

edgeFLEX

D7.3

Report on courses for professional practitioners and academia

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Abstract

edgeFLEX successfully organised an academic course for energy students and professionals centred on the research and innovation concepts developed in the scope of the project. The project results were introduced into academic teaching and research activities and the consortium members got important feedback on their results and disseminated the advantages of the edgeFLEX solutions to the energy research and innovation community.

Keyword list

Academic courses, H2020 projects synergies, innovation events

Disclaimer

All information provided reflects the status of the edgeFLEX project at the time of writing and may be subject to change.

Executive Summary

The consortium members successfully presented edgeFLEX concepts and solutions during a dedicated course for students and professionals in the energy domain. The participation to the event and the feedback obtained confirmed the high interest present in the energy domain for the topics investigated in the edgeFLEX project and served to improve the project's work and exploitation of the results.

The feedback obtained from the attendees showed that the topics related to power systems digitalisation and the effective usage of distributed energy resources for active grid management is of high importance for both the research and academic community as well as for system operators and VPP operators.

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1. Introduction

1.1 Objectives of the deliverable

This deliverable describes the task carried out in the scope of the communication and dissemination activities of the edgeFLEX project, specifically dedicated to engaging academic and professional audience by offering a course centred on the results of the edgeFLEX project.

This report includes a detailed description of the structure of the edgeFLEX course, including the content of each module. It also describes the procedure followed to organise the event, publicise it in order to generate interest inside the target groups identified as potential attendees and the methodology used to receive feedback from participants.

1.2 Related work

Over the duration of the project, edgeFLEX participated in and organised a high number of events to promote the project and its findings in the energy sector and academia as well as to engage in discussions with all relevant stakeholders.

Among the dissemination and communication activities, the project organised a dedicated course to be offered to university students, researchers and energy professionals. The course was composed by several modules, covering all the research and innovation concepts developed and implemented in the edgeFLEX project.

This document describes how the course was organised and publicised and reports the feedback from the participants, collected at the end of the project.

1.3 How to read this document

The document presents, in Chapter 2, the structure of the course and the descriptions of the different topics. It also describes how the registration process was organised and how the communication and dissemination activities were carried out in order to reach out to potential participants.

Chapter 3 presents the report from the course execution and the feedback received from participants, drawing conclusions on the acceptance and success of the proposed initiative.

For the detailed descriptions of the design and implementation of the different services and concepts developed in the edgeFLEX project, the reader can refer to the following deliverables:

- D1.2: Dynamic-phasor driven voltage control concept for current VPPs in large scale deployment [1]
- D1.3: Dynamic-phasor driven voltage control concept for Energy Communities with future VPPs [2]
- D2.2: Frequency control concept for current VPPs in large scale deployment [3]
- D2.3: Frequency control concept for Energy Communities with future VPPs [4]
- D2.4: Inertia estimation concept for low inertia power system [5]
- D2.5: Inertial response control concept for VPPs in large scale deployment [6]

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- D3.1: 5G ICT requirements, development and testing for EdgeFLEX solution [7]
 - D3.3: Report on VPP optimisation, V2 [8]
 - D4.1: Description of EdgeFLEX platform design [9]
 - D4.2: Description of EdgeFLEX MVP [10]
 - D4.3: Description of internal interfaces for control services [11]

Moreover, for a comprehensive overview of all other communication and dissemination activities carried out during the project, the reader can refer to deliverable D7.2: Updated plan for dissemination and communication of results, V2 [12].

2. Course preparation

2.1 Course structure and agenda

The edgeFLEX course on advanced power grids operations has been organised in 8 modules. The different modules have been directed by various energy and power systems experts from edgeFLEX consortium partners, including academia, research institutions and industry backgrounds.

The participants had the chance to dig into advanced research concepts for new fast dynamics services for grid management, such as voltage and frequency control in low inertia power systems and learn about the application of information and communication technologies to power grids, including 5G communication and edge cloud applications.

The list of modules and the respective presenters was the following:

- 5G in the energy sector
 - Fiona Williams and Robert Farac (Ericsson)
- ICT Architectures in the Smart Grid
 - David Ryan (Walton Institute)
- Voltage control to mitigate overvoltage events in active distribution network
 - Edoardo De Din (RWTH Aachen University)
- Instrument transformers for Smart Grids
 - Alessandro Mingotti (University of Bologna)
- Frequency Control of Low Inertia Systems
 - Federico Milano (University College Dublin)
- Inertia Estimation and Allocation of Frequency Support Services in Low Inertia Power Systems
 - Diala Nouti (RWTH Aachen University)
- Optimal balancing of RES with VPPs in a market environment
 - Vadim Omelčenko (ALPIQ)
- Cloud-based data processing and low cost synchronized data acquisition
 - Manuel Pitz (RWTH Aachen University)

The complete set of modules is depicted in Figure 1.

