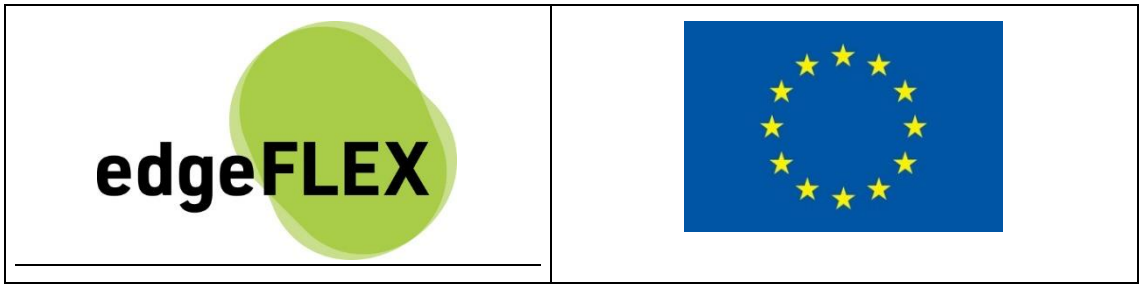


edgeFLEX

D8.3

Publishable Project Progress Report

The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 883710.

Project Name	edgeFLEX
Contractual Delivery Date:	30.04.2021
Actual Delivery Date:	30.04.2021
Author(s):	EDD
Workpackage:	WP8 – Project Management
Security:	P
Nature:	R
Version:	V1.0
Total number of pages:	22

Abstract
This document provides an overview of the plans and progress of the edgeFLEX project between its start on 1st April 2020 and 31st March 2021.

Keyword 5G, Mobile communications, Renewable Energy Source (RES), Voltage Control, Frequency control, simulation, co-simulation, hardware in the loop, field trial, VPP

Executive Summary

The project has made the progress planned for the first year of its three year duration and has even exceeded the expected level of results in several areas of activity. Research concepts, implementation and platform integration work have progressed well, providing good starting points for the field trials of the project, which will start to become operational later in 2021. The project is well positioned to achieve all its planned goals and KPIs in its coming two years of activity.

The edgeFLEX project started in April 2020, just as most project participants moved from working in their offices to working from home. The restrictions of Covid-19 have meant that project participants have not met for presence meetings since the beginning of the project. While this was a very unusual and stressful situation, project participants have made exceptional efforts to maintain progress on all work items of the project. These efforts contributed to the development of a positive mood among project participants, to establishing relationships between partners who have never met each other in a face to face meeting and to the very good progress of the project work.

Authors

Partner	Name	e-mail
EDD		
	Fiona Williams	fiona.williams@ericsson.com
	Karina Nees-Maric	knm@k-aix.de
UNIBO		
	Alessandro Mingotti	alessandro.mingotti2@unibo.it
	Diego Cavaliere	diego.cavaliere2@unibo.it
RWTH		
	Diala Nouti	dnouti@eonerc.rwth-aachen.de
	Gianluca Lipari	glipari@eonerc.rwth-aachen.de
ALPQ		
	Alexandre Junker	alexandre.juncker@alpiq.com
WIT		
	David Ryan	dryan@tssg.org
SWW		
	Evyatar Littwitz	evyatar.littwitz@es-geht.gmbh
CRE		
	Mihai Mladin	Mihai.Mladin@crenerg.org
BAUM		
	Anna Maaß	a.maass@baumgroup.de

Table of Contents

1. Introduction

1.1 Objectives of the report

The aim of this deliverable is to provide an overview of the results achieve in the first year of the project work and to highlight the key achievements.

1.2 Outline of the report

The report consists of two main parts. The first two chapters describes the overall approach of the project and includes a short overview of the key achievement of year 1. The third chapter gives a more detailed overview of the achievements of the main topics of the project.

1.3 How to read the document

This report can be read as a standalone document. However, the interested reader can refer to the following deliverables to get a better overview of the concepts and services developed within the edgeFLEX project.

D1.1 Scenario description for dynamic-phasor driven voltage control for VPPs

D1.2 Dynamic-phasor driven voltage control concept for current VPPs in large scale deployment

D2.1 Scenario description for frequency and inertial response control for VPPs

D2.2 Dynamic-phasor driven voltage control concept for current VPPs in large scale deployment

D2.4 Inertia estimation concept for low inertia power system

D3.2 Report on VPP optimisation, V1

D4.1 Description of edgeFLEX platform design

D6.1 Comparative analysis of potential business impact, V1

D6.3 Engaging with policy makers, with organisations and experts in regulation and standardisation, V1

D7.1 Updated plan for dissemination and communication of results, V1

2. The edgeFLEX approach to addressing the challenge

The challenge

With the dramatic growth of renewables, now is the time to revise the Virtual Power Plant (VPP) concept. VPPs need to support not only the promotion of intermittent Renewable Energy Sources (RES) but also the integration of all Distributed Energy Resources (DER) into the full scope of grid operations. Such a leap raises challenges: optimal combination of DER and RES in a new generation of VPPs is needed to jointly provide grid supportive flexibility with slow reaction time known from day-head and intra-day markets, as well as real-time reaction to provide fast frequency and inertial response and voltage control ancillary services. In a nutshell, in a DER-based power electronics-driven network, VPPs need to play all the roles that synchronous machines play in a traditional system. Flexibility can be provided by going beyond electrochemical storage and exploring opportunities offered by Power2X or by the dynamically controllable behaviour of power electronics driven DERs. Demand Side Management or low-cost solutions such as Power2Heat could be deployed in a neighbourhood. This could enable the expansion of the role and responsibility of Local Energy Communities, enabling them to cooperate with VPPs or even become VPPs as the role of VPPs evolves in future years. edgeFLEX links technical solutions to societal expectations. Short reaction times can be addressed by 5G-powered edge clouds linking dispersed devices in near real-time. In this respect, a new concept of VPPs becomes possible with communications corresponding to multiple layers of dynamics. edgeFLEX proposes a new architecture for VPPs deploying such a multi-layer solution, enabling the electrical system to cope with intermittent energy sources. VPPs are brought to a new level, enabling them to interact on markets offering ancillary services to System Operators. edgeFLEX develops this next generation VPP concept and demonstrates it in the context of three field trials and sets of laboratory tests. It explores innovative optimisations, financial tools and business scenarios for VPPs and assess the economic and societal impact. It works actively to remove barriers by contributing to standards and European level regulation.

