Capacity building in Smart and Innovative eNERGY management

WP4
Mutual Exchange of Personnel and
Early Stage Researcher Involvement

D4.3
Report on Early Stage Researcher Engagement and Mentoring

Deliverable due date	31/03/2022
Deliverable submission date	31/03/2022

Dissemination level (marked with "X")		
PU	Public, to be freely disseminated	x
CO	Confidential, only for members of the consortium including the Commission	

This project has received funding from the H2020 programme of the European Union under GA No. 952140

Project metadata

Project Acronym	SINERGY
Project Title	Capacity building in Smart and Innovative eNERGY management
Project Website	https://project-sinergy.org/
Grant Agreement no.	952140
Call identifier	H2020-WIDESPREAD-2020-5
Topic identifier	WIDESPREAD-05-2020
Funding scheme	Twinning
Project duration	January 1st, 2021 – December 31st, 2023 (36 months)
Coordinator	Institute Mihajlo Pupin (IMP)

Document metadata

Deliverable no.	D4.3
Deliverable title	Report on Early Stage Researcher Engagement and Mentoring
Related WP no.	WP4
Related WP title	Mutual Exchange of Personnel and Early Stage Researcher Involvement
Lead beneficiary	NUIG
Contributors	IMP, AIT
Deliverable type	Report

Document revision history			
Version/name	**Date**	**Institution**	**Author(s)**
V0.1 - draft	02/03/2022	NUIG	Luis Miguel Blanes Restoy
V0.2 - 1st set of inputs	08/03/2022	AIT	Stöckl Johannes
V0.3 - 2nd set of inputs	25/03/2022	IMP	Valentina Janev, Dea Pujić, Marko Jelić
V1.0 - Internal revision	30/03/2022	NUIG	Luis Miguel Blanes Restoy

Executive Summary

This document provides a brief overview of collaborative efforts on various projects, work packages, tasks and individual services between Institute Mihajlo Pupin (IMP), Austrian Institute of Technology (AIT) and National University of Ireland, Galway (NUIG). The collaborative actions are given as descriptions of the background motivation as well as the joint work that was conducted between the mentioned institutions. Furthermore, the document also outlines the joint proposal efforts as well as the brief contents of the past and planned PhD workshops at which students associated with IMP, AIT and NUIG will have or will be given an opportunity to exchange their knowledge and present the ongoing work.

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1. Introduction

This document follows the work outlined in the corresponding task T4.3 titled Engagement of IMP's early stage researchers. As envisioned in the description of work, young researchers from Institute Mihajlo Pupin have been actively collaborating with their colleagues from Austrian Institute of Technology and National University of Ireland, Galway, and their joint work is reported within this report.

1.1. Scope

The main scope of work package 4 (Mutual exchange of personal and early stage researcher involvement) can be summarized as:

- Task 4.1: Hosting of distinguished foreign researchers (for training lectures)
- Task 4.2: Organization of short-term and long-term stays (for all Sinergy staff)
- Task 4.3: Engagement of IMP's early stage researchers (to involve young researchers in projects)

Task 4.3 is reported in this deliverable.

1.2. Relation to other deliverables

The work outlined in this document mainly relates to the work which is also reported in:

- D1.1 Project Work Plan
- D1.2 Project Work Plan Update
- D3.1 Training Courses and Learning Material on Smart Grid Technologies (v1)
- D3.3 Training Courses and Learning Material on Energy Efficient Building Operation (v1)
- D4.1 Report on Mutual Exchange of Personnel and Training Activities

1.3. Deliverable structure

In line with the previously presented task goals, this deliverable presents the past and present collaborative efforts between researchers at Institute Mihajlo Pupin, Austrian Institute of Technology and National University of Ireland, Galway in Section 2 and Section 3. Following that, Section 4 presents the joint work on proposal writing that has taken place within the scope of the SINERGY project. Finally, Section 5 gives a summary of PhD events that have been organized within SINERGY and have provided a means of knowledge exchange between the participating institutions in SINERGY.

2. AIT and IMP Joint Engagement Activities

2.1. Energy conservation measures service

With the aim of increasing the effects of the Smart Energy Management Systems on the end users, AIT and IMP have collaborated on the Energy conservation measures service. This service was envisioned to analyze various IoT data from the residential home and provide proactive recommendations which would help users to decrease their energy wastes. Apart from the IoT time series data, such as energy demand, production, indoor temperature, occupancy, window opening status, etc. this service has been exploiting semantic repository, as well. More precisely, spatial arrangement of IoT sensors stored within the ontology is carefully considered.

