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CORDIS Results Pack on

the digitalisation of the energy system

A thematic collection of innovative EU-funded research results

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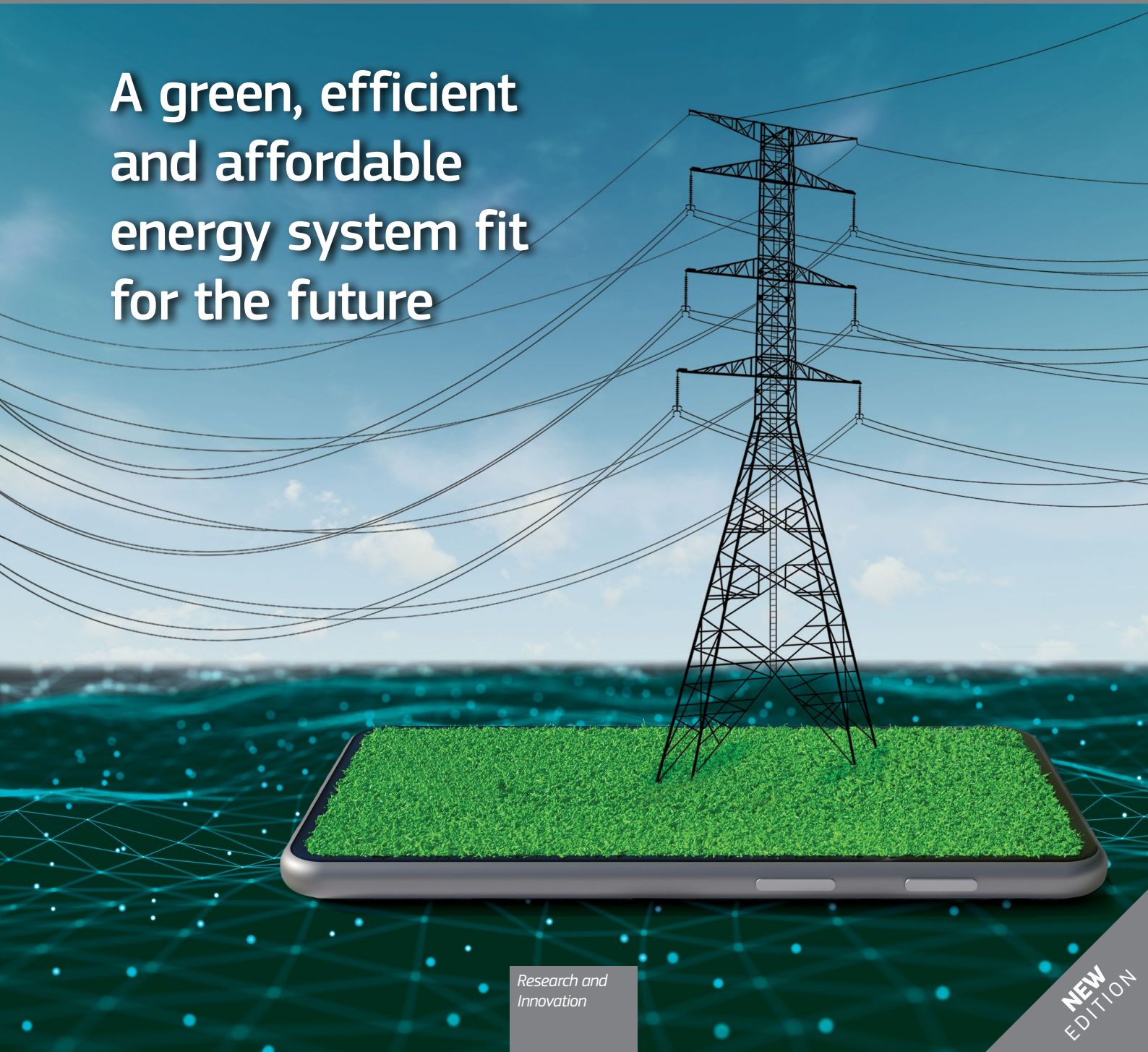
A green, efficient and affordable energy system fit for the future



Research and Innovation

NEW EDITION

Contents

Editorial

Digitalisation will transform the energy system by integrating more renewable energy and powering the transition to Net Zero. This will allow the EU to achieve its long-term energy and climate goals, while contributing to Europe's energy independence and security.

As society continues to transition from analogue to digital, organisation and use of data becomes easier, making our energy system more connected, intelligent, efficient, reliable and sustainable. The use of digital technologies such as AI, cloud computing, blockchain and the Internet of Things will improve how we use energy and help find ways to decarbonise our energy systems.

Digitalisation will contribute to the European Green Deal and a Europe fit for the digital age policy initiatives and support the objectives of the Energy Union by promoting connectivity, operability and use of renewable energy. The aim is for sustainable, competitive and affordable energy, and energy independence and security, which meets the EU 2030 and 2050 energy and climate targets for a low-carbon economy.

The need for more flexible electricity markets to match demand with supply from renewables, which can be intermittent and difficult to predict, is growing as renewables comprise a larger portion of Europe's energy supply. In addition, modern power grids are moving away from centralised, infrastructure-heavy transmission system operators towards distribution system operators (DSOs) more capable of managing diverse renewable energy sources.

All this will require an infrastructure fit for the future, with common standards, gigabit networks and secure clouds of both current and next generations. Such infrastructure will enable consumers to engage in the energy transition in a new way, while benefiting from better services based on digital innovations, and saving energy.

Digitalisation therefore is an essential tool to achieve the transformation of the energy system. It allows for more efficient load balancing, facilitates dynamic markets to provide a more secure and diversified supply, improves energy efficiency and reduces greenhouse gas emissions by increasing the uptake of renewable energy.

Project results will empower consumers and make possible the emergence of prosumers and the uptake of breakthrough technologies. The use of digitalisation to facilitate the shift towards more decentralised and variable solutions, such as smart grids, will also alter conventional energy production, distribution and consumption.

Putting the citizen at the heart of demand response solutions

Renewable energy sources create opportunities to maximise demand response at the consumer level by focusing on technology, business and social behaviour.

The current energy market incorporates a growing number of decentralised renewable energy sources (RESs). The EU-funded BRIGHT project deploys a multi-pronged approach to address efficient energy management and engage consumers in the co-creation of solutions.

According to project coordinator Vincenzo Croce: "The complexity of managing energy with the growing presence of intermittent renewable energies underscores the importance of decentralised solutions and innovative technologies to address challenges related to local energy congestion and to enhance energy services for consumers."

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Three pillars of BRIGHT solutions

Because energy from decentralised RESs fluctuates, it is difficult to match supply and demand. Solutions targeting social behaviour, business and technology are needed to optimise demand response (DR).

S-BRIGHT solutions deal with consumer behaviour, implementing a social science framework. Achieving greater load flexibility requires greater customer engagement. Energy cooperatives, peer-to-peer trading and citizen energy communities all have a place in this new economy. To maximise citizen engagement, the project implemented a participatory co-creation process where consumers play a central role. Additionally, the project explored game theory to understand how incentives that drive behaviour go beyond economic motivators.

B-BRIGHT solutions focus on business aspects of the energy ecosystem, involving such players as customers, DR operators, energy service companies, flexibility managers, e-mobility managers and aggregators to support hybridisation and flexibility. B-BRIGHT emphasises prioritisation of multi-commodity services, personal care services, efficiency and e-mobility management. One takeaway of the project is that integrated services have more flexibility potential than stand-alone services.

T-BRIGHT serves several technological goals, including embedded machine learning models to predict energy demand and offer flexibility valorisation. These data-driven tools have good scalability and low cost. Other tools include blockchain, digital twins and decision-making algorithms. All technological tools help increase the efficiency and flexibility of the energy ecosystem while drawing in greater consumer involvement.

Four demonstration sites

BRIGHT is a consortium of 16 partners from 7 EU countries. The project conducted demonstrations in four countries – Belgium, Greece, Italy and Slovenia – to test tools in different scenarios.

The Belgian pilot in the De Nieuwe Dokken community of Ghent includes 400 housing units, a sports facility, a kindergarten school and administrative offices under the management of DuCoop. The incentives that motivate human behaviour at individual and community levels is a primary focus at this site.

The Greek pilot encompasses several geographic areas with varying meteorological conditions. The project examines how

energy services connected to the Internet of Things in Halkidiki, Thessaloniki and Volos can support consumers.