The edgeFLEX Vision

VPPs are enabled to manage a new, wider range of generation and storage assets, including those of Energy Communities, offering a set of new fast and dynamic services to grid operators. This enables the emergence of a new market for ancillary services and optimizing the role and deployment of storage as described in Figure 1 below.

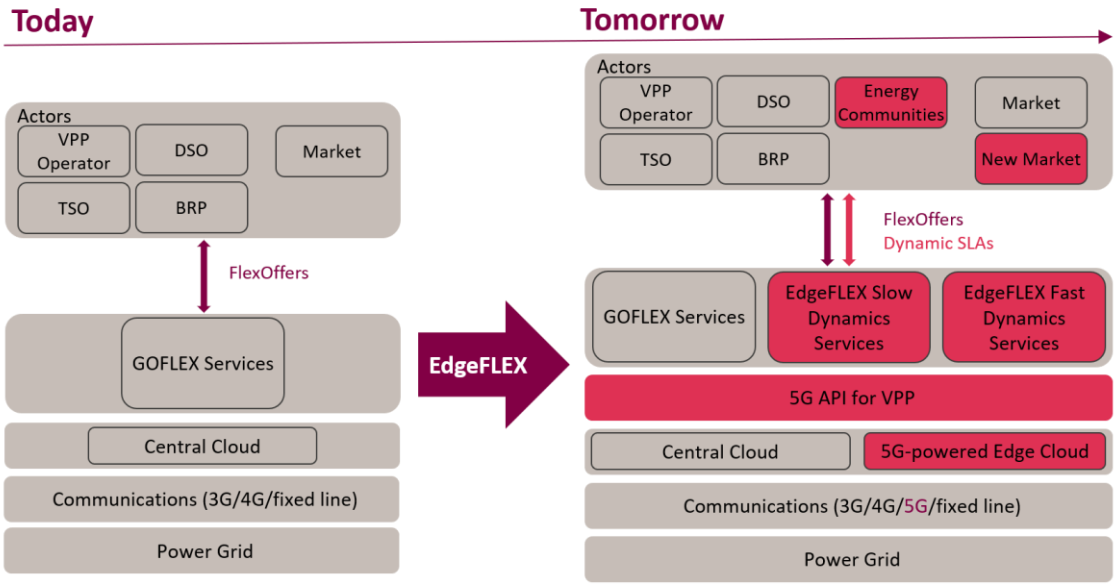


Figure 1 The edgeFLEX Vision

The edgeFLEX Objectives

- To research new fast and slow dynamics ancillary services and a new market for trading to VPPs and grid operators, introducing an innovative new way to run VPPs offering increased flexibility.
- To develop competitive optimisations of the operations of VPPs with storage assets including Power2Heat and biomass reducing the need for grid re-balancing and increasing its stability.
- To develop a new sustainable investment model promoting increased investment and penetration of RES.
- To validate our services in field trials and lab tests, packaging results to prepare impact.

Virtual Power Plants (VPPs) have already been commercially developed to provide effective ways to integrate new energy sources into the wholesale energy market: edgeFLEX proposes a completely redefined VPP able that is, on one hand, able to play a more technical role in supporting grid operation and, on the other hand, to fulfil the growing interest of local communities to participate actively to energy system management. VPPs become Dynamically Controlled Virtual Power Plants, enabled by the resilience, low latency and cost-effectiveness of 5G-powered near real-time ICT. Such solutions leverage the classical wholesale VPP level, while introducing new techniques for stabilising the power grid, i.e. enriching their operations with faster dynamics. At the same time, at local level, new solutions can enable Energy Communities to exploit their energy services in a new energy market. The edgeFLEX consortium partners believe that now is the time for them to meet these challenges, by undertaking joint research, innovation and communication actions leading to significant impacts on the energy stakeholders and markets.

Incorporating Energy Communities into the scope of a VPP means defining a VPP as an aggregation of anything that is connected to the community power network which can act as a resource providing flexibility. This enables prosumers and small generating units to play an active role in providing flexibility to the energy system and to form part of the energy value network. Such an approach brings significant advantages with respect to the simple application of electrochemical storages and it will involve such elements as biomass units, Power2Heat, boilers and various demand response capacities. The main point is that flexibility can be extracted from many existing assets with a dual-use concept which reduces investment needs.

The role of storage has become a key issue as within the set of European efforts to minimize green-house gas emissions, electrification is of utmost importance. In particular, if considering a more competitive fully decarbonized electricity generation, the electrification of the transport sector and of heating for buildings need to be urgently addressed. In this context, the use of Power2Heat is likely to increase and algorithms and systems capable of harnessing its inherent flexibility could be a very cost-efficient way to electrify transport and heating. The edgeFLEX consortium has extensive experience of the use of electro-chemical storage in both slow and fast dynamics applications. It brings this experience to bear on the definition and evaluation of appropriate solutions combining variable and dispatchable RES and electrochemical and other storage forms. In our field trials and business modelling, we challenge today's solutions based on electrochemical storage through the definition of new edgeFLEX solutions leveraging existing flexibility in the form of biomass units and Power2Heat highlighting the competitiveness of flexibility based on new ancillary services for fast dynamics and based on including biomass, Power2Heat and other resources accessible via Demand Response.

edgeFLEX stimulates investment in RES through promoting new sustainable finance instruments increasing the profitability of RES assets and targeting RES asset owners. It expands the definition of the VPP to include a broader range of assets and optimising the slow dynamics of VPPs for VPP owners, which could be implemented without regulatory change. Finally, it provides VPPs with fast dynamics ancillary services, made possible using 5G-powered ICT, which they could offer to grid operators trading these services on a new energy market and enabling the grid operators to exploit the TOTEX approach of the European Commission 2018/2019 Winter Package (Clean Energy for all Europeans Plan), if TOTEX is adopted by national regulators. Current regulation enables grid providers to offset investments in assets, but not investments in services, against the price they charge consumers for power. The TOTEX approach will allow them to offset the total costs of operating the power network, including services, against the price of power enabling them to purchase services while maintaining profitability. The European

Commission proposal on TOTEX needs to be adopted by National Regulators if it is to come into force in Europe, opening new markets for services in the energy domain. This overview is illustrated in Figure 2.

