Project co-financed by the European Regional Development Fund

RENEWABLE ENERGY

Creating energy communities through microgrids

Synthesis report on the PEGASUS project

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Pegasus

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Contents

Introduction

The PEGASUS project aimed at simulate microgrids in different contexts to demonstrate their applicability and profitability in the Mediterranean basin, for different kind of territories, mainly in islands and rural areas. For that, they modelled the functioning of microgrids, under different conditions, on 7 pilot sites all over the MED area, and especially in Croatia, Slovenia, Italy, France, Greece, Cyprus and Malta. On the basis of these simulations, a business model has been developed for each case.

The present document has been elaborated by the Interreg MED Renewable Energy Community, in collaboration with the PEGASUS project partnership, to give an overview of the main results and outcomes obtained by the project in terms of technical results and also contribution to the model developed by the Community of *Ecosystemic Transition Unit (ETU)*. This model has been built on the basis of the activities and results of the 6 modular projects belonging to the Interreg MED RES Community and dealing with:

> **PEGASUS:** Promoting effective generation and sustainable Use of electricity through microgrids
> **StoRES:** Promotion of higher penetration of distributed PV through storage for all
> **PRISMI:** Promoting RES integration for smart Mediterranean islands
> **COMPOSE:** Rural Communities engaged with positive energy
> **ForBioEnergy:** Forest Bioenergy in the protected Mediterranean areas
> **LOCAL4GREEN**: Local fiscal policies for Green Energy

An *Ecosystemic Transition Unit* is a territory implementing its energy transition taking into account an ecosystemic approach, based on the following main pillars: technological (energy facilities), social (energy community), legal (energy governance) and territorial (energy planning). As a conclusion of these 3 years of work, both for the project and for the Interreg MED RES Community, but also as a starting point for the implementation of the *ETU* at territorial level and consequently the transferring and capitalisation of the results of the projects of the community, it was important to underline better the different contribution each project gave to the *Ecosystemic transition Unit* Concept.

The present document is composed by the following main sections:

1. a general section, with the main features of the project and its general outcomes
2. a technical section dedicated to the results of the project pilot activities
3. a section dedicated to specify the contribution of the project to the "Ecosystemic Transition Unit" model

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Title of the project: PEGASUS - Promotion Effective Generation And Sustainable USe of electricity

Partners

1. Municipality of Potenza (IT)
2. CRES – Centre for Renewable Energy Sources and Savings (GR);
3. MIEMA - Malta Intelligent Energy Management Agency (MT);
4. AURA – EE, Auvergne Rhône-Alpes-Energy and Environment (FR);
5. DeMEPA - Design and Management of Electrical Power Assets (IT);
6. ENERGAP- Energy Agency of Podravje (SI);
7. Municipality of Preko (HR);
8. FOSS - Research Centre for Sustainable Energy - University of Cyprus (CY);
9. ABENGOA - Abengoa Innovación (ES);
10. FEDARENE - European Federation of Agencies and Regions for Energy and the Environment (B).

Budget and duration

> Total budget €1,868 m
> ERDF Budget: €1,5 m
> Duration: 36 months

Testimony of lead partner

PEGASUS is a cooperation project where a group of public and private Bodies involved in the energy sector try to design the business model of the microgrids in the coming future power system. The goal is achieved through the simulation of the microgrid operation in 7 pilot sites. Currently the collected energy data are analysed to perform the technical and economic assessment for each site.

Location of Pilot sites

> **Italy:** Municipality of Potenza (Basilicata region)
> **Greece:** Municipality of Farsala in the area of Mega Evydrio (Thessaly Region)
> **Malta:** Gozo Island
> **France:** Saint-Julien-en-Quint (Natural regional park of Auvergne-Rhône-Alpes)
> **Slovenia:** Sports Park Ruše (Drava region)
> **Greece:** University of Cyprus
> **Croatia:** Municipality of Preko (Preko Island)

The PEGASUS pilots are described in the following section.

Project outcomes

Main outcomes

The project succeeds in achieving the capacity to demonstrate that microgrids can be implemented with profitability in the Mediterranean basin under existing market conditions or with modifications of regulation and tariff.

In seven territories the functioning of seven microgrids was simulated under different conditions in terms of end-users (public offices, residential, private business…), loading, generation sources (high efficiency CHP, solar PV, hybrid solutions…), climate conditions, legal context and maturity of power market. All this represent a new knowledge and a step forward towards a new energy bottom-up organizational model.

