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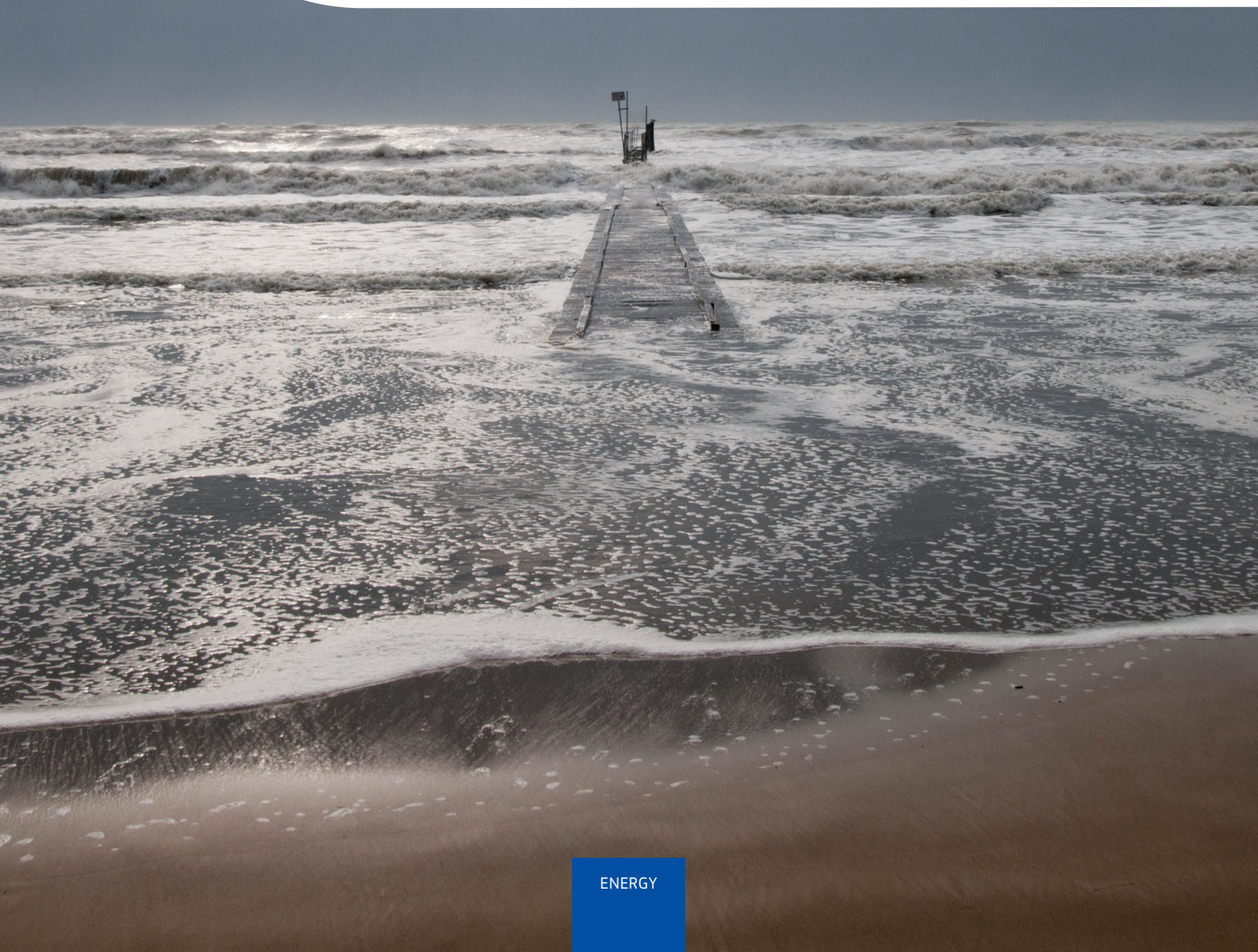
European Islands of Innovation: Digital Solutions for Sustainable Energy Communities in Europe

Case Study – EN



ENERGY

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Every1 can contribute to the energy transition

About EVERY1

Every1 project sets the goal of delivering an impactful concept that includes all elements needed to enable an effective participation of all European stakeholders in the digital energy market. The project starts with a deep, data-informed understanding of stakeholders and ecosystems to map who they are, what they know, how they use information and where they look for it. Similarly, existing and emerging solutions will be assessed and validated, and use cases will serve to understand what stakeholders need to know in order to take on a role that matches their potential. This gap is used to develop learning pathways that lead to the identification of the needed capacity building material. In parallel, Every1 works on making a market by exchanging best practices with policy makers and energy regulators, enabling discussions on barriers, and developing joint communication material for their peers.

