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Med-EcoSuRe

Building Energy Renovation process National Engineering School of Tunis Report

Authors

Date

November 2023

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Layout

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1. General Scope

1.1. Project overview

Low energy educational buildings are becoming the standard for new buildings in European and Mediterranean partner countries. Meanwhile, the potential of efficient renovation of existing buildings continues to be a development focus in these countries. Technical solutions are continuously proposed by universities for eco-sustainable building renovation, but there is still a gap between designed models and real world application. Med-EcoSuRe (Mediterranean University as Catalyst for Eco-Sustainable Renovation) project is rooted in the key role that Mediterranean universities must contribute to environmental development and combat climate change. The project brings together researchers and stakeholders, in the framework of A Living Lab (LL), to build a common understanding of the eco-sustainable building renovation issues and to empower regional knowledge-to-action process, starting by the university's immediate neighbourhood, which is the university building.
The project allowed Mediterranean university building managers mainly, among other key stakeholders, to tap into a wide array of proven technologies, policies, and financing mechanisms to improve energy efficiency and capture cost-effective energy savings in buildings.
Med-EcoSuRe succeeded in implementing, testing, and deploying innovative and cost-effective energy renovation processes in Tunisia, Palestine and Italy.
University Tunis El Manar, through the National Engineering School of Tunis, is the partner university from Tunisia which hosted a number of energy renovation actions enabling to ensure safety and comfort for users and continuity of services provided and to turn the buildings into a smart, green and healthy area.
The implemented renovation acions are proposed as part of a Living Lab established in the framework of Med-EcoSuRe project, while involving the project partners, stakeholders and decision makers in the renovation cycle of the buildings starting from the proposal of technological solutions until the phases of implementation and testing, leading to setting up policies and strategies adapted to the national context.

1.2. University of Tunis El Manar/ National Engineering School of Tunis (ENIT)

University of Tunis el Manar is located at El Manar campus in Tunis (Figure.1), and consists of four faculties, nine institutes and two schools, among which we can cite: Faculty of Law and Political Sciences, Faculty of Medecines, Faculty of Economic sciences and Management, Faculty of Sciences, Preparatory Institute for Engineering Studies, Institute for Engineering Studies, Bourguiba Institute of Modern Languages and National Engineering School of Tunis, object of renovation in the framework of Med-EcoSuRe project.

Figure 1: Map of University Tunis El Manar (with its related institutions)

ENIT (Figure.2) is founded in 1968 and is the oldest engineering school in Tunisia after the National Agronomic Institute of Tunisia (1898). The founder - and first director of the ENIT - is Mr. Mokhtar LAATIRI, engineer and senior Tunisian civil servant.

Figure 2: National Engineering School of Tunis (ENIT)

The school includes five departments namely: civil engineering, mechanical engineering, electrical engineering, industrial engineering, and Information and communication technologies. Each department offers different masters and doctoral programs and has its own research laboratories.

Two new majors were added in 2010-2011 which are advanced techniques as well as hydraulics and the environment. In the following year (2012) another new major attached to the department of applied was introduced which is modelling for industry and services.

ENIT, today, has three complementary missions:

- Undergraduate and postgraduate programs for engineers that meets real or potential market needs.
- Permanent and remote training to sharpen the performance of engineers.
- Research, innovation and transfer of know-how through development and technological entrepreneurship.

The energy renovation measures were implemented in following buildings and areas at ENIT:

- The central administration building (Fig.3.a) of the school, which consists of two floors and is dedicated to the administrative staff.
- A research unit "QehnA" within the Electrical Engineering Department
- A Solar Lab belonging to an energy building (including laboratories, research units, offices, calssrooms…) within the Industrial Engineering Department
- A Complex Building (called TOUR ROUSSEL) which includes classrooms, conference rooms, laboratories and the library. This building is the biggest in the school and thus has the highest number of occupants (students, professors, researchers, administrative staff…).
- Offices in the Energy Building
- The garden of the Industrial Engineering Department
- The parking of the Industrial Engineering Department

2. Implementation and deployment of the energy renovation process

An energy audit was performed at the National Engineering School of Tunis (ENIT), describing the current level of the energy situation covering several buildings and equipments (energy consumption, losses, building envelops…)

Based on the analyses of the obtained data as well numerical simulations results, several recommendations and opportunities for improving energy efficiency and renewable energy applications were identified.
The actions implemented were chosen based on these energy audit recommendations and on surveys performed within the school, which targeted the priorities and needs in terms of building performance improvement.

The energy renovation actions are illustrated below (also in figure.3):

- Rooftop generation and distribution photovoltaic (PV) Plant
- Micro-grids for energy generation and trading
- Solar Lab renovation
- Energy Efficiency improvement of the administration building
- Replacement of old cooling devices with high performance systems
- Installation of Surveillance & Security Cameras

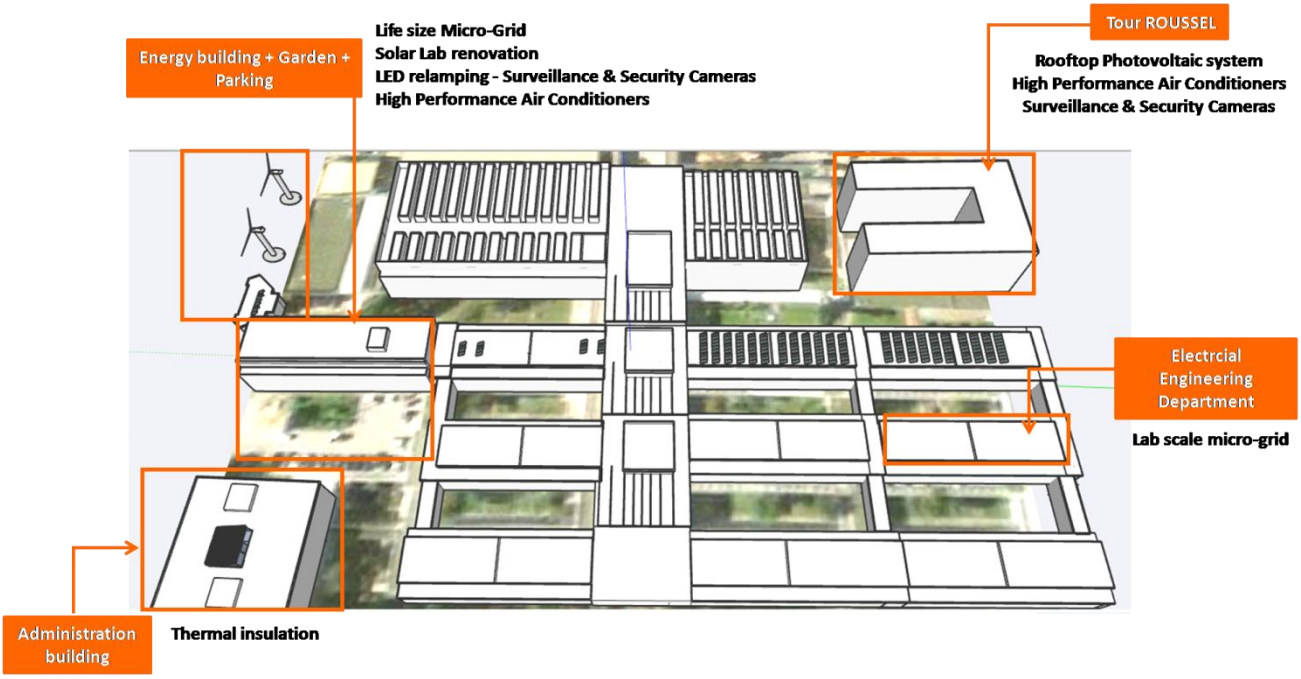


Figure 3: Implemented action per building/area

Feasibility studies were carried out for the implementation of the life size micro-grid and for the possibility of installing a PV system covering the courtyard of the administration building.