2.2. Energy Efficiency User Benchmarking service

Having in mind that social pressure and competition are significant influencers and motivators for behavior change, it was exploited in order to increase energy efficiency of end users. Therefore, AIT and IMP are collaborating on the development of Energy Efficiency User Benchmarking service, which creates a competitive environment with the goal of motivating users to change their behavior and improve energy efficiency. This service provides a fair, normalized and comparable ranking of a group of similar energy users which is presented to them, so that they are aware of how they are ranked amongst others. The corresponding grouping of similar users is carried out using a clustering approach depending on the users' load.

2.3. Energy-related forecasting

Energy forecasting, whether it be for the production or demand side, is a critical aspect that contributes to energy balancing and system stability. This issue has become even more prominent in modern times with the increase of individual renewable installation uptake. However, in order to properly manage variable production and make best use of flexible assets like battery electric energy storages and/or flexible appliances, it is crucial to know, ahead of time, what the expected energy production and consumption are. In collaboration with AIT that provides this type of services, IMP has utilized the forecasting outputs and built upon them in an optimization system. This synergy has enabled the resulting analytical loop to be able to make the best use of both demand and source side flexibilities and produce an optimal control strategy and energy dispatching schedule.

2.4. Grid capacity management service

In order to properly integrate smart energy management services like energy dispatching optimization into the workflow of energy distribution systems, proper constraints from said distribution system need to be considered. With that goal in mind, AIT and IMP have collaborated on developing a Grid capacity management service that would be capable of processing electric distribution grid topology and parameters and, in alignment with forecasted consumption and energy production, determine appropriate limits for each considered energy user (or prosumer), such that the grid "health" is maintained. In other words, the discussed service would provide constraints to a lower-level optimization algorithm such that no issues on the grid-level arise.

2.5. Hardware-in-the-loop testing

In order to assess how the selection of flexible assets for prosumer energy systems like batteries, inverters and heat pumps in conjunction with a specifically devised control strategy impacts grid performance, a collaboration has been organized between AIT and IMP to jointly tackle this research topic. Concretely, by using actual grid topologies provided by DSOs operating on geographical islands, an instance of the hardware in the loop (HIL) system was tested with the aforementioned assets that were set to operate in locally optimal conditions (with the objective set to maximize self-consumption) and the resulting impact on the grid has been assessed. These types of analyses are crucial to determine the expected impacts that the increase of prosumers in the energy system will have on its behavior.

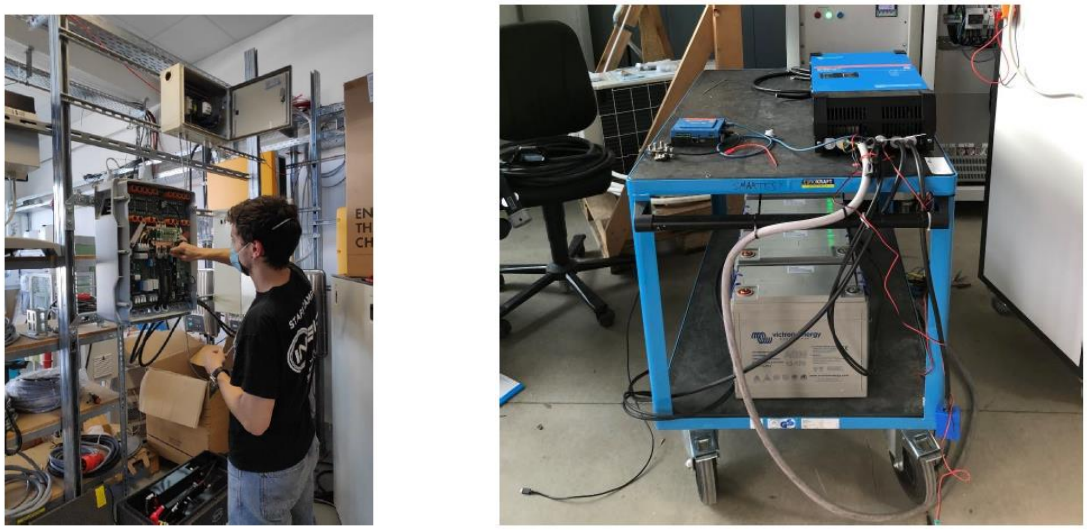

Figure 1. Inverter and Victron lead-acid battery system setup in the HiL laboratory at AIT