The city of Terni in Italy is part of an ecosystem with much experience in smart grid innovation and the use of RESs. The project worked with local aggregators to ensure fair distribution of flexibility in energy markets.

The aim of the Slovenian pilot is to provide one-stop shopping for P2P energy trading. The project integrates an edge secure gateway component with the metering infrastructure, digital twins and a blockchain platform.

The transformation of European electricity grids is an essential step in reaching Europe's goals for carbon neutrality. By leveraging social, business and technology solutions, BRIGHT takes advantage of opportunities presented by decentralisation in the energy ecosystem and the rise of RESs.

PROJECT

BRIGHT – Boosting DR through increased communIty-level consumer engaGement by combining Data-driven and blockcHain technology Tools with social science approaches and multi-value service design

COORDINATED BY

Engineering - Ingegneria Informatica in Italy

FUNDED UNDER

H2020-EU.3.3., H2020-EU.3.3.1., H2020-EU.3.3.4.

CORDIS FACTSHEET

cordis.europa.eu/project/id/957816

PROJECT WEBSITE

brightproject.eu/

An integrated energy management ecosystem for smart buildings

Energy and information technology experts develop a mediation layer between energy applications, smart devices and appliances to streamline the digitisation of buildings.

Buildings account for over 40 % of final energy consumption in Europe. With the growing presence of the Internet of Things (IoT), digitisation of buildings is happening, but progress is haphazard. Digitisation is siloed, usually in the hands of device manufacturers. The EU-funded domOS project proposes a solution that integrates seamless digital appliances with energy applications.

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The domOS ecosystem

In smartphones, apps are independent of the underlying hardware. Thanks to this feature, apps can be made available in an app store to all device users.

From a technical standpoint, the domOS ecosystem has two components: a protocol abstraction layer based on the Web of Things (WoT) architecture, and a nomenclature for building description called domOS Common Ontology (dCO).

The domOS ecosystem aims for a similar goal for buildings: applications for an energy dashboard, energy management and energy efficiency that can run on a domOS-compliant platform independently of the installed models of smart appliances.

A mediation layer – similar to an operating system – is needed to facilitate this development. According to project coordinator Dominique Gabioud: "From a technical standpoint, the domOS ecosystem has two components: a protocol abstraction layer based on the Web of Things (WoT) architecture, and a nomenclature for building description called domOS Common Ontology (dCO)."

In the framework of the project, the domOS ecosystem has also been ported to three IoT platforms: cloud.iO, S-IOT and domOS-Arrowhead. cloud.iO is a scalable open-source IoT solution that supports connection of devices to a central cloud platform. S-IOT is a novel decentralised approach to building IoT systems, and domOS-Arrowhead is a scalable platform for enabling applications to access domestic buildings and their installed devices.

The domOS demonstration sites

Project pilot sites include 10 partners across 5 European cities. All five demonstrations incorporate the mediation layer developed by domOS and address the two main axes of the project: the secure connection of smart appliances and devices, and the development of smart devices that increase efficiency in space heating.

The pilot in Sion, Switzerland, connects multiple devices – including smart meters, charging stations, heat pumps and solar inverters – to a building gateway. This cluster of devices is

made available to the energy provider to enhance flexibility and prosumer empowerment.

Similarly, the Paris demonstrator has partnered with EDF, an energy provider with 90 % of its energy coming from carbon-free sources. The installed IoT infrastructure, gateway and smart meters collect the global electrical load curve every 5 seconds to offer an electricity dashboard service.

Building sector stakeholders and domOS ecosystem uptake

The smart building sector includes many service and device stakeholders. Standardising digitisation in buildings with so many players is currently out of reach, which has led the project to prioritise exploitation.

The best course for bringing together diverse players in the smart building sector is a market-based approach. Gabioud states: "The objective is to team up with a market actor of the smart building sector to roll out a domOS-compliant platform." HES-SO, the University of Applied Sciences and Arts in Switzerland, is already partnering with a big building automation stakeholder to develop a platform inspired by domOS.

The development and management of smart buildings is still taking shape. While full standardisation is not yet within reach, development of a domOS-like ecosystem introduces a new role into the sector: that of smart building manager. The manager would function as a supervisor for the more and more complex building's energy system. Subsequent use cases will shed light on the evolution of this role.

Creating a system with a holistic approach to building energy will require communication, collaboration and commitment. domOS, leading with flexibility and ingenuity, shows the way.

PROJECT
domOS - Operating System for Smart Services in Buildings

COORDINATED BY
University of Applied Sciences and Arts Western Switzerland in Switzerland

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/894240

PROJECT WEBSITE
domos-project.eu/

Under new management: optimising efficiency and bolstering grid resilience

Aggregating and exploiting energy flexibility has never been easier thanks to an innovative energy balancing platform supporting scalable solutions and diverse data.

For more than a hundred years, electricity has been generated by large, centralised fossil fuel power plants. As we transition away from fossil fuels, distributed local production and storage are replacing the centralised production model. This new paradigm empowers consumers to play an active role in the green transition, producing and storing energy for themselves and the grid via technologies including photovoltaic (PV) and electric vehicle (EV) charging systems.

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Integrated Internet of Things sensors and technologies associated with these distributed energy resources (DERs) and renewable energy sources (RESs) provide a wealth of data that can be used to increase the grid's resilience. The EU-funded ebalance-plus project has created an energy balancing ICT platform to do just that. It will enable customers, energy operators and distributors to manage energy more efficiently, sustainably and cost-effectively for mutual benefit while opening the door to new flexibility markets.

A scalable energy balancing platform supports seamless integration and deployment

The ebalance-plus project has developed a system of distributed management units and software that can be located at all points of the grid from the consumer to generation and distribution. The system includes solutions for aggregating energy flexibility associated with general consumption, energy storage, air conditioning, PV electricity generation, EV charging, household appliances and more. Importantly, the solutions are scalable and accommodate heterogeneous data sources and communications protocols.

As project coordinator Juan Jacobo Peralta of CEMOSA explains, "the electricity grid's organisation allows nearly automatic deployment of flexible and reliable energy balancing services in any management unit at all levels of the grid. The services recognise the units from which they receive orders and those they must coordinate, establishing a logical hierarchy that also satisfies cybersecurity and data protection requirements."

The ebalance-plus platform can adopt any data ontology and semantics and connect and interact with existing energy management systems thanks to its middleware that establishes communications between services and devices. "The middleware is a distributed database that generates a so-called data lake in a natural and self-maintained way. It enables programmers to develop solutions based on any communication standards and data structures," notes Peralta.

Mobile applications including application programming interfaces specifically for aggregators and electricity distribution companies will help users better understand the flexibility services and their benefits.

Demonstrating success with real and virtual solutions

The ebalance-plus in-lab emulator allows stakeholders to test various management services and devices including advanced smart devices not yet commercially available. A prototype car park energy hub leveraged flexibility to enable maximum use of PV energy via PVs, storage, bi-directional EV charging points (vehicle-to-grid) and an innovative grid-tie inverter with silicon carbide semiconductors for converting DC to AC to inject in the grid.

"The pilots successfully demonstrated that new solutions can be deployed in the ebalance-plus platform without restrictions on technology or data compatibility. The services deployed demonstrated that flexibility can be easily estimated and aggregated as is currently done for energy," Peralta concludes.

The ebalance-plus project has delivered an energy balancing platform that exploits flexibility and which is capable of integrating any energy asset into the electricity management network. It is an important step towards unleashing the potential of DERs and RESs for a green energy transition to meet Europe's 2050 goals.

The pilots successfully demonstrated that new solutions can be deployed in the ebalance-plus platform without restrictions on technology or data compatibility. The services deployed demonstrated that flexibility can be easily estimated and aggregated as is currently done for energy.

PROJECT
ebalance-plus - Energy balancing and resilience solutions to unlock the flexibility and increase market options for distribution grid

COORDINATED BY
CEMOSA in Spain

FUNDED UNDER
H2020-EU.3.3., H2020.3.3.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/864283

PROJECT WEBSITE
ebalanceplus.eu/

Extending the assets of virtual power plants, expanding renewables penetration

An innovative 5G- and edge-enabled platform supports virtual power plants in management of distributed energy resources, stabilising frequency as well as voltage.

The global energy landscape is changing quickly. Large, centralised power plants are being replaced by smaller, decentralised distributed energy resources (DERs), and these are often renewable energy sources (RESs).

