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(1.04.2022– 31.03.2025)

LEAP-RE

Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy

Pillar-1 project

The LEAP-RE project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

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Consortium

Project coordinator:
- Irina G. Mocanu, Centrul IT pentru Stiinta si Tehnologie, **Romania**

Project partners:

-Tampere University (**Finland**)

- Laboratory of Applied Hydrology and Environment, University of Lomé, (**Togo**)

- Unité de Développement des Equipements Solaires / EPST Centre de Développement des Energies Renouvelables (UDES / EPST- CDER) (**Algeria**)

- Institut für Sozialforschung und Sozialwirtschaft e. V. - ISO (**Germany**)

Aim of the project

LEDSOL is aiming to foster long-term collaboration between Africa and European organizations on sustainable and affordable technologies by providing off the grid clean water through the use of a smart portable unit based on UV/LED disinfection augmented with classical decontamination and powered by renewable energy sources.

Relevance vs MARs

- LEDSOL will support remote areas and communities: (1) suburban areas in Algeria and nomads of Sahara; (2) Togo's rural areas where clean water is a huge challenge (MARS 3).
- The system is powered by renewable energies and adapted to the needs of the end-users (MARS 3).
- Testing in real life environments (MARS 3).
- Assessment of needs and potential resources at country or regional levels (MARS 1).
- Progress of EU-AU R&I cooperation on RES (MARS 1).

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Presentation of scientific and/or technical objectives as defined in the initial proposal submitted to the LEAP-RE program

1. Development and optimization of the UV/LED irradiation module for water disinfection
2. Development and testing of the solar energy module
3. Data processing and control software
4. Enhanced wireless positioning and tracking algorithms in order to keep track of the water sources and workforce/people
5. Pilots in realistic environments – Lome region, Algeria in (Tipaza and Blida) and Baragan region (Romania)
6. We aim for an affordable system which will be designed by keeping in mind the end-users' needs and local opportunities
7. A business plan for the future exploitation of the LEDSOL results

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Results achieved

- *Development of the LEDSOL architecture based on on-site surveys and focus groups in Togo and Algeria (ISO).*
- [1] E. S. Lohan et al., "Standalone Solutions for Clean and Sustainable Water Access in Africa Through Smart UV/LED Disinfection, Solar Energy Utilization, and Wireless Positioning Support," in IEEE Access, vol. 11, pp. 81882-81899, 2023.

Figure 11: Example of the water storage habit (left-hand picture) and drilled well in a Togo housing community (right-hand picture)

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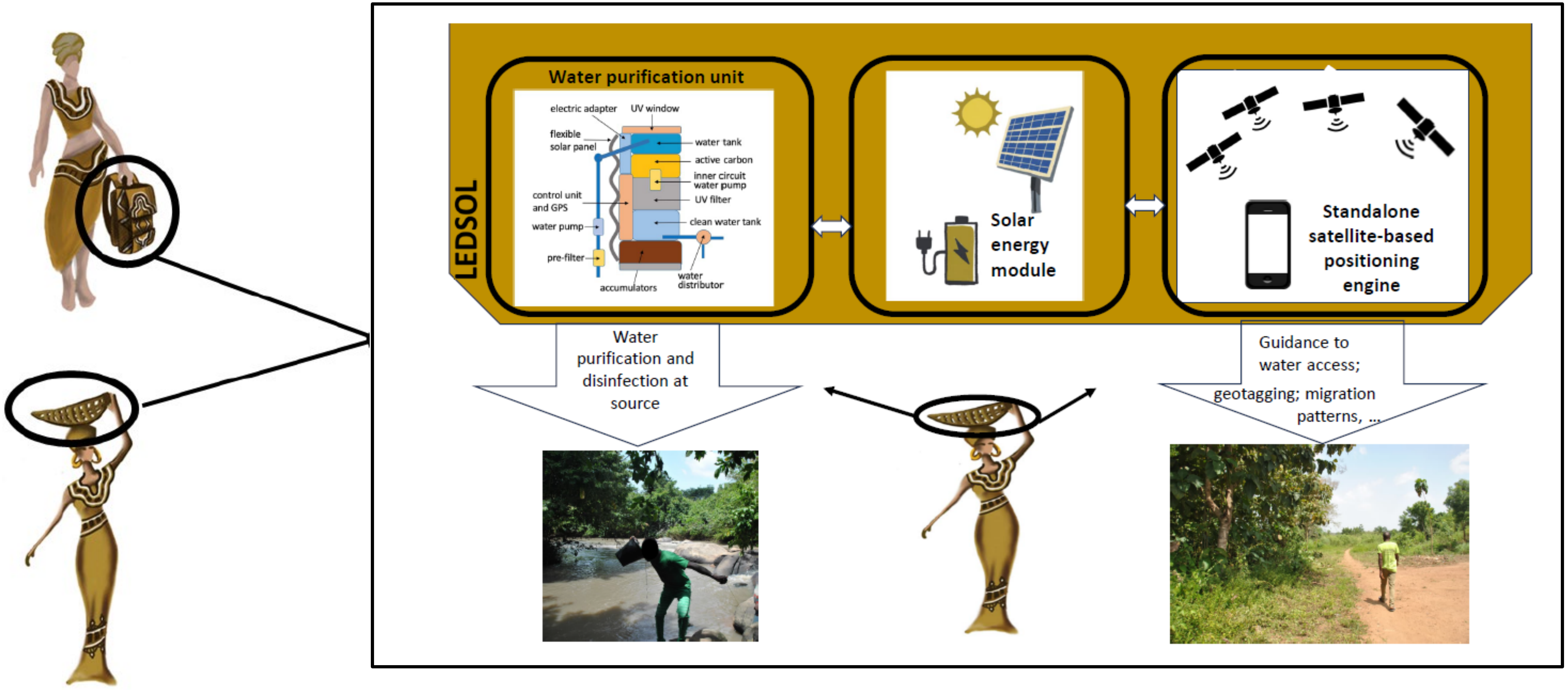
Results achieved