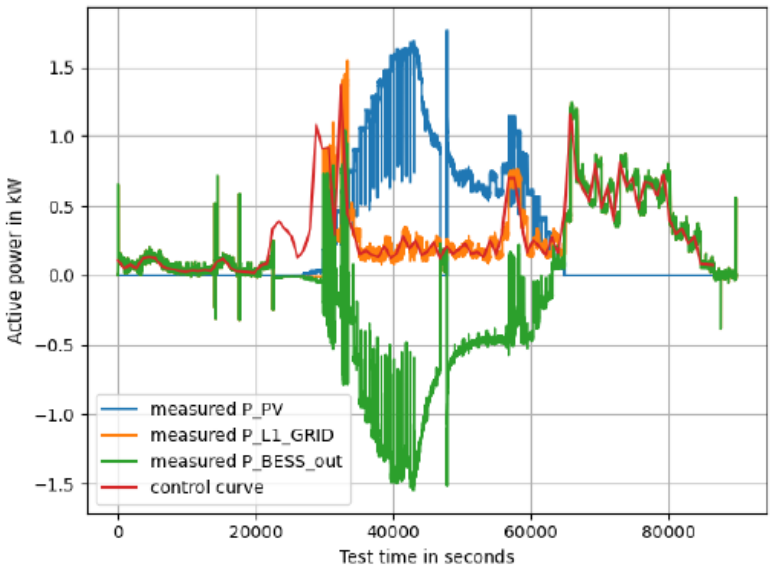

Figure 2. 24-hour lab test with Victron BESS: control_curve and measured powers

2.6. Multi-agent distributed energy optimization

With the proliferation of prosumers in the power network, each different entity is expected to operate their systems in a different way. However, some combination of control strategies may adversely impact the grid as the common energy exchange network that everyone needs to use. In order to properly manage this complex system, while also attempting to reduce the amount of information that necessarily needs to be exchanged, a distributed approach to energy use optimization can be utilized between a coordinating controller on a grid level and the variety of prosumer nodes that manage their individual assets. This topic has been of particular interest for AIT and IMP who are, as of writing this document, actively working on a system that employs this approach to manage residential users that want to incorporate demand response into the operation of their flexible energy assets.

2.7. Integrated platform for demand response management

The process of energy optimization in the context of demand response and grid requirements is a complex procedure that involves a set of different data sets to be analyzed and processed. In order to efficiently facilitate this process, an integrated platform needs to exist and be able to coordinate different services. For example, the ability to forecast future demand and production is crucial for the optimization system to be able to assist with the potential energy disbalance. Furthermore, grid impacts may also need to be assessed and so, the adequate processing service should also be included. Service orchestration (i.e., when each of the services should run, where its inputs should be sourced from and where its outputs should be directed to) is also an important aspect to ensure the robustness and proper operation of the entire analytical loop. One such system has been the focus of a collaboration between AIT and IMP which seeks to integrate a set of smart services for energy management in the context of demand response.

3. NUIG and IMP Joint Engagement Activities

3.1. Thermal building modeling

Many approaches in literature covering the state of the art of energy optimization focus on the electric domain only. However, in efforts to extend the present level of demand flexibility and help with progressive electrification of new domains, the thermal part of energy consumption has lately come into focus of the scientific community. In order to properly bridge the gap between the electric and thermal domains and close the control loop necessary for optimal control of end user assets, NUIG and IMP are working in collaboration to develop a system of services that would provide optimal electric energy dispatching but to also analyze the resulting suggested load modifications and electric energy usage to fit flexible heat pump operation so that both the electric domain is operated in the optimal way while thermal comfort is maintained for end users. However, in order to do so, both modeling and optimization need to be performed for the electric as well as the thermal side, and this particular problem is where thermal building models need to be utilized to generate the necessary heat pump controls based on input energy consumption.