The seven pilot projects were able to show that a model of organization of microgrids exists in France and that existing legislation in Italy allows already in some specific cases the exchange between consumer and prosumer and this can be applied on larger scale. Furthermore, the project demonstrates, that the energy security dimension can be a driver to make microgrids an applicable solution in Malta, Cyprus and Greece and that an attracting tariff is needed to make the business attracting in Slovenia and Croatia.

Capacity of replication in other territories

The identified solutions in the seven territories can be immediately applied in territories of the same nation that has the same market, organization and climate conditions. The replicability in such sense is inside each member states.

Contribution to know how and added value

Taking into account new European rules on the Renewable Energy Communities, the identified example of microgrids are fully compliant with them and can be a model for further development in different national contexts that are looking for a model of implementation of such local communities.

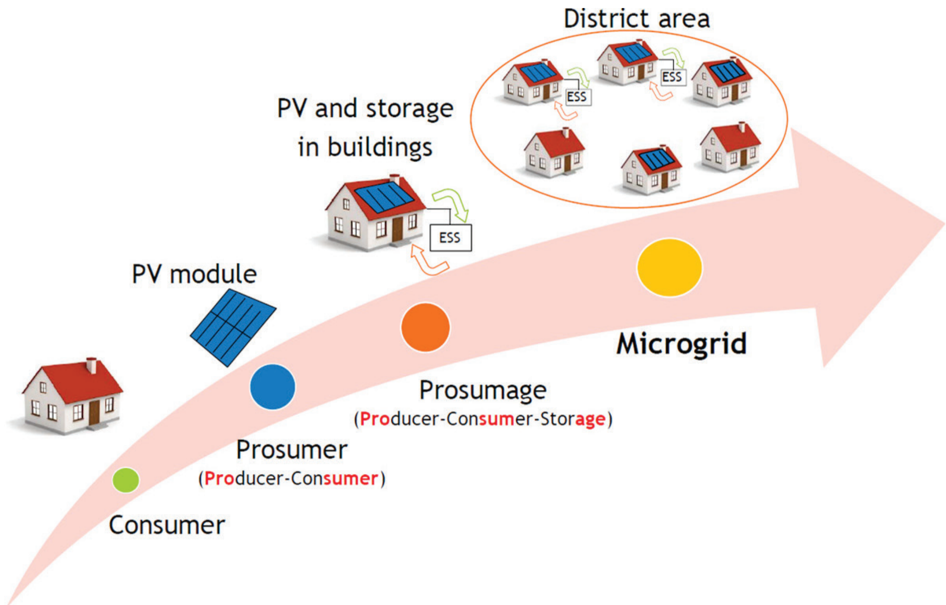

Figure 1 – Scheme representing the different steps from an energy model based on simple consumers, to an energy community model with a microgrid, consumers, producers, prosumers and prosumagers

PEGASUS pilot in Italy: Combined Heat and Power system in 2 sites - Municipality of Potenza

Brief description

The pilot includes **two energy-intensive infrastructures**: a **swimming pool of Montereale Sport Park** and the **Santa Lucia escalator**, 600 meters long, able to transport up to 9000 people/hour from the outskirts to the city centre. The pilot was aimed at demonstrating the achievable advantages by the application of the Italian regulation **"Scambio sul posto Altrove"**, according to which the **two plants can be considered as a single electric user** under the condition that a renewable generation is operating at least in one of the two sites.

To this purpose the existing boilers in Montereale swimming pool can be partially substituted by a **high efficiency Combined Heat Power system** (assimilated to RES in connection with its high efficiency), driven by the heat demand of the swimming pool. The electricity generated by this prosumer is used to meet the electric demand of the swimming pool and the surplus is fed into the local distribution network. In a symmetrical way electricity is withdrawn from the network when local demand overcomes the electric power available from CHP.

