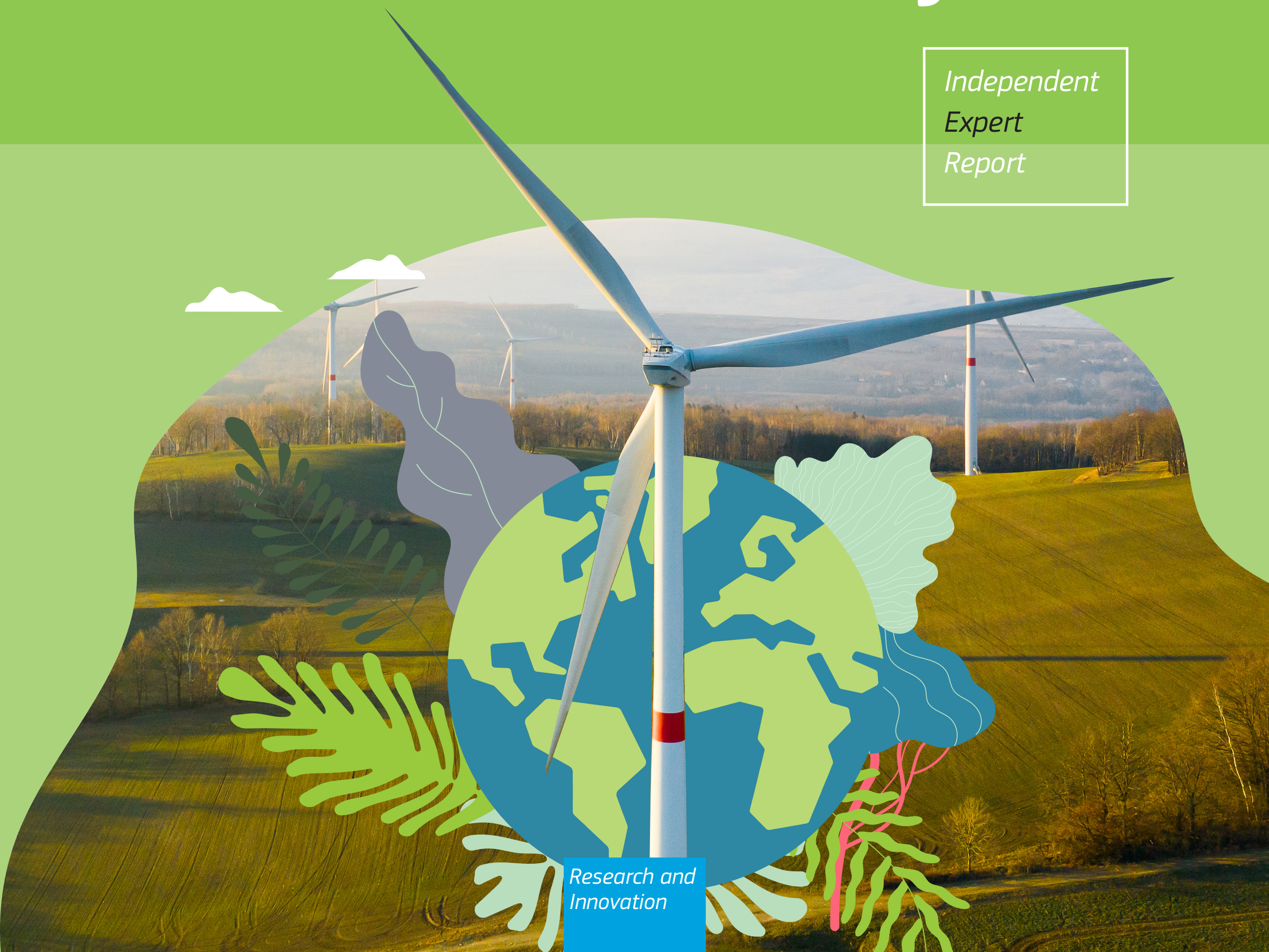
European Commission

Green Deal Projects Support Office

Clean energy and digitalisation as a key enabler for **Horizon 2020 Green Deal Call Projects**

Independent Expert Report



Research and Innovation

Clean energy and digitalisation as a key enabler for Horizon 2020 Green Deal Call Projects – Report Three