Want to dive deeper into the digital energy transition? Scan the QR code below or visit the EVERY1 project website at https://every1.energy/ for resources, case studies, and insights on how you can play a role in shaping a clean energy future.

Introduction

Islands, defined by their geographical isolation and unique resource limitations, face distinct energy challenges. Traditionally reliant on external energy sources, they are vulnerable to price volatility, supply disruptions, and the environmental impacts of long-distance transportation. Integrating renewable energy (see glossary) sources, while essential for a sustainable future, is often complex due to limited grid infrastructure and land constraints. However, these very challenges are fuelling innovation, particularly in the realm of digital technologies.

Across Europe, island communities are embracing this digital transformation as a key enabler of their energy transition. By leveraging smart grids (see glossary), data analytics, and advanced automation, they are optimising renewable energy integration, enhancing energy efficiency, and empowering citizens to actively participate in shaping their energy futures. This shift towards localised, digitally-enabled energy systems is supported by initiatives like the European Commission's "New initiatives for digital infrastructures of tomorrow", which recognises the crucial role of connectivity and data-driven solutions in achieving sustainable energy goals.

In this document, we delve into the technical infrastructure, operational strategies, and successes of four diverse island energy communities: **Kythnos** (Greece), **Orkney Islands** (Scotland, UK), **Les Îles du Ponant** (France), and the **Samsø Energy Academy** (Denmark).

This case study is intended for a diverse audience, including community leaders, community managers, policymakers, researchers, and individuals interested in learning about sustainable energy solutions for islands. It provides valuable insights into the challenges and opportunities associated with island energy transitions and showcases real-world examples of successful implementations.

> Our goal is to showcase how these communities have harnessed the power of digital tools to not only create more resilient and efficient energy systems but also to foster deeper community engagement and local ownership.

A | Community Profiles

I. Kythnos: The Digital Transformation Pioneer

Kythnos (*100 sq. km, population 1,500*) leads the way in island energy innovation, serving as a "living laboratory" (see glossary) for smart energy solutions. The island functions as a testbed for innovative approaches to energy, water, waste, transportation, and lighting, with the integrated focus of creating a truly sustainable island model.

The Kythnos Smart Island project, led by Network of Sustainable Greek Islands (DAFNI) and the Institute of Communication and Computer Systems (ICCS) of the National Technical University of Athens (NTUA), aims to accelerate the island's energy transition through a multifaceted approach:

- **Integrating Renewables:** Kythnos leverages both solar and wind power, with plans for tidal energy exploration.
- **Smart Grids:** The project prioritises developing a robust smart grid system, enabling the efficient integration of renewables, demand-side management, and optimised energy use across the island.
- **Holistic Sustainability:** Kythnos is actively testing and refining solutions for water management, waste reduction, sustainable transportation, and energy-efficient infrastructure.

II. Orkney: The Smart Grid & Data Leader

Orkney (*990 sq. km, population 22,000*) has emerged as a global leader in renewable energy innovation, generating over 100% of its electricity needs from wind power. They are also actively exploring wave, tidal, and hydrogen energy technologies. Community Energy Scotland and the Orkney Renewable Energy Forum (OREF) play crucial roles in promoting community ownership and collaboration. Their early success in wind power generation underpins their ongoing exploration of innovative marine energy (see glossary) technologies like wave and tidal power.

III. Samsø: The Digital Efficiency Champion

Samsø (*114 sq. km, population 3,700*) is a pioneer in community-led renewable energy transformation. Their early adoption of wind and solar, combined with a strong commitment to energy efficiency, has made them a role model for sustainable energy futures. Today, the Samsø Energy Academy focuses on sharing their experience and providing guidance to communities worldwide seeking to replicate their successes.

IV. Les Îles du Ponant: A Collaborative Digital Network

Les Îles du Ponant is a network of 15 French islands, home to 16,300 permanent residents, dedicated to achieving **100% renewable energy by 2030**. Through the Ponant Islands Association (AIP), they collaborate on projects focused on energy efficiency measures, renewable energy production, and smart energy management.