2.1. Energy efficiency improvement of the administration building

The administration building of ENIT needs a series of refurbishment to improve comfort, environmental quality and energy efficiency. This includes for instance: classical walls and roofs insulation, dynamic insulation, energy efficiency of artificial illumination, enhancing heating system (Absorption chiller), replacing single glazed windows by high performance double skin windows, adding shading systems, introducing Building Energy Management Systems, PV in roofing systems...
The action proposed and implemented by ENIT team in the framework of Med-EcoSuRe was the thermal insulation of the rooftop.
The rooftop of the pilot administration building was repaired, sealed, and insulated using polyurethane Sandwich Panels. The works were carried out in 2022 (figure.4)

Figure 4: Thermal insulation at the roof of the administration building

A Feasibility study was also carried out, in April 2023, based on the recommendations of the energy audit, for the installation of a PV system to cover the central courtyard of the administration building. This solution was proposed to mainly minimize the direct solar radiation reaching the court of the administration and which is causing overheating of the building in summer.
The system should allow also generating clean energy to power and consequently reducing the energy bill of the whole school.

The study proposed a system powered with PV panels having a capacity of 24.545 kWp fixed on the roof of the administration building, with an inclination of 10° (figure.5)

The feasibility study included the technical specifications, and estimation, in terms of budget and timeframe, of the foreseen pilot action. Based on this, it was not possible to concretize the pilot due to the available budget and especially tight timeframe of the project.

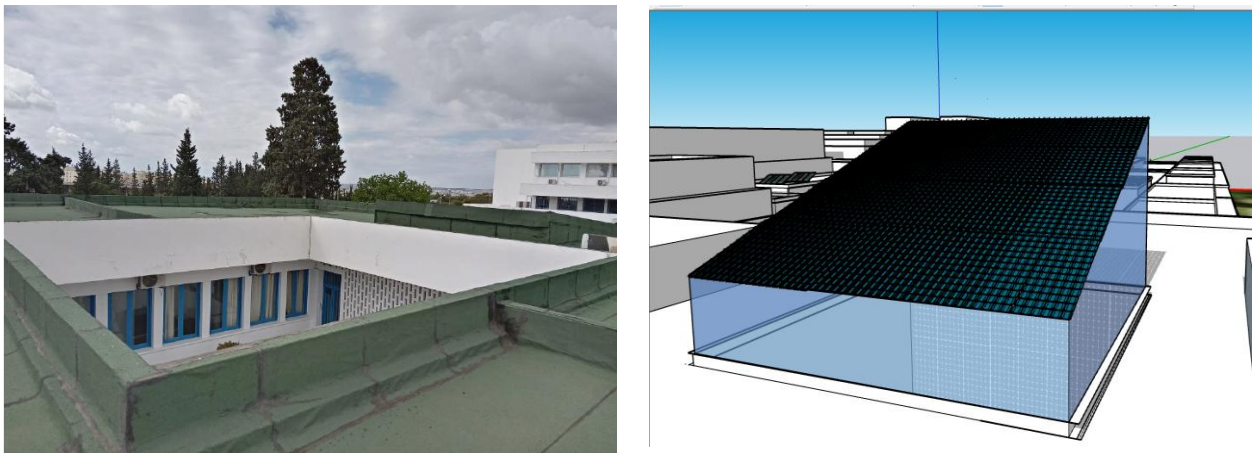


Figure 5: Roof of the administration (Left); Design of the PV system (Right)

2.2. Renovation of the Solar Lab

The solar Lab, within the Industrial Engineering department, is a space dedicated to provide the students and researchers with the opportunity to practice and learn experimental techniques and scientific processes related to renewable energies with a focus on solar energy.

The Four main actions proposed and implemented in this lab are the following:

- **Double glazing** (12 mm Gaz Argon) was installed on 8 windows of the room with a total surface of 25m^2. Double glazed windows reduce mainly the loss of heat during winter and coolness during summer, and thus reduce the energy bill automatically (figure .6)

- **Thermal insulation** of the ceiling through the installation of removable acoustic ceiling made of high-density rock wool. This creates a barrier to heat gain and loss in ceilings. It is a cost-effective and practical way to keep the building warmer in winter and cooler in summer (figure.7)

- **Shading devices** on the exposed windows by installing manually operated and adjustable sunshades for windows (2.00m x 1.50m). The installed solar shading devices are vertical slats in extruded aluminium profiles. These devices prevent the penetration of solar radiation into the building in summer, while allowing the needed solar gains in winter, which leads to a better thermal comfort with significant energy savings (figure.9; right)

- **Relamping** through the replacement of old lamps with Led Lights (76 units) for less power consumption and longer lifespan. One unit has a power of 9 Watt. (figure.8 and 9)

The refurbishment work, carried out in 2022, includes also upgrading the existing electrical installation as well as the building envelope (plastering, coatings, paints…)

Figure 6: Double glazing installation

Figure 7: Ceiling thermal insulation installation

Figure 8: LED light installation

Figure 9: Solar Lab after renovation

2.3. Rooftop generation and distribution PV Plant

A Rooftop PV power plant was installed, in July 2023, in the complex building (TOUR ROUSSEL) which a four-floor building including classrooms, conference rooms, laboratories and the library.
The aim of the plant is to generate renewable electricity that is fed to the national grid and which will cover 8% of the total electricity consumption of the school.

An engineering bureau was appointed to develop the study for the installation the solar PV generation and distribution system with a capacity of 71.5 kWp, and which is expected to generate 90 MWh per year (figure 10; left).

A monitoring system (figure.10; right) is implemented also to visualize the real-time performance of the power plant including the energy produced, the CO_2 emissions saved, and the savings (in Tunisian Dinars)

Figure 10: Rooftop PV power plant (Left); Monitoring system (Right)

2.4. Installation of high performance systems and security devices

New high performance air conditioning units were installed, in July 2023, in different rooms (offices, teaching rooms, labs…) of the school to replace the old cooling devices (figure.11).
The new devices have more advanced technology and better energy efficiency ratings. These models are designed to consume less electricity while providing higher level of performance than their older counterparts.
Besides, switching to new units will enable to benefit from better build quality and fewer maintenance and repair Costs. Furthermore, new air conditioning units are more environmentally friendly, and they help in reducing the carbon footprint.