- *The LEDSOL architecture.*



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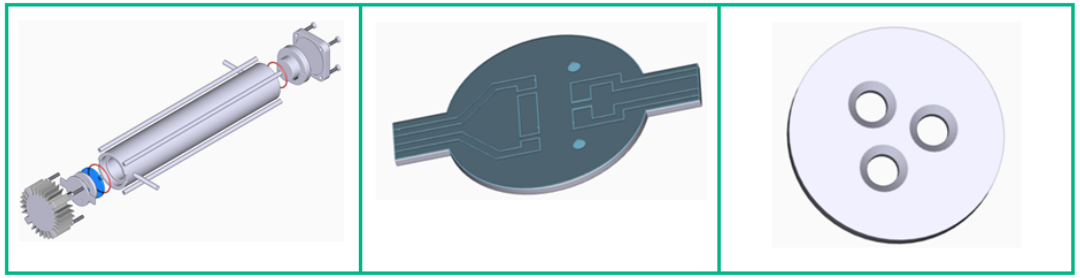
Results achieved

- *Development of the UV/LED irradiation chamber for water disinfection.*



a b c

The whole assembly of LEDSOL model (a), the printed circuit board (PCB) for LEDs (b) and the Teflon separator plate with holes for UV LEDs (c).

a b c

The developed LEDSOL model (a) and images of the interior showing the two switched on UV-A LEDs (b) and one UV-C LED (c).

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➢ *[2] E.S. Lohan et al., "Design and testing of LEDSOL components for sustainable access to clean water in Africa", submitted at 34th FRUCT conference, in evaluation).*

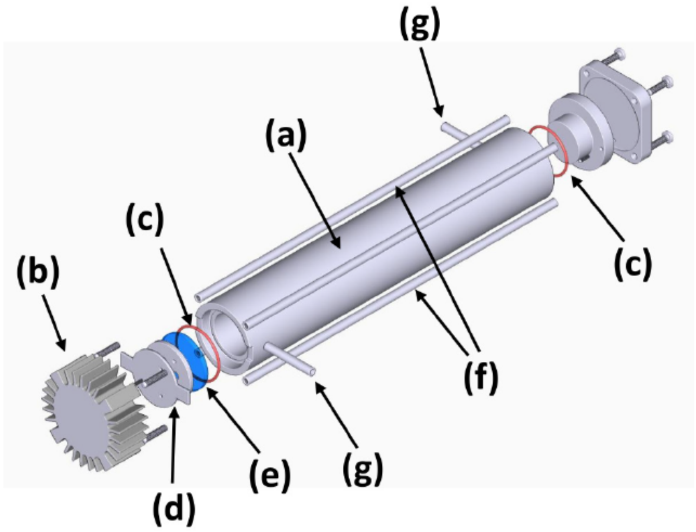

Figure 3: Treatment chamber comprising: (a) Teflon tube 25cm in length, inner and outer diameter 3 and 5 cm, respectively; (b) Aluminium radiators; (c) gskets; (d) PCB with LEDs; (e) quartz window; (f) fastening systems; (g) water flow pipes.

