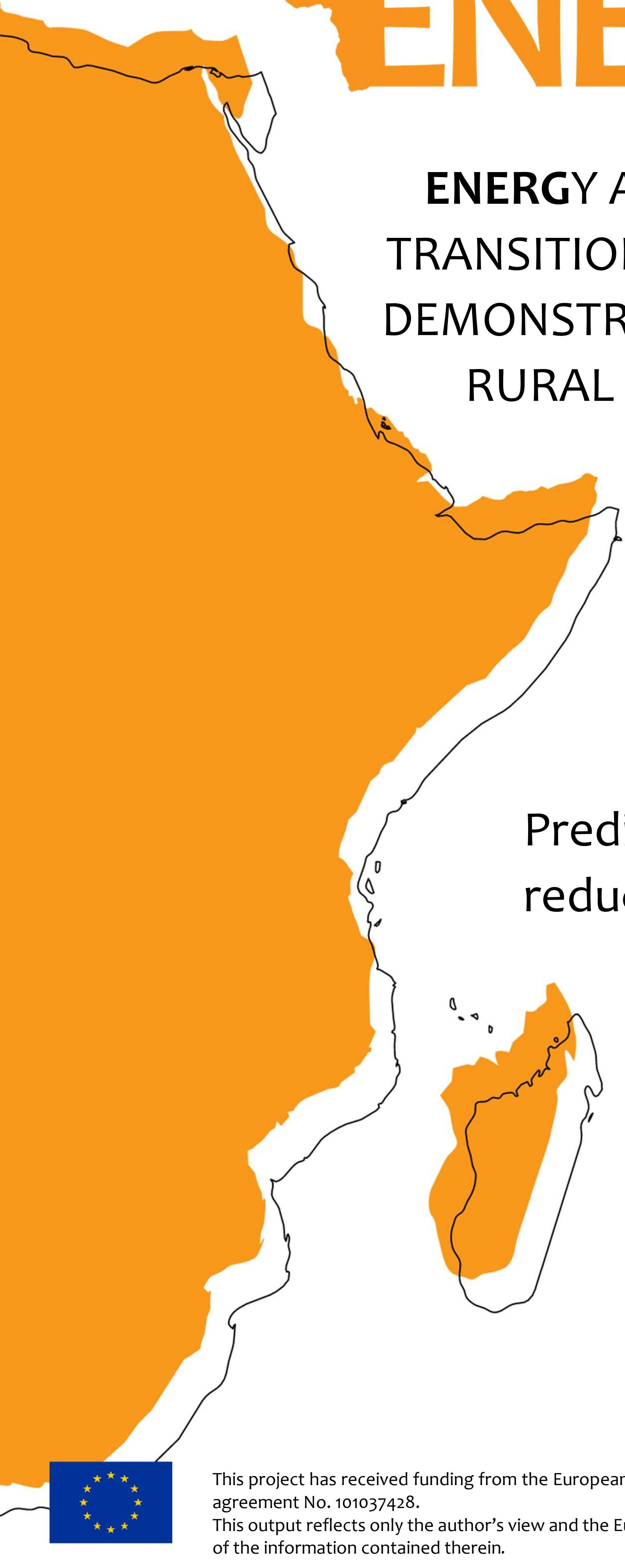
ENERGICA



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

D3.4

Predictive model for reduction of material uses

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Deliverable Report

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Nature of the Deliverable		
R	Document, report (excluding the periodic and final reports)	X
DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patents filing, press & media actions, videos, etc.	
OTHER	Software, technical diagram, etc.	X

Dissemination Level		
PU	Public, fully open, e.g. web	X
CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

Quality procedure			
Date	Version	Reviewers	Comments
02/10/2023	V1	TRIALOG	First version (built by ODITE) sent to TRIALOG.
31/10/2023	V2	TRIALOG	After first review by TRIALOG, consolidated version sent for final review
01/11/2023	V2	EG	Minor edits and formatting.

PROJECT SUMMARY

The ENERGICA project is an ambitious collaboration between 11 African-based partners and 17 European organizations with offices or subsidiaries in Africa, aimed at promoting energy access and sustainable energy development. The project's primary objective is to demonstrate the efficient implementation of renewable energy (RE) technologies that are tailored to the specific needs of local contexts. This will be achieved through the deployment of three demonstration sites, which will be managed by local Energy Transition Boards, and will utilize community-scale Integrated Community Energy Systems (ICESs).