Course modules

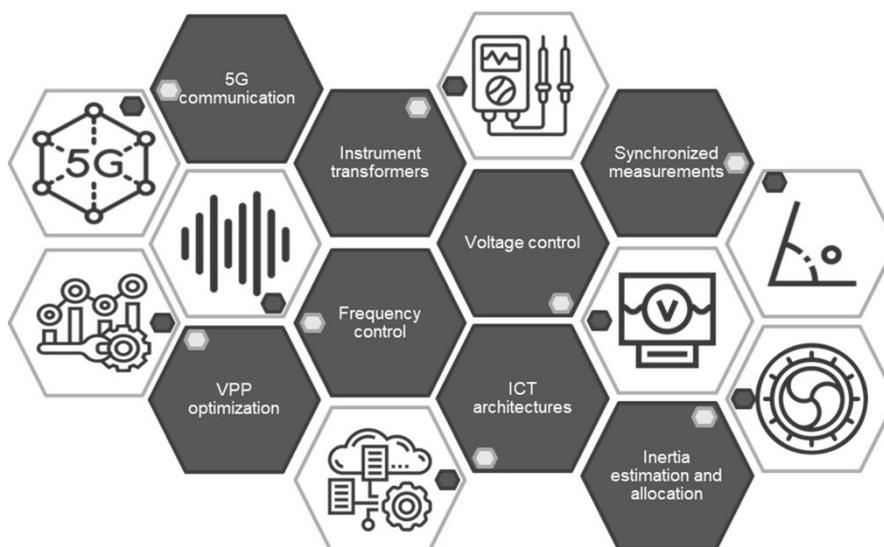


Figure 1 – edgeFLEX course modules

The course was organised in two sessions, in the morning of April 28th and in the afternoon of April 29th 2022, in order to better distribute the modules.

The full agenda of the course, including the introduction session, covering a brief presentation of edgeFLEX project's scope, is reported in Figure 2 and Figure 3, for the first and the second day respectively.

Day 1 agenda – 28.04.2022 (09:00-13:00)



Session	Presenter	Start	End
Welcome of participants	Gianluca Lipari (RWTH Aachen University)	09:00	09:10
Introduction to edgeFLEX course	Prof. Antonello Monti (RWTH Aachen University)	09:10	09:30
5G in the energy sector	Fiona Williams and Robert Farac (Ericsson)	09:30	10:20
Coffee break		10:20	10:30
ICT Architectures in the Smart Grid	David Ryan (Walton Institute)	10:30	11:20
Voltage control to mitigate overvoltage events in active distribution network	Edoardo De Din (RWTH Aachen University)	11:20	12:10
Instrument transformers for Smart Grids	Alessandro Mingotti (University of Bologna)	12:10	13:00

Figure 2 – edgeFLEX course Day 1 agenda

Day 2 agenda – 29.04.2022 (13:00-17:00)



Session	Presenter	Start	End
Welcome of participants	Gianluca Lipari (RWTH Aachen University)	13:00	13:10
Frequency Control of Low Inertia Systems	Prof. Federico Milano (University College Dublin)	13:10	14:00
Inertia Estimation and Allocation of Frequency Support Services in Low-Inertia Power Systems	Diala Nouti (RWTH Aachen University)	14:00	14:50
Coffee Break		14:50	15:00
Optimal balancing of RES with VPPs in a market environment	Vadim Omelčenko (Alpiq)	15:00	15:50
Cloud-based data processing and low cost synchronized data acquisition	Manuel Pitz (RWTH Aachen University)	15:50	16:40
Conclusion of the course	Gianluca Lipari (RWTH Aachen University)	16:40	17:00

Figure 3 – edgeFLEX course Day 2 agenda

2.2 Modules

2.2.1 5G in the energy sector

This module provided an overview of what 5G is and what it offers to energy use cases and the typical requirements which 5G has to fulfil to support these use cases.

The typical configurations of 5G networks for energy use cases have been described and several examples of such solutions have been provided.

Finally, the results of performance tests, conducted in the Ericsson 5G lab, of the edgeFLEX services energy use cases have been presented.

2.2.2 ICT Architectures in the Smart Grid

This module was centred on common ICT architectures (Centralised, Decentralised and Hybrid Mobile edge architectures) and the different scenarios in which they can be deployed. Additionally, it explained how modern software architectures, like micro service ones, can facilitate such deployments.