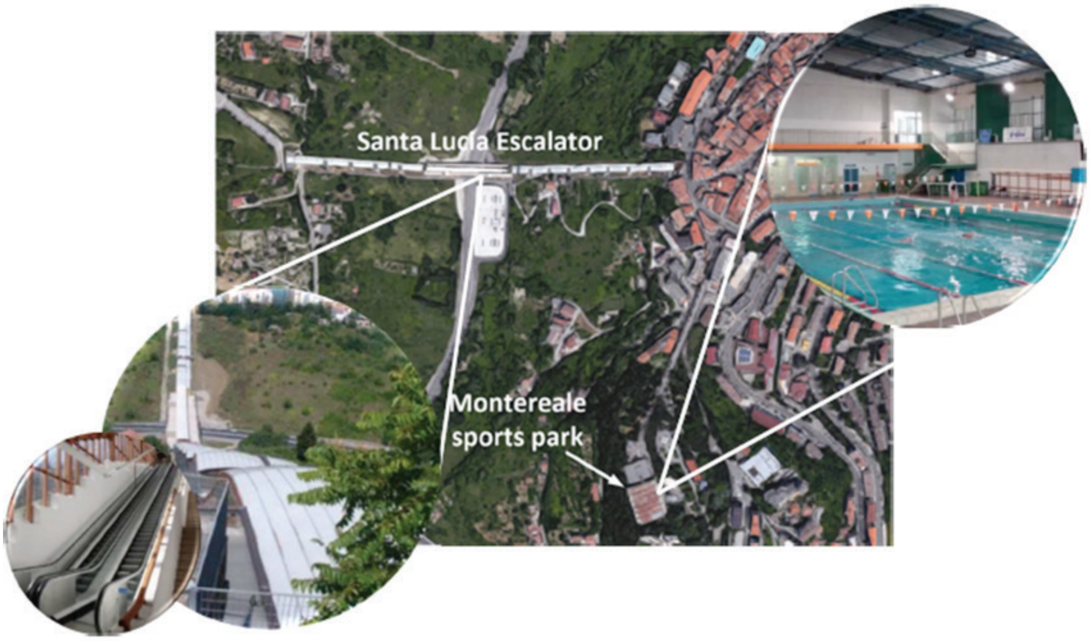

Figure 2 – Scheme representing the Potenza municipality microgrid

Results

A measurement campaign throughout the whole year 2018 of thermal and electrical consumption of the pool and the electricity demand of the escalator identifies in a **Combined Heat and Power system (CHP) 120 kW in thermal power and 65 kW in electric power**, the most profitable solution. This system can provide about **95% and 85% of the required thermal energy and electricity**, respectively. The electricity fed into the distribution network is about 25% of that consumed by the escalator.

Due to the use of the high-efficient CHP system, the **primary energy saved is globally 366 MWh/y**, the **natural gas consumption is reduced by 16 %** and the consequently **CO_2 emission of 80 t/y**, while the losses on the electrical network amounts to 25 MWh/y.

Comparing the capital and operating costs for the Municipality and the lower costs for the electric service the **IRR is 24,7 %** including the financial charges, with a **pay-back of 3,5 year**. These financial results induced the Municipality to a call for tender for the implementation of the solution designed by the pilot. **The full operation of the system is expected for the early year 2020**.

PEGASUS pilot in Greece: A microgrid in the Mega Evydrio Community – Municipality of Farsala

Brief description

The Greek pilot site is located in the Municipality of Farsala in the area of Mega Evydrio (Thessaly Region), and consists of public, commercial and private buildings and facilities. There are several PV power sources like PV systems on roofs and agriculture PVs. More precisely, the community of Mega Evydrio can count on:

> the following consumers: 295 houses, 16 shops, 4 public buildings, 471 public street lights, 2 public pumping stations for potable water circulation and 147 private pumping stations for irrigation.
> the following prosumers: 5 houses with PV systems on their roofs (total installed capacity of 45 kWp), 75 houses with new (to be installed) PV systems on their roofs (total installed capacity of 168.75 kWp), and 1 public building (total installed PV capacity of 9 kWp).
> The following producers: 5 electricity producers (PV parks) with total installed capacity of 500 kWp (5*100).

Operational scenarios were carried out by using the actual measurements of the installed smart meters at the microgrid and software tools such as HOMER and Matlab/Simulink. The microgrid is going to reduce the CO_2 emissions by introducing RES generation at a community level. The economic benefits will be the savings from self-generation.

The main objective of the Greek pilot is to simulate a microgrid operation, including storage systems and flexible electricity tariffs. The pilot microgrid is going to be connected to the main public grid, but it will also be able to operate in 'island' condition. The energy consumption monitoring started in March 2018, with measurements being taken every minute.

More specifically, the following cases have been investigated:

1. The microgrid with and without energy storage.
2. The microgrid with and without the water pumps for irrigation
3. The amount of energy storage in order to be protected against disconnection from the grid
4. The amount of renewable energy in order to achieve net balance with the grid.

