 13, 14, 15, 17, 18-24
4	Metering on going	Energy available report	The energy controller reports to the large consumer controller the energy available.	REPORT	Energy controller	Inf3	R1, 3, 4-10, 11, 12, 13, 14, 16, 18-24
5	The local entrepreneur needs to access the grid's data	Historic data report	The local entrepreneur gets access to the historic operational data from the energy controller.	GET	Energy controller	Inf4	R4-10, 12, 13, 14, 18-24



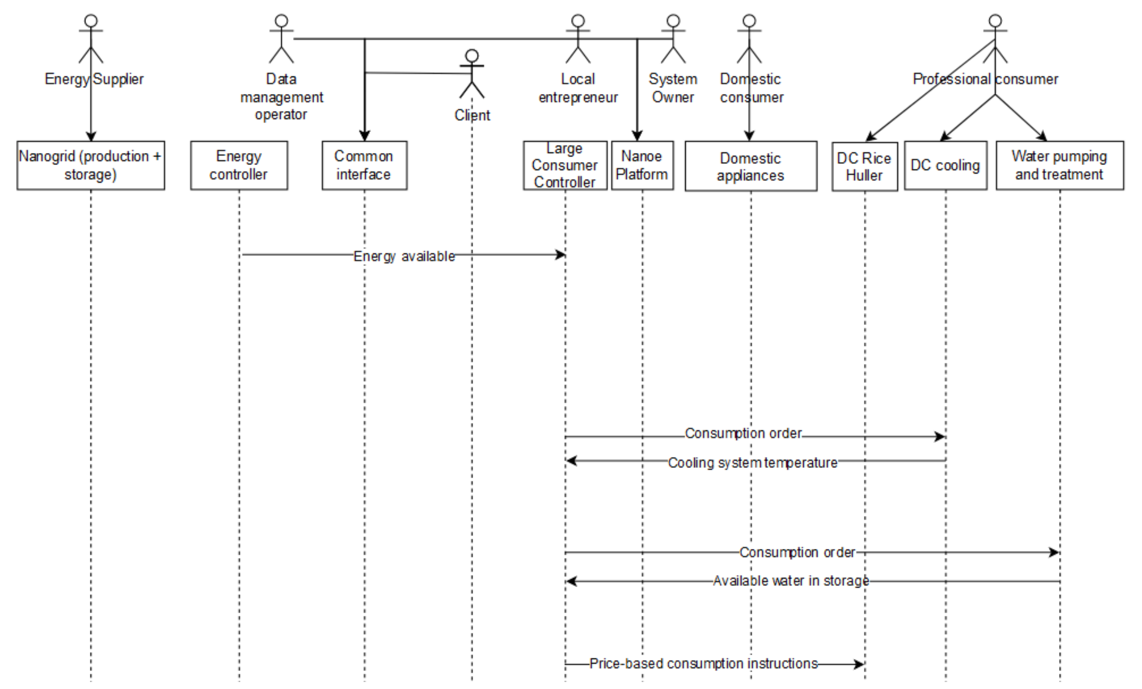
Scenario name	Client data management						
Step No.	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information exchanged (IDs)***	***Requirements, R-IDs***
1	Nano-grid installed	Client account creation	The local entrepreneur reports the new client to the Nanoe platform.	REPORT	Local entrepreneur	Inf5	R1, 4-10, 12, 13, 14, 18-24
2	Client wants to add credit to his account	Payment	The client pays Nanoe through its platform (via mobile) in order to get credit for his electricity consumption.	EXECUTE	Client		
3	Payment processed	Credit codes given	The client gets his credit codes.	CREATE	Nanoe Platform	Inf6	R1, 2, 4-10, 12, 13, 14, 18-24
4	Credits code given to the customer	Credit codes transmitted	The client inputs his codes into the common interface.	REPORT	Client	Inf6	R1, 2, 4-10, 12, 13, 14, 18-24
5	Client is consuming electricity	Client account information report	The energy controller updates the account's information as the client is consuming electricity.	EXECUTE	Energy controller	Inf5	R1, 4-10, 12, 13, 14, 18-24
6	Client wants to access his account information	Client account information visualisation	The client visualises his account information through the common interface.	GET	Common interface	Inf5	R1, 4-10, 12, 13, 14, 18-24



Scenario name	Nominal operation						
Step No.	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information exchanged (IDs)***	***Requirements, R-IDs***
1	Clients wants to use his device	Plug in	The client plugs his device to the grid.	EXECUTE	Devices		
2	Device plugged in	Electricity distribution	The nano-grid distributes electricity.	EXECUTE	Nano-grid		
3	Specific to productive use case	Production	Depending on the device, production of white rice, refrigeration / ice block, drinking water.	EXECUTE	Devices		



Scenario name	Energy constrained operation						
Step No.	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information exchanged (IDs)***	***Requirements, R-IDs***
1	Metering ongoing	Energy available report	The energy controller reports to the large consumer controller the energy available.	REPORT	Energy controller	Inf3	R1, 3, 4-10, 11, 12, 13, 14, 16, 18-24

2	Energy lacking	Consumption order	The large consumer controller issues consumption order to the DC cooling unit and/or the Water pumping and treatment system	CHANGE	Large consumer controller	Inf7	R2, 3, 4-10, 11, 12, 13, 18-24
3	Consumption order received	Device response	The device responds to the consumption order with information regarding its state (temperature for the cooling unit and water storage for the water system).	REPORT	DC cooling unit / Water pumping and treatment system	Inf8	R1, 3, 4-10, 11, 12, 13, 14, 18-24
4	Energy lacking	Price-based consumption instructions	The large consumer controller issues prices-based instructions for the rice huller.	CHANGE	Large consumer controller	Inf9	R3, 4-10, 11, 12, 13, 14, 18-24
							

5 Information exchanged

Information exchanged			
Information exchange, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf1	General information report	Report containing general and technical information related to the nano-grid.	R2, 3, 4-10, 12, 13, 14, 16, 18-24
Inf2	Metering information	Metering information monitored by the energy controller.	R2, 3, 4-10, 11, 12, 13, 14, 15, 17, 18-24
Inf3	Energy available	Energy available (production + storage) at a given time.	R1, 3, 4-10, 11, 12, 13, 14, 16, 18-24
Inf4	Historic data	Report containing the nano-grid historic operational data.	R4-10, 12, 13, 14, 18-24
Inf5	Client account information	Information related to the client’s account (credit, credentials, …)	R1, 4-10, 12, 13, 14, 18-24
Inf6	Credit codes	Credit codes given by Nanoe in exchange for payment. Gives access to a fix amount of electricity.	R1, 2, 4-10, 12, 13, 14, 18-24
Inf7	Consumption order	Consumption order issued during energy constrained operations.	R2, 3, 4-10, 11, 12, 13, 18-24

Inf8	Device response to orders	The devices answer the consumption order with information regarding their state of functioning.	R1, 3, 4-10, 11, 12, 13, 14, 18-24
Inf9	Price-based consumption instructions	Consumption instructions issued during energy constrained operations. Change the price of electricity for a certain time period.	R3, 4-10, 11, 12, 13, 14, 18-24