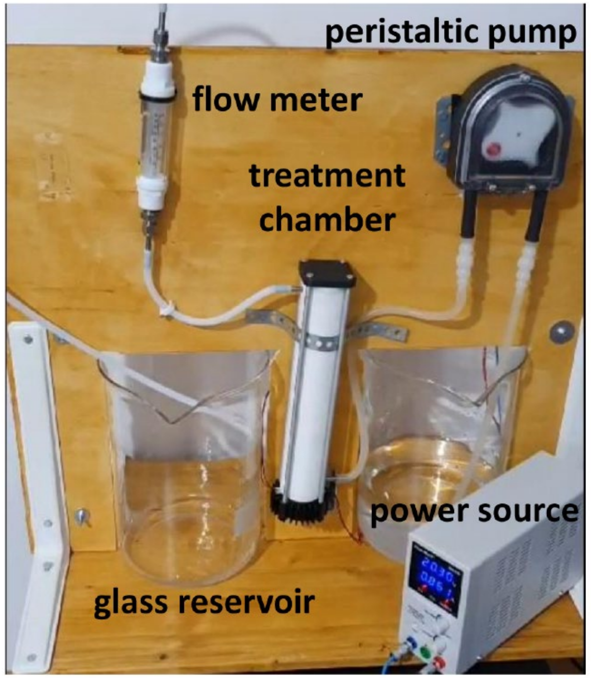

Figure 4: LEDSOL disinfection laboratory prototype based on UV/LED irradiation.

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Results achieved

- *Water sampling in Togo and Algeria [1,2]:*
  - *[1] Haho river in Latacopé, wells in Agoé Zongo (Lomé suburb),*
  - *[2] Four campaigns for water measurements have been conducted in Togo and Algeria: a) surface water from river Haho, Togo; b) ground Water from a well in Agoe-Zongo, Togo; c) water source in Aın Bahloul - Aın Tagourait, Algeria; d) water source in Sidi Bouzid - Kolea, Algeria*
  - *AFNOR1 standard methods were used for physical-chemical and microbiological characterization*
  - *To assess the water quality, the hydro-chemical and microbiological results were compared to WHO water standards*
  - *In general, the water is characterized by a high mineralization and salinity as well as high levels of germs and bacteria*

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Results achieved

- *Water sampling in Togo and Algeria [2]*

Table I: Measured water quality in four locations in Togo and Algeria; red values show abnormal levels

Parameter	River Haho SW, Togo)	Agoe-Zongo GW, Togo	Aïn Tagouraït GW, Algeria	Kolea GW, Algeria	Maximum value (WHO/EU standards) [7]
Date	26.09.2023	29.08.2023	21.03.2023	21.03.2023	
Total coliformes [UFC/250 ml]	60	200	375	375	1
Escherichia coli [UFC/250 ml]	N/A	N/A	375	5	0
Faecal Streptococi [UFC/250 ml]	10	120	7.5	0	1
pH	7.9	7.4	8.1	6.8	6.5 – 8.5
Temperature [^{o}C]	26.7	27	20.6	22.5 C	–
EC [µs/cm]	320	1130	1760	1270	400
TDS [mg/l]	253	856	940	670	1500
Turbidity [NTU]	20.2	2.2	N/A	N/A	5
Sodium [mg/L]	20	128	N/A	N/A	150
Potassium [mg/L]	3	20.8	N/A	N/A	12
Magnesium [mg/L]	0	0.4	N/A	N/A	0.5
Total Iron [mg/L]	0.6	0	N/A	N/A	0.3

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Results achieved

- *Sizing of the solar cell unit [1]*
  - *The use of flexible/foldable solar panels has been adopted for their lightweight and their ease of integration into any design*

Table 1: Estimated energy needs for our envisaged water-purification solar-powered system equipped with a standalone positioning engine