Virtual power plants (VPPs) have emerged on the scene to pool mid-scale DERs (2 MW minimum) such as solar, wind and biomass. The VPPs actively forecast, dispatch and trade the power and flexibility of the aggregated DER assets, playing an important role in stabilising power grid voltage in the face of intermittent RESs from solar and wind sources.

As RES penetration increases, so does the need to stabilise the frequency as well as the voltage. The EU-funded EdgeFLEX project has made this possible. Its platform offers fast and dynamic service-to-grid operations and simultaneously enables VPPs to support local energy communities, bundling and selling power generated by households and small businesses.

5G- and edge-enabled DER management

Monitoring, control and management of large-scale DERs is becoming an obstacle to greater RES penetration. 5G mobile communications networks and Internet of Things facilitate increased autonomy and use of the edges of the grid and communications network to solve issues locally rather than centrally.

"EdgeFLEX has created a pioneering 5G application programming interface (API) that will make it easier for power providers to connect and manage devices in the field, leveraging their flexibility. Its development contributed to the adoption of three global mobile systems standards by 3GPP during the project's lifetime," notes project coordinator Fiona Williams of Ericsson. The successful standardisation of the open 5G API will give organisations free choice of network provider and the security of knowing the products and services will be supported for years to come.

EdgeFLEX has created a pioneering 5G application programming interface (API) that will make it easier for power providers to connect and manage devices in the field, leveraging their flexibility. Its development contributed to the adoption of three global mobile systems standards by 3GPP during the project's lifetime.

The project has also supported edge-enabled DER management with its unique high-speed phasor measurement unit (PMU). PMUs measure both the amplitude and phase angle of current and voltage at selected points of the power system, supporting optimised grid operations and stability.

The edgePMU is unique in its separation of sensors and analysis software. The software, located at the grid's edge, can be upgraded remotely. The sensor data can be interpreted by any newer software, ensuring sustainability and minimising maintenance and operating costs.

© edgeFLEX

‘Complex frequency’ simplifies VPP modelling and control

Underlying the services to stabilise grid frequency, the development of a new theoretical concept called ‘complex frequency’ led to an extraordinary 39 scientific publications during the project’s lifetime. “The complex frequency concept extends instantaneous frequency to the complex domain, enabling straightforward derivation of power system devices’ models and controllers. This is particularly useful for power electronic converters – the building block of VPPs,” explains Williams.

Expansion of VPPs to local energy communities, large-scale RES adoption

The 5G- and edge-ready EdgeFLEX platform comprises modular, scalable components backed by an open-source architecture. It enables incremental and cost-effective deployment and scaling of new power grid systems and services. Field trials showed its ease of use and fast dynamic responses encouraged consumers and local businesses to join local energy communities, contributing flexibility to their local power grid.

“EdgeFLEX has demonstrated that digitalisation of the grid and edge-based maintenance of grid stability go hand in hand with increased RES use, optimised energy trading and management from local to regional levels, and CO_2 emissions reductions,” Williams concludes. Get ready for upscaled VPP and RES deployment backed by frequency stabilisation and 5G.

PROJECT
EdgeFLEX – Providing flexibility to the grid by enabling VPPs to offer both fast and slow dynamics control services

COORDINATED BY
Ericsson in Germany

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.2.

CORDIS FACTSHEET
cordis.europa.eu/project/id/883710

PROJECT WEBSITE
edgeflex-h2020.eu/

Better stakeholder communication key to flexibility in energy markets

A universal market enabling interface based on open-source code increases the uptake of renewable energy and facilitates communication among stakeholders.

As Europe pursues greater reliance on renewable energy, the energy market is poised for transformation. Markets must adapt to flexible energy resources while simultaneously meeting increased demand. The EU-funded EUniversal project addresses this by supporting communication between stakeholders.

UMEI: universal market enabling interface

The rise of renewable energy and distributed energy resources (DERs) has complicated the energy market landscape. The multitude of new actors and diverse technologies makes communication between stakeholders more difficult, decreasing usability and driving up cost.

Better data management is needed to simplify communication. The UMEI provides this. According to project coordinator Pedro Marques: "The UMEI represents an innovative, adaptable, modular and evolutionary approach that will be the basis of innovative services, market solutions and mechanisms for the active participation of consumer, prosumer and energy communities in the energy transition."

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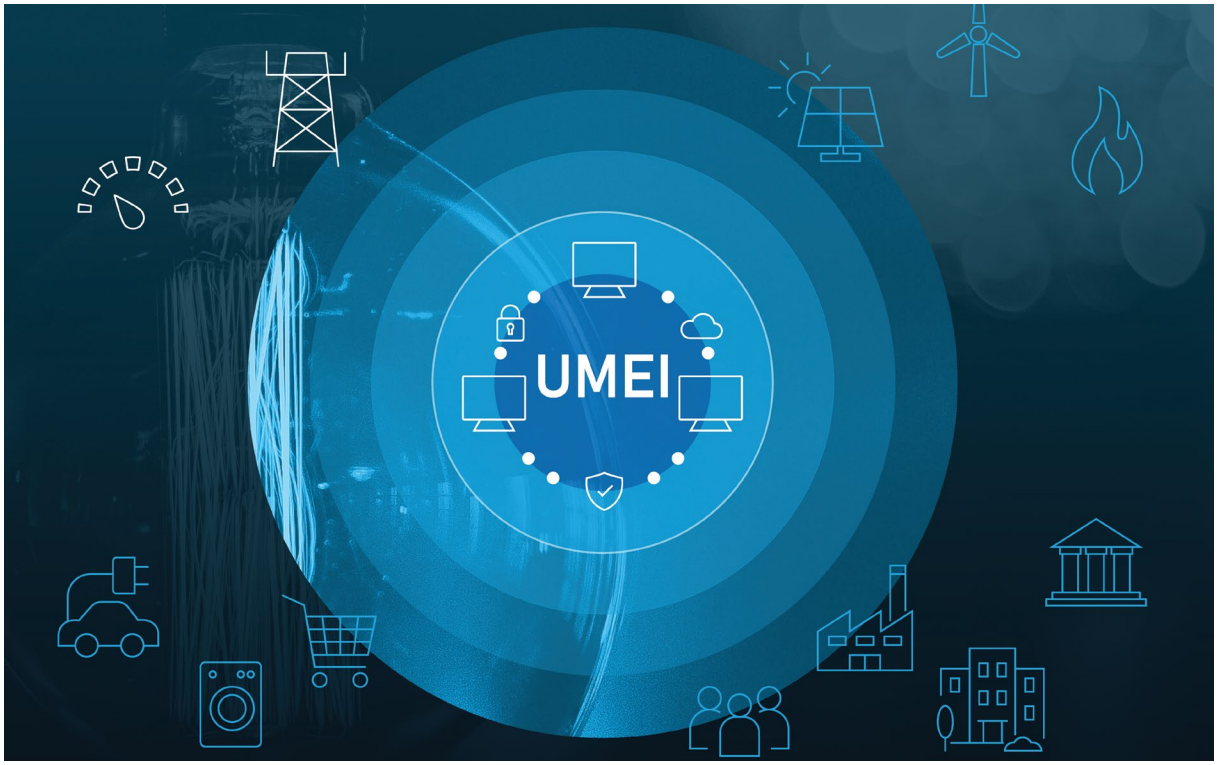
The UMEI is composed of application programming interfaces (APIs) publicly available on Github. It links smart grids with flexibility markets and coordinates communication between commercial parties and distribution system operators (DSOs). For the latter, the project also provides a specialised toolbox to help them solve their problems through the use of flexibility from flexibility service providers.

Distinct and diverse demonstration sites

EUniversal test sites in Germany, Poland and Portugal target specific goals in grid transformation. The Portuguese site allows researchers to assess needs in different areas while exploring medium voltage (MV) and low voltage (LV) network regulation. Marques says: "The operative objective is to validate the UMEI and the DSO toolbox in different contexts and scenarios. The demo has tested the provision of market-based flexibility from prosumers of the LV and MV grid via the UMEI." Resilience planning in a flexible market is an additional important component of the demo.

The German site focused on LV networks. The pilot examines the use of flexible resources for congestion management. Short-term congestion is a concern when integrating flexible energy sources, but mid- and long-term congestion planning are important too. EUniversal considers seasonal effects, increases in renewable energy sources and new demands on electricity.