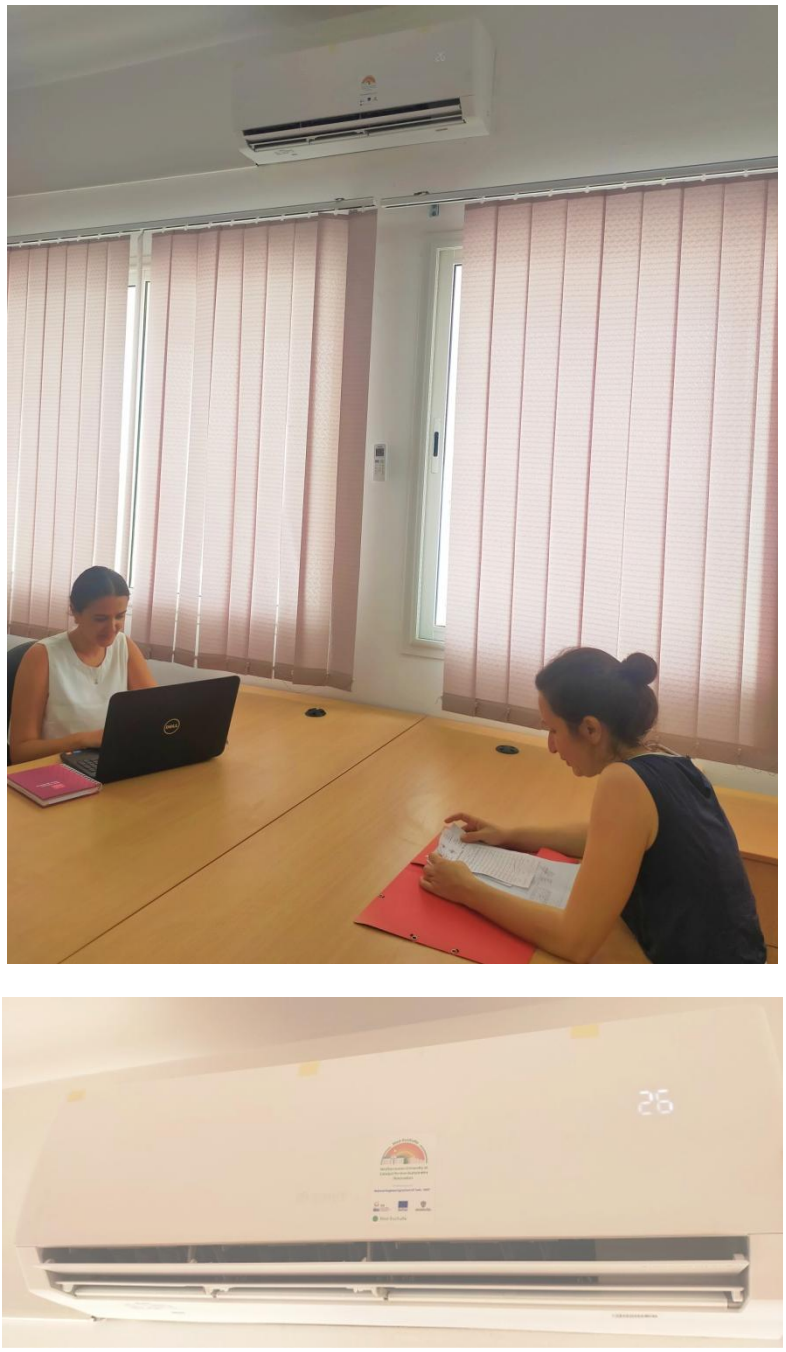


Figure 11: High performance air conditioning units

Surveillance & Security Cameras were also installed to be able to be more proactive with the school safety and when suspicious activities are happening in real time. The cameras are installed at the complex buildings TOUR ROUSEEL where the rooftop PV plant is implemented and the renovated Solar lab in the energy building (figure.12).

Figure 12: Surveillance and security cameras

2.5. Micro-grids for energy generation and trading

Two scales of micro-grids were implemented and deployed at ENIT with the aim of investigating, via numerical modelling and experimental testing, new renewable energy technologies and new concepts such as energy management systems, block chain, Virtual Power Plants (VPP), and Energy trading which enable to manage the energy generation in a decentralized way and to predict energy exchange and transactions.

Through the implementation of these micro-grids, Med-EcoSuRe team in Tunisia intended to demonstrate innovative technologies, in line with research carried out in the school laboratories while developing new research activities in the framework of Master and PhD projects.

The implementation of these technologies allowed to:

- Generate clean energy and manage in an efficient way the energy generation and exchange among a community within the school. This results in a reduced electricity bill and a notable amount of CO_2 emissions avoided.
- Produce energy to cover cooling demand peaks in summertime especially, and thus improving the thermal comfort and the building performance;
- Assess the energy performance and the economical feasibility of Micro-Grid solutions in a Tunisian context.

The implementation phase of the Micro-Grid systems was followed by extensive testing at both lab scale and small scale levels, which will enable to calibrate the climate change scenarios and thus accelerate achieving the goals of reducing greenhouse gas emissions mainly.

a. Lab-Scale micro-grid

The first micro-grid installed is a Lab-Scale system that was inaugurated officially in January 2021 at a research unit "QehnA" belonging to the electrical engineering department (figure.13).

The Micro-Grid platform SMARTNESS (Smart Micro-grid plAtfoRm wiTh aN Energy management SyStem) is powered by PV solar panels, and equipped with an energy management system.

The technical specifications of SMARTNESS are the following:

- Installed nominal power of PV generator: 18 kW
- Storage capacity: 7.2 kWh
- 04 Satellite Systems with Hybrid Solar Inverters
- 01 Central Power Generation Cabinet
- 01 communication system between the different elements
- 01 platform monitoring and control system via Web Monitoring which allows real-time monitoring as well as configuration of each element (central system and satellites)

Leaflet of SAMRTNESS

Figure 13: Lab-scale micro-grid SMARTNESS

From a technical point of view, SMARTNESS is composed of a central system that creates a local power system to feed four satellites. Each of this satellite is emulating a real house.
The central system is connected to a PV generation system (assured by 7 PV panels installed on the roof of this room) and central storage system. This central system can be connected to the grid or operates in a standalone mode, guaranteeing an energy feeding to the 4 houses since it is equipped wih a smart Energy management system.
Each of these four satellites/houses is called prosumer, since it can produce and consume Electrical energy, from its own production or from the SMARTNESS local grid.
Each of these houses has two types of loads: critical load that have to be always fed, and the non critical loads, which can be briefly not connected, if there is a fault fir example in the local grid.
All the energy flux management is monitored thanks to monitoring platforms we can connect to via internet.

Through the testing and deployment of this lab-scale micro-grid, the team was able to design and deliver a learning/training & capacity building program in order to promote the technology and to share the know-how and best practices acquired. This program covered various topics and addressed students and researchers, decision makers and economic operators as target group. This includes:

- MEDREC and ENIT supervised a research project, over one year (02/2021-01/2022), within a challenge-based module of the ERASMUS MUNDUS Master DENSYS (Decentralised smart ENergy SYStems) related to the management of energy in decentralized energy systems and including the design of energy networks, demand-side management and optimization (figure.14).

The master challenge, which started in February 2021, assesses the performance and techno-economic viability of SMARTNESS as a demonstration action of Med-EcoSuRe. This challenge was co-supervised in collaboration with Gamco Energy and Lightency, which are the solutions providers .
The work carried out by the group of students from Université de Lorraine includes:

- **Optimization** of the existing Micro-Grid platform, SMARTNESS, while adopting different architectures and Renewable Energy sources, and this is with the objective to assess the energy performance and the economic feasibility of Micro-Grid solutions in a Tunisian context while considering several factors (weather condition, utility tariff, discount rate, etc);
- **Numerical modeling** of SMARTNESS platform including its components : PV modules, battery modules and energy management strategies (EMS), with the aim to investigate the systems behavior under different weather and operating conditions;
- **Development of an energy trading model** to predict the energy exchange within the Micro-Grid community. This phase included the study of several energy market strategies, and then the adoption of the most suitable model to the Tunisian context;
- **Assessment of the Micro-Grid peroformance** by setting a number of Key Performance Indicators (economic, environmental, and electrical).

Based on the results obtained, it was concluded that the project carried out is based on the promotion of sustainable development in Tunisia, through the integration of renewable energies and the implementation of Micro-Grids for energy supply. Such technologies can lead to environmental benefits, economic advantages, and increased efficiency of the electrical supply. This is closely linked to the realization of the UN Sustainable Development Goal 7, which is aimed to ensure access to affordable, reliable, sustainable, and modern energy for all.
A scientific paper was presented at the Eurosun conference 2022 by the students on “An Energy Trading Model for a Lab-Scale PV Microgrid in the Tunisian Context”.

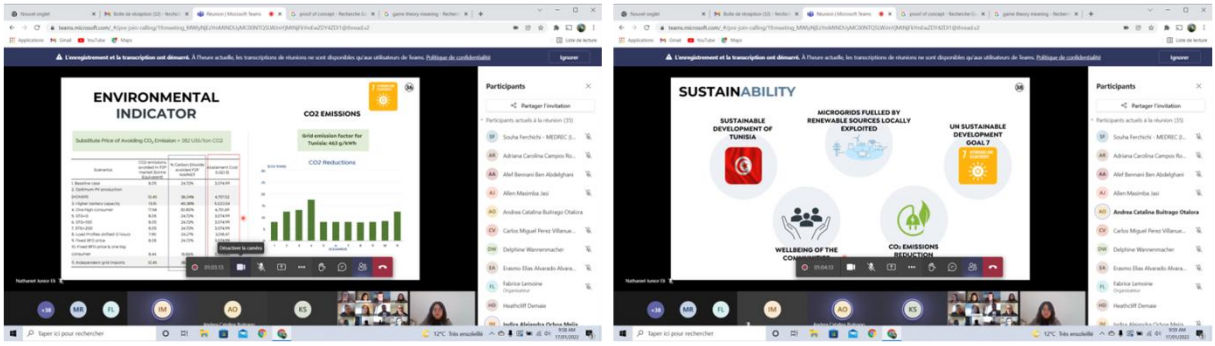


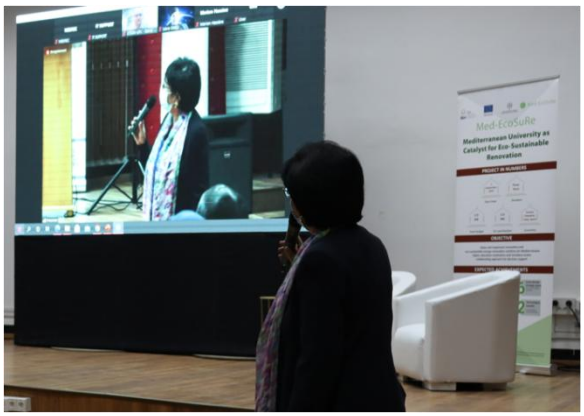
Figure 14: DENSYS master challenge

- A workshop was held also, in October 2021, with the participation of Euro-Mediterranean initiatives and projects in order to lay out the obstacles to the deployment of micro-grids and to explore the potential of scaling-up this technology in the Mediterranean (figure.15)