The project's focus on innovative technologies and methodologies is expected to yield positive social, environmental, technical, and economic impacts, resulting from the high energy efficiency and low carbon emission Renewable Energy Technologies (RETs). One specific initiative of the project is the development of nano grids in the rural Diana region of Madagascar. To ensure the project's replication and sustainability, the energy flow patterns and associated value flows within local communities are predicted as outlined in this report.

More information on the project can be found at https://cordis.europa.eu/project/id/101037428

OBJECTIVE AND EXECUTIVE SUMMARY

This report is part of the deliverables from the project "ENERGICA" which has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 101037428.

This deliverable details high level methodologies to estimate the benefits regarding material and energy savings linked to the different solution developed during the project that will be demonstrate on the 3 pilot sites in Kenya, Madagascar and Sierra Leone.

The objective is to pave the way to the WP8 partners that will implement at the end of the project:

- The environmental impact assessment
- The techno-economic studies
- A cradle-to-grave and cradle-to-cradle life cycle analysis for all technologies and their implemented circular value chains
- A comparison with other traditional and existing technologies' impacts on environment, climate change targets and socio-economic dimensions

To reach this objective, this deliverable will define relevant indicators for each pilot site, relevant data to be collected for each pilot site and a quick description of the tool that will be developed later in the project once all the data will be available, collected and analyzed.

TABLE OF CONTENTS

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

Acronym	Description
CAPEX	Capital Expenses
CO2eq	Carbon Dioxide Equivalent
DC	Direct Current
DNSH	Do Not Significant Harm
DSO	Distribution System Operator
EV	Electrical Vehicles
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LV	Low Voltage
ML	Machine Learning
MV	Medium Voltage
OPEX	Operating Expenses
PV	Photovoltaic
US	User Story
WP	Work Package

1. Overall methodology of the deliverable

1.1. Methodology for indicators definition

The methodology proposed in this deliverable to have relevant indicators is the following:

1. Identify the partners involved in each demo site that will contribute to WP8
2. With the contribution of partners, define relevant and measurable indicators for each solution demonstrated in the three demonstration sites
3. Define the data to be collected to quantify the above-mentioned indicators
4. Install monitoring systems when needed
5. Collect data thanks to the monitoring systems
6. Compute indicators with collected data
7. Define and describe an Excel based, robust and easy to adapt tool designed for replication purposes/Perform LCA as defined in WP8
8. Training and dissemination