6 Requirements (optional)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Requirement R-ID	***Requirement name***	***Requirement description***
R1	Number of Information Producers	Thousands to millions
R2	Number of Information Receivers	Thousands to millions
R3	Distance between entities	Many kilometres
R4	Communication configuration	WAN
R5	Communication media	Wireless required
R6	Communication ownership	Internet
R7	Communication bandwidth	2.4-56 kbps
R8	Data exchange methods	Client-server
R9	Communication access services requirements	Request-response
R10	Data exchange pattern	Data flow is <10% of bandwidth available
R11	Growth	10x number of participating devices - Over the next 5 years
R12	Operation mode of Information Producer	Manual & Automatic
R13	Operation mode of Information Receiver	Manual & Automatic
R14	Availability of information flows	99% + availability -Allowed outage: 3.5 days per year
R15	Precision of data requirements (normally relevant only for conversions, e.g. analogic to digital)	>0.5% variance
R16	Accuracy of data requirements	Adequate accuracy can be assumed
R17	Frequency of data exchanges	Every few seconds
R18	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data	Quite important
R19	Information integrity violation: Ensuring that data is not changed or destroyed	Crucial
R20	Authentication: Masquerade and/or spoofing: Ensuring that data comes from the stated source or goes to authenticated receiver	Crucial
R21	Repudiation: Ensuring that the source cannot deny sending the data or that the receiver cannot deny receiving the data	Quite important
R22	Replay: Ensuring that data cannot be resent by an unauthorized source	Quite important
R23	Information theft: Ensuring that data cannot be stolen or deleted by an unauthorized entity	Quite important
R24	Denial of Service: Ensuring unimpeded access to data	Quite important

7 Common terms and definitions

Common terms and definitions

Term	*Definition*
AC	Alternative Current
DC	Direct Current
DER	Distributed Energy Resources
NGO	Non-Governmental Organisations
UC	Use-Cases
WAN	Wide Area Network

8 Custom information (optional)

Custom information (optional)		
Key	*Value*	*Refers to section*

b. Sierra Leonean demonstrator

1. Description of the use case

1.1 Name of the use-case

Use case identification		
ID	*Area/Domain/Zone(s)*	*Name of the use case*
UC1	Area: Energy Systems / Agriculture Domains: DER, Customer Premises Zones: Process, Field	Sierra Leone – Organic waste valorisation and water purification in sub-urban and urban context

1.2 Version management

Version management				
Version No.	*Date*	*Name of author(s)*	*Changes*	*Approval status*
0.0.	1/02/2022	Hadrien Lafforgue - TRIALOG	Draft	
0.1		Dune Sebilleau - TRIALOG	Review	
0.2	05/05/2022		Draft of complete version	

1.3 Scope and objective of use case

Scope and objectives of the use case	
Scope	This use-case is limited to the study of the use of the biogas digester and water purification systems in peri-urban and urban context of the Sierra Leonean pilot.
Objective(s)	• Provide drinkable water • Produce organic fertilizer / electricity • Study replicability and scalability
Related business case(s)	

1.4 Narrative of use case

Narrative of use case
Short description
The Sierra Leonean pilot is composed of two different demonstrators. The first one, located in Waterloo, peri-urban Freetown will be implemented close to farming areas to test the coupling of fertilizer and water solutions – in addition to electricity and heat – with local farmers. It is based on a pre-existing system that already has processed around 200 kg per day of organic waste. The demonstrator

consists of a two-fold improvement of the existing system: an optimisation and simplification of the design for lower costs and easier uptake, and an establishment of local manufacturing of the plant for uptake and local series build.

The second demonstrator, located in downtown Freetown will capitalise on the results from the first one and upscale and focus on upscaling and replication. Tested in urban context, the demonstrator will have a larger capacity (3000 kg/day). The replicability will be focusing on validating the capability of adapting and redesigning technology to achieve an optimal performance. In addition, each site will also be the basis of a technical and non-technical case study for which data, media and other information will be gathered for input to perform further design and fine tuning. Based on real experience, the demonstrated project approach can more confidently be repeated, both more widely and on a larger scale.

Figure 20 : Sierra Leone demonstration area

Complete description

This use-case describes the use of the biogas digester and water purification systems in peri-urban and urban context by the Sierra Leonean pilot. It aims to provide drinking water, organic fertilizer and electricity to the local population while studying the replicability and scalability of the system.

The demonstrator is based on two different technologies coupled together: water purification systems and biogas digesters.

The solar-based water purification technologies developed by TEK and CIEMAT uses solar reactors that collects solar photons to accelerate the disinfection kinetics of microbial targets in water by the sole action of solar light. These solar reactors will be combined with photocatalytic materials, which are known to strongly accelerate the water disinfection and boost decontamination performance by generating powerful oxidative species.

The biogas digester consists of a gas tight and heated (37°C) tank where organic residues (food scraps, food processing residues or grocery store waste) are ground into a slurry. The material sits under consistent mixing for on average 20-40 days. During this time a naturally occurring consortia of microbes breaks down the material, converting longer carbon chains to methane and carbon dioxide (biogas) while mineralising a significant portion of the organically bound nitrogen to more immediately plant-available ammonium nitrogen. The residue, often called “digestate” contains all the nutrients of the ingoing materials and is recycled as an organic fertiliser for crop production. Depending on the hygienic quality of the ingoing material, the digestate may have to undergo some sort of hygienization step (often pasteurisation) to allow for safe fertilisation if it is to be used on above ground crops for direct consumption. This well-established technology uniquely addresses the challenges of safe organic waste management, access to energy and access to fertiliser. In its state-of-the-art form, large, centralised facilities provide an appropriate organic waste management option, converting the waste to energy in the form of biogas (methane) and nutrient rich organic fertiliser. The methane is a versatile energy carrier that can be used as a cooking gas in its original form or converted to electricity and heat or even to vehicle fuel. The organic fertiliser contains all the nutrients of the organic waste in a mineralised form as well as the residual carbon, ideal for conserving and building soil fertility.

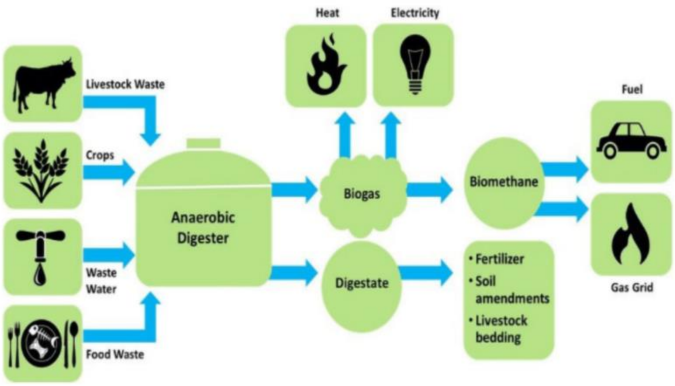


Figure 2: Principal system description for anaerobic digestion

The demonstrator aims to study the synergistic way that the two systems can compensate for each other’s weaknesses. The water purification system relies on UV light to drive the process and electricity for pumps to move water through the system. In that sense, without UV light or electricity, the system will not generate disinfected water. The biogas system will ideally produce electricity evenly 24/7 as any variation in operational parameters will result in reduced energy conversion efficiency. At the same time, there is often less use of electricity for normal day to day community activities during night-time. The project will attempt an integration of the biogas system and the water purification system. For this purpose, the use of the biogas system as a form of uninterrupted power supply for the water purification system will be explored. During normal operation, the water purification system will run on its built-in Solar PV electricity supply, but in case of failure of this system or for night-time operation, the biogas system will provide a secure electricity back-up to ensure uninterrupted water disinfection operation. Another innovation that will be tested is to fit electrically powered UV lights on the back side of the transparent water purification reaction tubes. The water purification system will then be able to run on under-utilised biogas electricity during night-time, effectively doubling the operational time of the system through artificial UV lights during night to compliment the natural sunlight during day.