European Commission
Directorate B – Healthy Planet
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Unit C.5 — Ecological and Social Transitions

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Clean energy and digitalisation as a key enabler for **Horizon 2020 Green Deal Call Projects**

Green Deal Projects Support Office

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The Green Deal Projects Support Office is operated for the European Commission – DG RTD by Ecorys and Ricardo

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About the Green Deal Projects Support Office

The Green Deal Projects Support Office has been developed to facilitate coordination between projects funded under the Horizon 2020 Green Deal Call and to maximise their positive impact in the longer term. The Green Deal Projects Support Office will operate until November 2026 and the key activities it carries out include supporting Green Deal projects to engage in effective collaboration, providing networking and knowledge exchange opportunities to develop synergies, and helping projects boost efforts to communicate their results. The Green Deal Projects Support Office supports networking, knowledge exchange and common capacity-building activities through five working groups:

- Climate Change and Biodiversity
- Clean Energy
- Knowledge and Citizens
- Urban Environment and Mobility
- Food and Health

For more information on the Green Deal Projects Support Office, please contact: **support@greendealprojects.eu**

1 Policy and research drivers towards a clean energy transition in Europe

1.1 Clean energy policy framework in Europe

Climate change and environmental degradation are an existential threat to Europe and the world. Recognising this, in 2019 the European Union (EU) responded by introducing the European Green Deal to overcome these challenges, outlining an ambitious set of sustainability targets to be achieved over the next few decades.

The European Green Deal will transform the EU into a modern, resource-efficient, and competitive economy, ensuring:

- no net emissions of greenhouse gases by 2050
- economic growth is decoupled from resource use
- no person and no place is left behind.

Against the backdrop of a rapidly changing and constantly developing energy landscape, clean and renewable energies form a cornerstone of the transition to decarbonising economies and promoting sustainable development. Clean energy provides not only a way to decarbonise our energy system but also to embed resilience and dynamic response into the system, while developing local industry and ensuring responsible consumption. These benefits range from developing greenfield industries like hydrogen to training and employing solar technicians to deploying community-driven microgrids ensuring reliable and affordable energy supply. Energy also underpins most other sectors, including transport, agriculture, and industry. As such, clean energy provides a mechanism through which to drive the multiplier effects of decarbonisation beyond just the energy sector.

Decarbonising existing energy systems, developing innovative new solutions, and improving energy efficiency are all critical to achieving the ambitions of the Green Deal. The clean energy transition will need new approaches, revolutionary technologies, and renewed paradigms for planning and implementing these. Digitalisation in particular holds immense promise to serve as a catalyst for enabling the technologies and delivery models needed to support the transition to clean energy. As a case in point, smart grids based on digital systems are much better for the integration of distributed energy resources (DER)[1] or dynamic load balancing, for example shifting consumption to times when energy prices are lowest.

In line with these requirements, the EU is developing policies to support the clean energy transition. The policy support packages discussed below provide an overview of the Green Deal Call clean energy projects that aim to develop, test, refine, demonstrate, and replicate these novel solutions. While the following list is not exhaustive, it provides a useful prefatory framework for the clean energy policy landscape.

1.1.1 Fit for 55

Fit for 55 is a package of policy initiatives under

[1] DER are local energy generation technologies which produce, store, and manage energy, oftentimes from renewable energy sources (RES) by integrating solar panels, small wind farms and battery storage systems.

the Green Deal that aims to reduce the EU's net greenhouse gas emissions by 55% by 2030. The package was released in two batches, in July and December 2021, and includes drafts of EU climate and energy legislation to underpin the EU's political pledge to cut greenhouse gas emissions by at least 55% in 2030 compared with 1990 levels. This target, a more ambitious one than the previously agreed 40% reduction goal for 2030, is part of the EU's aim to become climate-neutral by 2050 – and to spur the rest of the world to act under the 2015 Paris Agreement to fight climate change.[2]

The Fit for 55 package is a major revision of climate and energy legislation and comprises a set of interconnected proposals that aim to achieve the following industrial objectives:

- to reduce reliance on fossil fuels including coal, oil, and natural gas
- to expand the use of renewable energy sources, including solar, wind, and hydropower
- to accelerate the development of electric cars
- to spur clean energy options for aviation and shipping.