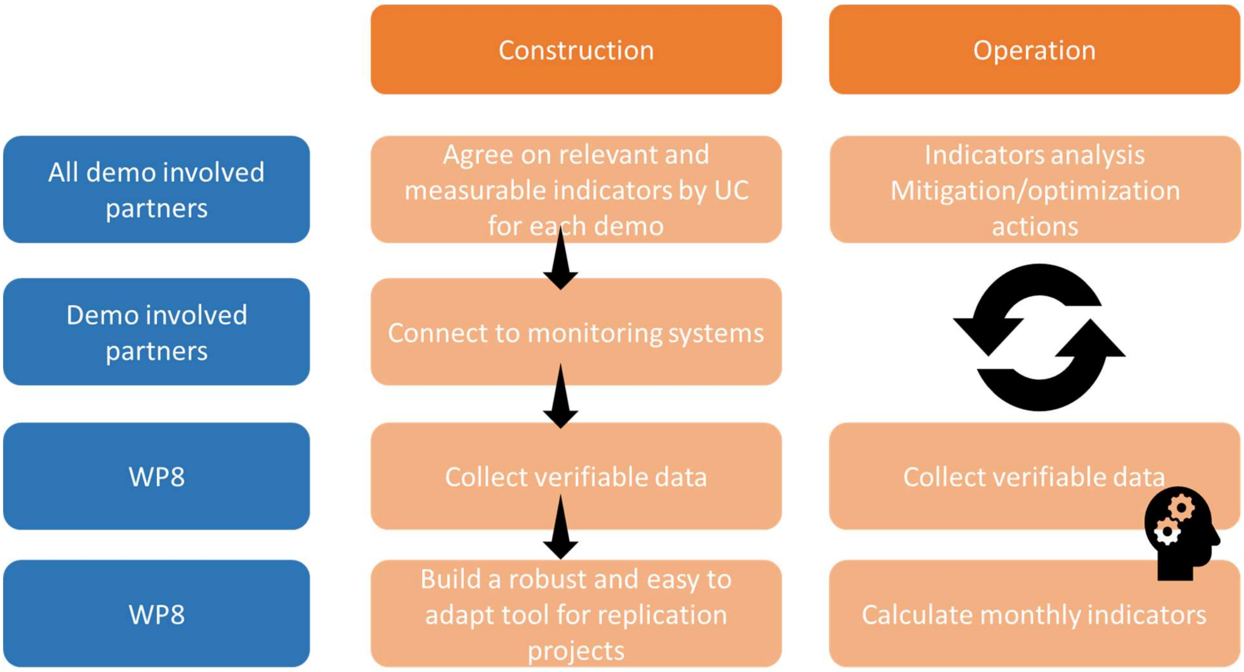


Figure 1: Methodology

1.2. Identification of involved partners in WP8 for each demonstration site

For each demo site, those partners will be able to contribute to the WP8 LCA, by agreeing on the definition of the indicators and then by collecting the relevant data. If necessary, monitoring systems will also be installed with the cooperation of the concerned partners.

<u>WP4 (Madagascar demonstrator):</u>

- NTNU
- TRIALOG
- CIEMAT
- RISE
- ECOSUN
- NANOE
- SACREEE
- ODITE

WP5 (Sierra Leone demonstrator):

- UAM
- TRIALOG
- ECREEE
- TEK
- CIEMAT
- RISE
- TWT
- FWT
- ARENYS

WP6 (Kenya demonstrator):

- TUB
- TRIALOG
- EACREEE
- KPLC
- ODITE
- HIVE
- ROAM (ex OPIBUS)
- STIMA

1.2. Monitoring system & data collection

After the identification of partners and a collaborative definition of the indicators to be measured, it is likely that the computation of those indicators will imply the installation of a monitoring system, at least in some cases.

This monitoring system should be in place till the beginning of each demonstrators, so that an evolution of each indicators could be observed along the project. If possible, already available data should be used to avoid the installation of too many new monitoring systems that may complicate and slow down the overall data collection process. As an example of already available data, ROAM, with the help of WP2 findings, is already able to provide statistics on the Kenyan demonstrator, such as:

- Average daily distance: 124.08 km per day
- Average daily fuel cost: 5.49 $ per day
- Average daily net income: 12.19 $ per day

These numbers will help in the design of the tool to evaluate the benefits (in this case, environmental and economic) of the innovative solutions implemented by ROAM in this demonstrator: the electric motorbikes.

During the data collection phase, each concerned partner should be able to send monthly (or with any other pre-defined timestamp) the data sets. The first data sets should be validated by WP8 to make sure that the data quality and quantity is sufficient to perform the LCA, compute the pre-defined indicators of each demonstrator and build the tool described in the paragraph hereafter.

1.3. Tool description

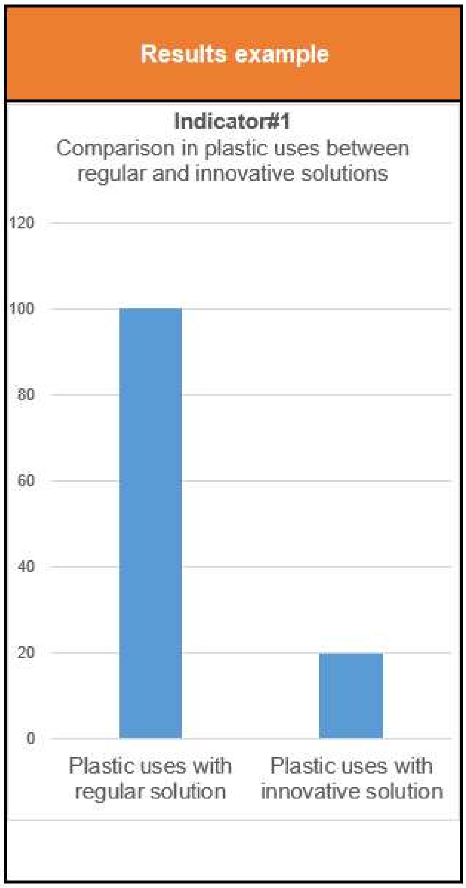
The tool developed within WP8 should be simple, adaptative to local specificities and easy to use for new projects (Excel based or equivalent…). The tool built by TUB within deliverable D2.3 could be a good example of interface for this tool.