1.5 Key performance indicators

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Water purification capacity per day (at the end of the project)	Target: 200-300L	Provide drinkable water
2	Degradation rate	Target: 60%	Produce organic fertilizer / electricity
3	Water quality (reduction of impurity)	Target: 80%	Provide drinkable water
4	CAPEX reduction compared to existing system	Target: 20%	Study replicability and scalability
5	OPEX reduction compared to existing system	Target: 20%	Study replicability and scalability
6	Methane yield per m3 reactor volume per day with addition of ash compared to without (demo)	Target: +25%	Study replicability and scalability
7	Waste treatment capacity (kg/day)	Target: +20%	Study replicability and scalability
8	Incidence of process instability with addition of locally sourced nutrients compared to without	Target: -20%	Study replicability and scalability

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
• Identify implementation site • Organize logistics in order to have a sufficient supply of organic waste

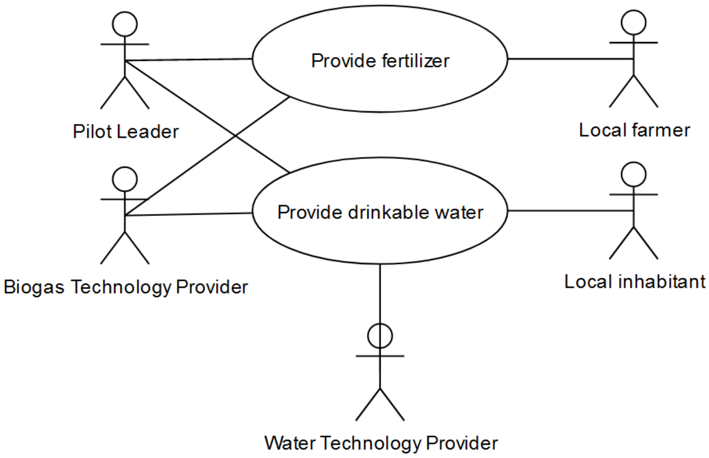
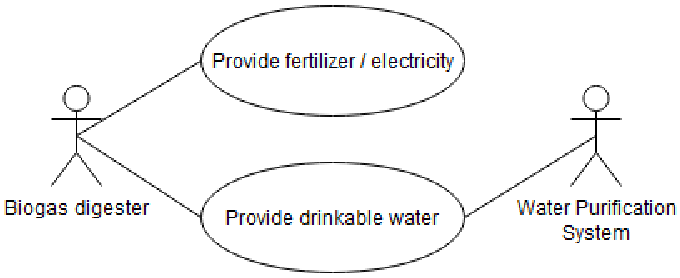
1.7 Further information to the use case for classification/mapping

Classification information
Relation to the other use cases
Level of depth
Generic
Prioritization
Obligatory
Generic, regional or national relation
Regional
Nature of the use case
Technical and business UC
Further keywords for classification
Distributed Energy Resource (DER), Biogas Digester, Water purification systems

1.8 General remarks

General remarks

2 Diagrams of use case

Diagram(s) of use case
 Figure 21 : Business Use Case Diagram  Figure 22 : System Use Case Diagram

3 Technical details

3.1 Actors

Actors			
Grouping		***Group Description***	
Business Actor		Physical or legal person that has his own interests, defined as "Business Goals"	
Operator		Business Actor that operates a system	
Logical Actor		Technical entity that takes part in the execution of a use case. A logical actor can be mapped to a physical component	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Business Actor			
Biogas Technology Provider	Business Actor	Develop the biogas digester	TWT (The Waste Transformers) Ref 1
Pilot leader	Business Actor	Pilots the demonstrators in Freetown in partnership with TWT.	FWT (FreeTown waste transformers) Ref 1
Water Technology Provider	Business Actor	Develop water purification technologies	TEK (Fundacion Tekniker) and CIEMAT (Centro de Investigaciones ENERGICAs, MedioAmbientales y Tecnologicas) Ref 1
Local farmer	Business Actor	A party in need of organic fertilizer	
Local inhabitant	Business Actor	A party in need of drinkable water	
Logical Actor			
Biogas Digester	Logical Actor	Produce organic fertilizer and electricity from organic waste.	Ref 1
Anaerobe Digester	Logical Actor	Produces fertilizer and biogas from organic waste.	Ref 2
CHP	Logical Actor	Combined heat and power system. Generates electricity and useful heat at the same time.	Ref 2
Pasteurizer	Logical Actor	Produces liquid fertilizer.	Ref 2
Water Purification system	Logical Actor	Produce drinkable water.	Ref 1

3.2 References

Version management						
No.	***Reference type***	***Reference***	***Status***	***Impact on use case***	***Originator/organization***	***Link***
1	Contract	Grant Agreement - ENERGICA			European Commission	
2	Documentation	Technical brochure The Waste Transformer			The Waste Transformer	