Then, the edgeFLEX architecture, which is designed to be flexibly deployed in different cloud configurations, was presented. In addition, it was described how this architecture can also be instantiated across company boundaries, in a secure and managed way, with the implementation of the edgeFLEX Policy Based Grid Management (PBG) functionality.

2.2.3 Voltage control to mitigate overvoltage events in active distribution network

This module presented an overview of voltage control solutions applied to distribution networks with a high number of distributed generators (DG) installed.

Starting with the problem description, the module continued with the classification of different voltage control implementations and presented the most relevant simulation results.

In addition, the module addressed the integration of voltage control in a cloud or edge cloud environment.

2.2.4 Instrument transformers for Smart Grids

Smart Grids are only possible if punctual and precise measurements are performed. Thus, it is essential to perform accurate measurements with accurate instrumentation.

Therefore, this module introduced the main technologies adopted for the measurement of current and voltage signals in the nodes and branches of the power network. Pros and cons of the different solutions were described and analysed, to better understand which instrument is suitable depending on the required applications.

2.2.5 Frequency Control of Low Inertia Systems

This module was organised into two parts.

The first part provided an overview of low inertia systems and the challenges that need to be solved in order to implement an efficient frequency control through converter interfaced generation and energy systems.

The second part described the novel concepts of complex and geometric frequency developed in the edgeFLEX project and presented some applications in the context of distributed energy resources and virtual power plants.

2.2.6 Inertia Estimation and Allocation of Frequency Support Services in Low Inertia Power Systems

This module focused on the research concepts developed within edgeFLEX on topics related to inertia in future power systems with a high penetration of distributed energy resources.

An overview of inertia estimation and system level inertia allocation algorithms were presented.

2.2.7 Optimal balancing of RES with VPPs in a market environment

The module presented an overview of optimisation methods applied to portfolios of assets within a VPP.

The role of price and RES production forecasts were discussed. Such forecasts are key inputs for a correct optimisation of VPP's portfolios.

Furthermore, the module focused on the scalability of the balancing and forecasting methods with respect to the rising number of assets in a VPP portfolio.

2.2.8 Cloud-based data processing and low cost synchronized data acquisition

This module presented the hardware and software stack used for the edgePMU design and implementation and provided insights into modern cloud and container-based data processing, as well as infrastructure management.

The advantages and challenges of different types of data samples' synchronisation, with a focus on cloud-based data processing, were discussed.

In addition, the measurements acquired in the initial laboratory validation, also comparing a commercial PMU with the edgePMU, were reported.

2.3 Dissemination and registration procedure

In order to publicise the course and reach out to the highest number of interested participants, three main channels have been used:

- Social media
- Power systems community mailing list
- Direct invitation of students

Specifically, for the social media communication the project's LinkedIn profile¹ has been used to create awareness regarding the proposed course, with dedicated posts presenting the scope of the course and the different modules, together with the related speakers.

The dissemination to the power system engineering community was undertaken through the POWERGLOBE² mailing list, which has more than 7500 registered users among students, researchers and professionals in the power system engineering community globally.

Finally, the academic partners RWTH, UniBO, UCD and WIT, publicised the course among the respective students and PhD candidates.

Additionally, a dedicated page on the edgeFLEX project website was created, as shown in Figure 4.

¹ <https://www.linkedin.com/company/edgeflex-h2020/>

² <https://pages.mtu.edu/~ljbohman/peec/globe/index.html>



The screenshot shows the top navigation bar of the edgeFLEX website. The URL in the browser is 'edgeflex-h2020.eu/events/edgeflex-course-on-advanced-power-grids-operations.html'. The navigation menu includes 'HOME', 'ABOUT', 'TRIALS', 'INSIDE EDGEFLEX', 'EVENTS', 'PROGRESS', and 'INTERNAL'. The 'EVENTS' menu item is highlighted in red. Below the navigation bar is a banner image showing power lines. The main heading is 'edgeFLEX course on advanced power grids operations', followed by the dates '28th and 29th of April 2022' and the schedule 'On the first Day from 9:00-13:00 and on the second day from 13:00-17.00'. The text describes the course content, including modules on advanced power grids operations, and provides a 'REGISTER HERE' link. It also mentions the edgeFLEX project's focus on Virtual Power Plants (VPPs) and the course's focus on future grids and ICT infrastructures.