For example, if the Excel format is chosen, one Excel file per demonstration site should be developed. A first tab could be used as a user guide that allows any new user to operate quickly and easily the tool for their selected demonstration site. Then a second tab could remind the innovative technologies developed in the demonstration site and the indicators associated to each technology. A third sheet would then be interactive: the user should fill in his parameters according to the data that has been collected by the monitoring system. Ideally, data could be automatically inserted in the tool every month. A fourth and final sheet should then show results in an interactive, graphical and easy to understand way, so that they could be directly used for internal or external communication purposes.

Ideally, this tool should be easy to adapt to any new solution, in case another project with different innovative solutions and different contexts could also use this tool.

The user-friendly interface should encourage new users in particular to improve their results and communicate widely to generate replication projects.

Predictive model for reduction of materials uses	
	Presentation of this template's sheets
Introduction	This tool allows the user to insert the data collected on its demonstration site and instantaneously visualize the impact of a given innovative solutions in terms of reduction of materials uses and reduction of CO2 emissions
Methodological background	The methodological background of this tool has been defined in D3.4: 1. Identify the partners involved in each demo site that will contribute to WP8 2. With the contribution of partners, define relevant and measurable indicators for each solution demonstrated in the three demonstration sites 3. Define the data to be collected to quantify the above
Steps to use the Tool	1. Read carefully the "User guide" tab 2. Read the "Innovative solutions" tab and check that the indicator that you want to visualize is available in this demonstration site 3. Fill in the "User data" tab. This is the only interactive tab where the user should give information based on collected and checked data coming from demonstration sites.



User guide | Innovative solutions | User data | Results | +

Figure 2: Mock-up of the predictive model for reduction of materials uses

1.4. Indicators calculation

The calculation of those indicators will be performed when data will be available, within the scope of the WP8. The results of this calculation will be available under the "Results" tab.

In the WP8, the task involves assessing the environmental sustainability of the ENERGICA approaches by performing Life Cycle Assessments (LCAs) of the technologies proposed, and on an expanded broader context (considering distribution power grids systems as a whole).

LCA follows ISO standards 14040, 14044 [1], as well as ISO 14067 [2] and identifies impact categories based on ILCD [3] Handbook guidelines. Also, following the EU Taxonomy, Do Not Significant Harm (DNSH) principle will be evaluated for preventing adverse environmental impacts due to ENERGICA proposed technologies.

A LCA will evaluate battery storage and electric road systems, to evaluate their environmental impacts. This would include analysing the emissions associated with each method and the energy efficiency of the options.

In a parallel way, power demands and energy consumption of large AI algorithms and integrated systems (considering their required HW substrate and representative runtime indicators – such as no. of executions or time consumed for calculation, among others) will be assessed through LCA as well

Secondly, results will be accordingly evaluated into the integrated environments representing the 3 case studies (Madagascar, Kenya, Sierra Leone) in order to evaluate the overall energy consumption including AI tools energy supply requirements, but also overall grid system, and sustainability efficiency of the innovative grid system provided by ENERGICA tools in previous WPs.

The results will be evaluated, regarding the savings in:

- grid/assets investment costs
- increase use of renewables,
- increase the number of EV on the road and reduce CO2 emissions,

Once stated, the final results will be to compare them with traditional systems (grid reinforcement/expansion) to assess expected benefits, such as fuel and rough material savings. The central aim is to set an as more realistic as possible comparison where the benefits of following AI tools, scenario generation, and overall grid expansion/adequation simulation are evidenced against the traditional, over dimensioned, and barely consistent manner.

The scenarios generated will constitute an input for the environmental impact assessment to be performed, the value of different alternative propositions (traditional, flexibility, waste usages, …) in increasing hosting capacity across networks with different characteristics will be considered.

A high-level frame for these indicators definition is given hereunder for each demonstration site.

2. Indicators associated to WP4: demonstrator in Madagascar

To facilitate investment in and operation of tailored solar solutions for productive use, ENERGICA will test and develop plug-and-play systems for the Madagascar site. The major new designs will focus on specific adaptation (DC coupling, local environmental conditions…). The innovative solutions developed in this demonstration are:

- to connect with DC current the agricultural machines thus lowering the Capex and cost of energy.
- to develop DC pumping, storage and treatment devices
- to adapt cooling-specific technologies

Tools will also be developed by Odit-e with grid optimization innovative solutions.

Firstly, the project results will be analysed regarding energy consumption, leveraging productive usage of electricity including water-specific, agri-specific and cooling-specific productive use machines.