4 Step by step analysis of use case

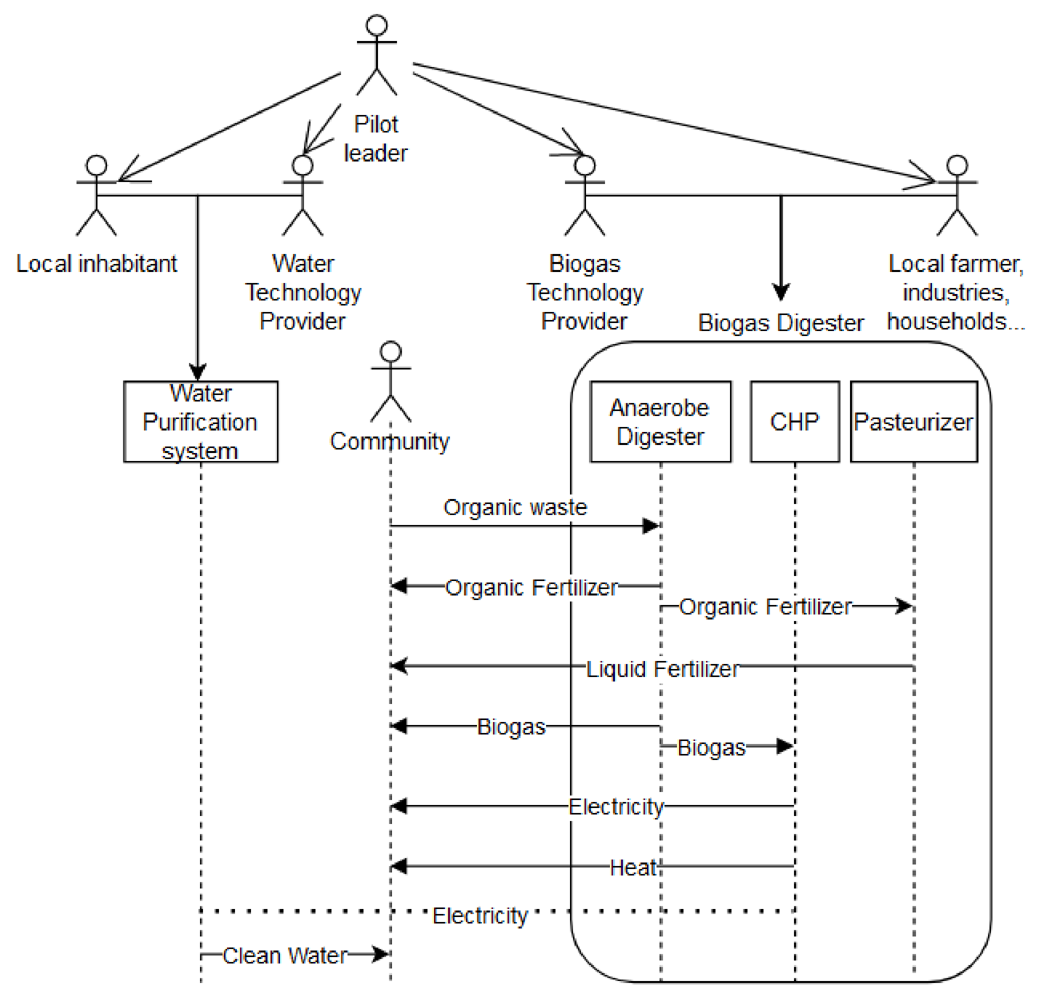
4.1 Overview of scenarios

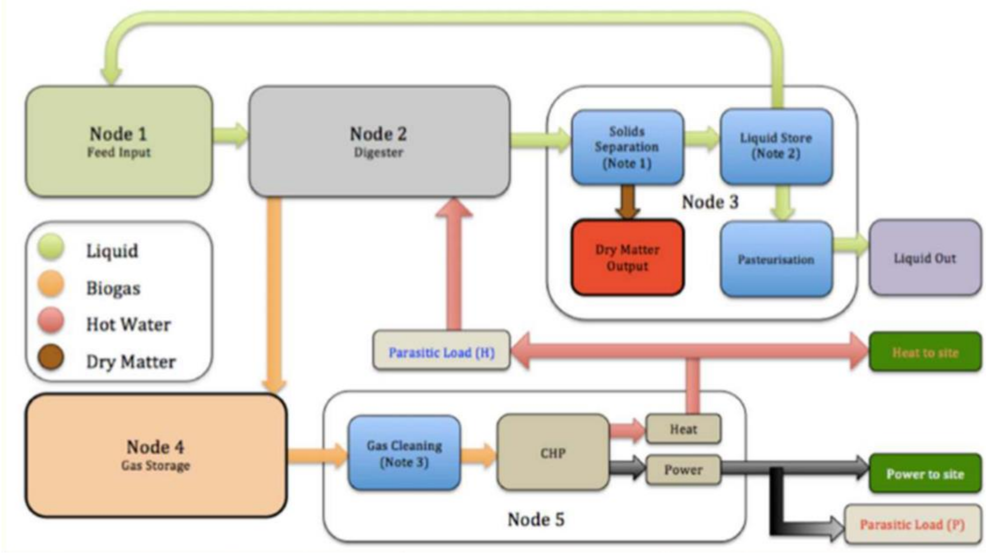
Version management						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Day to day operations	The system produces fertilizer, biogas, heat, electricity and clean water from organic waste.	Biogas digester	Organic waste is fed into the system	System operational	There is no more organic waste in the system

4.2 Steps – Scenarios

Scenario							
Scenario name		Day to day operations					
Step No.	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information exchanged (IDs)***	***Requirements, R-IDs***

1	The community produced organic waste	Organic waste input	The organic waste is fed into the system.	EXECUTE	Community		
2	Organic waste has been fed into the system	Organic fertilizer production	The organic fertilizer is produced in the anaerobe digester.	EXECUTE	Anaerobe digester		
3	Organic fertilizer has been produced in the anaerobe digester	Organic fertilizer transfer	The organic fertilizer is transferred to the pasteurizer.	EXECUTE	Anaerobe digester		
4	Organic fertilizer has been fed into the pasteurizer	Liquid fertilizer production	The pasteurizer produces liquid fertilizer.	EXECUTE	Pasteurizer		
5	Organic waste has been fed into the system	Biogas production	The anaerobe produces biogas.	EXECUTE	Anaerobe digester		
6	Biogas has been produced in the anaerobe digester	Biogas transfer	The biogas is transferred to the CHP.	EXECUTE	Anaerobe digester		
7	Biogas has been fed in the CHP	Electricity production	The CHP produces electricity.	EXECUTE	CHP		
8	Biogas has been fed in the CHP	Biogas production	The CHP produces heat.	EXECUTE	CHP		
9	(Optional) Electricity has been produced by the CHP	Electricity feed	The produced electricity is being fed to the water purification system.	EXECUTE	CHP		
10	Water has been fed into the water purifier	Water purification	Drinking water is being produced by the purifier.	EXECUTE	Water purification system		





5 Information exchanged

Information exchanged			
Information exchange, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***

6 Requirements (optional)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
Requirement R-ID	***Requirement name***	***Requirement description***

7 Common terms and definitions

Common terms and definitions	
Term	***Definition***
CAPEX	CAPital EXpenditures
CHP	Combined Heat and Power
DER	Distributed Energy Resources
OPEX	OPerational EXpenditures
PV	Photovoltaic
UC	Use-Case

8 Custom information (optional)

Custom information (optional)		
Key	***Value***	***Refers to section***

c. Kenyan demonstrator

1. Description of the use case

1.1 Name of the use-case

Use case identification		
ID	***Area/Domain/Zone(s)***	***Name of the use case***
UC1	Area: Energy Systems, Electric Vehicles Domains: DER, Customer Premises Zones: Process, Field	Kenya – Battery swapping stations in Urban Context

1.2 Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
0.1.	1/02/2022	Hadrien Lafforgue - TRIALOG	Draft	
0.1.	05/07/2022	Hadrien Lafforgue - TRIALOG	Scenarios description added	

1.3 Scope and objective of use case

Scope and objectives of the use case	
Scope	This use-case is limited to the study of the battery swapping stations and their surrounding ecosystem deployed in Kenya in urban context.
Objective(s)	• Enable electric mobility • Extend energy access for domestic use
Related business case(s)	

1.4 Narrative of use case

Narrative of use case
Short description
The Kenyan demonstrator will be conducted in 15 main motorcycle hubs in urban and sub-urban areas of Nairobi. It aims to develop a broadly geographically distributed network of chargers and test innovative services such as swappable batteries and swapping stations. Therefore, the demonstrator will be focused on how swapping stations optimally can be distributed including payment system and telemetry optimisation. After successful deployment in Nairobi, additional solar swapping stations will be deployed in Kisumu and Homa Bay.

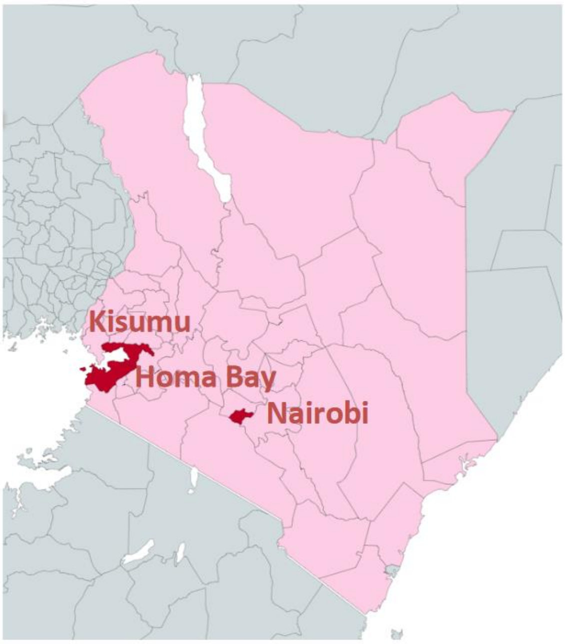


Figure 23: Kenyan demonstrating sites

Complete description

To enable a large-scale uptake of electric mobility in the two-wheeler industry, there needs to be a broadly geographically distributed network of chargers available in Nairobi, to enable agile driving patterns by the operators.