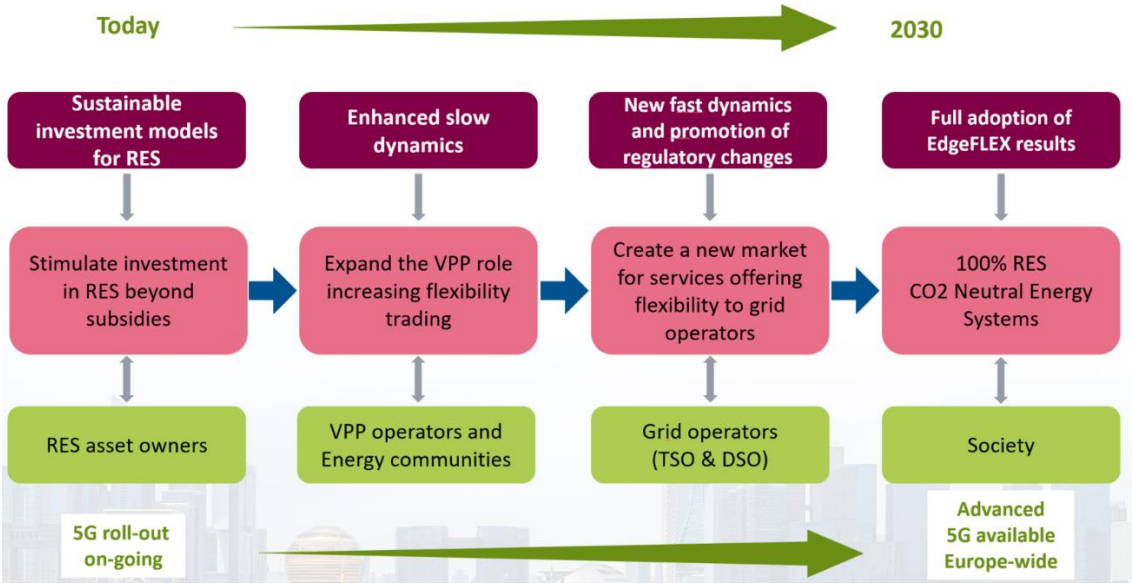


Figure 2 edgeFLEX from start to finish and beyond

edgeFLEX develops innovative solutions with the help of key academic players, applies the concepts, thanks to experts in VPP and 5G technology, and verifies their effectiveness in cooperation with open and advanced grid operators. Concepts are tested in real life scenarios with the goal of understanding the concrete challenges to determine the right balance between system level and local requirements, slow and fast dynamics.

Validation of the edgeFLEX services and architectures in field and laboratory tests

edgeFLEX organises **innovative field trials** and laboratory tests in two countries, as illustrated in Figure 3, validating our research and innovation results and creating confidence in our solutions.

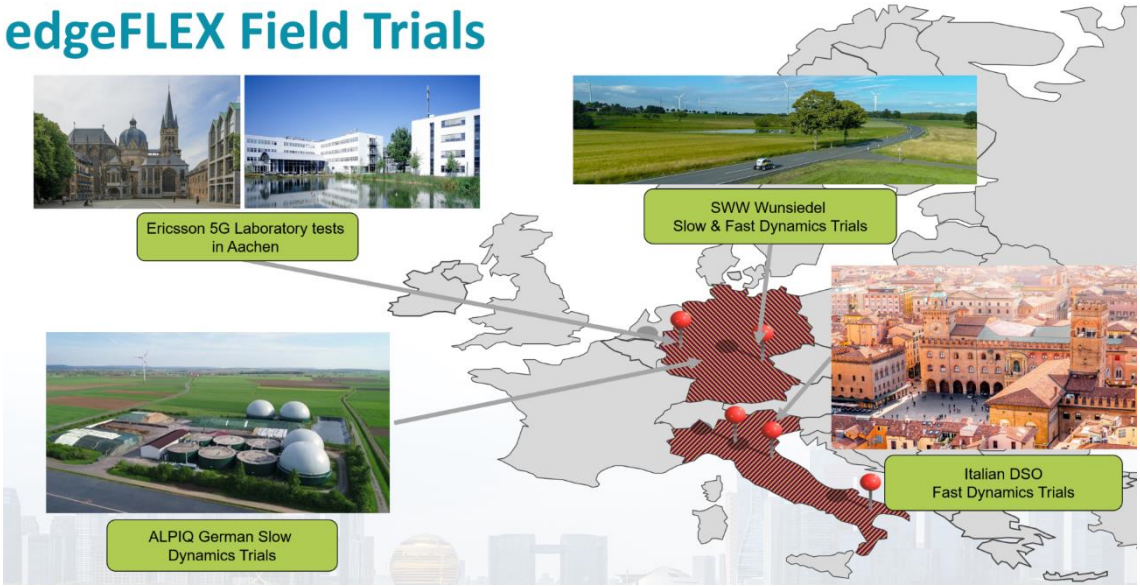


Figure 3 The edgeFLEX field trial locations

2.1 Expected impact results

edgeFLEX addresses the objectives described above in an innovative and structured approach. We combine our technical results with recommendations on how they can be deployed to provide:

- An investment environment and new financial tool making investment in RES more attractive. This can contribute to growth in investments in RES and hence growth in the penetration of variable output RES and can create jobs in Europe in RES manufacturing and services to RES asset owners.
- A boarder role for VPPs enabling them to manage a wider range of variable output and dispatchable RES assets, including storage assets and small plants, providing RES asset owners and VPP owners with new revenue streams increasing their interest in increasing their RES investment. This enables growth in the penetration of variable output RES and extends the flexibility which VPPs can offer to the grid by enabling them to manage a larger range of assets with a broader range of capabilities. It contributes to economic growth and new jobs in the VPP energy sector in Europe. It provides new streams of income to the new RES asset owners, improving return on the investment in RES and leading to enhancement of growth in RES investment and hence to growth of the energy sector in Europe.
- A new set of 5G-powered dynamic control services, enabling the opening of a new ancillary service market for fast and dynamic services. This enables VPPs, in their expanded role, to sell the flexibility of the fast dynamics, of an expanded range of RES generation and storage assets, to the grid operators to stabilise the grid.
- The new market enables Europe to optimise the operations of the European grid, maximising and aggregating the flexibility which can be provided by of all available assets and organising their participation in balancing markets through the new generation of VPPs. This will enable local grid balancing addressing one of the major challenges facing grid operators today to stabilise the gird.
- All RES asset owners again gain new sources of revenue, making investment in RES more attractive as the new ancillary service market for fast and dynamic services opens. Furthermore, European service providers and manufacturers gain a new market for their products and services enabling them to expand their businesses and improve their competitiveness.