Mini grid asset optimization will reduce the use of raw material, PV panel and batteries. These reductions will be assessed by using a set of indicators such as:

- CO_2eq per kg of final products on complete life cycle for DC agri-specific machines
- CO_2eq per litre for DC water pumps specific machines
- CO_2eq per kWh for DC cooling specific machines
- CO_2eq per kg of ice for specific DC ice production machines
- m^2 of PV panel and kVA of batteries per kWh distributed (for an equivalent quality of service)

Grid congestion, voltage excursions rate, current excursion rate available in the innovative solutions developed by Odit-e and will allow the DSO (in this case, Nanoé) to better operate its nano and microgrids and manage its assets. This enables:

- CO_2eq reduction associated to grid optimization
- Copper reduction associated to grid optimization
- Plastic reduction associated to grid optimization

3. Indicators associated to WP5: demonstrator in Sierra Leone

In Sierra Leone low-tech biogas and water purification systems will be demonstrated and tailored to peri-urban and urban contexts.

3.1. Water quality

Benefits estimation for both solutions innovative and regular solutions should include:

- CO2eq per liter of water purified during the life cycle
- CAPEX costs per liter of water purified
- OPEX costs per liter of water purified
- Energy conversion ratios
- Safety of use of nanotechnologies
- Use of local materials
  - Ratio of re-use material
  - Ratio of local materials
- Capability of the local partners to ensure the correct implementation and management of the systems

3.2. Biogas generation

This system will provide low-tech access to energy, freshwater and fertilisers for agriculture using an existing local plant as baseline scenario and increasing its affordability, local manufacturing and

Benefits estimation for both solutions innovative and regular solutions should include indicators such as:

- CAPEX per kWh of biogas produced
- OPEX per kWh of biogas produced
- Waste treatment capacity in kg
- CO2eq per kWh of biogas produced
- The affordable, locally available source of micronutrients (t) and associated gain on CO2eq for the same quantity of chemical fertilizers

4. Indicators associated to WP6: demonstrator in Kenya

The tool will evaluate the impact of EV charging infrastructures in terms of "environmental cost". The assessment will involve determining the economic equivalency of different EV charging infrastructures by considering their lower economic cost and subsequent minor environmental impact.

The assessment follows the Green Deal procedure for calculating pollution equivalent cost. The basis for this assessment will be the results of both Life Cycle Assessment (LCA) and Life Cycle Cost (LCC), this subtask focuses on assessing the economic face of the environmental impact of EV charging infrastructures based on LCA and LCC results, in order to bring an indicative monetary dimension accordingly to its environmental impact

Benefits estimation for both solutions innovative and regular solutions should include indicators such as:

- Urban decarbonizing of the economy through electric mobility optimization
- Energy efficiency of the motorcycles (km per month driven in electric vehicles by the operators)
- CO2eq per km on complete life cycle
- CAPEX and OPEX of battery charging and battery fleet management
- Mobility demand response service (kWh of flexibility per month)

Grid congestion, voltage excursions rate, current excursion rate available in the innovative solutions developed by Odit-e and will allow the DSO (KPLC) to better operate its LV grid and manage its assets. This enables:

- CO2eq reduction associated to grid optimization
- Copper reduction associated to grid optimization
- Plastic reduction associated to grid optimization

5. Similarities and differences between demonstrators

Every demonstrator will have many similarities in terms of objectives. For example, in each demonstrator, one of the objectives is to reduce the CO_2 emissions. However, when computing the indicators, differences may be found for a similar objective and solution. These differences will have to be explained when the results will be computed so that future users will be more inclined to predict the impact of innovation solutions implementation. In that sense, ratios and orders of magnitude will be compared and analysed between the three demonstrators in order to understand the limitations and prepare the replicability of the tool.

On the other hand, some of the indicators will be drastically different from one demonstration site to another, and therefore will not be comparable. For example, the results of water purification in Sierra Leone will not be comparable to any other indicator in any other demonstration site within the scope of ENERGICA.

REFERENCES

[1] ISO 14040 and ISO 14044 on life cycle assessment

These are the leading international standards on life cycle assessment (LCA). They focus mainly on the process of performing LCA, following a product's impact from cradle to grave. ISO 14040 describes the "principles and framework for LCA", while the ISO 14044 "specifies requirements and provides guidelines" for LCA.