Figure 4 – Course page on edgeFLEX website

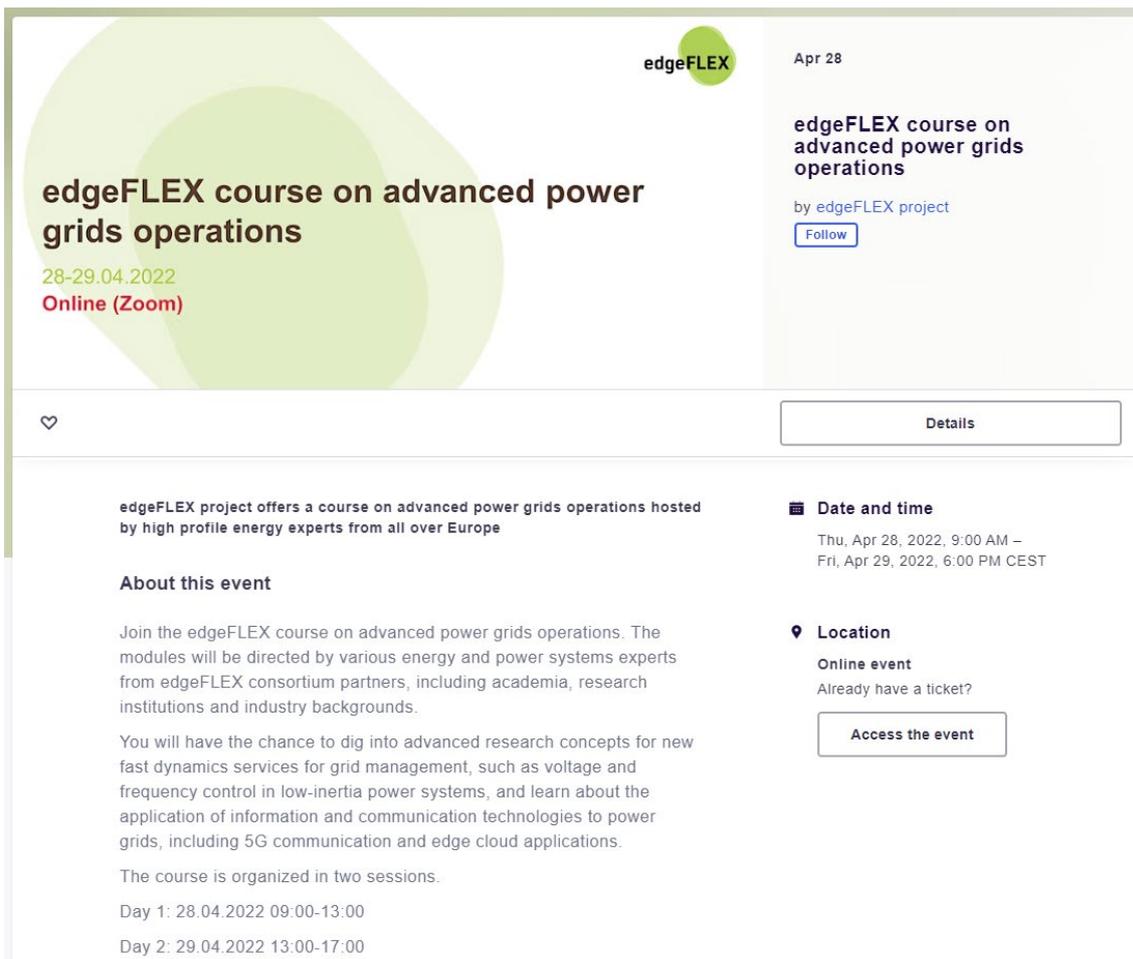
For the registration and the communications with the registered users the Eventbrite³ service was used. Eventbrite allows to create both private and public events and provides all the tools for managing registrations, messaging, distribution of documents and online meeting links. Additionally, it provides dedicated instruments for evaluating the outreach and impact of the event through relevant statistics, such as visitors of the event page, number of visualisations and the number of registrations.

³ <https://www.eventbrite.com/e/318463471817/>

3. Attendance report and participants' feedback

3.1 Course registrations and attendance

The course was offered as an online course using the Zoom videoconferencing suite. Participants registered on the Eventbrite dedicated page, shown in Figure 5, and automatically received a welcome message with the detailed agenda of the course. Before the start of each session, the participants also received a reminder email, with the Zoom link and the detailed description of the modules that would be presented in each session.