2.2 Key achievements in the first period

Short summary of key achievements in the period:

- Research concepts have been developed for the edgeFLEX services
- edgePMU concept developed and tested in the lab
- Platform architecture for the field trials has been defined
- Services based on research concepts have been implemented and integrated
- Tests of the ability of 5G to support the latency requirements of the use cases performed
- Initial planning of field trials undertaken
- New DSO participants in Italian Field trials, joining at their own expense
- Business models for edgeFLEX defined
- Regulatory and standards work started
- edgePMU use case description and requirements proposed and accepted into the 3GPP SA1 standard for 5G (3GPP S1-210455: “Edge cloud driven data acquisition (edgePMU)”)
- Communication and dissemination reaching our target audiences through virtual events and publications achieved
- Planning of solutions started as part of exploitation planning

3. Main achievements

3.1 Dynamic-phasor driven voltage control concepts

The work completed to date in WP1 to date is completely dedicated to the voltage control service that is being developed and tested. The spread of renewables affects both the stability and the way the power network is controlled. Therefore, system operators should adopt new solutions and techniques, such as the proposed voltage control service, to overcome those issues.

In summary, the voltage control allows immediate action when the voltage varies above the limits defined by the standards. Furthermore, such variations are increasing daily due to variability of production of renewables, which cannot be controlled like the legacy power plants of the past.

In view of the above points, the first phase of WP1 produced a set of interesting results that can be summarized as follows. First of all, the analysis of the academic literature and of on-going projects enabled us to develop an understanding of the advances in the field of VPPs and renewables. Consequently, a voltage control scenario has been defined with a subset of use cases which address specific requirements and configurations of the power network. In parallel, considering the heterogeneous background of the partners, the terminology to be adopted during the project has been defined and agreed within the consortium.

Finally, and most importantly, the voltage control algorithm has been developed and tested in simple and preliminary network configurations. These tests will enable us to develop a fully operational algorithm to be used in the field trials planned for the Phase 2 of the project.

Additionally, the core concept of the Phasor Measurement Unit (PMU) has been developed use in the voltage control service, as well as for other edgeFLEX services. We pursued an innovative approach to the design and development of the new PMU, called the edgePMU. Our general approach of the edgePMU, in contrast to classical Phasor Measurement Unit designs, is to split the data acquisition and the phasor estimation algorithm into two separate tasks and deploy them on separate computational units to gain flexibility for the algorithm. The data is acquired on a low-cost computational device and then transmitted over a reliable and fast communication interface, either wired or wireless, to an edge-cloud environment where the data processing is performed, and the final phasor is calculated. Because this approach transmits a continuous stream of raw samples, higher bandwidth is needed with respect to a normal PMU.

In summary, the achievements are the:

- Analysis of the state of the art related to VPP.
- Definition of a voltage control service scenario.
- Definition of use cases in which the voltage control will be implemented.
- Definition of the project technical terminology.
- Development of voltage control algorithm.
- Preliminary testing of the algorithm.
- Development and testing of the edgePMU concept

3.2 Frequency control and inertial response concepts

The objective of edgeFLEX is to develop frequency control and inertia monitoring services that will enable VPPs to participate in providing frequency control and offer it for grid operators as an ancillary service.

In the first phase of the project, WP2 focused on developing the frequency control and inertia estimation related algorithms and defining the relevant functional and communication requirements of these concepts. Moreover, we carried out computer-based simulation tests for initial validation of the algorithms. Last but not least, the first version of these algorithms was

implemented as software services and dropped to WP4 as docker containers for edgeFLEX platform integration.

In summary, the achievements are the:

- Analysis of the state of the art of frequency control.
- Definition of frequency control and inertia estimation scenarios.
- Definition of use cases in which the frequency control and inertia estimation will be implemented.
- Definition of the relevant functional and communication requirements for full commercial roll out.
- Development of frequency control and inertia estimation algorithms.
- Preliminary testing of the algorithm.
- First drop of the developed algorithms as software packages for platform integration.

3.3 Concepts for VPP optimisation

The target in the VPP optimization tasks is to accommodate an intermittent energy fleet (wind farms) thanks to a portfolio of flexible assets: biogas-fired power plants and batteries. The original purpose of the biogas-fired power plants that we are considering in the VPP was to earn money on the power exchange, primarily on the day-ahead market. When these assets become part of the VPP, their task changes as follows: maximizing profits from the sale of electricity while ensuring the balancing of the wind energy fleet, which also results in the participation in the intra-day market. This task is challenging in terms of optimization and price forecasting methods.

We concentrate on two aspects: with a mixed integer optimization we develop sophisticated decomposition methods; while with the price forecasts we design several forecasting methods based on machine learning with the goal of maximizing the resulting cumulative revenue. We also compared the obtained results with commercial forecasts and our forecasting methods turned out to be competitive with these forecasts in terms of the resulting cumulative revenue. We also pay special attention to the robustness of the VPP to handle large amounts of assets within it. Besides, we utilize Robust Model Predictive Control in order to take many scenarios into account during decision making.

In summary, the achievements are the:

- The VPP optimization optimization algorithm has resulted in an academic publication.
- Research results showing that the intraday market does not behave in a stochastic manner were developed. It has also been demonstrated that if suitable meteo data can be provided to a neural network, then the intermittent energy forecast can outperform the commercial models currently available.
- Revision of the research will be proposed to leverage and document the experience feed-back that we will obtain through the field trial in Work Package 5.