B | Technical Analysis

I. Kythnos Smart Island

Renewable Energy Integration

Kythnos has a long history of renewable energy adoption, starting with Europe's **first wind park in 1982** and an early **hybrid PV-battery system**. Their current energy mix combines fossil fuels with solar and wind power, with a total renewable capacity of 903.25kW. Efforts are underway to reduce reliance on fossil fuels by repowering a 500-kW wind turbine and potentially adding battery storage.

The **Gaidouromantra microgrid**, a pioneering project from 2001, continues to be an important research asset for high-penetration renewable systems. Consisting of solar PV, battery storage, and demand control systems, it was further advanced within the MORE project and remains an important research asset under the current "Kythnos Smart Island" project. Notably, Gaidouromantra has served as a testbed for advanced control strategies and demand response (see glossary) mechanisms, allowing researchers to evaluate the feasibility and effectiveness of various approaches in a real-world setting.

Energy Efficiency & Demand Response

The "Kythnos Smart Island" project prioritises energy efficiency upgrades for buildings and public spaces, including near-zero energy retrofits. The project actively explores demand-side management (DSM) strategies, including integrating storage into the distribution network, microgrid (see glossary) research, and sector coupling (see glossary) to optimise energy use across various sectors. This comprehensive approach aims to create a truly sustainable island model.

II. Orkney Islands

Renewable Energy Integration

Orkney generates over **100%** of its electricity needs through wind power and is pioneering marine energy technologies like wave and tidal power. A smart grid, incorporating domestic batteries, manages this diverse generation mix. Orkney has also explored hydrogen as a potential energy storage solution.

Energy Efficiency & Demand Response

The Orkney Islands Council prioritises energy-efficient buildings and the adoption of heat pumps (see glossary). They actively engage various sectors in demand response initiatives to optimise energy consumption. Recent investments in residential energy efficiency upgrades and the utilisation of digital twin (see glossary) technology demonstrate their commitment to reducing energy waste.

III. Samsø

Renewable Energy Integration

Samsø successfully generates over 100% of its electricity needs from renewable sources, primarily wind (**11 onshore and 10 offshore turbines**) and solar energy. They also utilise biomass for district heating.

Energy Efficiency & Demand Response

Samsø prioritises energy efficiency in residential buildings and public spaces through retrofits with improved insulation and the installation of highly efficient heating systems, namely district heating stations utilising biomass. Their widespread adoption of heat pumps offers significant potential for participation in demand response programs.

IV. Les Îles du Ponant

Renewable Energy Integration

Les Îles du Ponant has set a goal of achieving 100% renewable electricity by 2030. They focus on diverse renewable sources, including solar, tidal current, and wind power. To overcome the intermittency of renewable energy, they are exploring storage solutions like lithium-ion batteries (see glossary) and hydrogen.

Energy Efficiency & Demand Response

The islands have already made significant strides in energy efficiency through initiatives like smart appliances (see glossary), building optimisations, and public awareness campaigns. They continue to pursue further efficiency gains and local energy production projects.

C | Digital Solutions

Digital technologies are pivotal in enabling island communities to achieve energy independence and sustainability. As they transition to self-sufficient, clean energy systems, these tools play an indispensable role in their success. Smart grids, data analytics, and visualisation tools unlock the data-driven decision-making needed to optimise energy use, integrate diverse renewable sources, and foster active community participation in energy initiatives.

In this section, we will examine how four European islands – Kythnos (Greece), Orkney Islands (Scotland, UK), Samsø (Denmark), and Les Îles du Ponant (France) – are harnessing the power of digital technologies to accelerate their energy transitions. Each island offers a tailored approach, demonstrating the transformative potential of digital solutions in diverse geographic and regulatory contexts.

I. Kythnos: The Digital Transformation Pioneer

Kythnos leverages smart meters (see glossary) to gather real-time energy consumption data, providing the critical foundation for effective demand management strategies. This real-time monitoring allows the island to optimise energy use and maintain grid stability, particularly with fluctuating renewable sources. A centralised control system manages the island's energy mix and employs advanced energy management and data visualisation software for system optimisation. Greece's national focus on smart grid development and digital technologies further positions Kythnos as a leader in digital energy solutions for island communities.