Appliances	Power of appliances [W]	Average operation Hours [h]	Average daily energy consumption [Wh]
Pump 5L/min	5	0.58	2.91
Pump 1.5L/min	6	1.25	7.5
Electronic control boards 1	3	0.58	1.74
Electronic control boards 2	3	1.25	3.75
Solenoid valve	5	1.25	6.25
GNSS chipset	5	0.58	2.91
UV-LED unit	20	1.25	25
Standby system	0.22	24	5.28
Estimated total	43.42	10.16	57.24

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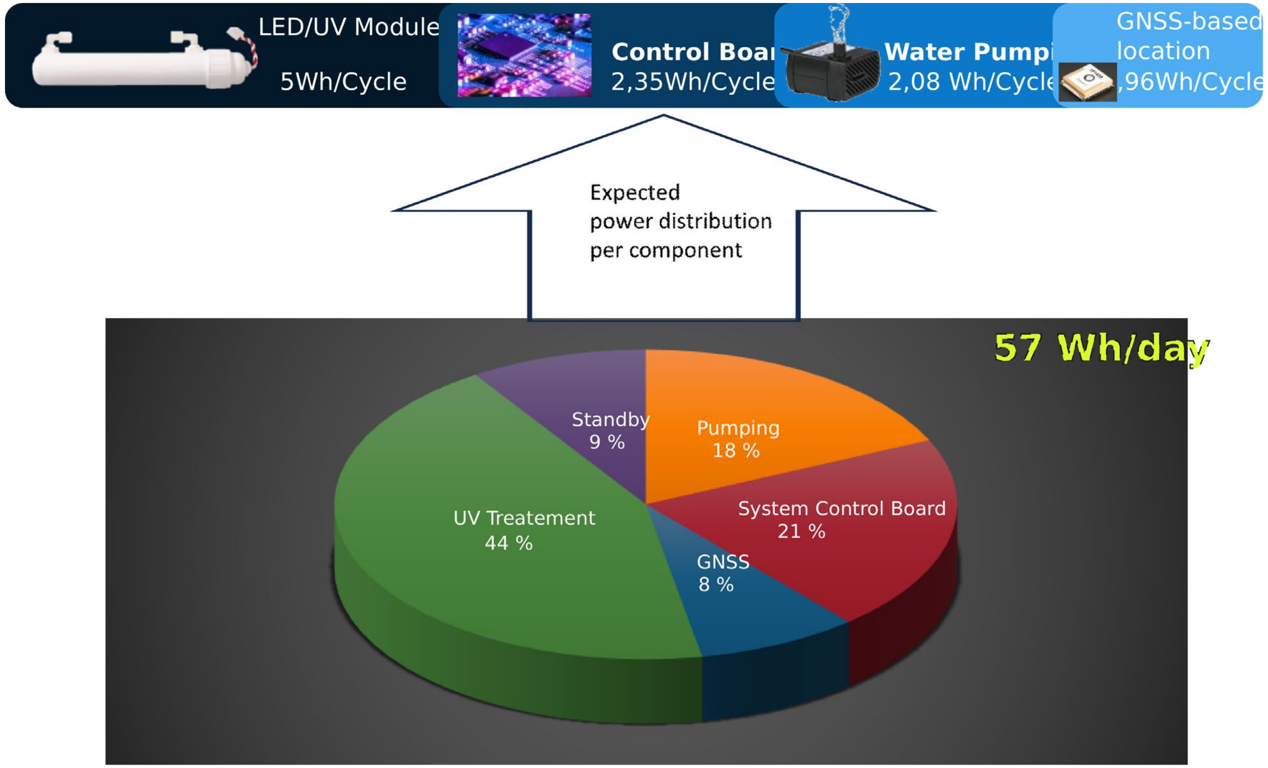
Results achieved

- *Sizing of the solar cell unit [2]*
  - *Distribution of electrical consumption by component and per day*



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Results achieved

- *Localization implementation and testing [1,2]*
  - *Android mobile phones with the GNSSLogger app were used to measure (dynamic conditions) and store GNSS raw measurements, together with reference tracks in NMEA format (latitude, longitude, altitude). The analysis was done with own in-house developed Matlab software.*

Figure 6: Example of one measurement track in Togo during our measurement campaigns.