The hybrid workshop included:

- **Conferences**: during which best practices of the implementation of micro-grids in the Mediterranean context were shared. For instance, the **PEGASUS** project, funded within the Interreg MED programme, was presented, which has as objective to implement a set of tools and measures facilitating the development of micro-grids. Besides, the design and technical framework for the development and implementation of micro-grid projects as forms of decentralized energy generation were presented by different organizations among which is the research and technology transfer center **CITCEA**, part of the Universitat Politècnica de Catalunya (UPC) specialized in power electronics and its applications.
- **A round table** engaging decision makers and key actors which was highly dynamic and included joint discussions on **"Opportunities and challenges for the development of decentralized energy generation"**, with a special focus on micro-grids, which enabled participants to explore in-depth knowledge related to technical and legal framework of decentralized energy generation. Below is a summary of the Question/Answer session of the round table:

The workshop was concluded with a visit to SMARTNESS Micro-Grid pilot in the Electrical engineering department of ENIT.



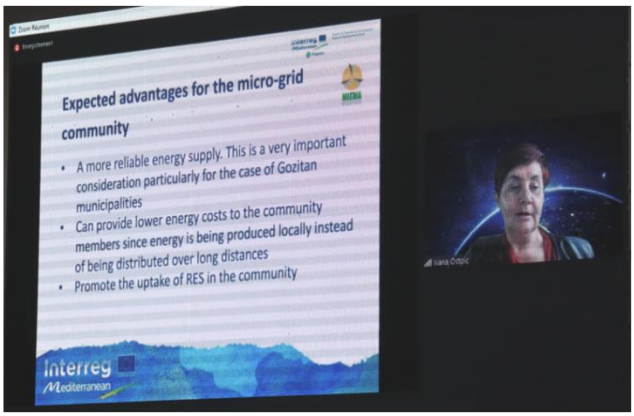


Figure 15: Workshop on deployment of micro-grids

[video of a Guided Tour of the platform]

- ENIT team has been conducting training sessions, site visits, courses for different types of stakeholders (decision makers, students, socio-economic operators) to showcase the experience gained through the implementation and deployment of SMARTNESS and to be able to replicate and scale-up this pilot system (figure.17). In particular, ENIT signed a collaboration agreement (figure.16.) with the STEG (Société Tunisienne de l'Electricité et du Gaz) in the framework of which a training and capacity building program has been designed and delivered for the benefit of the engineers and technicians of STEG on micro-grid and distribution systems based on renewable energy technologies, among other topics.

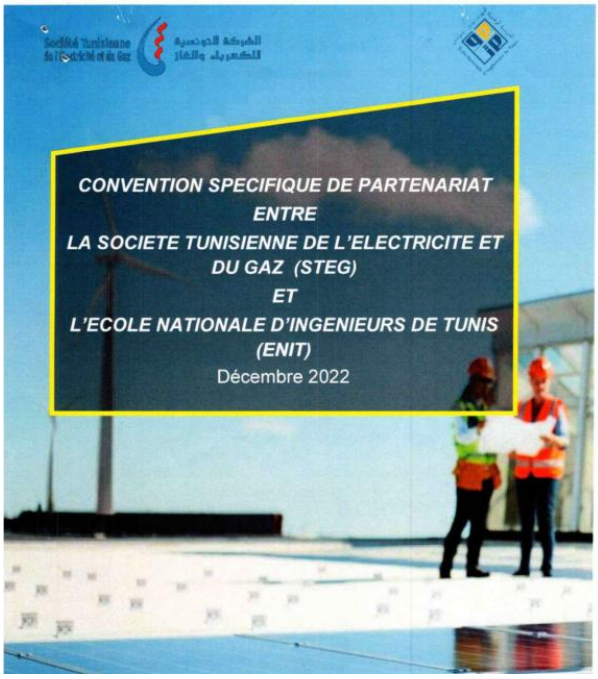


Figure 16: Collaboration agreement ENIT-STEG

Figure 17: Site visits to SMARTNESS micro-grid

b. Life-size micro-grid

Based on the experience gained and the lessons learned through the implementation of SMARTNES, the project team in Tunisia (MEDREC and ENIT) decided to scale-up the existing micro-grid platform and install an upgraded system which enables the energy generation and management between different buildings and areas at ENIT.

Following a feasibility study carried out, a call for tender was launched, for the acquisition and implementation of a life-size Micro-Grid unit powered by renewable energy sources and integrating software solutions for "energy management" and for the "creation and exchange of renewable energy certificates".
This life-size unit, associated with the proposed software solutions, is the object of demonstration, capacity building, research and innovation and training of the various actors and stakeholders of the project. It also allows testing new and innovative renewable energy technologies and concepts based on the needs of university buildings.
The unit, that was installed in August 2023, is powered by PV panels and enables the generation of electricity and the exchange of energy among the energy building rooms, the garden and the parking areas of the Industrial Engineering department.

Following are the technical specifications of the life-size micro-grid:

- Installed nominal power of PV generator: 25 kWp
- Storage capacity: 10 kWh
- One (01) central power generation system
- Three (03) so-called "satellite" systems serving different configurations of load curves
- One (01) communication system between the different elements based on the control of the frequency and voltage of the micro-grid.
- One (01) unit for monitoring and control via Web Monitoring which allows real-time monitoring and setting of each element (central system and satellites)

All these components are installed in the Solar Lab, and the PV panels are covering the energy Lab rooftop and its south vertical façade (figure.18).

The operation principle of this life size-micro grid is similar to the lab-scale one. The difference is that the satellite systems feed different rooms and areas within the school including offices, labs, garden and parking lighting...

Figure 18: Life size micro-grid

A customized energy management system software solution was developed for this micro-grid, which makes it possible to manage the energy exchange between the peers of the network, while monitoring the respective consumption and production. This solution will be open access and can be upgraded by researchers and students at ENIT. Besides, a software solution for the generation and management of **renewable energy certificates was provided**, which simulates the creation and exchange of certificates between micro-grid connected customers/prosumers (figure.19).

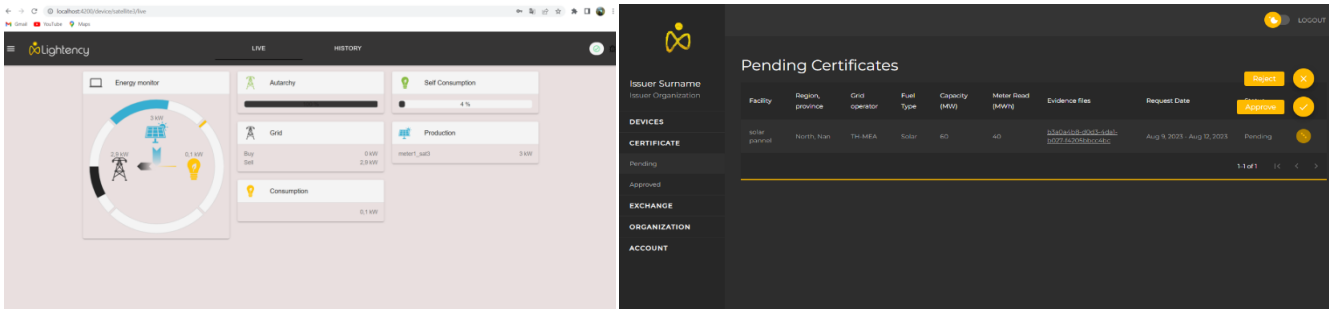


Figure 19: Monitoring and Energy Management System (Left), Renewable Energy Certificate (Right)

The pilot micro-grids installed are platforms that serve for Education, Research and Training through:

- Preparing future engineers for professional practices through practical workshops;
- Developing research activities that can be validated experimentally, within the framework of master and doctoral theses projects;
- Designing and conducting a training and capacity building programme, for socio-economic operators, to be able to face technological challenges in a rapidly evolving field.

