Cost-effective rehabilitation of public buildings into smart and resilient nano-grids using storage

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Priority: B.4.3 - Support cost-effective and innovative energy rehabilitations relevant to building types and climatic zones, with a focus on public buildings
Countries: Cyprus, Greece, Israel, Italy

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4 Contents

1 Project summary

In an effort to address high energy consumption in the building sector that is mainly fossil – fuelled, support rural areas and areas powered by weak grids, which are common in the MENA region, and achieve higher grid penetration of renewable energy sources (RES) while maintaining grid stability and power quality, this project aims at the implementation of cross border pilots that will support innovative and cost – effective energy rehabilitation in public buildings based on the nanogrid concept. Thus, BERLIN project focuses on the increase of photovoltaics (PV) penetration, which coupled with energy storage and demand – side management (DSM) will increase the energy efficiency (EE) of the buildings. The implementation of these technologies in a cost – effective way will result in high level of self – resilient public buildings that are green, smart, innovative, and sustainable. A total of 6 pilot buildings will be implemented: 1 in Cyprus, 2 in Greece, 2 in Israel and 1 in Italy.

The project has started in September 2019 and is expected to be completed within 48 months.

2 Introduction

The Intelligent Utilization of Photovoltaic Technology in the Mediterranean (MED) region (IUPVMED) Hub was created under the BERLIN project. The purpose of the Hub is to bring together key stakeholders to exchange knowledge and discuss challenges and opportunities for the wider adoption of cost-effective policies, which are related to the increase of the photovoltaic (PV) energy share, increased local consumption of PV-generated electricity, and the integration of PV, Battery Energy Storage Systems (BESS), and Demand Side Management (DSM), under the concept of a hybrid nanogrid system.

The Hub has been utilized for sharing and exchanging information within the relevant technologies with emphasis on regional legislations of the participating countries, and also to propose strategies that can aid in the promotion of the microgrid concept. The Hub consists of representatives from various countries and aims to become a leading resource for supporting research collaboration, dissemination, and technology transfer in the MED area. During the duration of the project, an annual meeting, in the form of a workshop was held; such meetings are expected to continue for at least three more years after the project end.

Overall, this report outlines the objectives, achievements, and outcomes of the IUPVMED Hub and describes the journey for its development and key findings.

3 Aims of the Hub

The specific aims of the IUPVMED Hub are the following:

- Enhance the wider adoption of PV+ESS+DSM systems in the MED region.
- Analyse and provide access to the latest information regarding regional legislation concerning PV+ESS+DSM systems.
- Propose strategies to promote regionally the use of hybrid PV+ESS+DSM systems.
- Suggest convenient operation schemes for hybrid PV+ESS+DSM systems.
- Become a leading MED resource supporting research collaboration, dissemination, and technology transfer.

3.1 Hub membership

Key stakeholders from each partner country were invited to become Hub members. Since the target of the Hub was to strengthen project cooperation beyond the partnership, Hub members are external people, i.e., not staff members of the organisations participating in the BERLIN project Consortium. After the first meeting, existing members were invited to the annual meetings, with new invitations to additional persons. Members had the chance to exchange information, experiences, and ideas on current regional situations, regarding PV+BESS+DSM systems in the participating countries. The members also had the opportunity of forming new collaborations with each other and advancing their expertise and knowledge in the field.

Overall, the Hub comprises of a wide range of key stakeholders, including:

- Policy makers from regulatory/public/local/regional/national authorities.
- Distribution system operators (DSOs).
- Transmission system operators (TSOs).
- Market players from companies, etc.
- Academics, scientists, and researchers involved in the field of energy systems.
- Building consumers and prosumers.
- Consultants.
- Installers.
- Engineers from the wider field of distributed energy resources (DERs).

3.2 Position paper

The final outcome of the hub is the writing of a position paper, mentioning news about regional legislations, technological advances, state-of-the-art methods and discussing current and future strategies for promoting systems under the nanogrid/microgrid concept. The paper covers information gathered from all IUPVMED Hub meetings with emphasis on the Hub meeting discussions. The paper will become publicly available on the BERLIN project website in the end of the project timeline. In this way the main outcomes will be communicated, detailing on the current regional and/or national situation, and also to propose relevant strategies, which can effectively provide solutions on

overcoming the existing barriers in each participating country. In this way, the wider adoption of the systems based on the nanogrid/microgrid technology will be facilitated, along with sharing the experiences from the developed pilot actions and sharing the various tools developed under the scope of the project.