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Results achieved

- *We found that reasonable horizontal accuracy (of few meters) can be attainable in most scenarios with Android-quality raw GNSS data. We can also see a good match between the estimated tropospheric delays, as well as good agreement between the ionospheric delays estimated with data from different phones.*
- *The vertical positioning accuracy is however rather low with all devices in standalone positioning and it is a part that needs further enhancements.*

Table IV: Variations across mobile phones, same location in Togo, mixed environments: walk; L1-B1-G1 carrier frequency; GP=GPS, GL=Glonass, BD=Beidou; c= speed of light.

Phone	Itel w6501	Moto E6 play	Tecno spark 7	Tecno Camon 16 pro	Infinix Hot 12i	Infinix Hot 6
Dates	10.3.2023	16.7.2023	26.8.2023	26.8.2023	24.8.2023	27.8.2023
T_{obs} [h]	0.51	0.37	2.54	1.55	0.64	0.61
$GNSS$	GP GL	GL	GP GL	GP GL BD	GP GL BD	GP GL BD
N_{sat}	8.6 4.8	5.8	9.8 6.6	8.0 5.8 7.4	8.7 6.7 7.2	10.2 6.2 5.4
$c\tau_{iono}$ [m]	6.6 6.6	5.1	2.2 1.9	5.5 6.1 6.1	6.2 6.5 6.2	10.2 10.5 9.4
$c\tau_{tropo}$ [m]	5.2 4.9	5.1	5.4 6.6	4.7 5.4 5.2	4.9 5.7 5.0	5.0 5.5 5.7
$c\tau_{other}$ [m]	52.8 168	54.2	245.4 373.9	223.7 201.6 203.2	166.2 126.3 133.1	516.3 606.4 527.4
$Best\ comb.$	GP+GL	GL	GP+GL	GP+GL+BD	GP+GL+BD	GP+GL+BD
ϵ_{2DMean} [m]	5.9	17.7	4.1	2.5	3.1	6.1
ϵ_{2Dstd} [m]	6.8	368.9	11.9	3.2	3.1	6.7
$\epsilon_{z,Mean}$ [m]	9.2	66.4	28.4	25.6	31.7	31.3
$\epsilon_{z,std}$ [m]	13.1	1409.9	50.2	8.4	10.3	5.3

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- ***Results achieved***
- *Increase in TRL from TRL 3 to TRL4-5*
- *New technology and products are under development*
- *System constraints and testing results: Based on our studies so far, the chosen design should comply with the following specifications:*
  - *The selected components need to have low electricity consumption attributes, thus operating in DC mode to avoid energy losses due to the DC-to-AC conversion process. Must operate with a maximum voltage of 12V to ensure the safety*
  - *The use of flexible/foldable solar panels has been adopted for their lightweight and their ease of integration into any design*
  - *Must provide a min of 2l/min water flow*
  - *Must operate under dynamically changing conditions*
  - *Must be light weighted and low cost*
  - *Achievable accuracies are of few meters in horizontal direction, but we need to improve on the altitude direction*

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- ***End of project expected results (2025)***
  - *Integrated and validated (real life conditions) LEDSOL system (Togo, Algeria, Romania)*
  - *Pilot results*
  - *Business plan for future commercial exploitation*
  - *Wide scale and scientific dissemination*
  - *Strategy for sustainable cooperation between the partners and with third parties from outside the consortium*

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Expected outcomes in case of success of the project (2030)

1. Certified solution for clean water production that can be easily and widely deployed in remote areas
2. Access to clean water for a large number of beneficiaries (at least 100 LEDSOL units in use)
3. LEDSOL advertised as product by CITST
4. Commercial exploitation contracts with local vendors in Africa and in Romania
5. Long-term and close scientific cooperation between Europe and Africa in terms of 2-3 common grant applications submitted

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Contribution of the project to AU – EU R&D partnership

1. Certified solution for clean water production that can be easily and widely deployed in remote areas
2. Access to clean water for a large number of beneficiaries (at least 100 LEDSOL units in use)
3. LEDSOL advertised as product by CITST
4. Commercial exploitation contracts with local vendors in Africa and in Romania
5. Long-term and close scientific cooperation between Europe and Africa in terms of 2-3 common grant applications submitted

Interest of Consortium members in participating in LEAP-RE clustering activities

- End-user input on needs and satisfaction from both pre- and post-piloting inputs
- Algorithms for localization relying on multi-system multi-frequency GNSS and possibly LEO signals (LEO-based validation to be done only through simulations, while GNSS validation is with measurement data)
- LEDSOL system performance

THANK YOU

CONTACT US FOR MORE INFORMATION

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