The focus of the Polish pilot is dynamic line rating (DLR) and the new flexstation. The goal of DLR is to maximise load when conditions permit. The role of the flexstation is to automate control of technical constraints at the secondary substation level while using flexibility. The solution ensures advanced monitoring and control of LV grids, autonomous control, and monitoring of photovoltaic (PV) generation, energy storage and electric vehicle charging infrastructure, faster failure detection, as well as maintaining the grid voltage within acceptable limits, especially with high PV saturation. Its functionality includes the remote control of the position of the tap changer.

Harmonising flexible energy markets

EUniversal's proposals are ambitious. To realise the potential of the UMEI concept, the project recommends several steps. Standardisation of APIs is desirable. The universal nature of continued growth and development of the UMEI relies on the universality of the building blocks that compose it.

Standardisation is also desirable in the manufacture of appliances. Regulation in this area will facilitate data sharing within the energy market. Further, EUniversal recommends increasing capacity for aggregation through algorithmic development.

Smaller scale DERs must be aggregated in order to participate in the market. To optimise the potential of these players, markets must do more to engage consumers. Currently, lack of awareness, incentive and confidence impede direct involvement.

Digitisation of the energy sector is under way, and there is no turning back. Smart grids, DERs and the necessity of reducing greenhouse gas emissions are driving change at a rapid pace. EUniversal, by designing a mediating communication structure for the energy market and developing the necessary tools to achieve it, addresses this challenge.

PROJECT
EUniversal – MARKET ENABLING INTERFACE TO UNLOCK FLEXIBILITY SOLUTIONS FOR COST-EFFECTIVE MANAGEMENT OF SMARTER DISTRIBUTION GRIDS

COORDINATED BY
E-Redes in Portugal

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/864334

PROJECT WEBSITE
euniversal.eu/

Advanced technologies and services unlock flexibility potential in energy

A data management platform integrating cutting-edge technologies and services enables distribution system operators to keep pace with the growth of variable renewable electricity sources.

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In response to the rising electricity demand, Europe's internal market has undergone significant transformation. Recently, there has been a shift towards decentralised renewable energy generation, variable electricity demand, and the electrification of the heating and transport sectors.

The resulting energy system is characterised by significant supply fluctuations and increased demand elasticity. This dynamic landscape presents operational challenges, especially for the approximately 2 350 small and medium-sized distribution system operators (DSOs) who link the physical electricity system and the majority of market transactions.

The EU-funded FLEXIGRID project has been established to develop an integrated architecture that effectively manages energy flexibility. This architecture comprises four key layers: market, ICT, grid and customer.

The focus has been to develop and test local market mechanisms to incentivise flexibility, particularly to mitigate network congestion and balance local energy needs.

"The architecture integrates multiple energy sources and services, a feature that surpasses traditional energy management systems. These include electricity battery storage, electric vehicle charging, demand response and variable generation to create smart grids that can adapt to the dynamic energy landscape while ensuring affordable and secure energy supply," notes project coordinator Magnus Andersson. "The focus has been to develop and test local market mechanisms to incentivise flexibility, particularly to mitigate network congestion and balance local energy needs."

Testing technologies in demonstration sites

FLEXIGRID established testing sites across Bulgaria, Sweden, Switzerland and Turkey, offering the opportunities to validate innovative energy solutions in diverse market conditions. These conditions helped ensure that project activities are scalable, replicable and facilitate knowledge transfer.

Project activities were centred on grid monitoring, control and flexibility intervention and local energy exchanges. The project also focused on blockchain-based energy services and flexibility measures provided by local energy storage and renewable sources.

Holistic approaches to congestion management

The demonstrated technologies include an Internet of Things platform for distribution grids that integrates data from all demonstration sites as well as a congestion forecast tool and a local flexibility market to ease congestion management. Furthermore, "we developed the eFlex peer-to-peer flexibility trading platform using blockchain technology. This system enables DSOs to interact with small prosumers to buy flexibility services to manage grid-related issues such as grid congestion and transformer overload," highlights Andersson.

Other developments within FLEXIGRID included the provision of financial roadmap services, an electric vehicle management platform, a control system offering flexibility services for distributed energy resources, and a guide enabling DSOs to implement flexibility services.

Theoretical advances

In the theoretical realm, project partners developed a number of new tools and algorithms. These included an algorithm regarding the process design for flexibility procurement and dispatch, and a distribution state estimation algorithm that solves the problem of unobservable networks at distribution level. Furthermore, they developed a tool to quantify the availability and certainty of various flexibility resources as well as for the optimal allocation and dispatch of flexibility services. An algorithm for grid reconfiguration and fault-initiated islanding provided a flexible option for DSOs. Ultimately, an advanced battery management algorithm and congestion forecast tool for distribution networks was developed.

Multiple benefits affecting different areas

FLEXIGRID advances affect different areas. By improving the utilisation of the distribution system's capacity for renewable energy sources, FLEXIGRID solutions enhance flexibility and reduce network congestion. The demonstrated solutions are expected to influence policy decisions and provide valuable case studies for future research.

The project ensures the replicability of its solutions to future distribution grids through its financial roadmap services and a step-by-step guide for implementing flexibility solutions. Furthermore, FLEXIGRID paves the way for new funding opportunities related to flexibility services, supporting the continued development and deployment of innovative energy solutions.

PROJECT
FLEXIGRID – ENABLING FLEXIBILITY FOR FUTURE DISTRIBUTION GRID

COORDINATED BY
Spinverse Sweden AB in Sweden

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/864048

PROJECT WEBSITE
flexigrid.org/

Interoperable solutions connecting smart homes and buildings to the grid

The smart energy sector we aspire to faces challenges from flexibly managing energy demand and harmonising digital platforms that link homes and buildings to the grid. EU-funded researchers sought to fix these issues, creating a flexibility marketplace and enabling flawless data exchange.

The energy sector is facing an unprecedented mission of ensuring that consumers, technologies, buildings and grids collaborate effectively to realise efficient and resilient energy use in different Member States.

A new era for interoperability and consumer participation

Interoperability plays a vital role here, allowing technologies to seamlessly integrate with both energy and non-energy services in the context of buildings and grids. Consumer-centric applications are being used to improve energy use, while also supporting the grid operations, all by using interoperable technologies. The EU-funded InterConnect project has validated the use of semantic-based interoperability in different pilots.

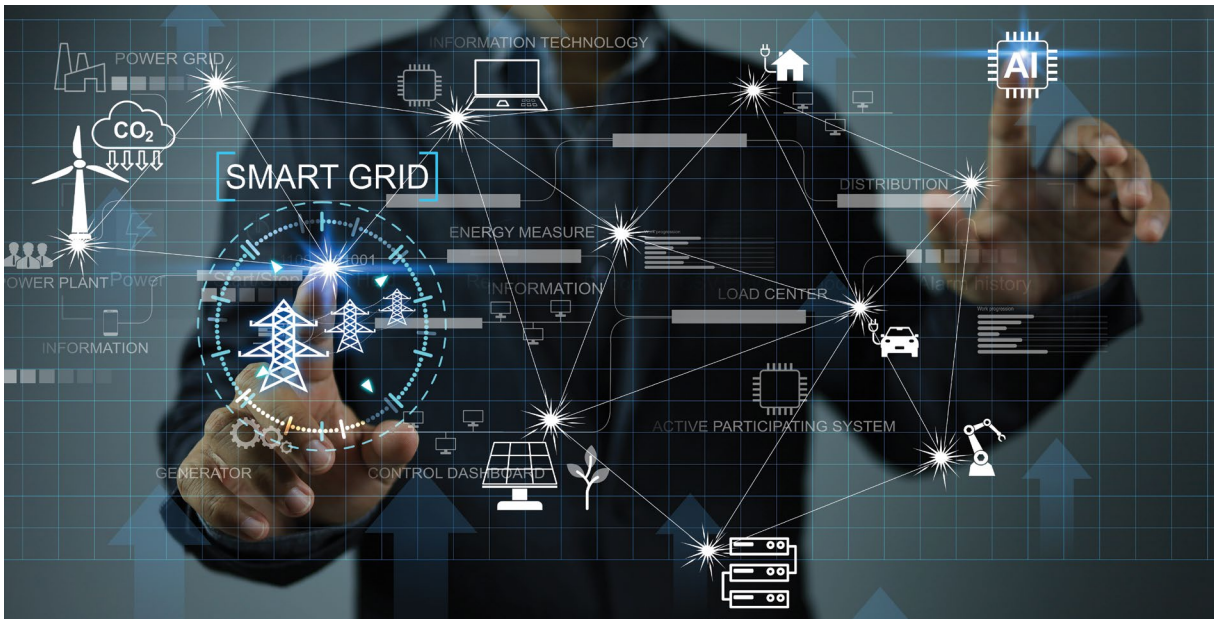
EU consumers are benefiting from the developments made by InterConnect in semantic interoperability. These have granted them access to new functionalities, seamlessly provided by manufacturers, integrators and service providers, which facilitate optimised energy management of their appliances and systems.