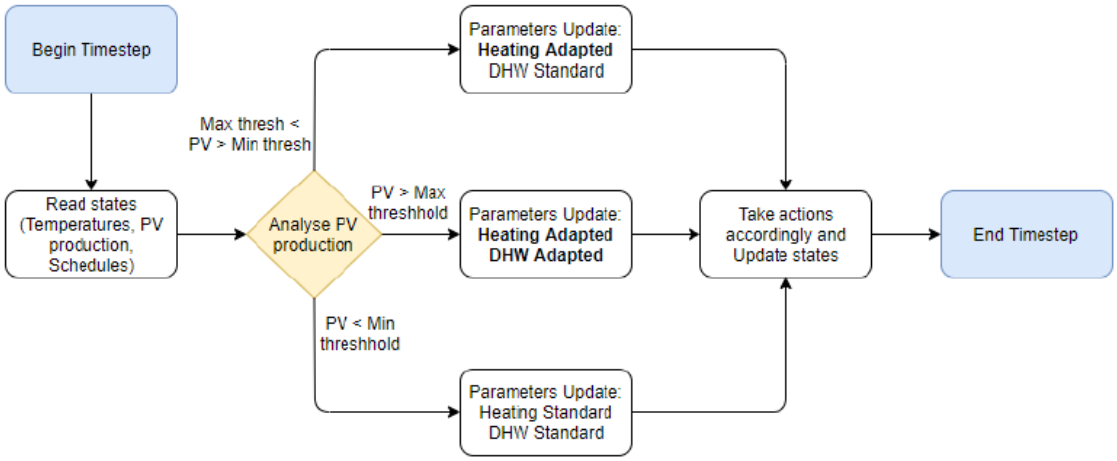

Figure 3. Simplified building model control methodology

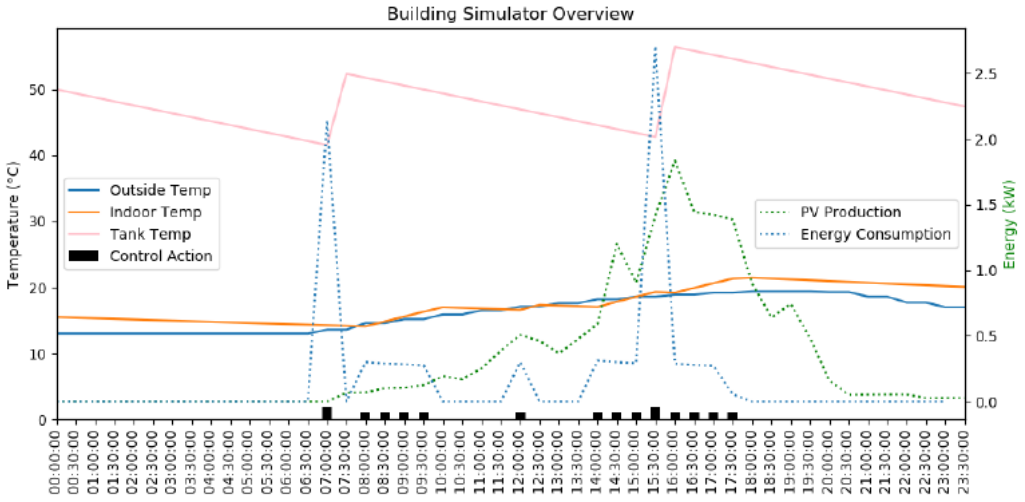

Figure 4. An example of building model optimized control results

3.2. Validation of demand response management platform

A crucial part of many contemporary research projects that are aiming to develop novel energy management solutions is the ability to validate the operation of the system. This is a rather complex task that NUIG and IMP have collaboratively worked on in previous projects, and are also doing so in ongoing projects. Namely, the validation process requires a thorough analysis of historical data that is coming from edge devices (smart meters, in-house sensors, IoT measurements, etc.) but also other services (previous forecasts and optimization results). Furthermore, these different data sets are often stored in different databases and so coordination in the processing needs to be ensured. The core analysis usually focuses on determining differences between baseline and validation data as well as conducting statistical analyses and analyzing data trends.