4 Hub Meetings

Hub meetings follow a general structure, with introductory presentations on the aims of the BERLIN project, the purpose of the IUPVMED Hub, followed by the current progress in each pilot action, and subsequently followed by open round-table discussions, moderated by the partnership.

4.1 First meeting

The IUPVMED Hub was launched with great success when the first meeting was held on 30 November 2020. The core objective of the initial meeting was to introduce the project and present the current situation in each country regarding PVs, ESSs, and DSM and the hybrid technology in order to increase the energy efficiency of buildings using the nanogrid concept.

For the creation of the hub, each partner country suggested at least two external experts as potential hub members. The members of the hub could be also from other countries that are located in the ENI CBC MED region. Members to the hub were from academia, local government, market player, NGO, Regulatory Authority and System Operator/Regulatory Authority.

In this meeting each partner presented the state of the art in partner's country regarding PV+ESS+DSM and a brief description of the pilot(s). Participants discussed the challenges and opportunities that exist for further penetration of DERs in the four Mediterranean countries participating in the project. Specifically, the round table discussion topics were:

(a) Issues and barriers preventing widespread adoption of PV+ESS+DSM. Moderator Prof. Grigoris Papagiannis, Aristotle University of Thessaloniki, Greece
(b) Good practices, solutions, and action plan to enhance the adoption of PV+ESS+DSM in the MED region. Moderator: Dr Venizelos Efthymiou, FOSS Research Centre for Sustainable Energy, University of Cyprus, Cyprus.

4.2 Second meeting

The second IUPVMED Hub members meeting was held on 14 February 2022. In addition to most of the members that participated in the first meeting, other organizations and individuals were invited to become members and/or participate in the second meeting. The second meeting consisted of presentations and round-table discussions.

The meeting commenced with various presentations, including a presentation delivered by Dr Esmat Al Karadsheh, representative of the ENI CBC MED Programme Eastern Mediterranean Office, where he gave an overview of the action and other projects under the same action. BERLIN partners gave an overview of the main actions on the project developments in each country.

Specifically, each pilot action was presented, emphasizing the progress so far and the next steps, as well as presenting summaries at high level of energy policies in participating countries related to the pilot actions (i.e., energy storage, PVs, and energy communities), and how the pilot actions may assist to promote new energy policies related to hybrid PV+ESS+DSM nanogrid systems.

In the second part of the meeting, representatives of the BERLIN project partnership introduced three distinct topics, yet of equal importance in assisting the uptake of the aforementioned technology and were discussed by the attendees of the meeting. The three round-table discussion topics were the following:

1. 'The role of PV+ESS+DSM towards full decarbonization of MED region' Moderator: Prof. Fabrizio Pilo, University of Cagliari, Italy.
2. 'Residents' awareness to energy efficiency', Moderator: Prof. Erez Gal, Ben Gurion University of the Negev, Israel.
3. 'Funding opportunities for innovative projects related to PV+ESS+DSM in the MED region', Moderator: Eliza Loucaidou, Deloitte Ltd, Cyprus.

Participants showed a lot of interest to express their expert opinion in the lively discussions that followed. The main challenges faced in the existing energy infrastructure were pointed out. It was highly emphasized that the introduction of new technologies is limited, due to the lack of energy policies that can help promote digitalisation and flexibility and increase of the RES share (especially in the form solar PV technology which is abundant in the four countries).

Ideas and solutions were expressed to resolve these issues in the future, in relation to the promotion of self-sufficiency and self-consumption that can be achieved by nanogrid systems which combine PV+ESS+DSM technologies.

4.3 Third meeting

The third IUPVMED Hub members' meeting was held on 4 May 2023 in Eilat, Israel (and online). Prior to the meeting, the IUPVMED Hub members related to each participating partner have been invited to the meeting. Members were notified of the date and agenda of the meeting. The meeting consisted of presentations and a round-table discussion. The meeting started with a presentation of the agenda from the BERLIN project coordinator (University of Cyprus).