"EU consumers are benefiting from the developments made by InterConnect in semantic interoperability. These have granted them access to new functionalities, seamlessly provided by manufacturers, integrators and service providers, which facilitate optimised energy management of their appliances and systems. The enhancements come in the form of recommendations and technologies tailored to their needs," explains project coordinator David Rua.

Building blocks for interoperability

The project has produced a Semantic Interoperability Framework (SIF), a publicly available suite of digital tools designed to facilitate data exchange among various digital platforms associated to devices and systems within buildings and the electric grid. "By semantically interconnecting systems that interpret data based on its meaning (semantic planes), we can establish reasoning and knowledge-based interactions to support fast-paced development of cross-domain services. The SIF enables the decentralised implementation of modular and scalable deployment of digital platforms for data exchange mechanisms based on ontologies, like SAREF, thereby fulfilling EU's action plan for digitalising the energy system," highlights Rua.

"To tackle the specificities of the distribution grid, InterConnect introduced the DSO Interface (DSOi) concept. This enables simpler strategies for monitoring and managing low-voltage grids, while also introducing new, standardised ways for data exchange between distribution grids and service providers. This is done from a geographical perspective, allowing discriminated actions from smart homes, buildings and communities," explains Rua.



The DSOi facilitates communication among the internal systems of distribution system operators and external entities. Semantic interoperable technologies are used to enhance interactions. The DSOi helps mobilise residential and commercial buildings to adapt their energy use flexibly, allows to monitor grid performance and provides accessible data analytics.

Setting new boundaries

The need to address the current energy crisis and ensure that consumers are placed at the forefront of supporting the efficiency and resiliency of the electric grids led InterConnect to support the Common European Reference Framework (CERF).

InterConnect has introduced a new set of tools, aligned with the CERF, to support the widespread development of energy applications. These can recommend to consumers the best time to increase or decrease energy consumption, thereby reducing their CO_2 footprint whilst supporting grid resiliency.

"This challenge has led the project to once more innovate in an incremental and sustainable way by providing a solution to support the new generation of energy applications for consumers and grid operators," mentions Rua. "We have created the Interoperable Recommender, a data-driven toolset designed to enable consumer participation in enhancing the resilience of the European energy infrastructure."

PROJECT
InterConnect - Interoperable Solutions Connecting Smart Homes, Buildings and Grids

COORDINATED BY
NESC TEC – Institute for Systems and Computer Engineering, Technology and Science in Portugal

FUNDED UNDER
H2020-EU.2.1.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/857237

PROJECT WEBSITE
interconnectproject.eu/

Buildings get smarter with data-driven architecture

Scientists leverage machine learning to define and deploy tools for smart building data exchange, management and analytics.

Improving energy efficiency in the European building sector, where nearly 40 % of the EU's energy is consumed, is of paramount concern. Advances in big data, AI and the Internet of Things (IoT) are creating new opportunities for exploiting data-driven solutions in smart building energy management. The EU-funded MATRYCS project delivers big data applications that align architecture and vocabularies to strengthen interoperability in the smart building ecosystem.

MATRYCS reference architecture

The MATRYCS architecture reflects scientific, technological and business objectives that have been validated in 11 large-scale pilots. The demonstration sites involve diverse constituencies with respect to region, scale and perspective. According to project coordinator Francesco Saverio Nucci: "Results from our pilots are relevant to many different energy consumption aspects, such as building energy performance and building design, but also policy and funding mechanisms in areas where buildings are located."

MATRYCS promotes building information management (BIM) in a number of ways. Aligning schematic vocabularies delivers improved interoperability in data management. Scientific and technological applications rely on exploitation of machine learning and digital twins to optimise analytics. These advances are in service to policymakers and the smart building business community, enabling wiser governance and investment.

The most promising result of the project is the MATRYCS modular toolbox. It realises a holistic, state-of-the-art AI-empowered framework for decision-support models, data analytics and visualisations for digital building twins.

Building on the reference architecture, MATRYCS offers stakeholders a one-stop shop analytics toolbox. Nucci says: "The most promising result of the project is the MATRYCS modular toolbox. It realises a holistic, state-of-the-art AI-empowered framework for decision-support models, data analytics and visualisations for digital building twins."

Big data alliance

In addition to many technical achievements, the project has advanced communication and dissemination of information within the smart building sector. In the course of the project, the consortium started a new community called the big data alliance (BDA). The BDA is a structured collaborative space for stakeholders to come together to work on problems facing smart building energy management.

One of the biggest challenges facing the building sector is access to data. There is a great deal of data relevant to smart buildings, but the low degree of interoperability in systems makes it difficult to exploit the full potential of big data analytics. Nucci states: "We have pushed and continue to push citizens, policy people and local governments to face this problem and to communicate the importance of access to data and to improve synergies in sharing them."

MATRYCS has organised and managed two online meetings of BDA members as well as the first in-person event. The project has made sure that BDA members are actively engaged in workshops related to toolbox replication. The alliance is a critical initiative for amplifying the dissemination of project results and will ensure the work of the project continues. Other avenues

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through which MATRYCS achievements will carry forward include other EU-funded projects, such as ENERSHARE.

Buildings that leverage big data, AI and the IoT are essential to meeting Europe's goal of carbon neutrality by 2050. Currently, their potential is being underutilised. MATRYCS, with a focus on big data architecture, helps to realise the full potential of smart buildings.

PROJECT
MATRYCS - Modular Big Data Applications for Holistic Energy Services in Buildings

COORDINATED BY
Engineering - Ingegneria Informatica in Italy

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/101000158

PROJECT WEBSITE
matrycs.eu/

IT architecture supports flexibility in energy markets

Computer science and stakeholder input lay the foundation for a single-market energy system based on new grid services that prioritise flexibility.

Europe is striving to create an energy system aligned with its sustainability goals. When it comes to electricity, the need to integrate renewable energy sources puts pressure on grid operators to implement flexible practices. The EU-funded project OneNet worked with partners across Europe to lay the groundwork for an energy system that integrates myriad existing platforms.

IT architecture

Energy markets consist of multiple stakeholders. In addition to consumers, systems include generators, distributors and transmitters of energy. Adding to the complexity, different regions have developed as separate systems. A critical need

OneNet's key contributions lie in two directions: the definition of a set of standard energy market products, and a corresponding IT architecture that will support their implementation.

of future energy markets is the capacity for efficient data sharing between all of these participants.

To address the challenges of the European energy market, the project adopted a two-pronged approach. According to project coordinator Antonello Monti: "OneNet's key contributions lie in two directions: the definition of a set of standard energy market products, and a corresponding IT architecture that will support their implementation."

A key feature of the IT architecture is the OneNet connector. Built on open-source code, the connector has the potential to link energy market players in a flexible and scalable way. It is based on key standards such as IDSA and FIWARE. To capitalise on this achievement, OneNet plans to bring the connector to the Linux Foundation where an open-source community can continue advancing the work.

Large field studies

OneNet conducted 10 demonstration studies in 4 clusters. Working with a large number of systems operating under different conditions was a desired feature of the field studies. Monti says: "The variety of demos gave important information on replicability and the challenges faced by operators in using OneNet's technology."

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A significant challenge was integrating OneNet technology with legacy platforms. The unprecedented number of grid operators involved in the field studies provided a unique opportunity for problem solving. Ultimately, partners found this process enriching, and they have confidence in the viability of OneNet solutions.

GRIFOn initiatives

The OneNet consortium included 72 partners in 23 countries. This large and diverse group was necessary to better understand the types of products needed in a pan-European energy market. In addition to developing IT architecture, the definition of energy market products was a major focus of the project.