Within these proposals is the revision of two major existing energy directives, namely the Energy Efficiency Directive (EED) to speed up the efforts to drive energy efficiency and the Renewable Energy Directive (RED) to promote and support the adoption of renewable energy sources.

1.1.2 REPowerEU[3]

REPowerEU is the European Commission's plan to end reliance on Russian fossil fuels by 2030. It was proposed in May 2022 in response to the challenges and disruptions resulting from Russia's invasion of Ukraine, with the following goals:

- **Saving energy**

Saving energy is a low-hanging fruit among interventions as it provides a cheap, safe, and clean option to reduce reliance on fossil fuel imports. Reducing or optimising demand by improving energy efficiency is also a prudent undertaking before investing in additional supply, as it usually complements clean and decentralised energy projects.

- **Producing clean energy**

A core part of the REPowerEU plan is accelerating the green transition and promoting significant investment in clean and renewable energy. Key achievements over the year to March 2023 have included generating, for the first time, more electricity from wind and solar than from gas, reaching a record new solar installed capacity of 41 gigawatts (GW), increasing wind capacity by 16 GW, and obtaining 39% of total electricity from renewables.

- **Diversifying energy supplies**

Diversifying Europe's energy supplies, and the infrastructure that supports those supplies, can improve the resilience of the energy system and help address high energy costs that result from economic and geopolitical shocks. Driven by the EU Energy Platform, diversification across sources of energy, technologies, and strategic partnerships has reduced EU gas imports from Russian pipeline gas from 41% in August 2021 to 9% in the same period in 2022.

1.1.3 Clean Energy for all Europeans

Under the Clean Energy for all Europeans Package, Europe has adopted the Renewable Energy Directive (RED), one of the world's most ambitious renewable energy policies[4]. The package combines a range of mechanisms across six categories, including increasing the energy performance of buildings, renewable energy, energy efficiency, governance and regulation, and electricity market design.

[2] *The 'Fit For 55' package at a glance – European Climate Foundation*

[3] *REPowerEU: affordable, secure and sustainable energy for Europe (europa.eu)*

[4] *directive_renewable_factsheet_0.pdf (europa.eu)*

1.1.4. EU Hydrogen Strategy[5]

The EU's Hydrogen Strategy and REPowerEU plan have put forward a comprehensive framework to support the uptake of renewable and low-carbon hydrogen to help decarbonise the EU in a cost-effective way and reduce its dependence on imported fossil fuels. The hydrogen strategy for a climate-neutral Europe was adopted in July 2020 and lays out a range of initiatives to support and scale the sector including a Hydrogen accelerator, a European Hydrogen Bank, and a Hydrogen Energy Network, among others.

1.1.5 Green Deal Industrial Plan and its reform of the electricity market

In February 2023 the Commission presented a Green Deal Industrial Plan to enhance the competitiveness of Europe's net-zero industry and support the fast transition to climate neutrality[6]. The framework will be complemented by the reform of the electricity market design[7], to make consumers benefit from the lower costs of renewables.

1.2 The research response to support the clean energy transition

With the aim of supporting and mainstreaming the policy transition towards clean energy, the Horizon 2020 call to support the Green Deal included a dedicated topic on clean energies. There is a clear need to transition to cleaner and more sustainable energy production, transport, storage, and consumption in both the European African contexts. To understand the motivation behind, and importance of, this transition, it is helpful to look at the main definitions and drivers of clean energy, as well as the range of initiatives that support the development of new approaches and technologies.

1.2.1 What are clean energy projects?

The clean energy projects funded under the Horizon 2020 Green Deal Call aim to develop solutions in land-based and offshore renewable energy production, large-scale hydrogen production, and the conversion of CO_2 emissions from industrial processes into synthetic fuels, and to accelerate the green transition in Europe and energy access in Africa. These projects are primarily focused on energy decarbonisation through the development, deployment, and continuous improvement of innovative technologies and their integration into the current energy system.

The Green Deal Projects Support Office[8] has clustered these projects together into a Clean Energy Working Group, with the aim of increasing coordination between them, fostering the creation of synergies among them, and facilitating wider communication of their impacts. This is being achieved through regular exchanges, networking opportunities, and the development and dissemination of communication materials and technical reports.