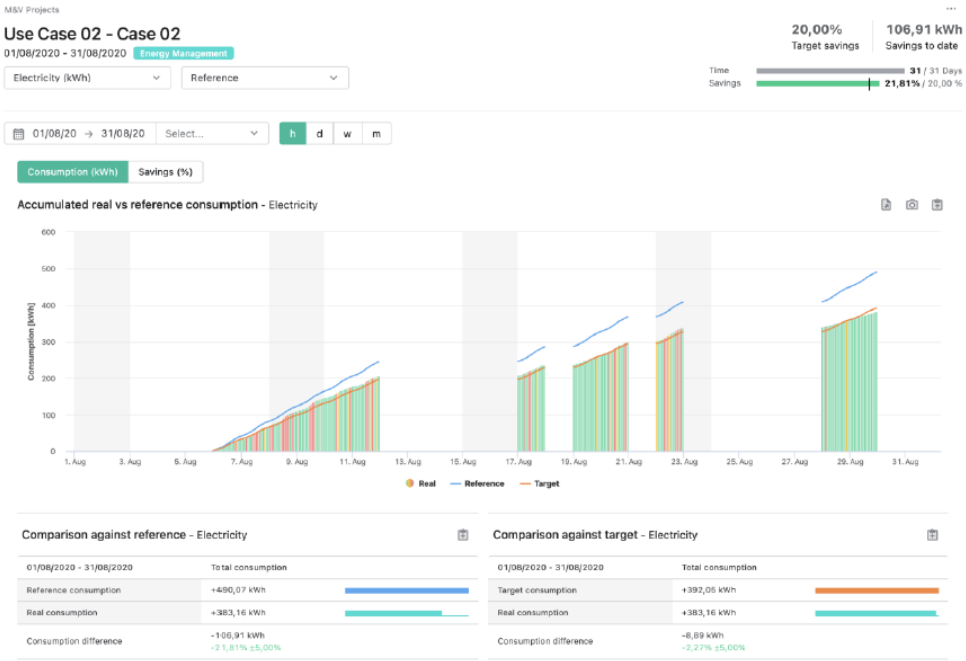

Figure 5. Screenshot of the validation dashboard

Several publications have come out of the AIT-NUIG-IMP collaboration. These include:

- M. Jelić, D. Pujić, N. Tomašević, P. Lissa, D. Peretti Correa, and M. Keane, "Case study of Aran Islands: Optimal DR control of heat pumps and appliances," in IDR2021: Industrial Demand Response: Methods, Best practices, Case Studies, and Applications, H. H. Alhelou, P. Siano, and A. Moreno-Muñoz, Eds. London: IET - Institution of Engineering and Technology, 2022. *(accepted, book in preparation)*
- Stöckl, J., Makoschitz, M., Strasser, T., Blanes, L. M., Janev, V., Lissa, P., & Seri, F. (2021, November). Survey on Technologies Driving the Smart Energy Sector. In 2021 29th Telecommunications Forum (TELFOR) (pp. 1-4). IEEE.

4. Joint Proposal Writing Activities

4.1. Replicable solutions for a cross-sector compliant energy ecosystem (AIT, IMP, NUIG)

In January 2022, the consortium started to develop a proposal for the call HORIZON-CL5-2022-D3-01-12, (deadline April 2022), based on the AIT Vlab environment. The VLab is an ecosystem of actors, sample actions, interfaces, Representational State Transfer (REST) Application Programming Interface (API)s and client Software Development Kit (SDK)s along with documentation packed in a portable environment to providing a mock-up of the proposed system to testing and integration. This could be equally beneficial for system architects, developers and other stakeholders.

Title of the proposal is Virtualized Energy Catalog of Smart Applications in a Replicable Integrated multi-Energy Ecosystem (VICTORY).