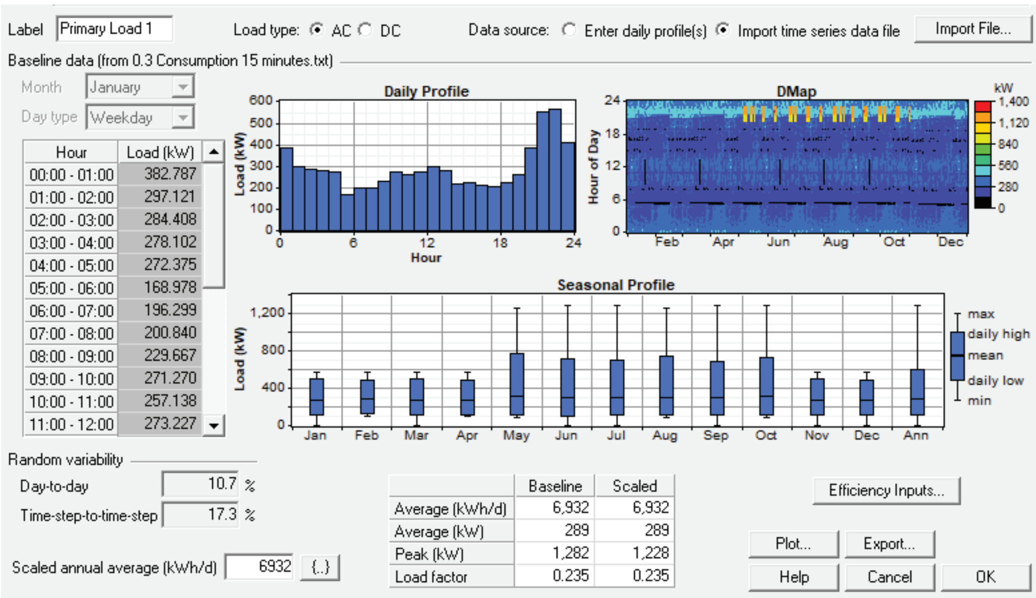

Figure 3 - Configuration of electricity consumption in the Greek pilot with the HOMER software

Results

The Greek pilot microgrid is going to be organized as a local "**Energy Community**" where the Municipality of Farsala and the residents of the community of Mega Evydro are going to participate.

The expected advantages of the micro-grid are summarized to a **30% reduction on the CO_2 emissions** (approx. 1.103 tCO_2) and an **increase of the renewable energy production in the energy mix** (increase of the installed PV capacity from 545,00 kWp to 722,75 kWp). The **produced PV energy is also going to be increased** form 699.898,93 kWh per year to 927.911,87 kWh per year.

The replicability of the Farsala energy community in other areas in the Region of Thessaly and all over Greece (now that the concept of "Energy Communities" has been institutionalized) can be achieved through the development of business model for the microgrid, the preparation of a series of benchmarks to evaluate the pre-feasibility and the organization of technical seminars for the local stakeholders.

PEGASUS pilot in Malta: A microgrid in the Gozo Island

Brief description

The Malta pilot site is located on the island of Gozo and consists of 15 public and private buildings, with both consumers and prosumers profiles. The pilot sites have been selected to allow the elaboration of consumer and prosumer profiles representative of a small community, which is connected to the same sub-station in order to be able to define a microgrid operating model for the locality.

The community is characterised by the following members:

- Ministry for Gozo (1 large PV system 108 kWp – 166 MWh annual electricity generated),
- San Lawrenz Local Council (Prosumer with 1 PV system of 34.5 kWp – 50 MWh annual electricity generated),
- 1 small office/commercial building
- 12 residential households (7 consumers, 5 prosumers for a total of 22 MWh annual electricity generated).

The general aim of the pilot in Gozo is to demonstrate the advantages of implementing community-based microgrids for small localities on the island and thus having a locality which has a "common" connection point to the main electricity grid.

Figure 4 - Energy facilities of the microgrid pilot in Gozo

Analysis and prediction of energy requirements would allow the micro-grid to be disconnected from the main grid (islanding) in case of main grid failure. Energy monitoring started in November 2017, with measurements being taken every minute.

Results

The Malta pilot focuses on simulation of a micro-grid operation, including energy storage systems and assessing the financial feasibility with respect to different electricity consumption tariffs and feed-in tariffs for generation for renewables. The micro-grid model also aims to reduce the costs of energy for the micro-grid community members, to provide a more reliable energy supply by using renewable sources (possibly in conjunction with energy storage) and to reduce losses in upstream distribution network.

PEGASUS pilot in France: A microgrid for the energy transition of a small village in the Vercors Massif – Saint-Julien-en-Quint municipality

Brief description

Like other **rural areas**, Saint-Julien-en-Quint has a **network that is sometimes the victim of failures**. The municipality is localised at the end of the line, on the edge of the network. This causes **cuts**, but, above all, **difficult maintenance**, especially since the **overhead lines are subjected to strong winds**. Power outages can occur and threaten electricity supply for farmers' cold stores or woodchip boilers. As a result, local representatives and inhabitants are searching for innovative solutions that can help the village to become **independent regarding its energy supply thanks to local energy sources**.