In the first part of the meeting, all BERLIN partners with a pilot provided an overview of the main actions on the project developments in each country. Specifically, each pilot action was presented, emphasizing on the progress so far and the remaining steps. The partners from Cyprus and Israel provided details on how the installation and commissioning of their pilots will be concluded. Partners from Greece and Italy elaborated on the results taken from the operation of their pilots, including data acquisition and their analysis. They also showed the level of approximation between their initial estimations in terms of PV-generated electricity, energy storage, and consumption and how these compare to the actual results and data collected from their pilots. Partners from Greece mentioned the importance of energy storage in their nanogrid systems, and also added that seasonal energy storage will be important in the future to improve further the self-sufficiency ratios of their pilots. Partners from Italy mentioned that they will optimize the standard operation of the storage to maximize self-consumption and develop alternative advanced operation (based on AI and forecasting techniques). They will also exploit interactions with other projects and expand the consumption

flexibility of the building (e.g., air conditioning system) to acquire the full potential of the nanogrid concept.

In the second part of the meeting, a round-table discussion was held. The topic of the discussion was 'Enhancing resident awareness on PV+BESS+DSM microgrid systems' and was moderated by Prof. Erez Gal of the Ben Gurion University of the Negev, Israel. Participants emphasized on the importance of educating people on sustainable energy solutions and how residents can become aware of the need to promote and use greener solutions. It was highlighted that this should be done from a young age in primary schools, where the future generations will be trained on the use of such systems and also convey the message to their parents and moreover to their community, through studying in 'green schools'. Therefore, children can be the ones who can be educated to change their behaviours towards energy efficiency of the buildings and are a force for change. Generally, a literate community on sustainable energy consumption behaviours is important as well as the fact that simplicity in choices of the technologies to be developed (DSM, BESS etc.) is also a requirement in order all people to be able to use them.

Hub members mentioned how the pilots of the BERLIN project could be beneficial in technical, environmental, and economic terms in the future. The discussion held among the participants focused on the challenges namely the complication of the technologies, the cost to be spent to adopt these technologies and measures or actions to convince residents to focus on sustainable systems. The strategies discussed to overcome these challenges were the enhancement of basic knowledge on these technologies for residents to take the necessary actions for a more sustainable energy usage. It was also mentioned that we should be able to link public awareness with the financial benefit perspective that these technologies will offer to people. For people to change their consumption behaviour, and to invest in energy storage, they need to understand what their economic benefit will be as well. Within the framework of BERLIN project, the partners are enabled to demonstrate this perspective with the technologies and solutions that have been developed.

4.4 Fourth meeting

The fourth IUPVMED Hub members' meeting was held on 13 July 2023 in the premises of the University of Cyprus in Nicosia, Cyprus (and online). Prior to the meeting, the IUPVMED Hub members related to each participating partner have been invited to the meeting. Members were notified of the date and agenda of the meeting. The meeting consisted of presentations and a round-table discussion. The meeting started with a welcome note and a presentation of the agenda from the BERLIN project coordinator (University of Cyprus).

The first part of the meeting included two presentations. The first presentation was entitled 'The Nanogrid concept: The FOSS Living Lab Nanogrid case study' by Dr Alexandros Arsalis of the University of Cyprus, Cyprus. The basics of the nanogrid concept aiming for increased penetration of renewable energy sources were described and then the steps from design to implementation through a case study for the developed pilot in the University of Cyprus ('FOSS Living Lab Nanogrid'). The replicability potential of this pilot was also analysed in terms of design, implementation, and concept.

The second presentation was entitled 'Network challenges resulting from revamped policies to achieve energy transition' by Dr Venizelos Efthymiou of the University of Cyprus, Cyprus. It was emphasized that presently some of the required services cannot be offered by providers without the inclusion of enablers. Specifically, a wide range of enablers can be implemented to encourage and facilitate participation in the market for flexibility services, such as (a) regulation and codes, (b) market rules and processes, (c) grid and retail products and tariffs, (d) ICT technology and standards, and (e) smart appliances and smart meters. It was also shown that the congestions or other problematic issues that often appear in the network can be resolved through the Flexibility Trading System, which enables the user (i.e., grid operator) to provide automatic demand response and stabilize the electricity grid, by having centralized control of consumers and producers on the electricity network.