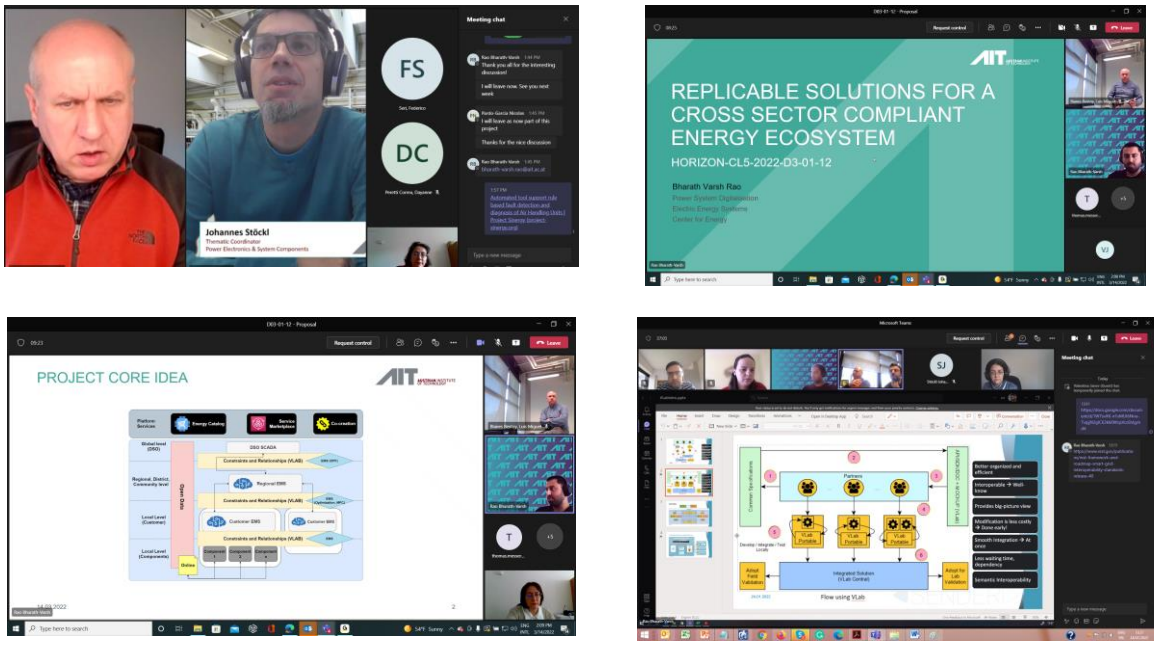

Figure 6. Screenshot of meetings during the proposal writing process

4.2. AI excellence hubs for boosting green transition in Danube countries

In December 2021, IMP and AIT started to develop a proposal for the call WIDERA-2022-ACCESS-04-01 (deadline March 2022). The proposal was submitted under the following title AI excellence hubs for boosting Green transition in Danube countries.

Abstract: AI4GreenDanube will establish a sustainable innovation ecosystem to facilitate the environmental friendly transition and the implementation of the Green Deal-related directives in the Danube Region. Eight interconnected excellence hubs (from Slovenia, Croatia, Serbia, Hungary, Bulgaria, Romania, Germany and Austria) join forces to define a long term R&I strategy.

Figure 7. An illustration of the Danube region and partner locations

Figure 8. Joint Research and innovation strategy and action plans

Measures for the implementation of common investment plans for R&I including infrastructures leveraging national, regional and European funds as well as private capital in a synergetic manner will be defined. The work builds upon activities and results from recently finished (LAMBDA) and currently running EU and national projects (SINERGY). AI4GreenDanube will outline a holistic framework to drive collaboration among relevant Quadruple Helix stakeholders. The partners will accelerate impact in the short-, medium- and long term towards 2030. During development of the R&I strategy, the consortium will explore emerging ICT technologies and elaborate scenarios and pathways for implementation of innovations in the energy sector. In particular this involves integration of respective value chains, renewables, Smart Grids & Cities, and energy efficiency. The business sector plays a critical role in helping to realize the Green Deal ambitions. It is an engine of economic growth and employment, a source of finance, and a driver of technology and innovation. The beneficiaries will implement an Effective Stakeholder Engagement Strategy for knowledge transfer and involvement of their partner networks with more than 10000 entities across Europe. The ecosystem is based on 5 research centers (SI, AU, HU, RS, BG), 4 Faculties (AU, SI, RO, HR), 3 public organizations (DE, RS), 2 umbrella organizations (SI, RS) and 2 companies (SI, BG).

5. PhD Workshops

5.1. 1st PhD Workshop, November 2021 (AIT, IMP, NUIG)

As concluded in SINERGY Deliverable 5.1, the overall experience gained from organizing the 1st Workshop on Smart grid technologies is very positive. A clear benefit for the IMP researchers as well as for Ph.D. students from AIT and NUIG was noted. The preparations for 2nd Workshop on Energy efficient building operation have already started and we anticipate that travel restrictions due to COVID-19 will be released and/or simplified. The Figure given below illustrates a selection of presentations from the first SINERGY workshop.