Today, electric motorcycles have been tested in Nairobi and end user demand verified for innovative services of swappable batteries and swapping stations. Therefore, the demonstrator will be focused on how swapping stations optimally can be distributed including payment system and telemetry optimization.

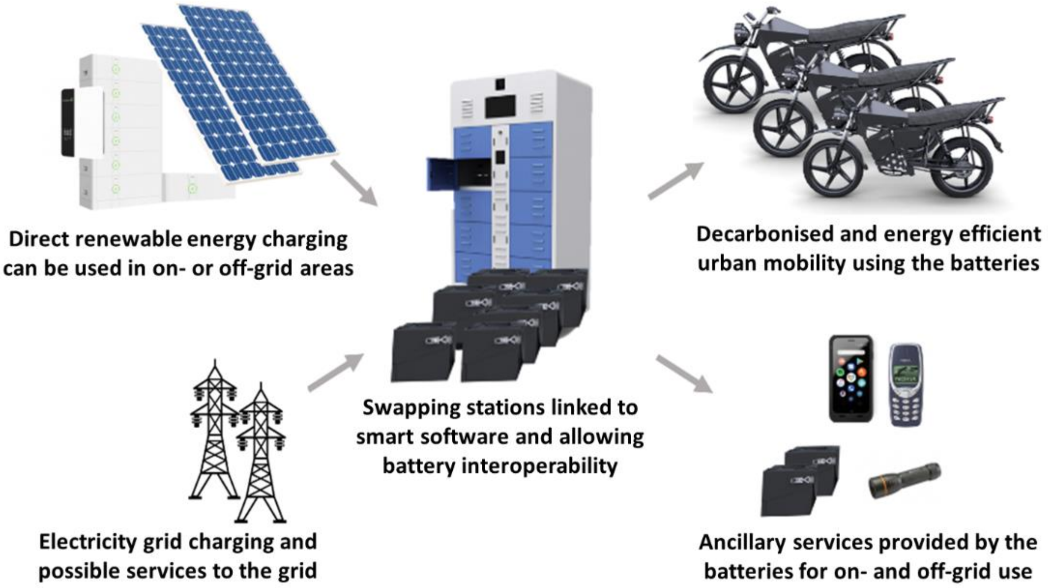


Figure 2: Eco-system for battery swapping [2]

The swapping stations are at the core of the demonstrator. The stations host 10 lithium batteries each and are interoperable with several battery voltages and chemistries, and are connected to a smart energy management software able to provide monitoring and charging optimisation. Each swapping station is designed to operate on a regular three phase grid connection while being fitted with a solar system and battery storage to bring down the cost of electricity and ensure operation during electricity black outs. The solar energy systems will be connected to the smart energy management system to be able to monitor and optimize charging utilization, but also allow for easy and preventive maintenance. As part of the swapping system, the charging hubs can charge several batteries then picked

up as a motorcycle battery or a portable energy bank used for 240V or USB appliances in households or on the go. This energy distribution model can provide power for both transport services and households in large areas around one centralised charging hub without having connected every individual household to the grid. Therefore, such an ecosystem maximises the distribution of energy access compared to traditional mobility systems.
Finally, considering the number of actors that are launching electric motorcycles and swapping service activities in Africa, the question of interoperability is crucial. Through implication of local battery systems and electric mobility technology providers and analysis of both the market and the end-users' requirement, the swappable batteries used in ENERGICA will be standardised. Therefore, the swapping stations will be interoperable with other batteries as the standard used in the demonstration takes into account the possibility of interoperability with other batteries. This allows for a healthy sector development centred on end-users' demand in services.

The electric motorcycles used for the Kenyan demonstrator are locally designed, developed and produced by ROAM in Nairobi. The electric motorcycles are low cost and durable, fitting the local market in terms of range, payload capacity, carrying volume, price and serviceability. Each unit includes a 2.7 kWh swappable battery giving the vehicle a range of 90km, 200kg payload, 90kph top speed and an acceleration of 6s (0-90kph). The robust motorcycle design is compatible with many local spare parts which ensure that the product is easily serviced and suitable for areas with inadequate infrastructure, therefore increasing the product lifetime and reducing cost over time.

1.5 Key performance indicators

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Number of swapping stations installed during the project	Target: 15	Enable electric mobility / Enable energy access for domestic use
2	Number of e-bikes made available during the project	Target: 150	Enable electric mobility
3	Increased utilisation of grid electricity	Target: > 200 MWh/Year	Enable electric mobility / Enable energy access for domestic use
4	Number of users		Enable electric mobility / Enable energy access for domestic use
5	Total energy demands		Enable electric mobility / Enable energy access for domestic use
6	CO2 emission avoided		Enable electric mobility
7	Savings	Average savings made by an individual rider who switch to an electric motorcycle	Enable electric mobility
8	Total distance travelled by electric bikes		Enable electric mobility
9	PV self-consumption	Share of local PV in the total consumption of the station (in %).	Enable electric mobility / Enable energy access for domestic use

1.6 Use case conditions

Use case conditions
Assumptions
• Grid installation is compliant with EPRA standards.
Prerequisites

1.7 Further information to the use case for classification/mapping

Classification information
Level of depth
Generic

Prioritization
Obligatory
Generic, regional or national relation
Regional
Nature of the use case
Technical and business UC
Further keywords for classification
Distributed Energy Resource (DER), Battery, Electric Vehicle