In the second part of the meeting, a round-table discussion was held. The topic of the discussion was 'What are the actions needed to bring the nanogrid concept to the mainstream?' and was moderated by Prof. Georgios Christoforidis of the University of Western Macedonia, Greece. The key discussion points were the following:

- Standards and Regulations: Establishing clear standards and regulations specific to nanogrids is necessary.
- Pilot Projects: Conducting pilot projects allows for real-world testing and demonstration of nanogrid technologies.
- Cost Reduction: The cost of nanogrid components, especially batteries, and control systems, needs to decrease for wider adoption.
- Financial incentives like tax credits or subsidies can make nanogrid installations more economically viable.
- Education and Awareness: Public outreach campaigns, workshops, and educational programs can help familiarize communities, policymakers, and industry professionals with the benefits and potential of nanogrids.
- Grid Interoperability: Nanogrids should be designed to seamlessly integrate with the existing power grid. This allows for two-way power flow, enabling energy exchange between nanogrids and the main grid.
- Standardization of communication protocols and grid connection requirements is necessary to ensure compatibility and grid stability.
- Incentives and Policies: Governments can promote nanogrid adoption through supportive policies and incentives.
- Demonstrate Benefits: Case studies, success stories, and quantifiable data can demonstrate the positive impact of nanogrids on energy security and sustainability.

The discussion focused on the readiness level of grid regulations in regard to nanogrids in low voltage, the relevant regulations regarding islanded operation, whether current incentive policies are favourable for the adoption of nanogrids, whether a nanogrid could exploit possible services to the grid through the market (e.g., provision of flexibility), whether the technical community is adequately

trained to implement nanogrids at large scale, and ways to make nanogrids financially attractive for a building or a household (e.g., seek for multiple benefits).

Dr Andreas Stavrou of the Electricity Authority of Cyprus emphasized on the need for DSOs to improve their visibility and ability capabilities of distributed energy generation and storage technologies in the future, since currently storage is not monitored sufficiently due to lack of communication systems. He also mentioned that most of the storage has to be integrated with PV generation, as a first bulk to enable these technologies until policies, intensives and prices are in a level that allow prosumers to freely install integrated PV + storage solutions. Prof. Gianni Celli of the University of Cagliari noted that islanded operation is still not allowed in Italy, but the visibility of the system and distribution network is growing, especially in terms of flexibility. This is facilitated with ongoing projects that allow the DSOs to exploit flexibility from prosumers/distributed resources. Additionally, storage is being developed, both from the transmission and installation levels to provide such flexibility capabilities. Finally, he mentioned that PV + storage incentives are currently available.

Dr Venizelos Venizelou of the Cyprus Energy Regulatory Authority noted that market reforms is not the immediate solution for the Cyprus energy market since it is not mature enough. He also mentioned that CERA is in the process of creating a flexibility services scheme to provide incentives to the DSO. This will be done to pave the way for local flexibility markets, and accelerate Demand Response capabilities, while activating citizens to engage and participate in the market (e.g., large consumers). Additionally, he noted that efforts are currently being made for both upwards and downwards flexibility actions. Finally, he mentioned that the nanogrid concept is not currently regulated in Cyprus or in the EU, but closed distribution systems such as Energy Communities) are already available, which can offer flexibility. Dr George Makrides of the University of Cyprus mentioned that currently, even with the net-billing scheme, the energy storage is not appealing due to the high payback time needed.

Mr Panayiotis Demetriou of Ecotricity, which was the responsible as the contractor of the pilot developed in Cyprus, mentioned that the main challenge lied on the commissioning of the switch between the two operational modes, namely grid following and grid forming, in relation to the BESS. Many tests with the battery supplied were necessary to achieve this, and also reveal and identify the possible risks of switching between the two modes of operation and observe the response of the EMS of the BESS during real-time operating conditions. Dr Venizelos Efthymiou of the University of Cyprus noted the added cost of facilitating grid-independent operation for distributed energy systems operating in islanded mode. Currently, this added cost is only meaningful if users require added security of supply in case of central grid failures (e.g., hospitals, airports). He also mentioned that nanogrid operation will also require optimizing the demand side in a controlled way that will maximize the economic benefits of the local system and allow it to run in three levels of optimization, namely: (a) building-side, (b) neighbourhood-side, and (c) nanogrid/microgrid level. This optimization will have to run in parallel to the whole system, which to also optimize the 'leftovers', which is not currently done, i.e., there is a need to optimize the local use of resources. It seems more economically beneficial to integrate nanogrids with nearby energy communities or larger local grids.