The screenshot shows the Eventbrite event page for the 'edgeFLEX course on advanced power grids operations'. The page features a green and white color scheme. At the top left, the edgeFLEX logo is displayed. The main title is 'edgeFLEX course on advanced power grids operations', with the dates '28-29.04.2022' and 'Online (Zoom)' below it. A 'Follow' button is visible. The event details section includes a description: 'edgeFLEX project offers a course on advanced power grids operations hosted by high profile energy experts from all over Europe'. The 'About this event' section describes the course content and the opportunity to learn from experts. The 'Date and time' section lists the sessions: 'Thu, Apr 28, 2022, 9:00 AM – Fri, Apr 29, 2022, 6:00 PM CEST'. The 'Location' section indicates it is an 'Online event' and provides an 'Access the event' button. The course is organized in two sessions: Day 1 (28.04.2022 09:00-13:00) and Day 2 (29.04.2022 13:00-17:00).

Figure 5 – edgeFLEX course dedicated page on Eventbrite

The total number of unique visitors on the event page was beyond 300, with a daily distribution shown in Figure 6.

The generated traffic on the event page was concentrated in the days right before the course, mainly because of the registrations completed by attendees, but also continued for some days after the course, with attendees accessing the event page for gathering the course material and contacts with the organisers.

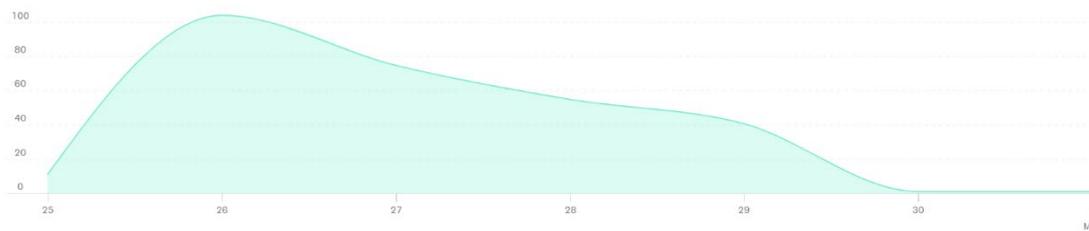


Figure 6 – Event page daily visits

The total number of registered participants was 74, most of them registered before the first session, but there were some more registrations at the end of Day 1. The final report on registered users is shown in Figure 7, while the cumulative distribution of registrations is shown in Figure 8.

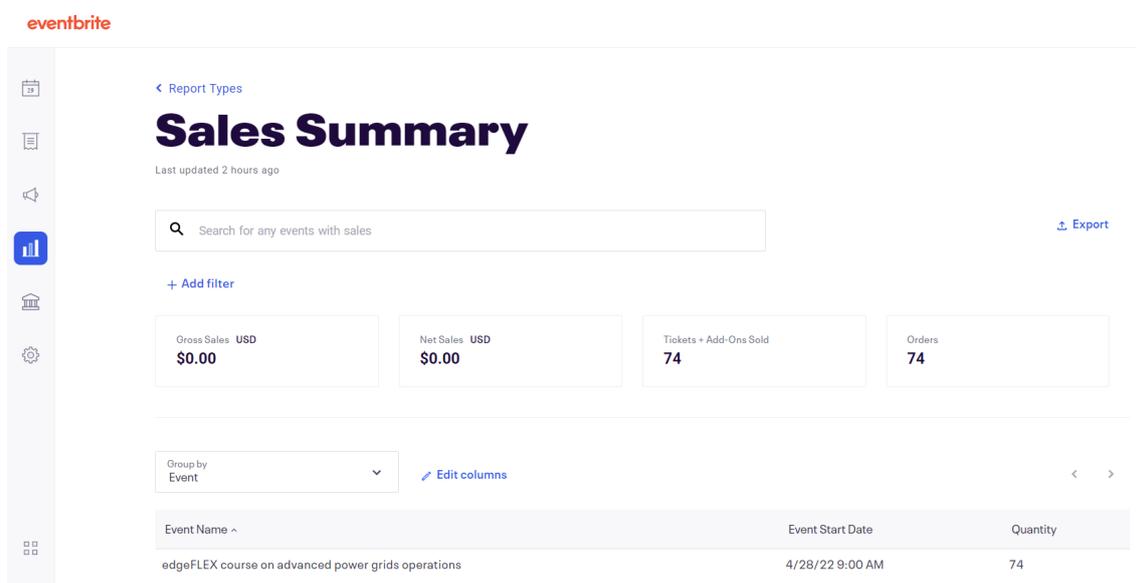


Figure 7 – Total number course registrations

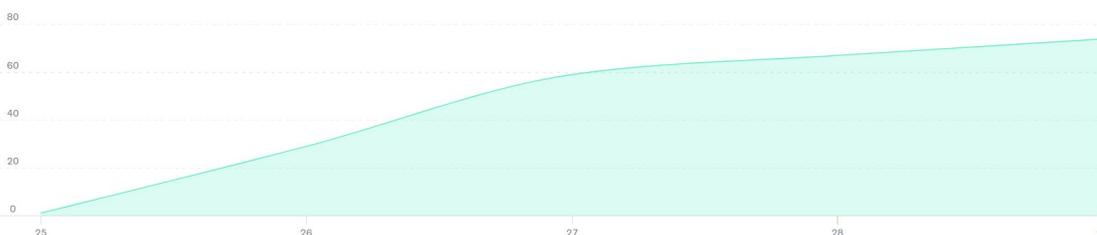


Figure 8 – Cumulative distribution of course registrations

Most of the participants came from Europe, mainly from Germany with 23 registered attendees, but also included participants from Asia, America, Africa and Australia. The locations of all participants are shown in Figure 9.