Reaching consensus about services, products and design in the energy market required a series of forums involving a multitude of stakeholders. The inaugural GRIFOn event in 2021 was a success, with over 200 participants. Since then, two additional GRIFOn workshops have brought together stakeholders for continued discussion.

Two more GRIFOn workshops are planned for the near future. The forum has been an important tool for OneNet to publicise progress in achieving a flexible commercial platform for electricity and to gauge stakeholder interest. The GRIFOn workshops have also guided OneNet. Monti states: "We do not see communication as a unidirectional process but as an interactive process between the project and the power community in Europe."

Increases in population, ever-growing energy demands, the prioritisation of renewable energy and the rapid advance of digitisation all contribute to a complex situation in European power production. Through consensus building and open-source IT architecture, OneNet is planning for a future in which flexibility and interoperability are at the heart of the energy market.

PROJECT
OneNet – One Network for Europe

COORDINATED BY
Fraunhofer Institute for Applied Information Technology in Germany

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/957739

PROJECT WEBSITE
onenet-project.eu/

An unparalleled conductor of the energy sharing and trading symphony

A transactive energy and local flexibility market platform with smart grid monitoring and management tools unleashes the power of renewables and distributed energy resources.

Digitalisation of the energy system creates the opportunity to use a wealth of optimisation and automation tools. These will help the EU integrate increasingly larger shares of renewable energy sources (RESs) and distributed energy resources (DERs) while ensuring efficiency, sustainability and real-time performance.

A transactive energy market in which prosumers and other stakeholders share and trade energy in near-real time will foster efficiency and stability. Gone are the flat-price, end-of-month consumer energy bills, replaced by real-time cost-effectiveness driven by market incentives.

The EU-funded PARITY project has delivered the technologies to support this. Its smart contract-enabled, transactive grid and local flexibility market platform backed by Internet of Things (IoT) and blockchain technologies facilitate energy and flexibility transactions on multiple levels.

IoT-enabled DER flexibility management tools

The PARITY IoT platform integrates heterogeneous DER assets and sensors and leverages blockchain technology for flexibility control and automated transactions. The PARITY aggregator toolset facilitates bundling and trading of flexibility resources, coupling prosumers to local energy, national energy and ancillary service markets. "Functionalities include prosumer flexibility estimation, cost minimisation, dynamic virtual power plant formation, and a bidding strategy using price forecasts for participation in the wholesale market (intraday) as well as the 'frequency containment reserves for disturbances' (FCR-D) ancillary services market," explains project coordinator Dimitrios Tzovaras of the Centre for Research and Technology Hellas.

Functionalities [of the PARITY aggregator toolset] include prosumer flexibility estimation, cost minimisation, dynamic virtual power plant formation, and a bidding strategy using price forecasts for participation in the wholesale market (intraday) as well as the 'frequency containment reserves for disturbances' (FCR-D) ancillary services market.

The PARITY storage-as-a-service framework includes virtual energy storage (power-to-heat, or P2H) and actual storage (stationary batteries and electric vehicles (EVs)). The P2H model evaluates the thermal preferences of building occupants to uncover demand side flexibility. A stationary battery manager optimises battery use via functionalities including power peak shaving. The EV profiling and smart charging components implement AI-based algorithms for EV usage profiling, EV load and flexibility forecasting, and EV charging optimisation.

Smart grid monitoring and management tools

The distribution system operators (DSO) toolset performs automated smart grid monitoring and active management of network assets to optimally manage the low-voltage distribution network in the presence of increasing RES penetration. "It

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leverages the traffic light concept for signalling congestion in the grid and can forecast future grid states. It also provides scheduling and dispatch services. It can thus improve grid operation for both intraday and day-ahead scenarios," Tzovaras explains.

An innovative 'distribution static synchronous compensator' hardware for current balancing and voltage regulation addresses power instability and power quality restoration. It operates autonomously unless the active network management software tools forecast a grid problem, at which time the DSO toolset takes full control.

Impact assessment and policy/market reform recommendations

The PARITY system was successfully demonstrated in four pilots with different characteristics. A holistic solution evaluation and impact assessment considered the environmental and social impacts, technical performance, user acceptance, and economic and market influences. Overall, "the PARITY solution offers financial benefits to participating prosumers, services to the DSO for greater grid stability, and services to external actors such as transmission system operators through participation in the ancillary services market. Participation in the FCR-D market and the day-ahead market through the aggregator seem to be the most profitable options," notes Tzovaras.

PARITY's policy and market reform recommendations, backed by high end-user acceptance (87 %) and participant retention (73 %), should lead to broad, fair and sustainable deployment of local flexibility markets in Europe.

PROJECT
PARITY - Pro-sumer AwaRe, Transactive Markets for Valorization of Distributed flexibilITY enabled by Smart Energy Contracts

COORDINATED BY
Centre for Research & Technology Hellas in Greece

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/864319

PROJECT WEBSITE
parity-h2020.eu/

Smart buildings breaking away from their past roles, 'giving back' to the environment

New technology helps buildings turn from mere energy users into active energy participants. This allows optimising their energy consumption, production and storage, ultimately leading to enhanced occupant comfort and a smoother-running grid.

In 2018, the EU introduced the Energy Performance of Buildings Directive (EPBD). This initiative aims to enhance the energy efficiency of buildings by providing occupants with valuable information about their building's energy performance and recommending viable improvements.

In a bid to further drive energy efficiency, it later introduced a smart readiness indicator (SRI) for buildings. The SRI clearly demonstrates a building's capacity to use ICT and electronic systems to optimise operations and to interact dynamically with the grid. In other words, it nudges building owners and occupants to transition from traditional, hands-on management of systems to intelligent, automated interactions.

Buildings transitioning from bystanders to players

The EU-funded PHOENIX project marks this transition towards smarter buildings. Project members demonstrated a portfolio of ICT solutions to increase the 'intelligence' of legacy systems and appliances in existing buildings. By retrofitting these buildings with cutting-edge technology, PHOENIX helps significantly boost their SRI and overall energy efficiency.

"PHOENIX has been designed to enhance building intelligence, facilitating service provision thanks to internet-connected devices," notes project coordinator Antonio Skarmeta. "By developing methodologies to make the equipment within our buildings smarter, the project aims to improve control, maximise the number of services, minimise energy consumption and enhance occupants' comfort and well-being."

By developing methodologies to make the equipment within our buildings smarter, the project aims to improve control, maximise the number of services, minimise energy consumption and enhance occupants' comfort and well-being.

From individual smart devices to a unified smart building ecosystem

The coordinator elaborates that the process of transforming buildings into smart structures has hitherto been somewhat fragmented.

"Each device typically operates on its own, with separate communication protocols, databases and services, thereby hindering the full potential of smart building technology. The PHOENIX solution tackles this, by establishing connections between

devices at a fundamental level. This helps creating a unified set of engines, where data streams are valued and intelligent services are integrated seamlessly," he explains.

A multi-layered approach

The PHOENIX solution architecture is divided into different layers. The asset layer integrates legacy equipment using multiple sensors and communication systems to monitor and control their operation. The integration layer enables remote control and data monitoring of different building systems, equipment and external data sources – homogenising communication protocols and data formats. Gathering and analysing data, the knowledge layer enables self-learning capabilities and automatic decisions.

Reflecting the interactions between end users and stakeholders, the business layer fosters democratic participation of all parties, while the function layer offers smart, cost-effective solutions to end users. Ultimately, the vertical protection layer ensures the security, privacy and trust of all operations.

PHOENIX leverages AI and edge cloud computing to provide the highest level of intelligence to existing buildings. Its portfolio of ICT solutions covers everything from hardware and software upgrades needed in legacy equipment and optimal sensor deployment, to data analytics and services for both building users and energy utilities.

Real-world pilots

The technologies developed within the PHOENIX project are all within the framework of an Internet of Things platform that manages data from sensors and generates knowledge from them. These services are delivered to users through a website and a mobile app.

To validate and evaluate the proposed solution, PHOENIX partners demonstrated five different real-world pilots in Ireland, Greece, Spain and Sweden. These pilots have demonstrated a reduction in energy consumption without compromising the occupants' comfort. A series of exploitable results has been identified that may become business models for companies in the future.