[5] Energy | Hydrogen (europa.eu)

[6] The Green Deal Industrial Plan: putting Europe's net-zero industry in the lead (Europa.eu)

[7] Electricity market design (europa.eu)

[8] The Green Deal Projects Support Office is a contract funded by DG-RTD to support the coordination and maximisation of impacts from the Green Deal Call projects through a series of joint activities that promote and disseminate synergies towards the generation of broader combined impacts. For more information visit the website: Green Deal Projects Support Office | Research and Innovation (europa.eu)

1.2.2 Rationale for clean energy

The Green Deal Call priority areas, and particularly the projects selected under the Clean Energy Working Group, share many objectives and design elements with the Clean Energy for all Europeans Package and other policies outlined in Section 1.1. Even projects that are Africa-focused incorporate core features from these policies, like strengthening knowledge and empowering citizens. Common characteristics evident from projects that support policy objectives include:

- **Reducing emissions**

The production and use of energy accounts for more than 75% of the EU's greenhouse gas emissions[9]. Buildings are responsible for around 40% of energy consumption and 36% of CO_2 emissions in the EU, making them the single largest energy consumer in Europe[10]. Transport, industrial processes, commercial activities, food cultivation, and many other daily activities also rely on energy consumption and in the process contribute to CO_2 emissions if energy is derived from fossil fuel sources.

Generating energy from sources that do not produce greenhouse gas emissions effectively decouples energy consumption from emissions, and allows households, businesses, and industries to use energy without having negative impacts on the environment or climate change.

- **Reducing reliance on imports**

In addition to reducing emissions, reducing or eliminating the EU's reliance on imports of energy and fossil fuels is a key priority in regard to ensuring the sustainability of the regional energy supply. The recent energy crisis in the EU[11], with unprecedented increases in energy prices and ensuing hardship for the region's citizens, has put into sharp focus the need for strong action towards achieving energy sovereignty.

The need for energy security and autonomy is similarly important in developing contexts like Africa, where transport and electric grid infrastructure is weak, supply chain disruptions are common, and energy poverty remains pervasive. In this context, renewables offer a feasible and cost-effective option for generating energy domestically, reducing the need for energy imports.

- **Improving accessibility and affordability**

Renewables are the cheapest and cleanest energy available and can be generated domestically and locally in most countries[12]. In Europe, the EU introduced the Clean Energy for all Europeans Package to address several elements of the energy equation. Intervention levers under the package range from improving energy efficiency and building energy performance to transforming governance and regulation and optimising energy market design, with the aim of making energy as available and affordable as possible.

[9] *Clean Energy | Research and Innovation (europa.eu)*
[10] *Clean energy for all Europeans package (europa.eu)*
[11] *EU action to address the energy crisis (europa.eu)*
[12] *Clean Energy Factsheet (europa.eu)*

There is also a clear need for systemic solutions that address accessibility and affordability challenges in Africa, particularly in Sub-Saharan Africa, where nearly half of the population currently lacks access to electricity[13] and lives in poverty. Cost-effective and fit-for-purpose clean energy technologies deployed in a manner that responds to unique local needs and operating conditions in developing areas are therefore critical to establishing sustainable energy systems in this region.

Fortunately, clean energy solutions like renewables become cheaper as production and installed capacity are increased, unlike electricity from nuclear and fossil fuels[14]. This means that the unit cost decreases as production increases. This is not to mention the social, environmental, and economic benefits of developing new, climate-friendly domestic industries. Investments to scale up energy production from renewable sources are therefore not only an opportunity to reduce emissions but also to achieve more economic growth – particularly for the poorest places in the world.

Conclusion

The Green Deal Call-funded clean energy projects promote and support the adoption and scale-up of clean energy technologies as well as faster electrification and replacement of fossil-based heat and fuel in industry, buildings, and the transport sector. The clean energy transition will help reduce energy prices, energy dependency, and greenhouse gas emissions over time, and will ultimately drive modern, sustainable energy infrastructure.