Figure 9 – Locations of edgeFLEX course participants

During both sessions (Day 1 and Day 2) there have been around 35 participants actively joining the Zoom sessions.

During the sessions all participants were invited to pose questions either using the chat functionality offered by Zoom or directly addressing the presenters after each module. In both sessions the participants demonstrated high interest in the chosen topics, also proved by the active discussions had after each module.

3.2 Attendance feedback

In order to gather proper feedback from all attendees, complementary to the discussions carried out during the presentations, the project has prepared an online feedback formular which was circulated among all participants after the conclusion of the course.

The form was created using the Microsoft Forms tool⁴, which allows to automatically collect answers to the questions posed to participants and export results as Excel table for further analysis.

The form consisted of 5 questions on the overall evaluation on the course and the topics, with grading between 1 and 5 to be given, and additional questions asking for most appreciated part of the course and suggestions for improvement. Finally, participants were asked to provide information regarding their background and education.

The online form interface is shown in Figure 10.

⁴ <https://forms.office.com/r/CxCkXgQuP7>

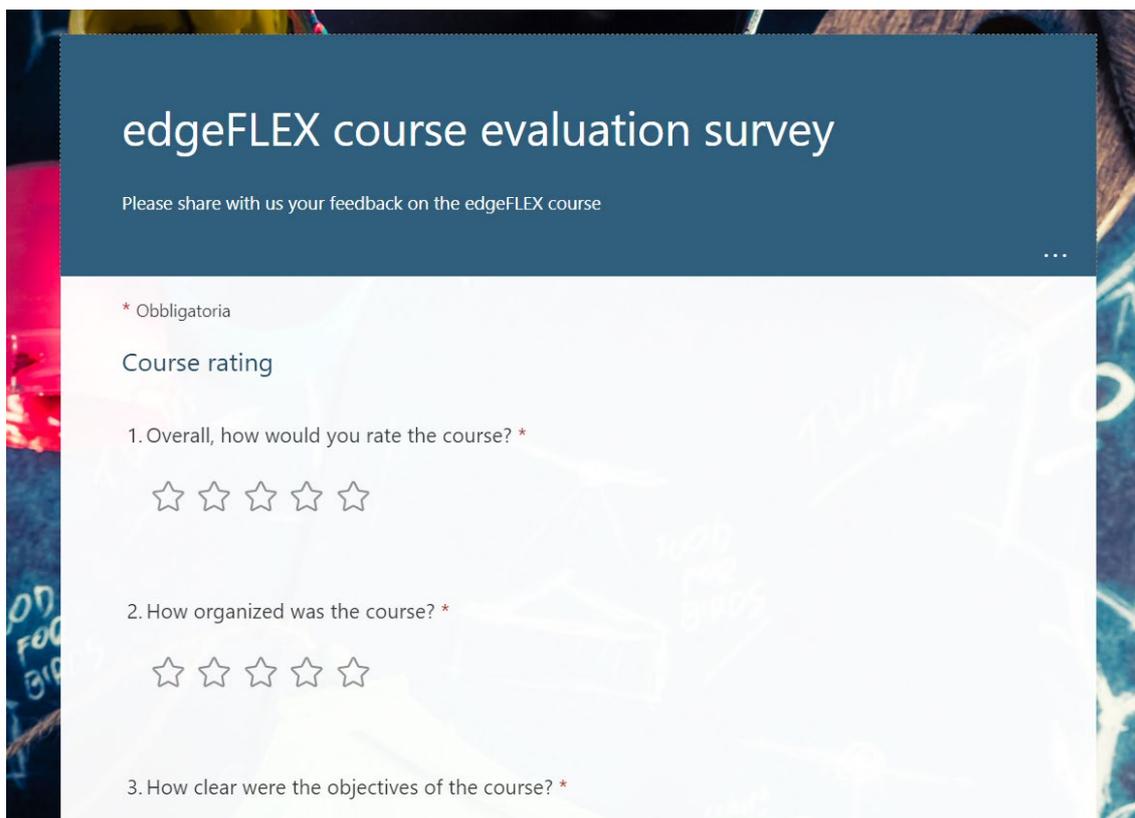


Figure 10 – edgeFLEX course feedback formular

The results from the feedback questionnaire are reported in the following paragraphs.