The perimeter of the pilot is delimited by all the **45 consumers connected to the main local power substation**. 32 houses in the village have equipped with **measurement devices**. 2 different types of measurement have been performed, depending on the preference of the owner and what is technically feasible. The measurement apparatus is either located on the electric internal board of the house or located on the meter. This second type allows for more detailed load curves. Where it was possible, **controllable loads**, such as electric water tanks, were registered. An **online visualization platform** allowed to monitor power and voltage every 10 minutes. Some measurements on the local substation have been taken as well.

Figure 5 – Illustration of the Saint-Julien-en-Quint village weak grid

Results

The annual electricity consumption of the pilot area is about **180 MWh/y**. **A PV production of 36 kWp can be used for collective self-consumption with a self-consumption rate of 85%**. This production will be financed by a **local citizen-owned cooperative**, where local consumers will also be shareholders.

After one year of measurements and an economic feasibility, it seems that a financial balance could be obtained for **a local price of electricity of about 8 c€/kWh**, but with the help of subsides for the producer.

A detailed analysis of the consumers' bill has been led to assess the impact of collective self-consumption on their future bill, according to various hypotheses on taxes and grid fees.

The results of the pilot have been presented to the local inhabitants finding a **considerable consensus**.

PEGASUS pilot in Slovenia: A microgrid at the Ruše Sports Park

Brief description

In the Sport Park Ruše in Slovenia, the pilot site is based in a **sports resort** and includes **two existing PV plants of 50 kWp each**. A group of **four buildings** was selected that would represent the **loads of a microgrid with about 500 MWh/year total electricity consumption**. A system was established for continuous monitoring of the generated electricity by PV plants and the consumed electricity supplied by PV plants and public grid. The measures are taken every 15 minutes. The pilot aims to demonstrate the economic and environmental advantages for users and producers through an energy-efficient microgrid which would help to make the best use of existing resources, eventually using storage systems, and would provide cheaper electricity to end-users while ensuring at the same time a good remuneration to the PV generators. The pilot can be a showcase for other public facilities.

The site of the project was chosen for its great potential, consisting in a **yearly electricity consumption of 515.188 kWh** and **two existing solar powerplants with a yearly production of 79.173 kWh**. The high and constant heat demand made it ideal for the simulation of possible CHP generation units.

Figure 6 – Sport Park Ruše in Slovenia

Figure 7 – Measuring system established for continuous monitoring of microgrid pilot in Slovenia

Results

Different possible scenarios regarding the operation of the microgrid with the support of solar energy and CHP have been simulated. Energy storage was also considered.

After taking into account all the measurements it has been established that the **solar powerplants are a viable energy source for the microgrid operation as long as the production does not exceed the consumption**. It is viable even if the production exceeds the consumption up to a certain percentage. Then the **return rate is about 7,9 years**.

However, the **natural gas-powered CHP units are identified as an economically feasible system for self-consumption only if the price of fuel vs the price of electricity reaches a difference of 0,1 c€/kWh**, it also provides the **greatest self-sufficiency and reliability**.

A **Battery Electrical Energy Storage system** was considered as a support for the use of excess PV power and peak shaving. The results show that it could **greatly improve self-sufficiency**.

PEGASUS pilot in Cyprus: A nanogrid at the Cyprus University

Brief description

The target of the pilot is **to transform the large campus of University of Cyprus into a self-consumption controllable microgrid**, which will be fed by **PV** and **central and distributed energy storage systems**. The campus microgrid will be able to operate either **grid-connected**, offering at the same time the possibility for ancillary services to the DSO, or **isolated** in case of a grid fault or other operational necessities.

The PV Lab microgrid has been set up at the FOSS Research Centre for Sustainable Energy, University of Cyprus. It acts as a testbed and a subset of the planned microgrid of the University of Cyprus and includes existing PV installations, Battery Energy Storage Systems (BESS), smart meters, an electric load and an EV charging station. It is implemented with real time data acquisition systems and smart metering infrastructure. Operational scenarios are carried out by using the actual measurements of the installed smart meters at FOSS microgrid and tools such as Matlab/Simulink and PowerSim and Digsilent.