3.4 5G Solutions Optimisation

Investigations of the use cases defined for edgeFLEX demonstrate that ICT solutions supporting such use cases, such as the edgePMU, will have to meet stringent requirements on the transmission capacity, latency and reliability of the communications network. Definition of ICT requirements of the use case in edgeFLEX have been developed and 5G tests of use cases have been run using synthetic data representative of the use case. The results of the tests confirm that 5G has the capability to meet the stringent latency requirements of the use cases.

In order to undertake an extra test series to measure the latency performance of 5G under various conditions of attenuation of the radio communications link, the establishment of the required laboratory configuration began during the year and is currently continuing. The test series was not planned as part of the work described in the Grant Agreement and is provided as extra results.

The edgeFLEX edgePMU use case, developed by RWTH, was proposed by Ericsson to the global standardisation body responsible for standardising 5G use cases, 3GPP Working Group SA1, in its March 2021 meeting. The use case was accepted as part of the 5G global standard.

To facilitate the management of devices, such as sensors and actuators, attached to the 5G network, a novel 5G API has been defined by Ericsson and this API will be extended with new features during Phase 2 of edgeFLEX.

The investigation of the ICT requirements of the edgeFLEX use cases have led to the definition of a general 5G solution supporting the edgeFLEX solution, as illustrated in Figure 4 below. Sensors and actuators required to provide voltage, current, frequency and power measurement services generate data which is communicating through 5G networks to 5G edge infrastructure hosting virtualised power services in the cloud. The virtualisation of the service algorithms used in the edgePMU, and the frequency, voltage and inertia estimation services require the use of edge infrastructure to improve the power system resilience and to reduce latency to a minimum. The output of the virtualised services is displayed on dashboards in the power management systems of VPP's, power system operators and Energy Communities, as required.

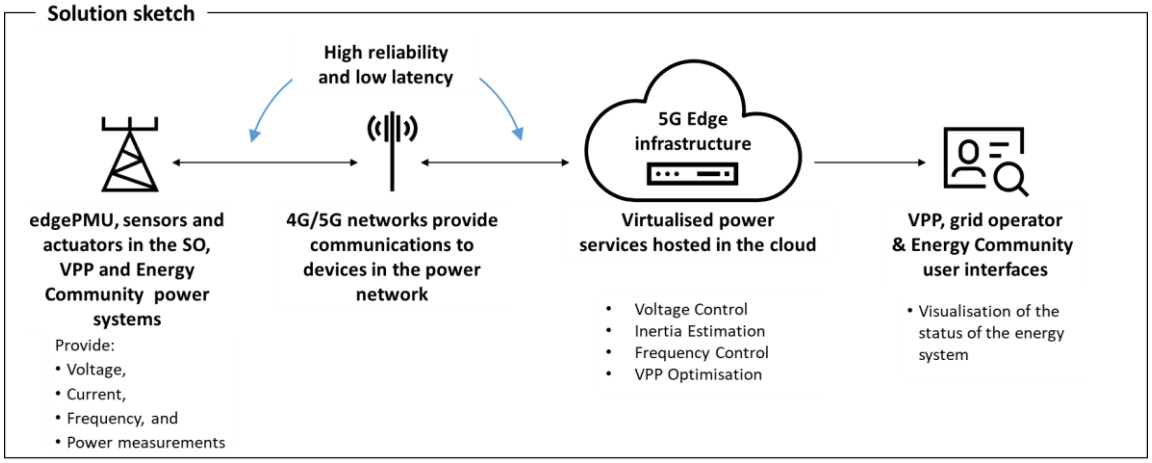


Figure 4 5G Solutions for edgeFLEX

In summary, the achievements are:

- The definition of the ICT requirements of the edgeFLEX use cases.
- The preparation of the laboratory environment for 5G tests of latency performance.
- A test series measuring latency performance under different conditions of attenuation of the radio communications link the required laboratory configuration was prepared.
- The testing of the ability of 5G networks to fulfil the edgeFLEX use case latency requirements on live 5G networks with synthetic data was undertaken.
- The preparation of the edgeFLEX use case for consideration at the 3GPP SA1 meeting in March 2021 and its successful adoption into the 5G global standard was completed.
- The preparation of the laboratory environment to undertake the development of new features for the 5G API was undertaken.
- The definition of a solution sketch for 5G support of edgeFLEX services was completed.

3.5 The edgeFLEX Platform and Services

One of the main technical aims of the edgeFLEX project is to build the software components to containerise the research and innovation concepts from WP1, WP2 and WP3 so that they can be deployed in the field and laboratory trials. To enable these deployments, we needed to build a set of common backbone services allowing the services to communicate with the trial site measuring devices, to store the data for post processing and visualisation purposes and also to provide a service to visualise the results. The integration of these components constitutes the

edgeFLEX Platform and in the first phase of the project work many results relating to the platform and services were developed.

In summary, the achievements are the:

- Requirements Gathering
    - The functional and non-functional requirements for the services were collected, correlated and a generic basic container for hosting the services was defined.
    - An identity matrix was created, and the project wide services and components were aligned to their specific actor and function within the energy sector. The output of this work was the identification of a natural synergy between three components of the edgeFLEX Platform, Voltage Control, the Dynamic SLA Monitoring Tool and the FlexOffer.
    - Solution architecture workshops were conducted to develop a multi-layer view of the Grid Management Services so that the interfaces, goals and supplementary components and data streams could be identified.

- Software Service Integration
    - From the outputs of the requirements gathering phase a set of backbone services (those are needed for all the Grid Management Services) were identified and built so that the Grid Management Services could interface with them when delivered.
    - Taking input from WP1 & WP2 in the form of software modules, and using the outputs of the requirements gathering, a set of containerised services were created for Voltage Control, Frequency Control and Inertia Estimation and integrated into the platform.
    - One of the key activities of the integration work was to build a deployment method in which the services could be configured, when deployed to connect to trial site components, as well as to edgeFLEX specific components. This is carried out using configuration files that are injected to the service as it is being deployed, and such configurations can include connection strings, or data streams, which the service can automatically pick up.

- Architecture
    - Based on the use cases linked to the trials, a set of architecture diagrams were created, to ensure that the goals of the first phase of the project were achieved.
    - These diagrams provide the starting point around which the complete edgeFLEX platform architecture can be developed.