Figure 11 shows how the attendees evaluated the course. It can be seen how the course received extremely positive ratings in all categories, with a high rating given to the presenters and in general to the whole course and its structure and organisation.

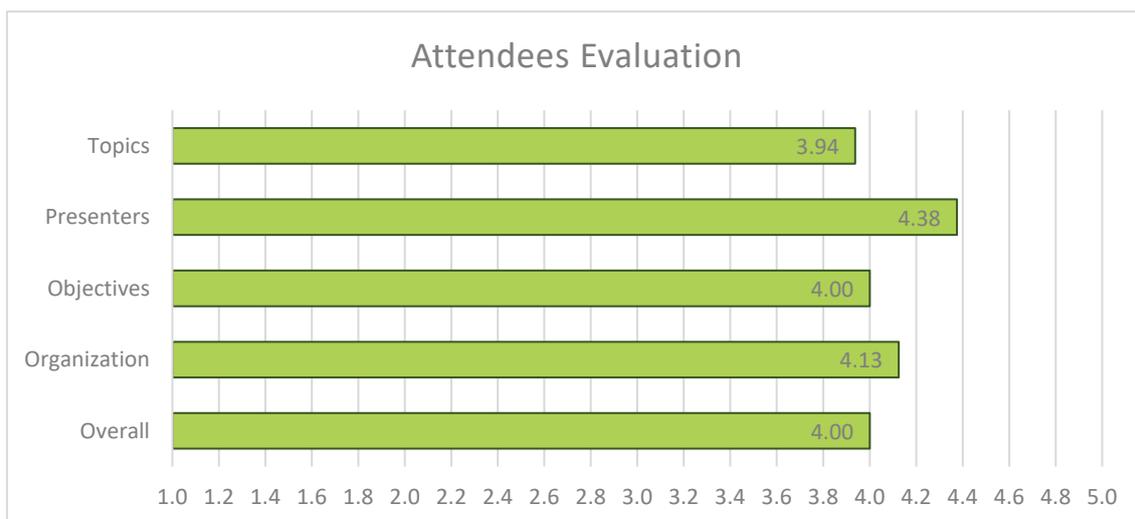


Figure 11 – Attendees evaluation

All modules were positively received by attendees, with small differences according to the ratings given by the participants. The highest rating was given to the Frequency

Control module, but in general all topics were appreciated by the participants, as shown in Figure 12.

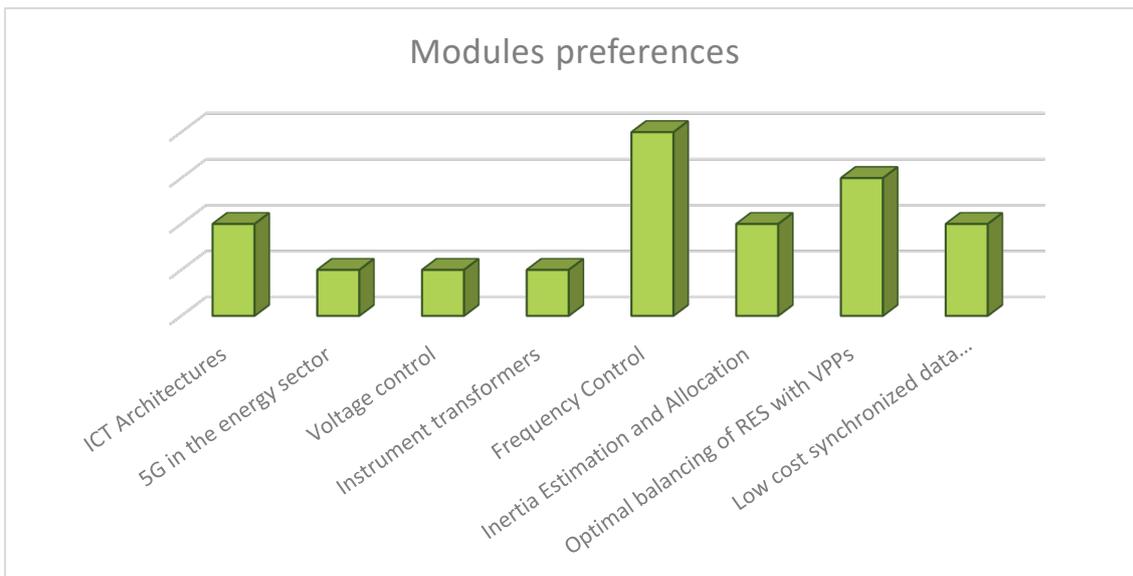


Figure 12 – Modules preferences

Finally, all attendees had a university degree, spanning from Bachelor to Doctorate, with the latter being the most frequent. This can be interpreted that in general the topics presented were well received in the academic community and especially, for their marked research and innovation characteristics, from higher education levels such as doctoral students and university researchers. The distribution of the attendees’ degree levels is shown in Figure 13.