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PROJECT
PHOENIX - Adapt-&-Play Holistic cOst-Effective and user-frieNdly Innovations with high replicability to upgrade smartness of eXisting buildings with legacy equipment

COORDINATED BY
Universidad de Murcia in Spain

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/893079

PROJECT WEBSITE
eu-phoenix.eu/

New modular microservice-oriented platform redefines energy management for everyone

Leveraging open-source software together with blockchain technologies, a new platform helps ensure secure and optimised energy distribution between generators and consumers. Integrating transparency, the platform grants all participants access to authenticated, accurate data about energy usage, production and transaction records.

As we shift towards renewable energy, distribution system operators (DSOs) need new tools to manage unpredictable energy sources and changing consumption patterns. Traditionally, these two aspects have been addressed separately. The EU-funded PlatOne project is changing this through shared data management, making grid management more efficient.

A three-layered approach

Project members have developed the Platone Open Framework that consists of three open-source components that facilitate peer-to-peer market models across DSOs, transmission system operators, customers and aggregators.

These components include a DSO Technical Platform for deploying distribution grid services, a Flexibility Market Platform to ensure fair market participation for all stakeholders and a blockchain access layer for secure energy data sharing.

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Modernising grid management through microservices

"The Platone DSO Technical Platform, building on the foundations laid by SOGNO (Service-based Open-Source Grid automation platform for Network Operation of the future), is transforming the way utility companies operate," states project coordinator Antonello Monti. SOGNO leverages cloud-native microservices to create a flexible, modular system for data-driven monitoring and control. This enables utilities to adapt to evolving needs by adding components over time.

"The platform uses this microservice-based architecture to deploy various services such as state estimation, load prediction and microgrid management. This design not only enhances flexibility but also allows for seamless integration with existing proprietary and cloud-based DSO platforms," explains Monti.

Promoting transparency and putting customers at the centre

"PlatOne is transforming the way DSOs function, using cutting-edge blockchain technology to automate and decentralise processes," adds Monti. The layer 1 blockchain integrates, models and secures diverse energy data from the physical infrastructure, preventing tampering. Leveraging blockchain technology, the framework integrates Internet of Things metering devices with unique identifiers, certifies and verifies measurements, and manages data access to ensure control and governance.

PlatOne is transforming the way DSOs function, using cutting-edge blockchain technology to automate and decentralise processes.

"The Platone Open Framework prioritises its users, catering to their needs and expectations, leveraging the potential of blockchain for more dynamic customer interactions. With its real-time grid observability, our framework ensures transparency in data sharing, encouraging customers to actively participate in local flexibility markets," highlights Monti. What's more, use of energy storage allows the grid to operate in cooperation with customers, providing flexibility without intruding on privacy or disrupting daily life.

Pilot demonstrations

In Italy, the Platone Open Framework was adapted to enable flexibility activation through the Platone market mechanism. This included installing a light node at users' premises to collect data from DSO smart meters and relay activation commands to customers' systems. A local flexibility market was also established for DSOs to engage distributed energy resources (DERs), reducing grid congestion by matching demands with aggregated bids. The Blockchain Access Layer (2) further boosted trust in this market by certifying real-time meter measurements.

In Greece, the focus was on enhancing grid observability and controllability using phasor measurement units. A network tariffs model was created to analyse historical data to optimise DER control and facilitate real-time ancillary services. A state estimation tool was also developed to estimate the grid's operating state.

In Germany, efforts were directed towards increasing the self-sufficiency of renewable energy communities. To this end, a local flexibility controller was developed to balance between local generation and consumption.

"PlatOne's impact extends through its forward-looking initiatives, ensuring its platform extends beyond its primary scope. Its inclusion in the LFE project guarantees sustainability and promotes global collaboration by aligning with similar initiatives across the globe," concludes Monti.

PROJECT
PlatOne - PLATform for Operation of distribution NEtworks

COORDINATED BY
RWTH Aachen University in Germany

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/864300

PROJECT WEBSITE
platone-h2020.eu/

Power to the people: consumer/prosumer-centric energy approaches

Empowered consumers and prosumers will have an outsized impact on the clean energy transition through local energy communities and flexible on-demand consumption.

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Dialogue surrounding the green energy transition often focuses on countries and industrial sectors – big players in the energy game. However, every individual living in the EU and the United Kingdom (UK) contributes 6.5 tonnes of CO_2 emissions annually – equivalent to the weight of about four and a half cars – and there are more than 500 million inhabitants.

Turning the conventional passive consumer model on its head, the EU-funded REDREAM project delivered tools and services empowering consumers to use energy more sustainably and to actively participate in achieving the EU's goals for a zero-emissions society by 2050.

Enabling flexible energy consumption on demand

Modifying consumption or production dynamically in response to changing market, grid and environmental conditions will enable more efficient use of energy resources, reduced energy costs and a smaller environmental footprint. "REDREAM developed a platform using cloud services and AI to help an ecosystem of consumers and prosumers exploit the benefits of flexible energy consumption on demand," explains Ruben Rodriguez, part of the coordinating team at Comillas Pontifical University.

The platform collects and evaluates data on energy consumption patterns from smart devices and on environmental factors like wind and sun. Inputs include electricity price, current consumption, country, building location, and the type of consumer (residential, commercial or industrial). It also takes into consideration whether it's a private or public photovoltaic system, the type and number of electrical consumers, and mobility behaviour (when using an electric car). Based on analyses of the information using AI, REDREAM optimises the energy use of consumers to reduce their bills and fosters the sustainability of the electricity system.

"The platform offers consumers a choice of more than five energy-related plans to enhance energy efficiency by harnessing flexibility. The plans are specific to the individual data of each consumer and are all based on the service-dominant logic paradigm approach in which all developments and solutions were aimed at the needs of consumers," says Francisco Martín, part of the coordinating team at Comillas Pontifical University.

Knowledge is power: inspiring change

REDREAM not only delivered technical services and tools, it also provided resources to enhance knowledge and understanding.

Patrick Rembe of the European Science Communication Institute and project communication coordinator notes: "The energy knowledge discovery centre has a wealth of information available for download in the form of white papers, videos and infographics. It is aimed at three basic target groups: consumers/prosumers, technical installers and policymakers. The content is designed to explain basic concepts and REDREAM's technical solutions and, importantly, to create trust."

This was complemented by a games area and a social energy network fostering the active exchange of ideas and experiences among demo participants.

Lessons learned: demos in Spain, Croatia, Italy and the UK

The REDREAM demos showcased the diverse ways in which flexible energy consumption on demand and the formation and/or promotion of local energy communities with decentralised production can benefit consumers and other stakeholders. These social energy networks can enable consumers to play active roles in energy markets with positive impact on cost and future sustainability.

The demos confirmed that flexibility on demand is one of the most important approaches to a fair energy transition. Furthermore, consumers participating in the demos understood the concept of flexible consumption, adapting their behaviour accordingly.

"The demos confirmed that flexibility on demand is one of the most important approaches to a fair energy transition. Furthermore, consumers participating in the demos understood the concept of flexible consumption, adapting their behaviour accordingly," notes project coordinator Alvaro Sánchez Miralles of Comillas Pontifical University. In fact, inspiring consumers and triggering their curiosity despite the complexity of the topic and their previous lack of interest was among the highlights for the consortium.

Consumer enthusiasm and adaptation of behaviours to exploit flexibility on demand underscores the potential of REDREAM's outcomes to affect real and rapid change. Policies standardising the regulatory and legal preconditions for the flexibility-on-demand approach should expedite implementation throughout Europe.

PROJECT
REDREAM - REAL CONSUMER ENGAGEMENT THROUGH A NEW USER-CENTRIC ECOSYSTEM DEVELOPMENT FOR END-USERS'ASSETS IN A MULTI-MARKET SCENARIO

COORDINATED BY
Comillas Pontifical University in Spain

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.1., H2020-EU.3.3.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/957837

PROJECT WEBSITE
redream-energy-network.eu/

New tools boost short-term forecasting accuracy of renewable energy sources

Short-term prediction of renewable energy production – from minutes to days ahead – is crucial for maintaining the efficiency of power systems heavily relying on renewables. EU-funded researchers have developed new tools to improve short-term forecasting accuracy.

Our approach encompasses the entire model and value chain related to RES forecasting, from weather forecasting to end-use applications.

As renewable energy sources (RESs) become a larger part of the electricity generation mix in many European countries, their inherent intermittent nature presents operational challenges. The key to secure and economical operation of power systems heavily dependent on RESs is to improve short-term forecasting of RES generation.