Implementing and deploying the micro-grids is proving to strengthen research and capacity building within ENIT on one hand, and on the other hand to generate electricity in a sustainable way while relying on Renewable sources.

3. Testing and monitoring results

Following the monitoring phase performed, and based on numerical simulations, the energy performance and related indicators are obtained for all the renovation actions implemented, and the results are summarized in the table below:

Table 1: Specifications and performance indicators of the renovation actions

Site of project	Description of the project	Capacity installed	Energy generated	Savings and CO_2 emissions
	Installation of a Lab scale Micro-Grid			
Research Unit "QehnA"	(SMARTNESS) PV generator: 18 kWp	18 kWp	35,9 MWh/ year	
	Storage capacity: 7,2 kWh			
	Inverter: 6kW			
Energy Building (Solar lab + offices)	Renovation: • Renovation of windows • Lighting and solar shading space • Thermal insulation in the roof	• Installation of 76 LED Lamps • Double glazing windows (25 m^2) • Shading devices on the exposed windows. • Thermal insulation of the roof (exterior) (100 m^2)		• **11,76 MWh/year (LED lamps)** • **132 kWh/year (Windows glazing)** • **630 kWh/ year (Shading devices)** • **50 kWh/year (Roof insulation)**
	Installation of a Life scale Micro-Grid			
Energy Building + parking + garden	PV Generator: 21.5 kWp Storage capacity: 10 kWh Total Inverters (satellites) capacity: 21.5 kW	21 kWp	41,9 MWh/ year	• **23,17 tCO_2/year**
	Equipped with, Energy Management System, Monitoring			
Administration Building	Renovation project: • Installation of roof thermal insulation	Rooftop external insulation with PU		• **250 kWh/year**
All school	Installation of a rooftop Solar PV generation and distribution systemx	71,5 kWp	145,61 MWh/ year	• **80,52 tCO_2/year**
Teaching Rooms in different	Electrification and replacement of old cooling and heating devices with high performance systems (13 units)			• **8,73 MWhh/year**

buildings of the school				
	specifications of split units: Cooling capacity: 4950 W Heating capacity: 5220 W			
TOTAL		**111 kWp**	**223,5 MWh/ year**	**123,5 t CO_2/year** **21,5 MWh/year** **20.542 €/year**

4. Lessons learned and recommendations

- Engaging the target groups/stakeholders is important since the design phase of the pilot projects to accelerate the implementation phase
- It is necessity to prepare the feasibility studies and tender documents related to the pilot project at an early stage to prevent potential delays/to minimize the risk of not respecting the implementation timeframe that may be due to lengthy bureaucracy procedures.
- It is important to have an energy manager/building manager within the university to ensure the deployment and sustainability of the actions implemented.
- Based on the results obtained, the focus should be more on RE measures than on EE efficiency measures in order to reduce the electricity bill within the university.
- The feasibility of active and passive renovation measures in the Tunisian context was proved through the implementation of innovative technologies.
- The university showcased the relevance hosting Micro-Grids to generate and manage distributed energy, while deploying innovative technologies such as EMS, VPP, GEC…
- Raising the awareness among the target groups, and beneficiaries through events, trainings, Nudges, proved to be effective in terms of adoption of solutions.
- Installing smart monitoring devices is crucial to improve the performance of the building.
- The Micro-Grids system can be scaled up to the Campus level, and can include more diversified energy sources and technologies (Solar and wind) and while covering a wider demand range. As the national policies do not take into consideration energy trading in Tunisia, this concept can be only demonstrated at the Campus level, and a feasibility study as well as proposals of national regulatory framework of energy trading can be proposed. The technology can be also deployed in within agriculture communities.

ANNEXES

Annex.1. Video of the renovation actions in Tunisia

Med-EcoSuRe delivering more sustainable and efficient buildings in Tunisia

Annex.2. Lab-scale micro-grid monitoring

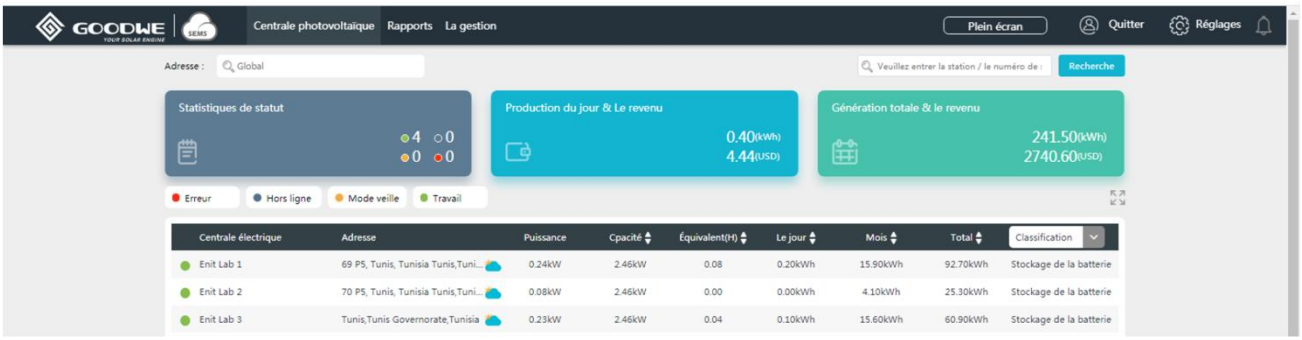
Access details

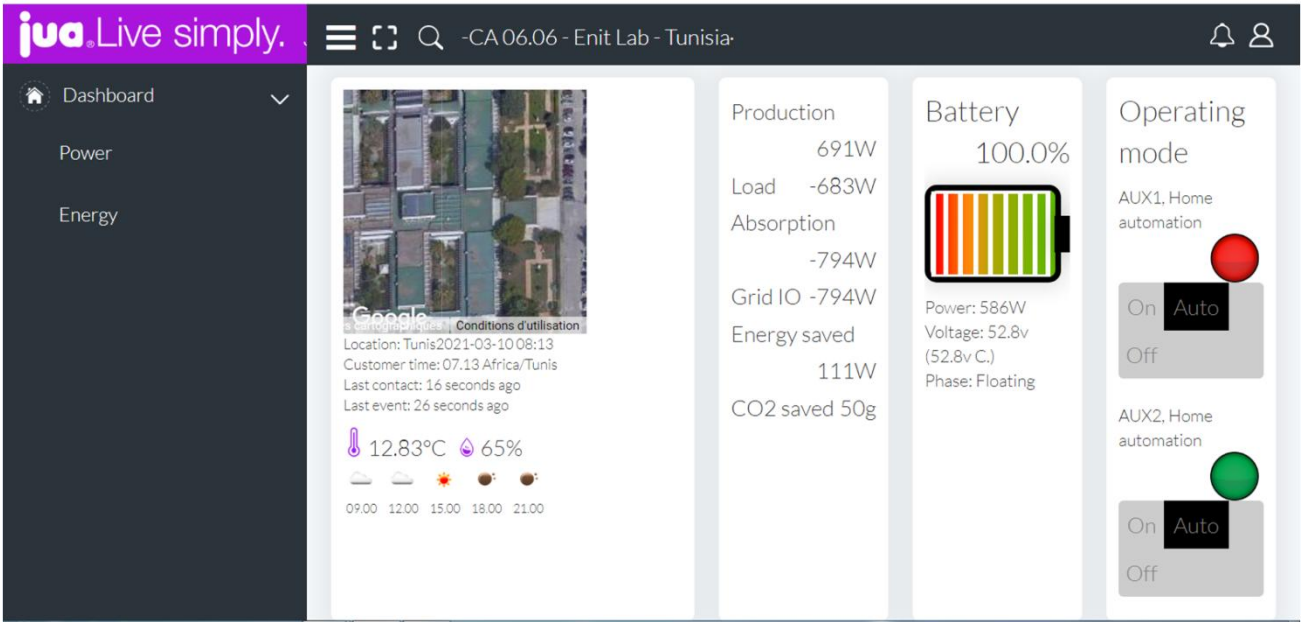
- SEMS portal: monitoring each of the four satellites/houses energy consumption, storage and production.