The pioneering Gaidouromantra microgrid, launched in 2001 as Europe's first with almost 100% renewable generation, exemplifies Kythnos' early commitment to renewables. The ongoing "Kythnos Smart Island" project further propels this digital energy transformation. This innovative work is supported by networks like the Network of Sustainable Greek Islands (DAFNI) and EU initiatives such as the Smart Islands Initiative and Clean Energy for EU Islands.

Digital Infrastructure

Central to the Kythnos Smart Island project is a focus on digital infrastructure and data-driven decision-making. The Gaidouromantra microgrid, a testbed for high penetration of renewables, showcases the island's early adoption of smart energy technology. The project utilises intelligent load controllers, developed by the National Technical University of Athens, to manage energy demand, prioritise critical loads, and optimise renewable energy usage. Although the specific software platform used is not explicitly mentioned, the microgrid's success demonstrates the effectiveness of a centralised control system with distributed intelligent agents. This innovative approach, combined with the utilisation of smart meters, advanced energy management software (see glossary), and data visualisation tools (see glossary), enables Kythnos to efficiently manage its energy resources, ensure grid stability, and foster community engagement in the energy transition.

II. Orkney: The Smart Grid & Data Leader

Digital Infrastructure

Orkney's core digital infrastructure includes:

- **FlexiGrid Platform:** Solo Energy's FlexiGrid platform is the cornerstone of Orkney's digital energy landscape. This sophisticated solution provides real-time monitoring and control, enabling Orkney to intelligently manage energy resources like batteries, heat pumps, and electric vehicles, balancing the variable supply from renewables with community demand.
- **Smart Meter Foundation:** Orkney's widespread adoption of smart meters provides the granular, real-time consumption data essential for optimising energy use and implementing demand-side management strategies.
- **Connectivity Focus:** Collaboration between the Orkney Islands Council and national schemes ensures reliable broadband (see glossary) access across the islands – a crucial ingredient for the uninterrupted operation of their smart grid systems.

Further Innovation

Orkney's drive for continuous energy innovation extends beyond these foundational components:

- **Transport Electrification:** Orkney actively promotes the adoption of electric vehicles (EVs) and integrates the required charging infrastructure. Digital management systems play a key role in orchestrating EV charging to align with demand patterns and the availability of renewable power.
- **Marine Energy Leadership:** The renowned European Marine Energy Centre (EMEC) positions Orkney at the forefront of tidal and wave energy development. The centre leverages advanced data collection, analytics, and optimisation tools to assess the performance of these technologies, driving further innovation in this sector.

The project "*Energy system of the future to be demonstrated in Orkney*" shows the commitment to developing a digital energy system that allows for the seamless integration of renewable energy sources with consumer demand, creating a virtual energy system.

Awards and Recognition

Orkney's ground-breaking work has been internationally recognised. In 2020, they received the prestigious EU Prize for Innovative Renewable Energy Solutions, acknowledging their transformative energy model.

Supporting Networks

Orkney's success is bolstered by initiatives like the Clean Energy for EU Islands network.

Digital Solutions in Action: Orkney: Optimising Renewable Integration

The tools: Orkney's FlexiGrid platform, along with smart meters and weather data integration.

The process: The platform analyses real-time energy generation (wind, potentially marine sources), household consumption patterns, and weather forecasts. Using this, it orchestrates the charging of electric vehicles, battery storage, and even adjust heat pump operation to align with periods of excess renewable generation.

The outcome: Maximises the use of locally produced renewable energy, minimising reliance on the mainland grid or fossil fuels. This could even lead to Orkney becoming an energy exporter in the future.

III. Samsø: The Digital Efficiency Champion

Samsø, a Danish island with a population of roughly 3,700 residents, is widely recognised for its pioneering role in community-led renewable energy transformation. Their early adoption of wind and solar technologies, combined with a strong commitment to energy efficiency, led to the island achieving 100% renewable energy self-sufficiency by 2007.

Digital Infrastructure

While precise details of Samsø's historical digital infrastructure are limited, their early achievements highlight the importance of digital solutions in facilitating their energy transition. The island uses data collection and monitoring tools to assess the performance of its wind and solar installations, allowing for optimisation and informed decision-making. Additionally, the integration of various renewable sources into a cohesive energy system suggests the use of software for energy management and potentially early forms of demand response programs.

The region of Midtjylland, where Samsø is located, has consistently emphasised the importance of digital infrastructure for regional development. This supportive environment has undoubtedly contributed to Samsø's ongoing progress and innovation in the energy sector.