- Dynamic Service Level Agreement Monitoring Tool and Brokerage
    - The requirements for this item were determined.
    - The nature of the component, in terms of what technological solutions it could provide for the platform, was identified.
    - A proof of concept of the tool was built and deployed.

- Voltage Control – SLA Monitoring Tool – FlexOffer Use Case
    - Based on the identity Matrix, the use case that combined grid control with the creation of flex offers via the SLA Monitoring tool was identified.
    - This use case has now been finalised in terms of the components needed for it to work in the trials in SWW Germany.
    - A development plan was created so that we can begin building the software and the data streams needed to perform the trials.

3.6 Field Trials

The concepts developed in edgeFLEX will be validated in field trials of three different methods:

- Slow dynamics
- Fast dynamics
- Slow and Fast dynamics

These field trials are planned to be run in Germany and Italy and shall be presented in this section of the document. In addition to field trials, the developed concepts will be tested in the laboratory environment in Germany.

3.6.1 German Slow Dynamics Trials

The work completed to date includes:

- The identification of the wind parks and the biogas powerplants in Germany to be used in the field trials.
- We have elaborated the algorithms for the management of the field trial systems, with two biogas power plants and batteries, operating on the day ahead and intraday markets and for managing the imbalances.
- The algorithms have been optimized to work very efficiently to provide decisions in a matter of seconds.
- The platform in which the algorithms will be deployed has been chosen. It runs on Python and can be easily deployed either on a cloud or on a personal computer. Everything can be run on open-source software.

3.6.2 Italian Fast Dynamics Trials

The aim of the Italian trials is to assess voltage control services in a live medium voltage network.

Phase 1 of the project was dedicated to presenting the services and the added values that edgeFLEX may offer to potential third parties. Consequently, the Italian trial is based on those new connections. During Phase 1, three potential utilities showed interest and they are willing to run edgeFLEX in their facilities and power networks at their own expense.

The integration of the hardware and software is currently being carried out and the preliminary testing of the project's PMUs is ongoing.

Measures were taken to ensure that none of the parties controlling the data collected can exploit that data.

3.6.3 Wunsiedel Slow and Fast Dynamics Trial

The main goal of this field trial is to implement and optimise electricity market related flexibility services, using both slow (Day-Ahead) and fast (reaction to current voltage deviations) approaches.

This trial will be one of the first to demonstrate integrated energy trading and grid operation. As it operates based on flexibilities on a market platform, unbundling requirements can still be met.

Work completed:

- Mapping the grid's topology in PowerFactory.
- Possible locations for edgePMUs were selected.
- The Cloud infrastructure to be used was selected.

- The communication infrastructure for the field trial was assessed.

In the first phase of the project, the trial site and its importance for the project were identified. To that, it was imperative to identify potential locations for the edgePMUs and to set up the communications and asset interaction.

The calculations for cable 3, on which the edgePMUs shall be installed, shall be finalised.

Final system compatibility check with the controlling system shall provide the “green light” for deployment and utilisation of the PMUs. This deployment consists of installing up to 6 PMUs on the mentioned-above cable and connecting them to those already existing in the infrastructure developed for a previous project.

3.6.4 edgeFLEX Energy and 5G Laboratory Tests in Germany

5G performance tests

Laboratory tests offer a unique opportunity to evaluate the performance of the 5G mobile network when transmitting data streams typical of those which the edgeFLEX services would send in a full-scale commercial deployment of the services for a power grid use case. The laboratory test results offer a first evaluation whether the 5G mobile network can fulfil the requirements of the edgeFLEX services.

During edgeFLEX Phase 1 (M1-M12), test cases for each edgeFLEX service were defined and synthetic data streams typical of each service were specified. Additionally, the 5G laboratory equipment was configured and integrated in the Ericsson laboratory in Aachen, with the architecture illustrated below.

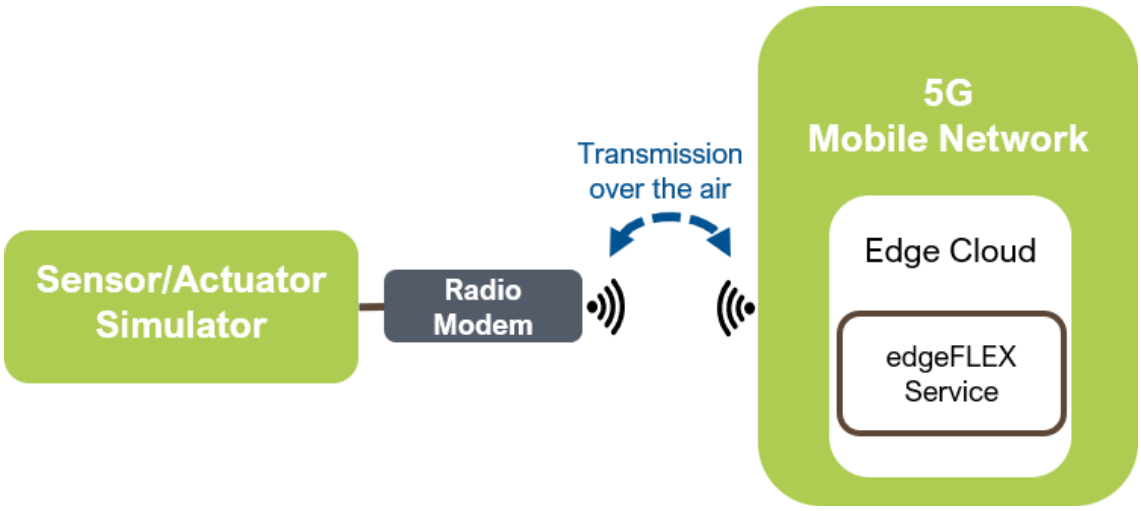


Figure 5 Ericsson 5G laboratory configuration

The ICT requirements of each edgeFLEX service were defined. Tests of each edgeFLEX service were performed in the 5G network using synthetic data streams. The results of the test series demonstrate that 5G has the basic capability to support the latency requirements of the edgeFLEX use cases. Further tests, with real data rather than synthetic data, are planned to take place during Phase II of edgeFLEX.

Investigations of possibilities to support field trials with 5G using commercial network services

Investigations of possibilities to support the edgeFLEX field trials, using any live 5G commercial networks which might be operating at the field trial locations, have recently started. The field trials are planned to run during 2022 and the precise locations of sites where the field trial equipment will be installed will be defined during 2021.