Username: souha.ferchichi@medrec.org
Password: medrecteam*1
website: www.semsportal.com

- Jua: monitoring the central system energy consumption, storage and production

Username: souha.ferchichi@medrec.org
Password: medrecteam*1
Website: https://dev.jua.solar/main/pv/dashboard.php

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Dashboard
Power
Energy
Conditions d'utilisation
Location: Tunis2021-03-10 08:13
Customer time: 07.13 Africa/Tunis
Last contact: 16 seconds ago
Last event: 26 seconds ago
12.83°C 65%
09.00 12.00 15.00 18.00 21.00
Production 691W
Load -683W
Absorption -794W
Grid IO -794W
Energy saved 111W
CO2 saved 50g
Battery 100.0%
Power: 586W
Voltage: 52.8v
(52.8v C.)
Phase: Floating
Operating mode
AUX1, Home automation
On Auto Off
AUX2, Home automation
On Auto Off


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Dashboard
Power
Energy
2021-03-09
2021-03-10
search
Energy Use
Battery I/O
PV Production
Grid I/O

Annex.5. Life-size micro-grid: monitoring, Energy management system and Renewable Energy Certificates platforms

All documentation
Link : https://github.com/
Username : MedEcoSuRe
password : enicbcmed123*

Online platform for the Energy Management System

Link : http://localhost:4200/index
Username : admin
Password : admin

H1 EMS software :

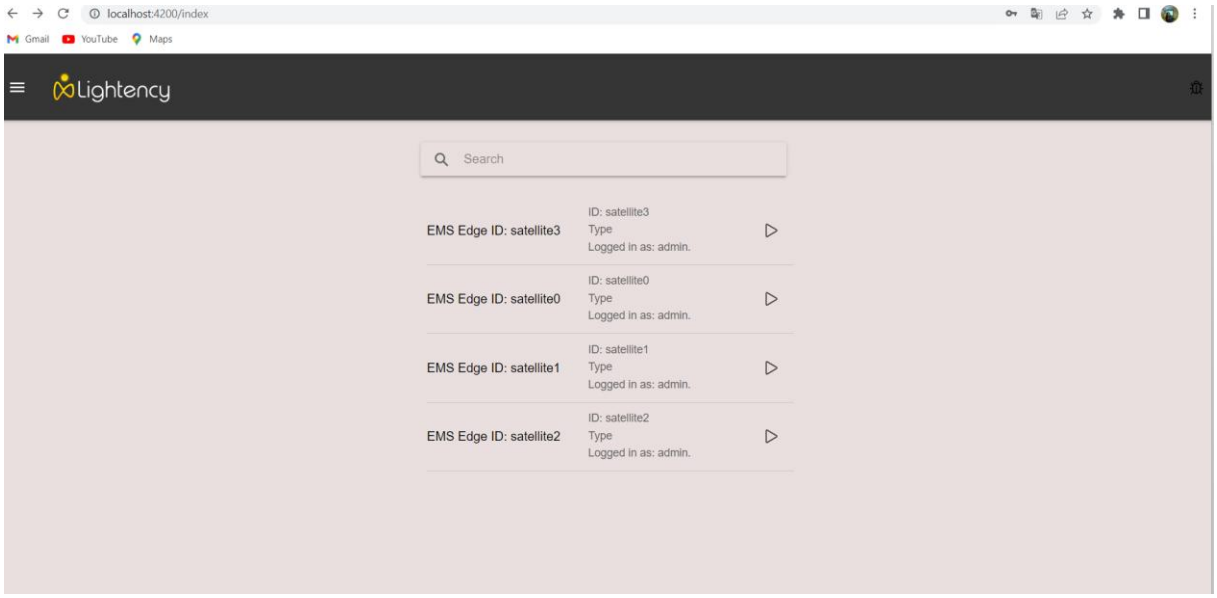
- Documentation: Link to EMS Software documentation
- Source Code: GitHub.
- Configuration :
  - Centrale : 3.84.159.21 | 172.31.87.125
  Config Port: 8080
  UI Port: 8085
  - Satellite1: 52.91.3.8 | 172.31.29.45 / Config Port:8079 , UI Port: 8082
  - Satellite2 : 34.201.136.11 | 172.31.80.163 / Config Port : 8079, UI Port : 8082
  - Satellite3 : 34.204.67.118 | 172.31.80.163 / Config Port : 8079, UI Port : 8082
  - Backend : 44.202.145.58 | 172.31.87.250 / Config Port : 8079, UI Port : 8082

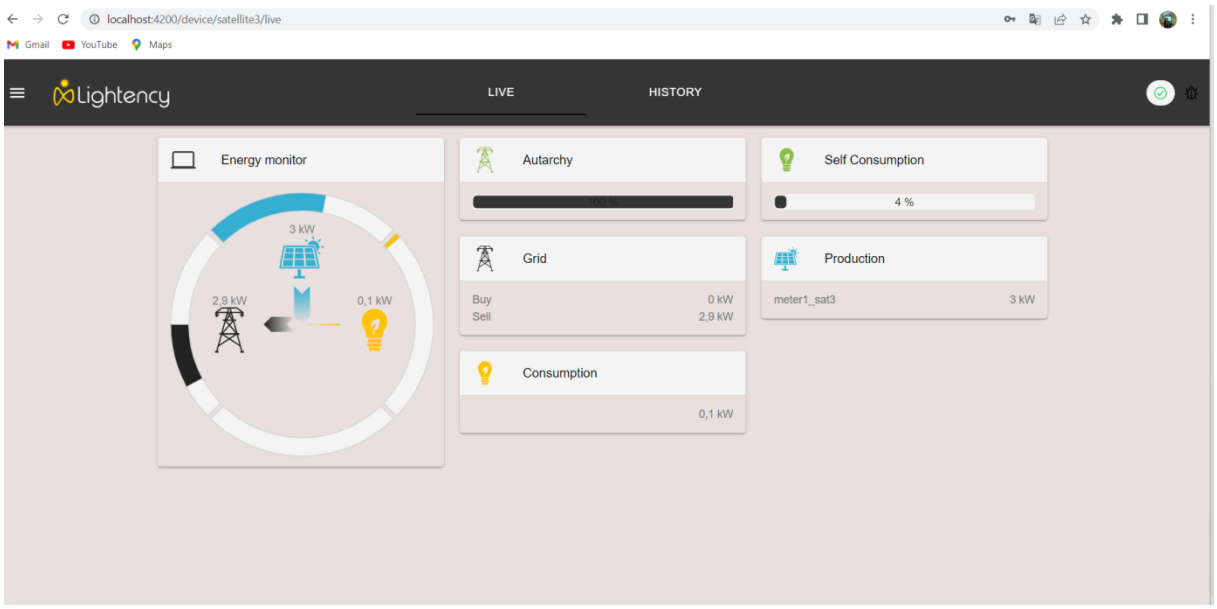
H2 Blockchain module :