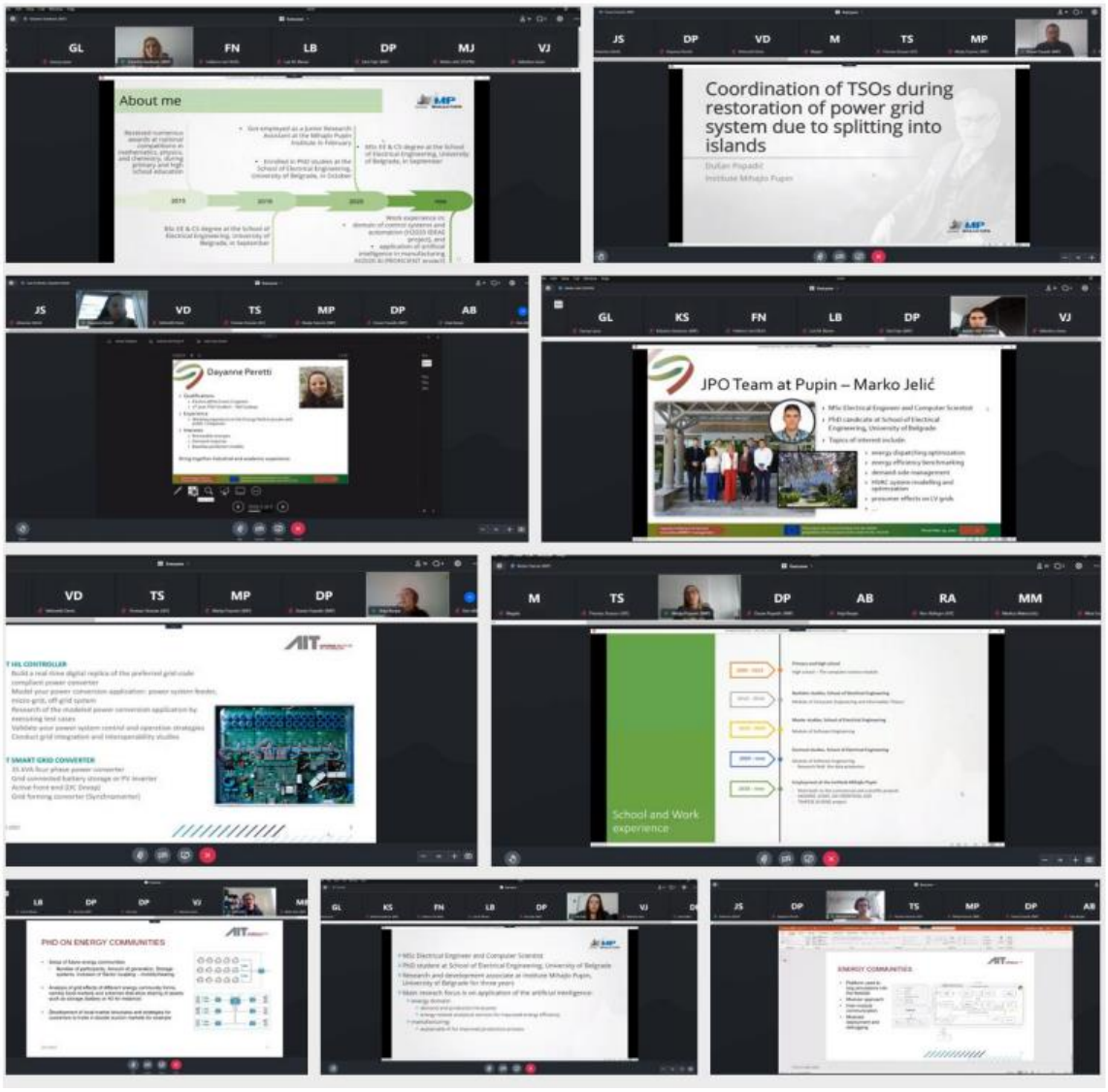

Figure 9. Selection of young researcher presentations

Within the scope of the first PhD workshop, a list of potential collaborative topics between IMP, AIT and NUIG researchers was collected. The analyzed titles can be found in the Table below.

Researcher	Potential topic(s)
Dea Pujić	• Renewable energy sources production forecast based on machine learning models • Machine learning based models for electrical and thermal demand forecast • Non-intrusive load monitoring (NILM) for residential energy disaggregation utilizing deep learning approach • End Users energy efficiency evaluation and benchmarking • Application of Explainable AI (XAI)
Marko Jelić	• User-centric optimization and scheduling of multi-source energy systems (electricity & heat) • Demand Response / Flexibility optimisation in smart grids (optimal load flow applications/Energy Hub integration) • Numerical simulation of thermodynamic heat pump loops • End Users energy efficiency evaluation and benchmarking
Dušan Popadić	• Emergency and restoration in smart grids: detection of system split and blackout, frequency deviation • Critical information exchange and coordination in power grids
Katarina Stanković	• Multi-criteria optimization techniques for decision support systems • Clustering of multivariate time-series • Control and automation of HVAC systems with integrated renewable energy sources • Thermal modelling of HVAC system components
Marija Popović	• Advance mechanisms for field data protection and processing: Use Case in Energy Communities • Blockchain technology applications for innovative transparency and immutability of the data: Use Case in Energy Communities

5.2. 2nd PhD Workshop, May/June 2022 (AIT, IMP, NUIG)

Following the positive outcomes from the 1st SINERGY PhD workshop, an agenda has been drafted on the event page at https://project-sinergy.org/2nd-Workshop that outlines the events that are scheduled to take place at the NUIG premises in Galway in May, 2022. The current version of the agenda is given below.