The Samsø Energy Academy and Knowledge Sharing

Today, the Samsø Energy Academy serves as a beacon of knowledge-sharing, leveraging digital platforms to disseminate lessons learned and best practices to a global audience. This includes online courses, webinars, and educational resources like their "Pioneer Guide", which outlines a roadmap for community engagement and change management. The academy's digital presence is instrumental in inspiring and guiding other communities on their sustainable energy journeys.

Awards and Recognition

Samsø's pioneering work has earned them prestigious recognition, including the EU Prize for Innovative Renewable Energy Solutions in 2020. This award highlights their continued leadership and innovative approach within the clean energy field.

IV. Les Îles du Ponant: A Collaborative Digital Network

Les Îles du Ponant, a network of 15 French islands, has embraced a collaborative approach to achieving their goal of 100% renewable electricity by 2030. Digital tools play a pivotal role in coordinating their efforts and sharing knowledge across the diverse islands.

Digital Infrastructure

- **Smart Meter Deployment:** Smart meters are being implemented across member islands, providing essential data for accurate consumption monitoring and future optimisation strategies. This standardised approach enables comparison between islands and facilitates a data-driven understanding of energy consumption patterns.
- **Energy Management Software:** The islands are exploring energy management software solutions to analyse energy data, identify inefficiencies, and optimise their renewable energy systems. This software could also help in forecasting energy demand and supply, ensuring grid stability, and integrating energy storage solutions.
- **Data Visualisation Tools:** Data visualisation tools are crucial for presenting complex energy data in an understandable and actionable way. These tools can help communities understand their energy usage patterns and make informed decisions about energy conservation.
- **Emerging Technologies:** Les Îles du Ponant is investigating peer-to-peer (see glossary) energy trading as a way to further decentralise and democratise their energy markets. This innovative approach could empower local communities by allowing them to buy and sell excess renewable energy directly with each other.

Specific Island Examples

- **Sein Island:** EDF SEI leads the development of a smart grid on Sein Island, leveraging smart meters (Linky) to gather real-time energy consumption data. This data is then used to inform decision-making and promote community engagement in energy conservation efforts.
- **Ouessant Island:** Ouessant's "Heures Creuses Renouvelables" experiment utilises smart meters for real-time energy tracking and employs dynamic pricing to incentivise energy consumption during periods of high renewable energy production. The island's "energy consumption observatory" serves as a database for energy data storage and analysis.
- **Molène Island:** Smart meters and remote monitoring systems are employed to ensure grid stability and efficient energy management on Molène. The island's remote location necessitates remote control capabilities to effectively manage its energy assets.

Supporting Networks:

- **Association Les Îles du Ponant (AIP):** This association provides a platform for collaboration and knowledge exchange among the member islands. The AIP offers technical support, develops energy transition projects, and coordinates actions related to renewable energy and energy efficiency.
- **Clean Energy for EU Islands Initiative:** This EU initiative provides resources, guidance, and funding opportunities to support island communities in their transition to clean energy systems.
- **Smart Islands Initiative:** Les Îles du Ponant participates in the Smart Islands Initiative, which promotes the use of digital technologies and innovative solutions for sustainable energy development on islands across Europe

D | Comparative Analysis: Digital Strategies for Island Energy Transitions

The case studies of Kythnos, Orkney, Samsø, and Les Îles du Ponant showcases a diverse array of digital strategies employed in island energy transitions. While all share a community-driven ethos, the specifics of their digital infrastructure and focus areas differ, showcasing the adaptability required for success in diverse contexts.

Comparative Analysis

Island	Strengths	Focus Areas	Key Challenges
Kythnos	"Living lab" approach fosters comprehensive testing of smart grids and data-driven systems for integrated solutions.	Optimisation across energy, water, waste, and transport sectors.	Integrating complex datasets and ensuring interoperability.
Orkney	Advanced grid management with widespread smart meter adoption supports a complex landscape of wind, marine, and hydrogen energy.	Data analytics and visualisation are crucial for balancing variable supply and exploring flexibility for potential energy exports.	Maintaining secure and accessible infrastructure as the system evolves.
Samsø	Early adoption of digital monitoring and data-driven decision-making have maximised the impact of their clean energy transition.	Prioritising energy efficiency retrofits, widespread heat pump adoption, and potential for community-level demand response.	Adapting legacy systems to support emerging technologies.
Les Îles du Ponant	Network structure fosters collaboration and knowledge sharing for tailored digital solutions across member islands.	Smart meter deployment, data visualisation, and exploration of peer-to-peer energy trading models.	Ensuring equitable access to digital infrastructure across all islands.