1.8 General remarks

General remarks

2 Diagrams of use case

Diagram(s) of use case

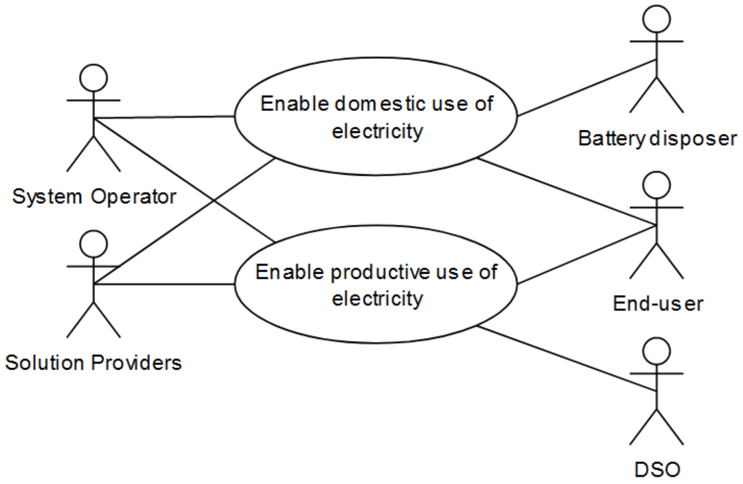


Figure 24 : Business Use Case Diagram

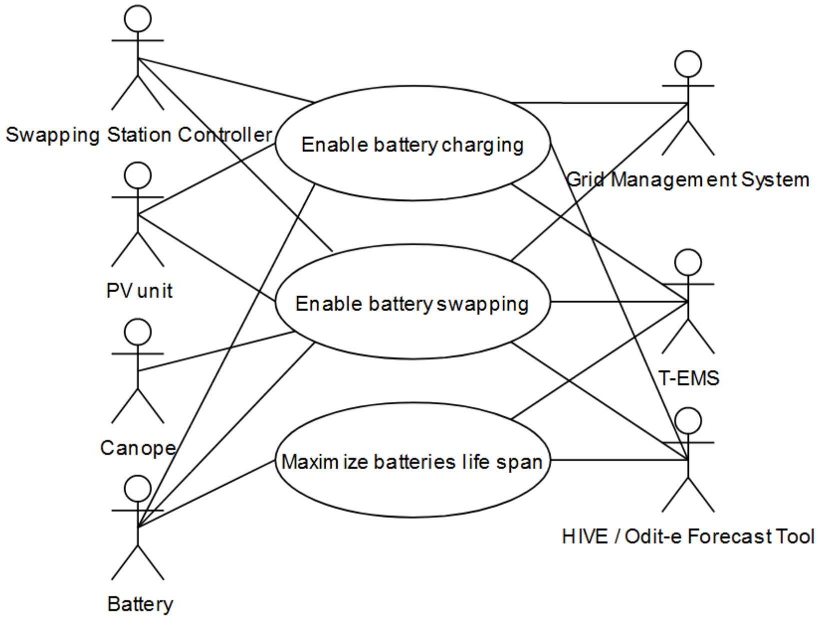


Figure 25 : System Use Case Diagram

3 Technical details

3.1 Actors

<table>
<tr><th colspan="4"><i>Actors</i></th></tr>
<tr><th colspan="2"><i>Grouping</i></th><th colspan="2"><i>Group Description</i></th></tr>
<tr><td colspan="2">Business Actor</td><td colspan="2">Physical or legal person that has his own interests, defined as “Business Goals”</td></tr>
<tr><td colspan="2">Operator</td><td colspan="2">Business Actor that operates a system</td></tr>
<tr><td colspan="2">Logical Actor</td><td colspan="2">Technical entity that takes part in the execution of a use case. A logical actor can be mapped to a physical component</td></tr>
<tr><th><i>Actor name</i></th><th><i>Actor type</i></th><th><i>Actor description</i></th><th><i>Further information specific to this use case</i></th></tr>
<tr><th colspan="4"><i>Business Actor</i></th></tr>
<tr><td>System Operator</td><td>Business Actor</td><td>Designs and operates swapping stations and motorcycles.</td><td>ROAM</td></tr>
<tr><td>DSO</td><td>Business Actor</td><td>Distribution System Operator</td><td>KPLC</td></tr>
<tr><td>Solution Providers</td><td>Business Actor</td><td>Odit-e provides modelling / forecasting software.
STIMA provides management software for batteries.</td><td>Odit-e, STIMA, Trialog</td></tr>
</table>

Battery disposer	Business Actor	Salvage batteries at the end of their lifespan and incorporate them in their solar home systems.	JKS
End-User	Business Actor	Owner of a ROAM motorcycle. Can own its own battery or rent it from ROAM.	
Logical Actor			
Swapping station controller	Logical Actor	A charging station that holds 10 lithium batteries, connected to the grid and equipped with a solar energy system.	Ref 1
PV unit	Logical Actor	A PV panel will be installed on the station's roof. Its production will be monitored through a specific meter.	Ref 1
Battery	Logical Actor	Swappable, interoperable with several battery voltages and chemistries. Designed to power electric motorcycle or domestic use.	Ref 1
Distribution substation meter	Logical Actor	IoT sensors provided by Odit-e and installed in distribution substation by KPLC.	Ref 1
T-EMS	Logical Actor	Trialog Energy Management System allowing for the supervision and management of the charging station. Collects data from the station, the PV unit and the batteries.	Ref 1
Grid Management System	Logical Actor	Collect and aggregate data from the distribution substation meter.	Ref 1
ROAM Canope	Logical Actor	Roam cloud-based infrastructure. Stores all data relevant to the system and makes it available for other subsystems.	Ref 1
Roam mobile application	Logical Actor	Mobile application helping the end-user to locate and select a charging station to use.	Ref 1
Roam charging front-end	Logical Actor	Front-end used at the station for battery charging / swapping operations	Ref 1
STIMA EMS	Logical Actor	In charge of optimization of the charging process of batteries.	Ref 1
HIVE Forecast Tool	Logical Actor	Generates a load profile forecast for the swapping stations at meter and hierarchical aggregation levels.	Ref 1
Odit-e Forecast Tool	Logical Actor	Provides real time grid status visualization, impact studies of flexibilities and grid optimization strategies.	Ref 1

3.2 References

Version management						
No.	***Reference type***	***Reference***	***Status***	***Impact on use case***	***Originator/organization***	***Link***
1	Contract	Grant Agreement - ENERGICA			European Commission	

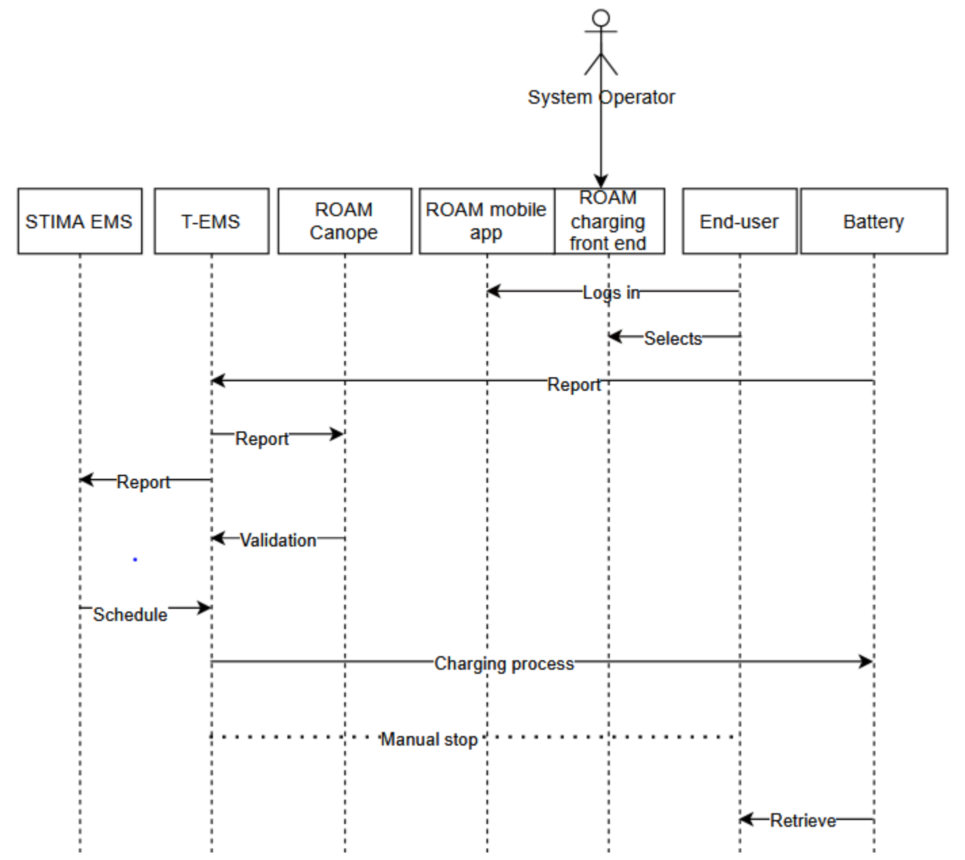
4 Step by step analysis of use case

4.1 Overview of scenarios

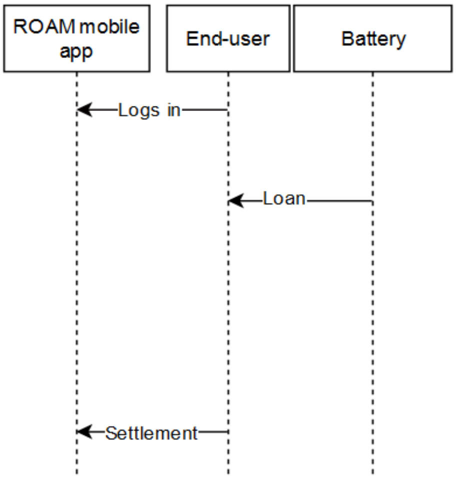
Version management						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Optimized battery charging	Charging process, from locating a nearby station to end of charge.	T-EMS / Canope / STIMA	The end-user needs to charge his battery	The user has a Roam account	The user's battery is charged
2	Optimized battery swapping	Swapping process, from locating a nearby station to giving back the battery.	T-EMS / Canope / STIMA	The end-user needs to swap his battery	The user has a Roam account	The battery in a station
3	Forecast	Odit-e and Hive provide grid related forecast.	Canope / Odit-e			