3.7 Regulatory and business model work

In the first year of implementation, our work focused on planning activities related to business modelling and regulatory assessment, as well as on the completion of the preliminary steps in this direction.

The initial step was to define a new financing model for RES, to simplify investments in RES beyond subsidy schemes, and to develop a preliminary comparative analysis of potential business impact.

An important action taken was to devote effort to developing an understanding of the position of stakeholders and of the market. This is needed to more precisely correlate regulatory and business model with the technical activities in the project.

After this work had been completed, our attention was focussed on outlining initial regulatory proposals addressing the technical challenges of edgeFLEX solutions, considering the input received from the technical work packages and a series of assumptions to be further validated through stakeholder consultations.

Engaging with policy makers and with organizations and experts in regulation and standardization is an ongoing and complex activity, to be carried out throughout the full project implementation period, and it involves interactions and consultations with all stakeholder categories.

The initial defined edgeFLEX proposals in terms of updating the regulatory framework are the following:

- “New ancillary service – Providing inertia”.
- “VPPs – as new participants in the Electricity Balancing Market”
- “New Voltage regulation market”
- “ICT chapter requirements update within existing Network Codes”
- “Update the Renewable Energy Law”
- “New rules for the management of RES electricity generation”

Considering the above-mentioned proposals, during the first year of edgeFLEX project activity, the process of engaging with policy makers, with organizations and experts in regulation and standardization materialized was undertaken through participation in events and workshops, initiating meetings with standardization bodies and organizing the first Advisory Board meeting. Each action presented opportunities at both European and local level to support the context of Dynamically controlled VPP solutions proposed by edgeFLEX through appropriate regulations.

Hence, at the time of writing we are completing the first phase of regulatory framework assessment through stakeholder engagement, as illustrated in the diagram below, Figure 6.

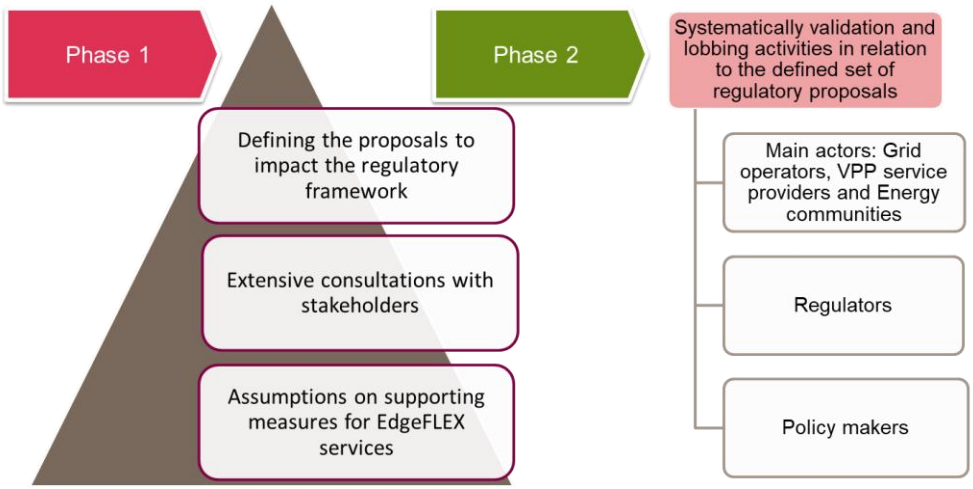


Figure 6 The edgeFLEX regulatory framework assessment

In summary, the achievements are:

- The comprehensive plan of the business modelling and regulatory assessment activities.
- The definition of a new financing model for RES, to simplify investments in RES beyond subsidy schemes.
- Preliminary comparative analysis of potential business impact.
- Defining initial proposals in regulation, mainly addressing in a first stage the technical challenges of edgeFLEX solutions.
- Laying the foundations for preparing the exploitation of the project results.
- Carrying out an intense activity in the process of engaging with policy makers, with organizations and experts in regulation and standardization:
    - participation in specific events and workshops in which we had interactions and exchanged ideas with the main categories of stakeholder.
    - organization of sessions dedicated to the regulatory aspects of the edgeFLEX project within consultation events with wide international participation.
    - bilateral meetings with relevant sector actors.
    - organizing the first session Advisory Board.

3.8 Dissemination and Communication

The overall dissemination and communication strategy follows a 3-step process, aiming to stimulate investment in renewable energy sources, to provide new options in flexibility trading exploitable within the current regulatory framework by a new definition of a VPP and to enable the creation of new local energy markets with new fast dynamics services requiring extensions of the current regulatory framework to be adopted at national level.

To reach our dissemination objectives, stakeholders and suitable interest groups have been identified and our main messages as well as suitable approaches and tools have been prepared. Our strategy considers that the dissemination and communication activities need a change of focus as the project progresses. During the first project phase, our activities focussed on raising awareness of the project and getting in touch with selected key stakeholders.

To spread edgeFLEX content, a multichannel approach was chosen, using synergy effects wherever possible. A corporate identity has been designed ensuring a high recognition value and templates for the communication of results have been created. The main communication channels – the project website and the LinkedIn channel – were set up. All channels are regularly updated with non-sensitive and publicly available information on the progress and outcomes of the project and serve as a means of engagement with stakeholders.