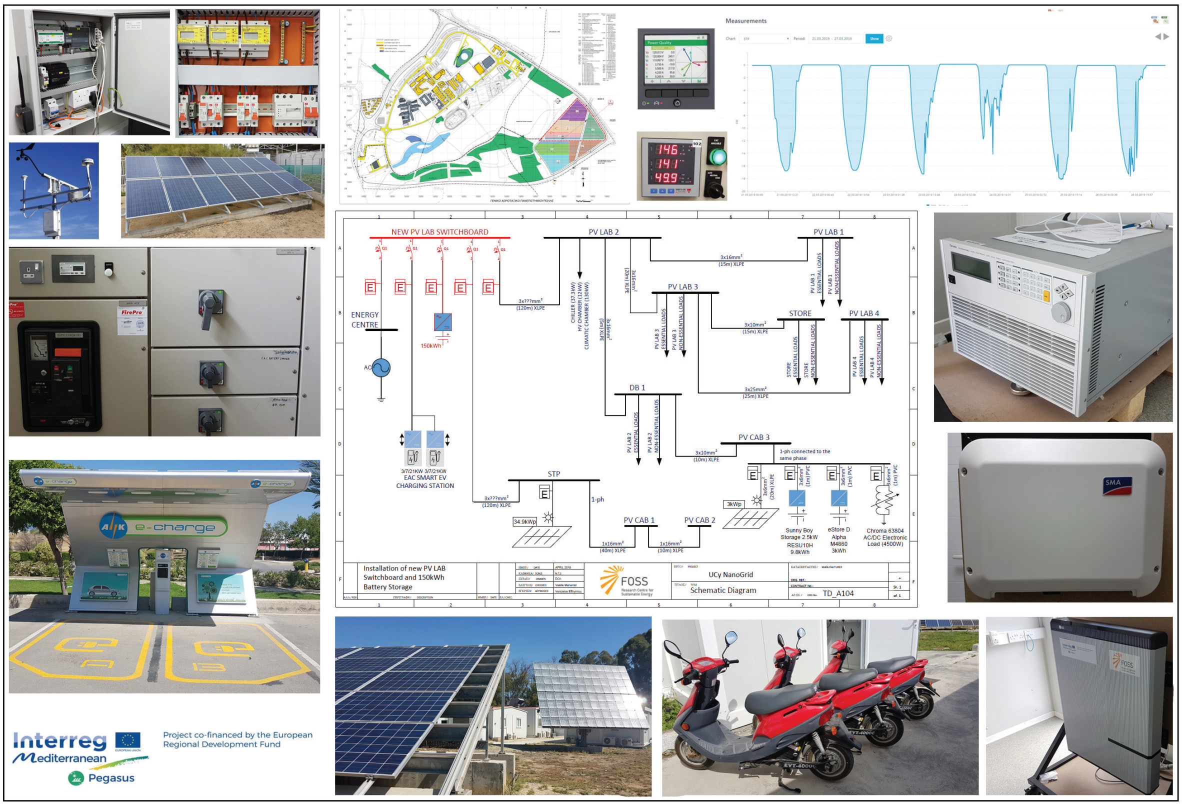

Figure 8 - Ccomponents of the nanogrid at the Cyprus University

The following cases have been investigated:

1. Grid-connected operation of the microgrid aiming to balance the flow at Point of Common Coupling (PCC)
2. Islanded operation of the microgrid. Stabilizing the microgrid under different dynamic load conditions
3. Transition from Grid-Connected to Islanded Mode and vice-versa.

Results:

The results of the studied cases show that, under steady state conditions, the FOSS microgrid can satisfy the following conditions as summarised below:

> The successful transition between grid-connected and islanded mode of operation and vice versa in an automatic and seamless way.

> To achieve energy demand reduction as a result of the automatic negotiation between agents.

> The planned purchase of a 150 kWh BESS system in FOSS microgrid and efficient demand-side management during islanded operation would allow the microgrid to disconnect from the main grid and operate seamlessly in islanded mode.

> The ability to work in islanded mode increases the security of supply.

Cost Benefit Analysis for the University microgrid has been assessed to demonstrate all the advantages of the net billing tariff for investments in PV and storage systems transforming the university campus into a totally green campus satisfying its energy needs from local PV sources. **The payback period of such systems is as low as 7 to 8 years** giving evidence that microgrids can play a decisive role in the energy transition.

PEGASUS pilot in Croatia: A microgrid in Preko island

Brief description

Municipality of Preko is small island community situated on Preko Island. In 2015, the municipality adopted the strategy of Sustainable Development with one of the goals is a **long-term energy efficiency and promotion of renewable energy**. A microgrid is fully compliant with these requirements and moreover would improve the security of supply: following thunderstorms there is high probability of network shutdown**.**

Preko pilot project has 3 major goals:

- to prove feasibility as well as economic and environmental benefits of microgrid solution using PV as RES source,
- to develop sustainable and applicable business model that can be transferred to other Croatian municipalities and EU regions,
- to overcome existing legal barriers.