5 Conclusions

The IUPVMED Hub created under the scope of the BERLIN project aims at promoting the wider adoption of distributed energy resources in the MED area, in the form of PV+BESS+DSM systems under the nanogrid concept. It has been utilized to share information on regional legislations among participating countries, regarding this technology and to propose strategies to aid its promotion. The specific purpose of the Hub was to be a leading source for supporting research collaboration, dissemination, and technology transfer in the MED area in the field. The Hub comprises of a wide range of key stakeholders in the field, including distribution and transmission system operators, regulatory authorities, consultants, installers, engineers, and scientists. Members exchange information, experiences, and ideas on current regional situations regarding such systems, while potentially collaborating with each other and enhancing their knowledge and expertise. A position paper has been written and will be published in the BERLIN project website, mentioning news about regional legislations and technological advances (within the scope of the Hub) and discussing current and future strategies for promoting this technology.

In total, four hub meeting have taken place in the period 2020-2023. In conclusion, the key outcomes of these meetings can be summarized as follows:

- The nanogrid concept has been identified as a possible solution for the promotion of self-sufficiency and self-consumption.
- A significant challenge faced in the existing energy infrastructure is the difficulty in introducing new technologies, due to the lack of energy policies that can help promote digitalisation and flexibility and increase the abundant solar energy of the MED area.
- It is important to educate people on sustainable energy solutions; especially residents which need to become aware of the use of greener energy solutions. This should be done from a young age, by training future generations on using such systems and also conveying the message to their parents and moreover to their community, through studying in ‘green schools’. Therefore, children can help change the public behaviour on energy efficiency in buildings.
- A significant barrier for the nanogrid concept is the complexity and high cost of such systems. Therefore, effective measures/actions are needed to convince residents to use sustainable energy systems.
- It is necessary to establishing clear standards and regulations specific to nanogrids.
- Conducting pilot projects allows for real-world testing and demonstration of nanogrid technologies.
- The cost of nanogrid components, especially BESS and controllers must decrease to allow a wider adoption.
- Financial incentives like tax credits or subsidies can make nanogrid installations more economically viable.

- Public outreach campaigns, workshops, and educational programs can help familiarize communities, policymakers, and industry professionals with the benefits and potential of nanogrids.
- Nanogrids should be designed to seamlessly integrate with the existing power grid. This will allow a two-way power flow, enabling energy exchange between nanogrids and the main grid.
- The standardization of communication protocols and grid connection requirements is necessary to ensure compatibility and grid stability.
- Governments can promote nanogrid adoption through supportive policies and incentives.
- Case studies, success stories, and quantifiable data can demonstrate the positive impact of nanogrids on energy security and sustainability.
- There is a need for DSOs to improve their visibility and ability capabilities of DER and storage technologies because currently storage is insufficiently monitored (absence of communication systems).
- Most of the storage has to be integrated with PV generation, as a first bulk to enable these technologies, until policies, intensives and costs are in a level that allow prosumers to freely install integrated PV + storage solutions.
- Islanded operation is still not allowed in the participating countries.
- In some countries, such as Italy, PV + storage incentives are currently available.
- In Cyprus, a flexibility services' scheme is currently under development to provide incentives to the DSO. This will be done to pave the way for local flexibility markets, and accelerate Demand Response capabilities, while activating citizens to engage and participate in the market (e.g., large consumers). Additionally, efforts are currently being made for both upwards and downwards flexibility actions.
- Although the nanogrid concept is not currently regulated in the EU, other similar systems, such as closed distribution systems, i.e., Energy Communities, are already available, which can offer flexibility.
- Energy storage in the framework of the existing net-billing scheme is not yet appealing since a high payback time is needed.
- A key challenge for nanogrid systems lies on the commissioning of the switch between the modes of operation, namely grid following and grid forming, in relation to the BESS. Many tests with the battery supplier are often necessary to achieve this, and also to reveal and identify the possible risks of switching between the two modes of operation and observe the response of the EMS of the BESS during real-time operating conditions.
- The operation of a nanogrid requires optimizing the demand side in a controlled way that will maximize the economic benefits of the local system and allow it to run in three levels of optimization, namely: (a) building-side, (b) neighbourhood-side, and (c) nanogrid/microgrid level. This optimization will have to run in parallel to the whole system, to allow optimization of the 'leftovers', i.e., optimization of the local use of resources.