4.2 Steps – Scenarios

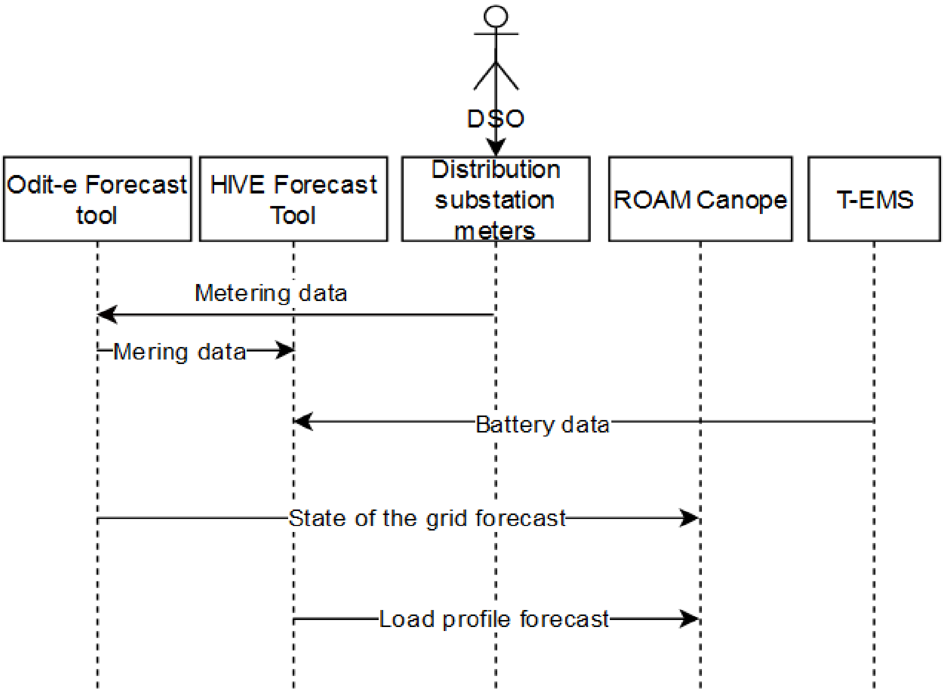
Scenario							
Scenario name		***Optimized battery charging***					
Step No.	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information exchanged (IDs)***	***Requirements, R-IDs***
0	The end-user needs to charge his battery	Locating station to use	The mobile app helps the rider locate and select a nearby station (depending on available slots and electricity price).	GET	Roam mobile app	Inf1	R3, 4, 6, 7, 8-10, 15, 17-23
1	The end-user arrives at the station	End-user’s authentication	The end-user logs in.	REPORT	Roam mobile app	Inf2	R1, 2, 5, 7, 8-10, 11, 12, 13, 15, 17-23
2	End-user authenticated	Selection of battery locker	The end-user selects a battery locker to use.	CREATE	Roam Charging front end	Inf3	R2, 8-10, 15, 17-23
2	Battery locker selected	Battery authentication	Battery authentication through CAN to the T-EMS.	REPORT	Battery	Inf4, Inf 5	R1, 2, 7, 8-10, 12, 13, 14, 15, 16, 17-23
3	Battery information collected by the T-EMS	Report to ROAM	The T-EMS sends battery data toward Canope and waits for a validation from ROAM.	REPORT	T-EMS	Inf4, Inf5	R1, 2, 7, 8-10, 12, 13, 14, 15, 16, 17-23
5	Battery information collected by the T-EMS	Report to STIMA	The T-EMS reports to STIMA information relevant to their operation.	REPORT	T-EMS	Inf4, Inf5	R1, 2, 7, 8-10, 12, 13, 14, 15, 16, 17-23
6	Battery information received by Canope	Validation from Canope	Canope either validates the beginning of the charging process.	CREATE	Canope	Inf6	R5, 7, 8-10, 15, 17-23
7	Battery information received by STIMA	Charging profile from STIMA	STIMA calculates and sends to Canope and T-EMS a charging profile for the battery.	CREATE	STIMA EMS	Inf7	R5, 8-10, 14, 15, 17-23
8	Validation and charging profile received by the T-EMS	Start of charging process	The T-EMS starts the charging process.	EXECUTE	T-EMS		
9	(Optional) The end-user manually stops the charging process	(Optional) Manual stop	The charging process ends.	CANCEL	End-user	Inf8	R8-10, 15, 17-23
10	The battery is at full capacity // The prepaid amount has ran out	Ending of charging process	The T-EMS ends the charging process.	CLOSE	T-EMS		
11	Charging process has ended	Battery retrieval	The end-user validates the end of charge through the ROAM mobile app and retrieves the battery.	CREATE	End-user	Inf9	R2, 8-10, 13, 14, 15, 17-23



Scenario name	***Optimized battery swapping***						
Step No.	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information exchanged (IDs)***	***Requirements, R-IDs***
0	The end-user needs to rent a new battery	Locating station to use	The mobile app helps the rider locate and select a nearby station (depending on available battery).	GET	ROAM mobile app	Inf1	R3, 4, 6, 7, 8-10, 15, 17-23
1	The end-user arrives at the station	End-user's authentication	The end-user logs in.	REPORT	ROAM mobile app	Inf2	R1, 2, 5, 7, 8-10, 11, 12, 13, 15, 17-23
2	End-user authenticated	Selection of battery locker	The end-user selects a battery locker to use.	CREATE	ROAM Charging front end	Inf3	R2, 8-10, 15, 17-23
3	Battery locker selected	Battery loan	The end-user takes the battery and places it in the motorcycle.	EXECUTE	End-user		
4	Battery placed in the motorcycle	Battery use	The end-user rides his motorcycle and uses the battery.	EXECUTE	End-user		
6	Battery emptied	Settlement	The rider comes to a station, authenticates and proceeds to the settlement for the battery loan (function of remaining energy, time spent, …)	CREATE	End-user	Inf 9	R2, 8-10, 13, 14, 15, 17-23



Scenario name	*Forecast*						
Step No.	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information exchanged (IDs)***	***Requirements, R-IDs***
1	At regular time intervals	Substation meter input	Odit-e retrieves metering information	GET	Distribution substation meter	Inf10	R7, 8-10, 16, 17-23
2	At regular time intervals	T-EMS input	Hive retrieves battery information	GET	T-EMS	Inf5	R2, 8-10, 13, 14, 15, 16, 17-23
3	At regular time intervals	Odit-e input to HIVE	Hive retrieves metering information	GET	Odit-e forecast tool	Inf10	R7, 8-10, 16, 17-23
4	At regular time intervals	Forecast	Hive and Odit-e produce their respective forecast	REPORT	Odit-e / Hive forecast tool	Inf11	R8-10, 17-23