Preko pilot consists of microgrid using a 10 kWp PV plant, installed on the top of an olive oil mill building, acting as Prosumer, and “Pučko otvoreno učilište” building, acting as Consumer. The “Pučko otvoreno učilište” building is currently occupied by 4 different users: 3 public and 1 private. Each of the users has its own consumption meter installed. One office is used by ‘Pučko veleučilište’; the second is a Tourist board; the third user is a multimedia hall used for various local events; and the fourth is a privately-owned cafe and bar. The microgrid is so composed by 4 consumers and 1 prosumer.

Figure 9 – Location of Preko's pilot – Pucko otvoreno uciliste building

Figure 10 - Installed Siemens Power Mete in the Preko pilot microgrid

Results

The electricity consumption, equal to 12.145 kWh/y, is lower than the generated electricity (amounting to 12.546 kWh/y) by the PV plant installed on the roof top of the olive oil mill. The average annual electricity consumption (12.145,00 kWh) has an annual cost of 1.671,33 EUR, and correspond to annual CO_2 emission 2.8 t of CO_2/y.

A net metering regulation would significantly reduce the cost of electric service.

The simulated **microgrid, allowing to pay less for electricity and to reduce CO_2 emission by using RES**, represents an example of good practice for other communities, especially on island where grid is typically unstable.

Contributions to the Ecosystemic Transition Unit model

The Ecosystemic Transition Unit model has been defined by the Interreg MED Renewable Energy Community during on the basis of the activities and results of the projects belonging to the community, as a capitalisation methodology of the latests. An Ecosystemic Transition Unit **is a territory implementing its energy transition taking into account an ecosystemic approach**, based on the following main aspects/pillars: **technological** (energy facilities), **social** (energy community), **legal** (energy governance) and **territorial** (energy planning).