E | Conclusion: Islands at the Vanguard of Digital Energy Transformation

The energy communities of Kythnos, Orkney, Samsø, and Les Îles du Ponant demonstrate the indispensable role of digital technologies in achieving successful, citizen-driven energy transitions. These islands are not merely local success stories; they are paving the way for a global future powered by clean, sustainable, and community-centred energy solutions.

Key Takeaways:

- **Data is the Currency of Transformation:** Digital solutions, from smart meters to advanced analytics, empower communities with the information needed to make informed decisions and optimise their energy systems. Data-driven approaches underpin successful energy transitions.
- **Community Engagement is Enhanced:** Digital platforms foster transparency, allowing residents to track their energy usage, understand the impact of their choices, and participate actively in community energy initiatives.
- **Networks Accelerate Innovation:** Collaborative networks enable islands to share knowledge, pool resources, and develop tailored solutions that address their unique challenges and opportunities.
- **Adaptability is Key:** There is no one-size-fits-all solution; digital tools must be adapted to local contexts and needs to create a more sustainable and resilient energy future for all.

> By embracing the power of digital solutions alongside community engagement, these islands are proving that the energy transition is not just possible, it is already happening. Their success serves as a blueprint for other communities to follow, offering valuable lessons in harnessing technology for a more equitable, sustainable, and citizen-centred energy system.

Glossary

Broadband
A high-speed internet connection capable of transmitting substantial amounts of data quickly. Essential for many digital energy management tools.

Community-Owned Energy Projects
Energy generation or distribution initiatives owned and operated by local communities, increasing local control and economic benefits.

Data Visualisation Tools
Software applications that transform complex energy data into easily understandable charts, graphs, and maps, aiding decision-making.

Demand Response
Programs that encourage consumers to adjust their energy use during peak periods, helping balance the grid and reduce costs.

Digital Twin
A virtual replica of a physical asset, such as a building, allowing for real-time monitoring, simulation, and optimisation using data.

Energy Efficiency
Using less energy to perform the same tasks, reducing waste, and saving costs.

Energy Management Software
Software platforms that monitor, analyse, and optimise energy usage in buildings, homes, or across an entire grid.

Grid Modernisation
Upgrading the electricity grid with advanced technologies for improved efficiency, reliability, and integration of renewable energy sources.

Heat Pumps
Energy-efficient devices that transfer heat from one location to another for heating or cooling purposes.

Living Lab
A real-world environment where innovations, like new energy technologies, are evaluated and developed with active community participation.

Marine Energy
Harnessing the power of waves, tides, and currents to generate electricity.

Microgrid
A localised electricity grid that can operate independently of the main grid, often incorporating renewable energy sources and energy storage.

Peer-to-Peer (P2P) Energy Trading
A system allowing individuals or communities to buy and sell energy directly to each other, often using blockchain technology.

Renewable Energy
Energy derived from sources that naturally replenish, like solar, wind, and geothermal power.

Smart Appliances
Home appliances that can communicate with the energy grid, potentially allowing for automated energy use optimisation.

Smart Grid
An electricity grid incorporating digital communication technology, enabling real-time monitoring and control for improved efficiency and reliability.

Smart Meter
A digital meter that records electricity consumption in detail, providing insights to consumers and grid operators.

Zero-Injection Photovoltaic Systems
Solar power systems designed not to feed excess energy back into the main electricity grid.

Lithium-ion battery
A lithium-ion or Li-ion battery is a type of rechargeable battery that uses the reversible intercalation of Li^+ ions into electronically conducting solids to store energy.

Open Source
Software where the source code is freely available for anyone to use, modify and share, fostering collaboration and innovation.

Electromobility
The use of electric vehicles (EVs) and their supporting charging infrastructure as an alternative to fossil fuel-powered transportation.

Sector Coupling
The linking of different energy sectors (e.g., electricity, heat, transport, water) to optimise resource use and overall efficiency.

Acknowledgements

General sources

The Potential of Digital Business Models in the New Energy Economy

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Kythnos

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