DAY 1 – 31st. May 2022 – AGENDA

Location: Alice Perry Building – Boardroom – 3052 (3rd. Floor)

Online: Connection Details (TBD)

Note: Irish Standard Time (IST) is CET less 1hour.

9:00 (IST) – Welcome

9:30 – 12:30 SINERGY General Assembly

- Coordinator updates
- WPs
- Deliverables
- Reporting Status
- 1st. Review Meeting Rehearsal
- Other business

12:30 – 14:00 - Lunch – Friars

14:00 – 15:00 – Presentations to the SINERGY *Steering Committee*

15:00 – 15:30 – Coffee Break

15:30 – 17:00 – NUIG Pilot workshop

- Introduction to BMS systems in campus (Karl Byrne – EWA Controls Ireland)
- Workshop session around SINERGY pilots and proposed collaborations
- Tour of the Alice Perry Engineering Building Living Laboratory
- Visit to Aras de Brun Building

18:30 – Social Dinner

Kirwans Lane Restaurant

Steering Committee Participants

Prof. Miloš Banjac, Faculty of Mechanical Engineering, University of Belgrade

Ruth Buggie, Sustainable Energy Authority of Ireland

Andreas Lugmaier, Siemens, Austria

Prof. Dimitar Taškovski, Faculty of Electrical Engineering, Ss. Cyril and Methodius University in Skopje

Gordana Danilović Grković, Science Technology Park Belgrade

Prof. Vedad Pašić, Faculty of Natural Sciences and Mathematics, University of Tuzla

Marko Poznanović, Belit, ICT Network

DAY 2 - 1st. June 2022 - AGENDA

Location: Alice Perry Building – Boardroom – 3052 (3rd. Floor)

Online: Connection Details (TBD)

Note: Irish Standard Time (IST) is CET less 1hour.

9:00 (IST) – Coming together

9:15 – 9:55 – 1st – Module of Efficient Building Operation (TBD)

10:15 – 10:55 – 2nd Module on Efficient Building Operation (TBD)

Coffee Break – Refreshments Provided - Networking

11:15 – 11:55 – 3rd. Module on Efficient Building Operation (TBD)

12:30 – 14:00 - Lunch – Friars

14:00 – 15:30 – Wrapping of the 2nd. SINERGY Workshop

- PhD workshop conclusions
- Proposed Mentoring Activities
- Personnel Exchange
- Publications Plan

SINERGY Open Event

Sponsored by Engineers Ireland (EI) – CIBSE Ireland – ASHRAE Ireland

Location: Alice Perry Building – G047 (3rd. Floor)

Smart Grid Technology underpinning Sustainable and Secure Energy in Europe

16:00 – 16:15: **Opening – SINERGY project**

Dr. Marcus M. Keane – NUIG

16:15 – 16:35: **Impact of Energy Security and Green Agenda at NUIG Campus**

Michael Curran – CIBSE Chair and Head of NUIG Building and Estates

16:35 – 16:55: **Green Hydrogen – GenComm project**

Dr. Rory Monahagan

16:55 – 17:15 **Metabuilding Labs project**

Jamie Goggins or Magdalena Hajdukiewicz

17:15 – 17:35 – **Smart Grid in Ireland**

Speaker from Industry or SEAI - TBD

17:35 – 17:55 – Cybersecurity in Infrastructures

Speaker - TBD

18:00 – 18:45: Q&A Panel Discussion

Moderator: Marcus M. Keane

18:45 End of Event – Refreshments provided

6. Conclusion

In conclusion, this document presents the collaborative efforts between researchers from Institute Mihajlo Pupin, Austrian Institute of Technology and National University of Ireland, Galway. It depicts descriptions of past and ongoing joint efforts on several European research projects (from the Horizon 2020 funding schema) as well as joint efforts on proposal writing for future projects and new research work. Finally, a summary of PhD workshops organized within SINERGY is given as these events present notable opportunities for researchers from participating organizations to exchange their expertise and knowledge.