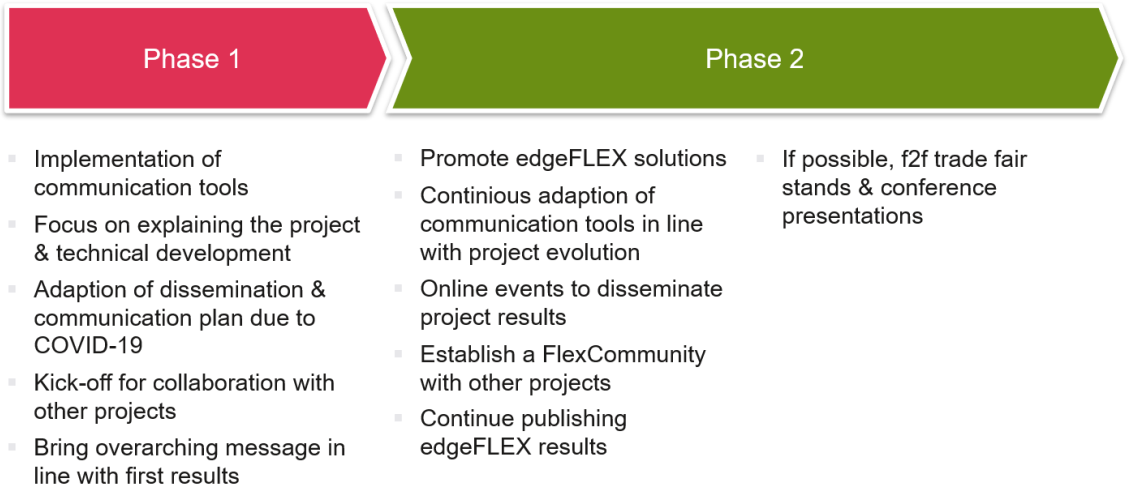
A total of seventeen scientific publications have been written by the academic consortium partners; nine thereof have already been published, eight have been submitted and awaiting approval. edgeFLEX ensures open access (free of charge online access for any user) to all peer-reviewed scientific publications relating to its results.

Events of all kinds are indispensable to distribute information about the project, offering a place to initiate cooperation and collaboration activities and to contact users and customers. Due to the ongoing pandemic and the cancellation of all face-to-face events, the dissemination and communication planning had to be adjusted with a shift towards online activities and more communication via videos. A video has been produced and an online workshop has been organised for the Wunsiedel trial site.

To actively join forces with other Horizon 2020 projects for a broader outreach, a collaboration with the H2020 sister projects FEVER, Platone and DECIDE was kicked off with a joint online

event in November 2020. It was hosted by BRDIGE and the SES taskforce on energy communities and co-organised by edgeFLEX.

In March 2021, a virtual booth was organised at the projects zone of the online IEEE Smart Grid for Smart Cities conference.



In summary, the achievements are the:

- Design of the visual identity: an overall design was developed to make sure all project activities will be recognized as part of edgeFLEX.
- Set-up of the website as the communication hub for the project containing all central information on edgeFLEX.
- Set-up of the edgeFLEX LinkedIn group.
- Creation of the template for slides, deliverables and milestones; set of basic slides.
- Publication of scientific papers, nine in 2020, eight more already submitted and to be published in 2021.
- Production of a video describing the Wunsiedel trial site.
- Participation in the projects zone of the online IEEE Smart Grid for Smart Cities conference.
- Organisation of Wunsiedel trial site workshop (virtual).
- Project presentations as ten invited talks talks in workshops and at international events, all of them at digital events, were prepared and undertaken.
- Co-organisation of an online event to enable the closer collaboration with the H2020 sister projects FEVER, Platone and DECIDE was undertaken.

3.9 Project Management progress

The management of the project has been challenging during the first year of activities due to the Covid-19 restrictions. The situation was stressful for many project participants and the project management organised many online meetings to develop the common understanding of participants of the goals and approach of the project. In order to help develop personal relationships between participants, many of whom have never met each other in a face to face meeting, virtual coffee meetings were organised and small gifts of chocolates and teas to eat and drink during project meetings were distributed by post, to contribute to a more relaxed atmosphere in the online meetings.

Working from home with limited access to laboratory and field trial sites has meant that execution and planning of activities had to be undertaken in a very flexible manner given the uncertainty in the planning of many activities, particularly those such as tests requiring, at least occasional,

access to laboratory facilities. In general, the switch to using remote operation of laboratory facilities and development environments has progressed smoothly. Additionally, several project participants have school age children requiring home schooling, which has stressed the ability of participants to focus on work tasks.

However, it is noticeable that restricted reliability and bandwidth of the internet connections available to partners causes disturbances to project and work package meetings. Commercially available tools to support virtual meetings have many weaknesses and are not as mature as required to smoothly organise virtual events.

The continuing restrictions of Covid-19 will continue to require flexibility in the planning of project activities in the final two years of activity of the project. It may not be possible to run field trial open days and other presence events planned as part of dissemination. Virtual events will be organised as a substitute wherever possible. Trade fairs at which the project would normally have been present have not been organised in 2020 or 2021.

The planning of the project field trials has progressed well. An excellent development in the planning of field trials is that several Italian distribution system operators want to participate in the field trials at their own expense to try out the novel services and approach of edgeFLEX.

A further positive development is that the Linux Foundation has taken on the further development of the SOGNO project platform (https://www.sogno-energy.eu/) as the Linux Foundation SOGNO energy project (https://www.lfenergy.org/projects/sogno/). The edgeFLEX platform is based on the SOGNO platform, creating a new global opportunity for edgeFLEX to contribute to the platform and to promote its early results on a global basis. A final positive point is that the global standardisation body responsible for 5G standards has adopted the use case description of the edgePMU being developed in edgeFLEX as part of the 5G global standard

4. Conclusions

Progress in the first year of the edgeFLEX project has been excellent. All planned goals were reached and exceeded in some areas, progress towards achieving several project KPIs exceeds the expected achievement level and work on Phase II (Month 13-36) of the project activities has started.

The restrictions imposed by the Covid-19 pandemic have meant that almost all project participants have been working from home with restricted access to laboratory and field trial locations. Despite these difficulties and the absence of any presence meetings of project participants, we have been able to develop a good team spirit and to cope with the high stress level which the pandemic has led to in the lives of many project participants. We have run many virtual project meetings and organised and taken part in many virtual dissemination events and are continuously adapting our working procedures to the new working environment to optimise our output.

edgeFLEX is well positioned to achieve its full potential in the coming two years of the project duration and beyond in the exploitation of the results of the project.

5. List of Figures

6. List of Abbreviations

API	Application Programming Interface
DER	Distributed Energy Resources
DSO	Distribution System Operator
edgePMU	edgeFLEX Phasor Measurement Unit
ICT	Information and Communication Technology
PMU	Phasor Measurement Unit
RES	Renewable Energy Source
SLA	Service Level Agreement
TSO	Transmission System Operator
VPP(s)	Virtual Power Plant(s)
VPS	Virtual Power System
WP	Work Package