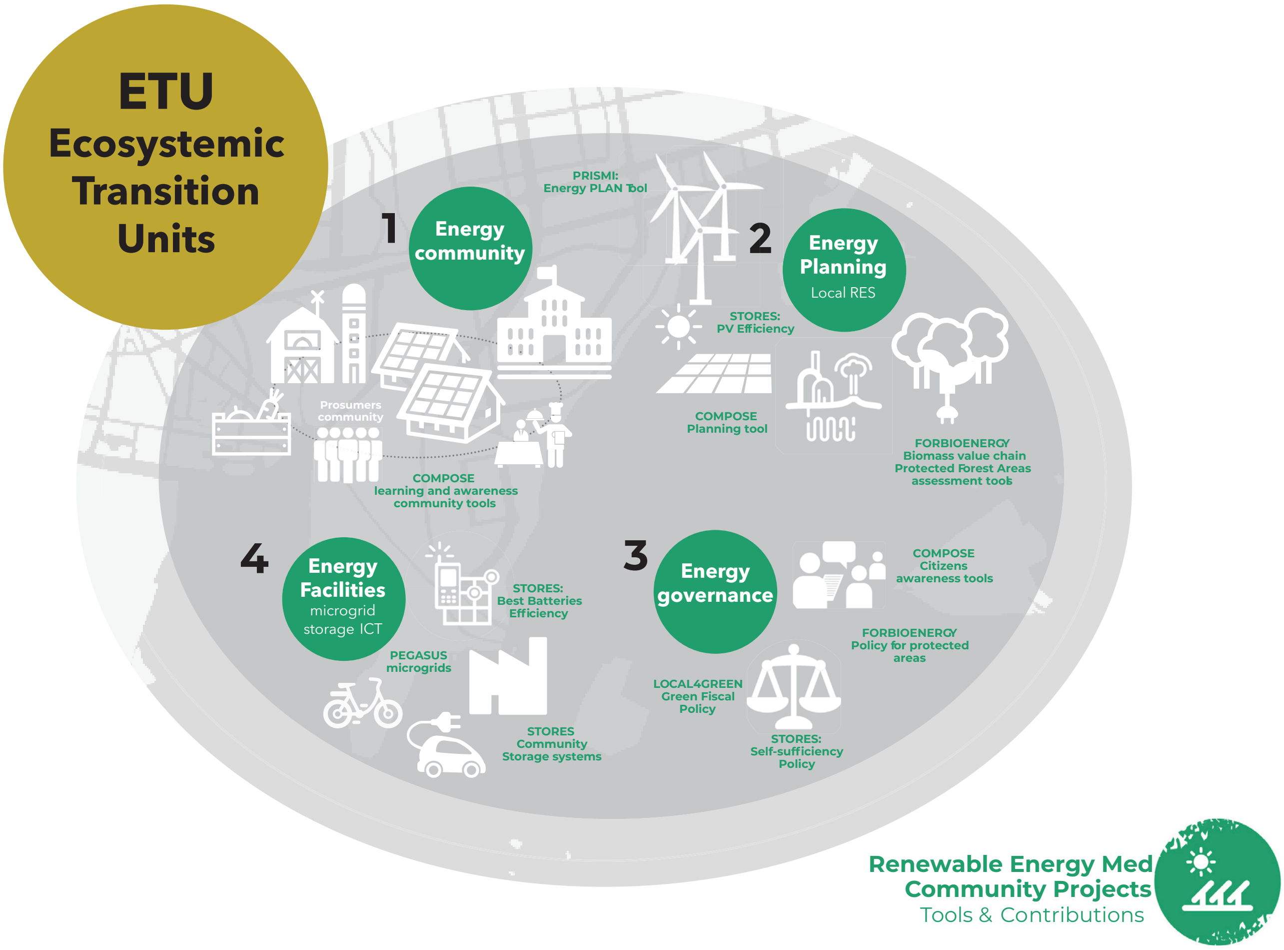

Figure 11 – Scheme representing the 4 components of the Ecosystemic Transition Unit model

In that conclusion phase of the project of the community, it is important to understand more precisely the **contribution of each project to the general ETU model**. Regarding the PEGASUS project, it is possible to underline the following impacts on the 4 main characteristics of an ETU:

Energy Community

The PEGASUS simulation of microgrids and realisation of related business model is a source of inspiration for any other energy community that would like to constitute itself. The pilots are located in different contexts, mainly Mediterranean islands and rural areas and the different microgrids have been modelled following different conditions, creating a set of test sites taking into account a huge range of solutions, market and legislative conditions.

Energy planning

The microgrid simulations allow to understand the energy facilities necessary to answer to the consumers' needs. In that sense, the PEGASUS project activities and especially the study of the different energy profile and the modelling of the microgrids participate to the energy planning of the related energy community.

Energy facilities

The PEGASUS project, brought together public and private bodies involved in the energy sector to design the business model for microgrids in the future power system. The project identified schemes that were technically feasible, simulating the microgrid including different kind of energy facilities, depending on the characteristics of the pilot sites. Energy facilities in terms of energy production (PV, CHP, hydroelectric) and in terms of energy storage (Batteries Storage System, Electric Vehicle storage) have been taken into consideration in the modelling the different microgrids.

Energy Governance

Within the different schemes identified by the PEGASUS project team, the different regulation systems for self-consumption and energy tariff have been taken into consideration and studied and a number of barriers to their implementation linked to financing and investment have been individuated. The best conditions, for each case, have been investigated, identified and selected for the microgrids modelling.

Conclusion

The PEGASUS project addressed the implementation of microgrids for the major integration of Renewable Energy Sources and the increase of the self-consumption in the optic of Energy communities Building. Energy storage system, together with other options for energy flux measurement have been taken into account for the simulation and modelling of 7 microgrids in pilot sites located in diverse kind of territories in the MED basin. The PEGASUS project concentrated its effort mainly on islands and rural areas, that have similar issues related to energy network and supply and similar characteristics in terms of isolation. For each pilot site, a business model has been built to demonstrate the feasibility of the implementation of microgrids in different contexts and under different conditions.

As part of the Interreg MED RES Community, the PEGASUS project participates mainly and in a very relevant way to the “Energy Community”, “Energy Governance” and “Energy Facilities” as *Ecosystemic Transition Unit* components. The model of *Ecosystemic Transition Unit* has been thought to be used by the territorial/energy planners of the local authorities of remoted and isolated territories in the MED areas. As a community, our main work now is to diffuse these results, policy recommendations and tools already available and tested and to support local authorities to applied it on their own territory.

This report describes very briefly the *modus operandi* of the PEGASUS project and more precisely the pilot activities implemented in the MED area, in order to make the conclusions, in technical and economic terms, easily understandable and applicable for the local authorities potentially interested in applying it in their process of energy transition. For more details, it is possible to refer to the PEGASUS project website (https://pegasus.interreg-med.eu/) and particularly its deliverable library (https://pegasus.interreg-med.eu/what-we-achieve/deliverable-library/) and to the Interreg MED RES Community website (https://renewable-energies.interreg-med.eu/) and its deliverable library (https://renewable-energies.interreg-med.eu/what-we-achieve/deliverable-library/).

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