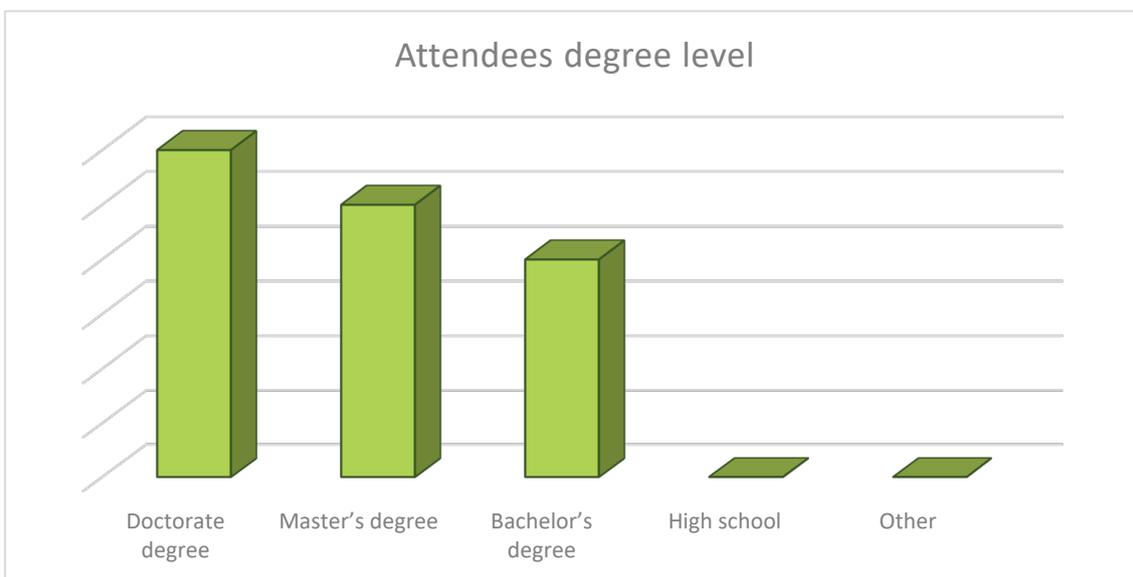


Figure 13 – Attendees background and education

4. Conclusions

This deliverable presented the activities carried out for the organisation and execution of a course for energy professionals and academic audience, focused on the results, research and innovation concepts developed within the edgeFLEX project.

The course was held on April 28th and 29th 2022 and attracted a good number of attendees, both from academic world and energy experts and professionals. The interest and satisfaction of the attendees has been confirmed during the course itself, proven by the active participation of all attendees and the lively discussions and Q&A sessions that accompanied each module. Additionally, the attendees have been requested to provide a comprehensive feedback and evaluation of the course and the results gathered from the online formular showed a high appreciation of the topics and how they were introduced and presented, as well as a general excellent evaluation of the overall course organisation.

The extremely positive evaluation of the course highlights, on one hand, how interesting and relevant the research and innovation concepts developed within edgeFLEX are with respect to the actual energy sector state of the art and future evolution. On the other hand, it also confirms the quality of the developed concepts and the related results.

The results of the overall activity related to the edgeFLEX course will also be used and further exploited in coordination with the EDDIE⁵ (Education for Digitalisation of Energy) project, providing insights that will be useful to define and develop a more consistent and future oriented approach in education in the energy sector.

⁵ <https://www.eddie-erasmus.eu/>

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7. List of Abbreviations

DER	Distributed Energy Resource
DG	Distributed Generation
DSO	Distribution System Operator
ICT	Information and Communication Technology
LV	Low Voltage
MV	Medium Voltage
PBGM	Policy Based Grid Management
PMU	Phasor Measurement Unit
Q&A	Question and Answer
RES	Renewable Energy Source
RoCoF	Rate of Change of Frequency
RoCoP	Rate of Change of Power
TRL	Technology Readiness Level
TSO	Transmission System Operator
VPP	Virtual Power Plant
WP	Work Package