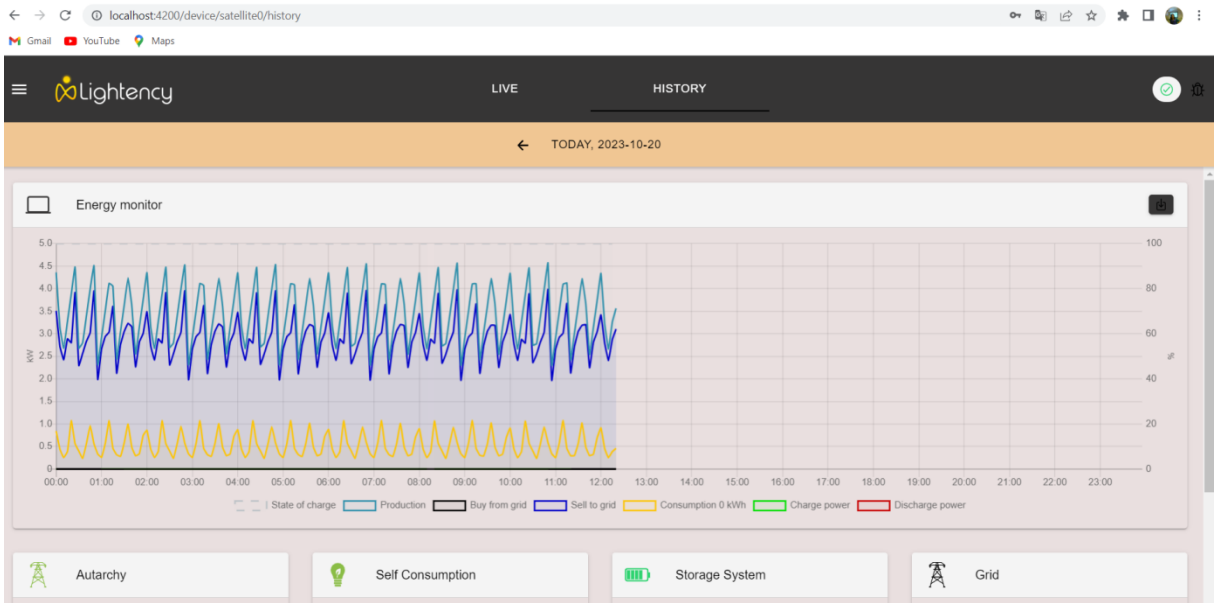
- Private chain on polygon: 35.174.153.116 | 172.31.86.55
- Port: 8545
- Status Command: 'systemctl status geth'
- Documentation link
  : https://docs.google.com/document/d/1Za5aIzICiD3slu6qhxcklYRVm4IOWBBCsj_4yySUzVU/edit

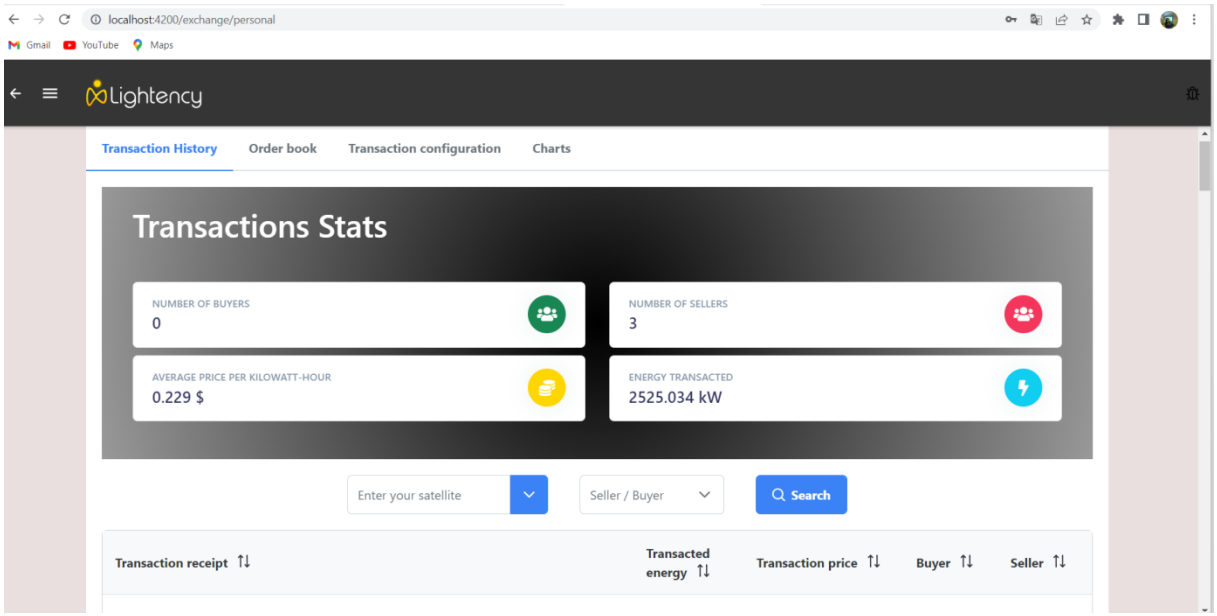
H3 Documentation & Design :

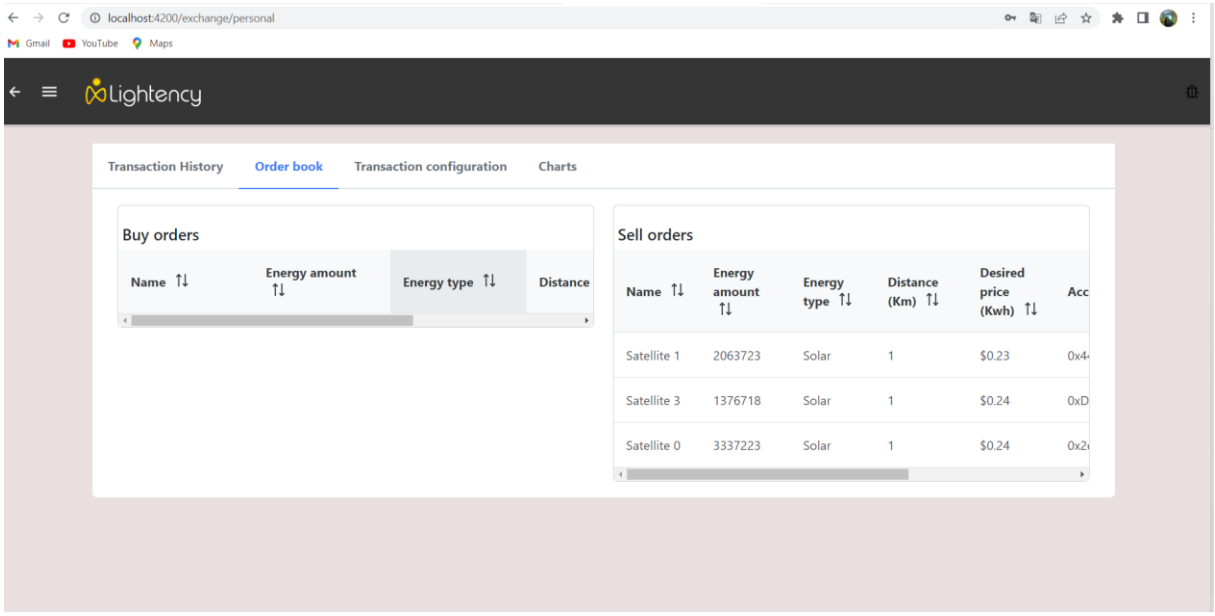
Access the design on Canva


localhost:4200/index
Gmail
YouTube
Maps
Lightency
Search
EMS Edge ID: satellite3
ID: satellite3
Type
Logged in as: admin.
EMS Edge ID: satellite0
ID: satellite0
Type
Logged in as: admin.
EMS Edge ID: satellite1
ID: satellite1
Type
Logged in as: admin.
EMS Edge ID: satellite2
ID: satellite2
Type
Logged in as: admin.