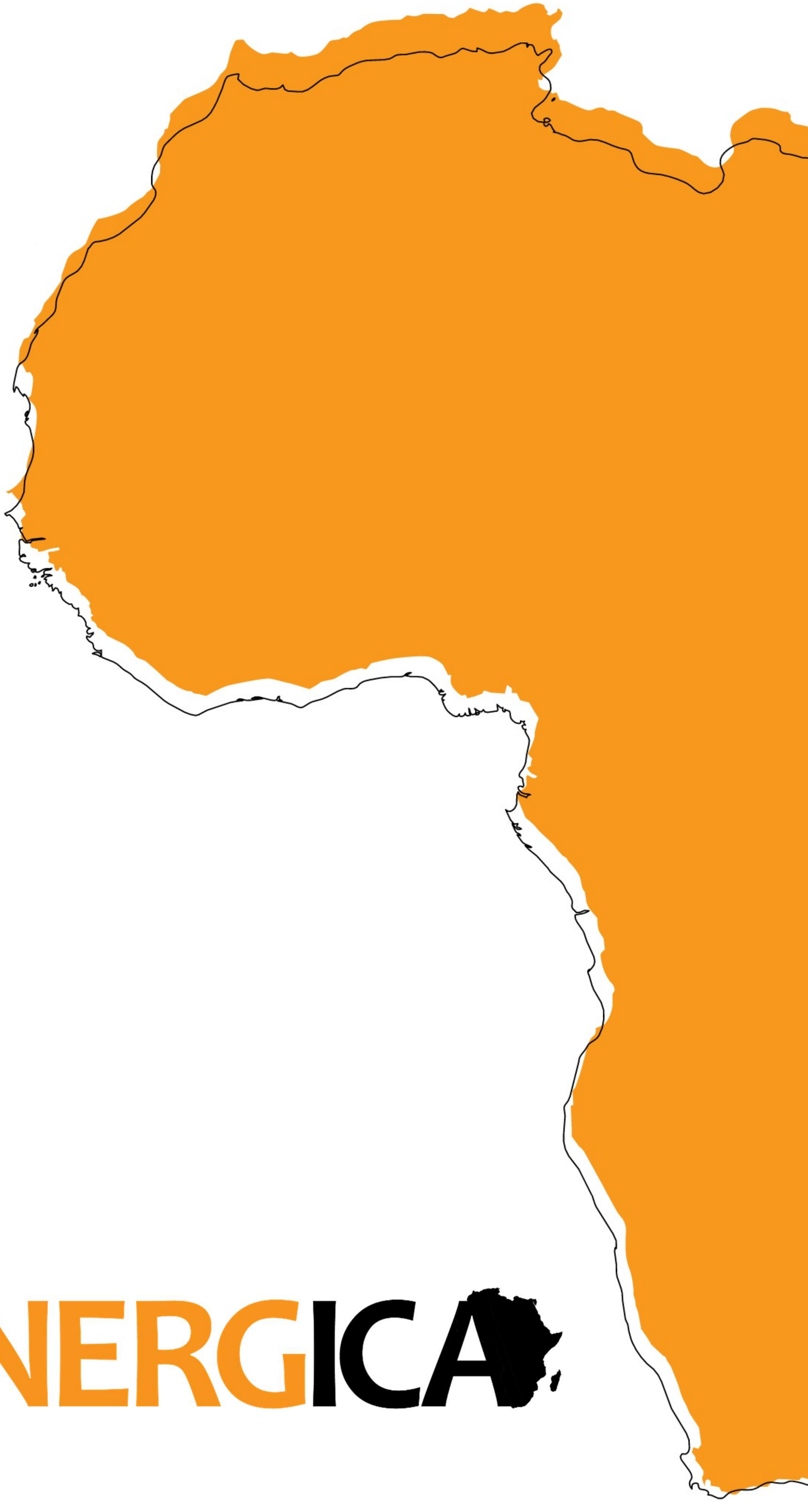
[2] ISO 14067 on the carbon footprint of products

ISO 14067 "specifies principles, requirements and guidelines for the quantification and reporting of the carbon footprint of a product"— that is, its impact on climate change. "Carbon offsetting and communication of CFP" are "outside the scope" of the standard.

The standard is consistent with ISO 14040 and ISO 14044. However, it also includes requirements on specific issues relevant to carbon foot printing, including land-use change, carbon uptake, biogenic carbon emissions, and soil carbon change.

[3] ILCD (EU) on life cycle assessment

The International Reference Life Cycle Data System (ILCD) handbook, which was developed by the European Commission Joint Research Centre, offers technical guidelines on conducting detailed LCA studies. It contains detailed descriptions and requirements in order to reduce flexibility in choices and to support the consistency of LCA results and quality assurance related to these. It is consistent with the ISO 14040 and 14044 LCA standards.



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