5 Information exchanged

Information exchanged

Information exchange, ID	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf1	Location of station	Location of station to use for battery charging	R3, 4, 6, 7, 8-10, 15, 17-23
Inf2	End-user authentication	Information authenticating the end-user before the beginning of the charging process.	R1, 2, 5, 7, 8-10, 11, 12, 13, 15, 17-23
Inf3	Selected locker	Locker selected for the charging process.	R2, 8-10, 15, 17-23
Inf4	Battery authentication	Information authenticating the battery and validating the ownership of the user.	R1, 2, 7, 8-10, 12, 13, 15, 17-23
Inf5	Battery state of health	State of health information concerning the battery.	R2, 8-10, 13, 14, 15, 16, 17-23
Inf6	Charging validation	Validation from ROAM allowing for the beginning of the charging process.	R5, 7, 8-10, 15, 17-23
Inf7	Charging profile	Charging profile calculated by STIMA.	R5, 8-10, 14, 15, 17-23
Inf8	Manual stop	Manual stop of the charging process.	R8-10, 15, 17-23
Inf9	Charging report	Report containing information regarding the charging process.	R2, 8-10, 13, 14, 15, 17-23
Inf10	Metering data	Metering data coming from distribution substation meters provided by Odit-e and installed by KLPC.	R7, 8-10, 16, 17-23
Inf11	Forecast	Forecast regarding state of the grid, load profile and other data to be determined.	R8-10, 17-23

6 Requirements (optional)

Requirements (optional)		
Categories ID	*Category name for requirements*	*Category description*
Requirement R-ID	*Requirement name*	*Requirement description*
R1	Number of Information Producers	Hundreds to thousands
R2	Number of Information Receivers	Two to a few
R3	Distance between entities	A few kilometres
R4	Location of Information Producer	Mobile
R5	Location of Information Receiver	Commercial customer site
R6	Communication media	Wireless required
R7	Communication ownership	Internet
R8	Communication bandwidth	2.4-56 kbps
R9	Data exchange methods	Client-server
R10	Communication access services requirements	Request-response
R11	Growth	100x number of participating devices - Over the next 5 years
R12	Operation mode of Information Producer	Automatic
R13	Operation mode of Information Receiver	Automatic
R14	Elapsed time response requirements for exchanging data	4-10 milliseconds
R15	Availability of information flows	99% + availability -Allowed outage: 3.5 days per year

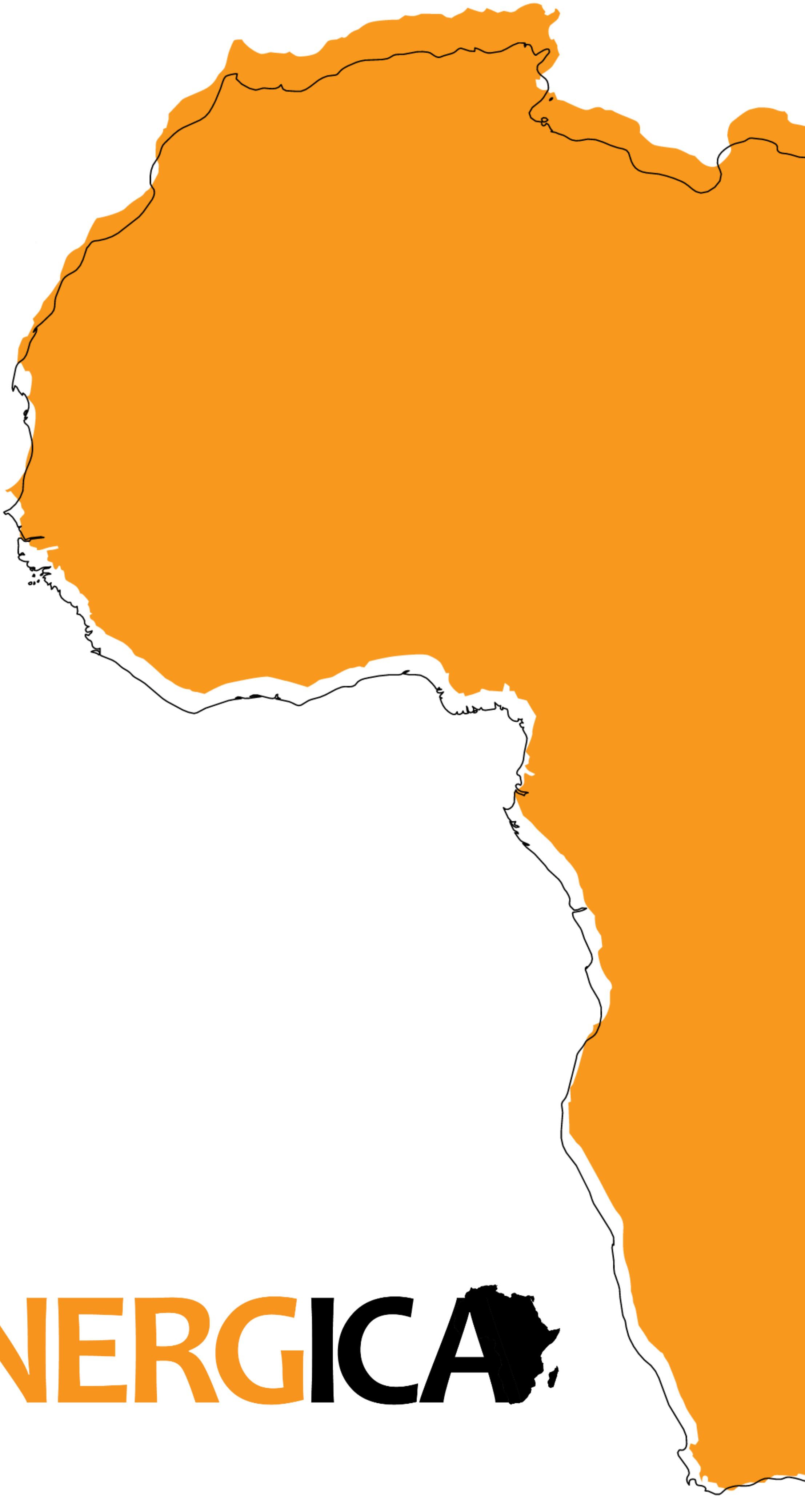
R16	Frequency of data exchanges	Continuous
R17	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data	Crucial
R18	Information integrity violation: Ensuring that data is not changed or destroyed	Crucial
R19	Authentication: Masquerade and/or spoofing: Ensuring that data comes from the stated source or goes to authenticated receiver	Crucial
R20	Repudiation: Ensuring that the source cannot deny sending the data or that the receiver cannot deny receiving the data	Crucial
R21	Replay: Ensuring that data cannot be resent by an unauthorized source	Crucial
R22	Information theft: Ensuring that data cannot be stolen or deleted by an unauthorized entity	Crucial
R23	Denial of Service: Ensuring unimpeded access to data	Crucial

7 Common terms and definitions

Common terms and definitions	
Term	***Definition***
DER	Distributed Energy Resources
DSO	Distribution System Operator
EMS	Energy Management System
PV	Photovoltaic
UC	Use-Case

8 Custom information (optional)

Custom information (optional)		
Key	***Value***	***Refers to section***



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