localhost:4200/device/satellite3/live
Gmail
YouTube
Maps
Lightency
LIVE
HISTORY
Energy monitor
3 kW
2,9 kW
0,1 kW
Autarchy
Self Consumption
4 %
Grid
Buy 0 kW
Sell 2,9 kW
Production
meter1_sat3 3 kW
Consumption
0,1 kW


localhost:4200/device/satellite0/history
Gmail
YouTube
Maps
Lightency
LIVE
HISTORY
TODAY, 2023-10-20
Energy monitor
kW
%
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
State of charge
Production
Buy from grid
Sell to grid
Consumption 0 kWh
Charge power
Discharge power
Autarchy
Self Consumption
Storage System
Grid


localhost:4200/exchange/personal
Gmail
YouTube
Maps
Lightency
Transaction History
Order book
Transaction configuration
Charts
Transactions Stats
NUMBER OF BUYERS
0
NUMBER OF SELLERS
3
AVERAGE PRICE PER KILOWATT-HOUR
0.229 $
ENERGY TRANSACTED
2525.034 kW
Enter your satellite
Seller / Buyer
Search
Transaction receipt
Transacted energy
Transaction price
Buyer
Seller



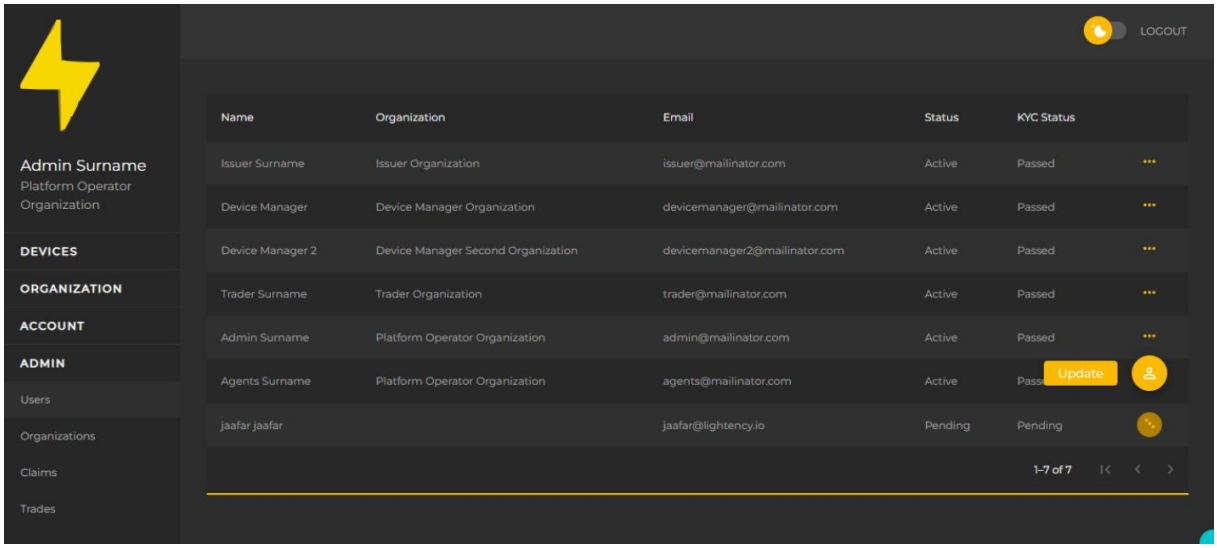
Green Energy certification platform

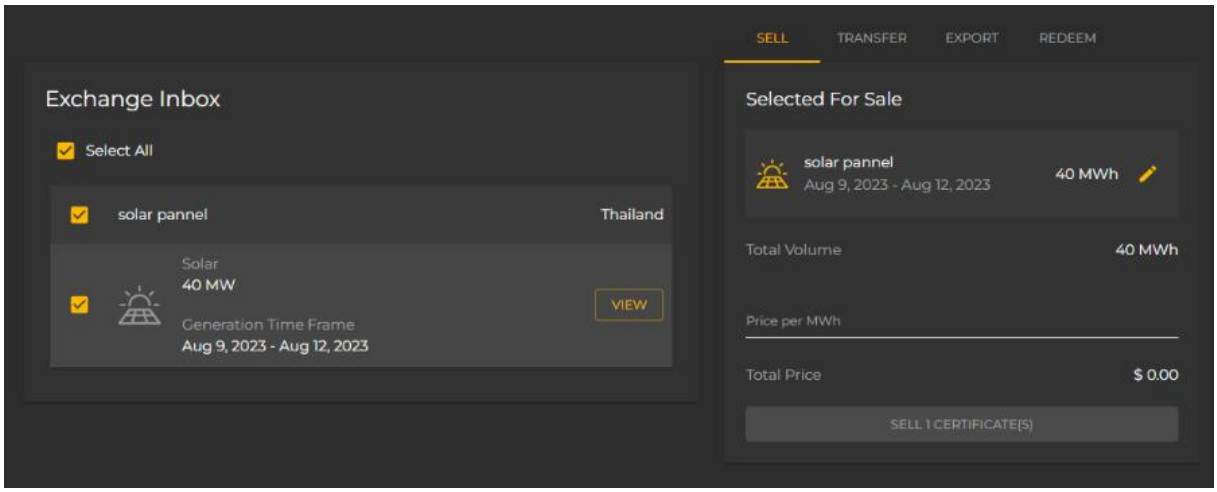
H1 Certification platform documentation :

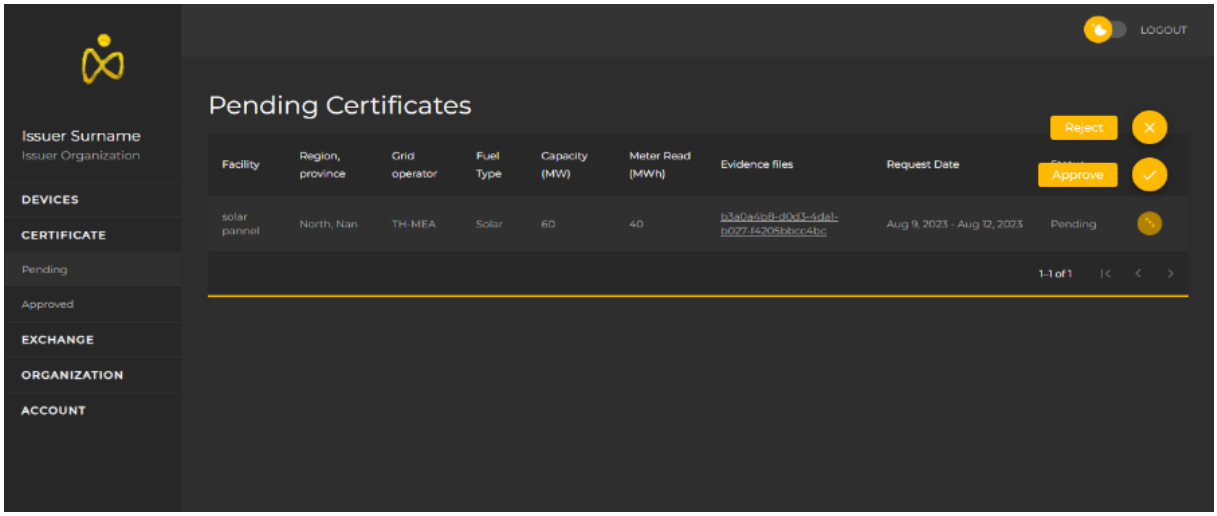
Documentation: Link to REC platform documentation

H2 Graphic chart : Access the design on Canva

H3 REC platform : GitHub.




SELL
TRANSFER
EXPORT
REDEEM
Exchange Inbox
Select All
solar pannel
Thailand
Solar
40 MW
Generation Time Frame
Aug 9, 2023 - Aug 12, 2023
VIEW
Selected For Sale
solar pannel
Aug 9, 2023 - Aug 12, 2023
40 MWh
Total Volume
40 MWh
Price per MWh
Total Price
$ 0.00
SELL 1 CERTIFICATE(S)


LOGOUT
Issuer Surname
Issuer Organization
DEVICES
CERTIFICATE
Pending
Approved
EXCHANGE
ORGANIZATION
ACCOUNT
Pending Certificates
Reject
Approve
Facility
Region, province
Grid operator
Fuel Type
Capacity (MW)
Meter Read (MWh)
Evidence files
Request Date
solar pannel
North, Nan
TH-MEA
Solar
60
40
b3a0a4b8-d0d3-4da1-b027-f4205bbcc4bc
Aug 9, 2023 - Aug 12, 2023
Pending
1-1 of 1