The EU-funded Smart4RES project sought to tackle these challenges with a holistic approach. "Our approach encompasses the entire model and value chain related to RES forecasting, from weather forecasting to end-use applications," notes project coordinator George Kariniotakis. "We sought to achieve groundbreaking improvements in RES forecasting technology rather than just incremental advancements."

Improvements across broad time and spatial scales

Smart4RES' ultimate goal was to develop and validate next-generation tools to improve RES forecasting performance by at least 15 %.

Project partners worked on improving numerical weather prediction models for the RES industry, integrating data from satellites and sky images. "We have developed an ultra-high resolution large eddy simulation approach for very local weather forecasting. To improve prediction of weather variables, we used for the first time a network of sky cameras spread over a large area, which is a step up from the traditional method of using just one camera at a site," explains Kariniotakis. He adds: "The use of sky camera images for solar power prediction has yielded a 20 % performance boost, specifically for predictions 15 to 30 minutes ahead."

"We also developed a seamless forecasting model that simplifies traditional model chains, providing a single, continuous model for probabilistic forecasting of solar and wind production from minutes to days ahead. This method dramatically reduces the computational load by 99 % while delivering comparable results to existing models," notes Kariniotakis.

Furthermore, to improve short-term accuracy, researchers created methods to share data between different renewable energy plants, while keeping the information private and secure. This helped improve the probabilistic score by up to 20 % for 1 up to 6 hours ahead.

Increasing forecast value and aiding decision-making

The project team have built a cutting-edge data market prototype for sharing data from distributed energy sources armed with new algorithms and business models. "This system goes beyond just being accurate – it squeezes the most value out of data, supporting better renewable energy forecasts," states Kariniotakis. "Decision-making for RES integration in power systems and markets is now more efficient, with predictive dispatch for standalone power systems, multi-service storage options, data-driven renewable energy trading and local control algorithms that handle grid congestions. We managed, for example, to reduce by 30 % the flexibility activation costs for the electricity grid operators."

"To make things simpler than the traditional forecast-then-optimise model, we have proposed a prescriptive analytics approach, based on interpretable AI, that permits to streamline learning from available data to decision-making," Kariniotakis explains.

Testing models in real conditions

Project partners have integrated the newly developed weather forecasting methods into the operational models of Meteo-France and Whiffle. These improved models were benchmarked against commercial forecasts and used to assess key performance indicators for RES trading in electricity markets. They have also tested frequency control strategies for standalone islands using real-time simulations that mirrored high RES usage.

Ultimately, a cost-benefit analysis of RES forecasting and decision-support tools was conducted. The aim was to identify the most effective combinations of data sources and understand the potential advantages of advanced decision support. For instance, one such benefit could be the possibility to delay grid upgrades by intelligently managing local flexibility.

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"We have laid the groundwork for advanced forecasting tools for weather-dependent RES production. These next-generation tools aim to mitigate the effects of RES intermittency in power systems with high renewable shares, covering a wide range of timeframes – from minutes to over 10 days – and spatial scales – from individual RES plants to regional or national levels," concludes Kariniotakis.

PROJECT

Smart4RES - Next Generation Modelling and Forecasting of Variable Renewable Generation for Large-scale Integration in Energy Systems and Markets

COORDINATED BY

Association pour la Recherche et le Développement des Méthodes et Processus Industriels (ARMINES) in France

FUNDED UNDER

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CORDIS FACTSHEET

cordis.europa.eu/project/id/864337

PROJECT WEBSITE

smart4res.eu/

Facilitating participation, unleashing energy flexibility's potential

Novel tools for all grid stakeholders will support the integration and optimised use of decentralised flexible energy assets for a more resilient energy system.

What once seemed like an infinite reserve of fossil fuels enabled a centralised electricity supply that was generally able to meet fluctuating demand. Today's green energy transition is powered by an increasing contribution of renewable energy sources (RESs) and small-scale distributed energy resources localised to homes and buildings.

Decentralised generation, storage and usage along with intermittent RESs create fluctuating energy flows. Digitalisation will support smart grids and flexibility markets, enabling stakeholders to respond to market signals – matching supply and demand sustainably and efficiently.

To exploit this potential, the EU-funded X-FLEX project has developed effective and affordable solutions to enable the optimised use of decentralised flexible energy assets, reducing costs and enhancing resilience.

Tools for grid optimisation, market participation and data integration

X-FLEX set out to enable all stakeholders to actively participate in energy markets to increase grid reliability and energy efficiency and create new market opportunities. To do this, they developed and piloted four tools.

According to project coordinator Antonio Marqués of ETRA Research and Development, "the Gridflex tool for grid and microgrid operators leverages flexibility to mitigate congestion-related issues such as voltage and current instabilities and maintain power quality as the share of intermittent RESs increases."

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For flexibility managers, the Serviflex tool can effectively optimise flexible energy assets' utilisation considering business and operational requirements and constraints.

The Marketflex tool helps consumers and prosumers participate in energy markets either as individuals or via intermediate parties like retailers and aggregators. Finally, the X-Flex platform integrates data from various flexible energy assets and leverages the other tools to ensure a more secure, stable and environmentally friendly energy supply.

Improved grid operations, flexibility and resilience

The tools were piloted at four sites in Bulgaria, Greece and Slovenia, highlighting both benefits and challenges. "All pilots demonstrated an increase in renewable energy utilisation and self-sufficiency. The tools enabled effective unit forecasting and operation, and high flexibility availability particularly related to electric vehicle charging," Marqués notes.

The tools enabled effective unit forecasting and operation, and high flexibility availability particularly related to EV charging.

Excellent observability and forecasting resulted in a comparatively short congestion mitigation time and, frequently, lower peak-to-average power ratios – an indication of greater efficiency. Fault mitigation following strong winds was also much faster, promising greater resilience in the face of increasingly frequent extreme weather events.

However, the current lack of regulatory frameworks in most EU countries must be addressed to support the local energy communities essential to full exploitation of market-based flexibility services.

Economic, environmental and social benefits

X-FLEX energy management tools can reduce costs via smart energy production and storage and by leveraging flexibility in the energy market. The inherent environmental benefits are augmented by the increased local RES production seen in all pilots as an indirect consequence of using the tools. The economic and environmental benefits could have a positive impact on the tourism sector, not to mention the tools' deployment impact on jobs in the IT sector.

"Reducing costs, enhancing resilience and efficiency, and lowering emissions are all achievable by facilitating the smooth integration, management and optimisation of RESs into the grid and improving the matching of electrical generation and demand," Marqués concludes. Having already identified enthusiastic potential replication sites, X-FLEX is well on its way to bringing stakeholders on board in leveraging flexibility markets with benefits for consumers, industry and the environment.

PROJECT
X-FLEX - Integrated energy solutions and new market mechanisms for an eXtended FLEXibility of the European grid

COORDINATED BY
ETRA Research and Development in Spain

FUNDED UNDER
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CINEA manages the Connecting Europe Facility 2 (Transport and Energy), the LIFE programme, the Innovation Fund, the European Maritime, Fisheries and Aquaculture Fund, the Renewable Energy Financing Mechanism and the Public Sector Loan Facility under the Just Transition Mechanism. CINEA is also managing and implementing the Climate, Energy and Mobility Cluster of Horizon Europe and three of the five missions under the Horizon Europe framework programme. These missions are: Adaptation to Climate Change, Restore our Ocean and Waters by 2030, and 100 Climate-Neutral and Smart cities by 2030.

CINEA also implements two societal challenges of the Horizon 2020 programme: Secure, clean and efficient energy, and Smart, green and integrated transport. CINEA provides technical and financial management services at all stages of the programme and project life cycle – from the calls for proposals, evaluation of projects and the award of financial support, to the follow-up of project implementation and control of the use of funds allocated.

CINEA provides visibility for EU funding opportunities and project results – and supports potential applicants and beneficiaries, allowing them to benefit from the Agency's long-standing experience of programme implementation with a high level of performance and seeks to promote synergies between the programmes in order to benefit EU citizens and promote economic growth.

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CLEAN ENERGY TRANSITION TO REPOWER THE EU – A SYNERGY INFO PACK BY CORDIS

Europe's energy independence, security and climate commitments must go hand in hand. This CORDIS Synergy Info Pack highlights the range of EU funding programmes, sectors and projects managed by CINEA that are working to advance Europe's clean energy transition and end Europe's reliance on fossil fuel imports, accelerating progress towards a climate-neutral Europe by 2050.

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