[13] *African Presidential Roundtable on Securing Africa's Universal Energy Access (worldbank.org)*

[14] *Why did renewables become so cheap so fast? – Our World in Data*

2 Digitalisation in the clean energy context

Digital tools, technology, and infrastructure increasingly underpin the energy systems we use today and will intrinsically determine the way we plan and deploy energy systems in the future. To effectively navigate the complex dynamics at the intersection of digitalisation and clean energy, we need a better understanding of several different dimensions. First, identifying the most critical gaps and needs, including knowledge, skills, and technologies. Secondly, taking advantage of current and emerging opportunities to better integrate digital solutions with clean energy technologies and maximise the mutual benefits of each. And thirdly, exploring and testing how transitional mechanisms can be incorporated into policies and programmes in Europe and beyond.

2.1 Introduction to digitalisation

In a world driven by technological advancement and ever-increasing complexity, digital integration is no longer a luxury reserved for first adopters and frontier technology companies. Rather, digital transformation and its effective integration form a critical part of most modern systems, including the energy system, all the way from energy generation through to energy governance. While digitalisation has long been seen as a necessary inconvenience, often perceived as adding undue complexity and points of failure, concerted digital reform and the appropriate application of digital tools hold immense potential for improving technological efficiency and accessibility. The benefits and potential gains from introducing digital tools and smart systems are set out in the next sub-section.

2.1.1 Benefits of digitalisation

- **Digital planning tools** are used to inform data-driven decision-making, optimise system design, and derive market design intelligence.
- **Digital platforms** streamline technical, financial, and social processes and coordinate a range of stakeholders within a pre-determined environment. Examples include technical fault reporting (e.g., power outages), raising investment (e.g., crowdfunding), and community engagement (e.g., enabling transparent energy consumption).
- **Digital operations** improve responsiveness and enable energy system optimisation while reducing operating costs. Solutions include real-time load balancing, time-of-use optimisation, early warning systems, and accurate load forecasting and response.
- **Digital payments** enable easy and efficient transactions between customers, energy service providers, and other actors. Consumers can pay for the energy they consume, adjust their consumption based on changes in energy prices, and even receive payment for excess energy sold to the community or the grid.

The need for a system-wide approach is clear, not only to maximise the benefits outlined above but also to ensure fair and effective integration, application, and distribution of these benefits. Information from digital operations can be used to inform subsequent digital planning. Digital payments improve the user experience on digital platforms. Improved digital access and reduced transaction costs enable even the lowest income groups to participate in the digital energy economy.

2.1.2 Digitalisation in the European energy context

The growing digitalisation of energy systems and the benefits it brings will be critical to achieving the ambitious climate and energy targets set out in the Fit for 55 and REPowerEU packages described above. The **Green Deal Call clean energy projects** already highlight many of these benefits, including network integration, load balancing, intelligent consumption, local integration of renewable energy, and efficiency gains through data insights and optimised system control. The Green Deal Call emphasises the importance of developing 'smart' energy systems to ensure they remain future-proofed and avoid premature obsolescence.

Smart systems are relevant for, and hold promise for, projects that require dynamic flexibility or seek to integrate variable energy sources. For example, **HYPERGRYD** is using data analytics and machine learning to forecast energy generation and demand to create a hybrid coupled network for thermal-electric integrated smart energy districts. **BioFlex-Gen** similarly uses a combined heat and power plant (CHP) system with hourly, daily, and seasonal flexibility through producing hydrogen from biomass. These examples demonstrate how digital tools can help increase flexibility and optimise energy consumption through the use of data, algorithms, and smart management systems.

Smart integrated systems also allow consumers who produce their own energy to respond to changing prices and to sell excess energy back to the grid. Moreover, smart energy networks enable market actors, including suppliers, energy communities, aggregators, and energy service companies, to offer innovative services, empowering consumers to adjust their consumption and to receive the benefits of grid flexibility. Governments and industry alike should seek to employ digitalisation to develop new levels of agility, flexibility, and insight, but be careful not to make any trade-off with efficiency, viability, and sustainability[15].

2.1.3 Outline of the EU digitalisation action plan

The ongoing European transition to clean energy demands simultaneous digital reform while also accelerating the deployment of clean energy technologies. To respond to this dual challenge, in October 2022 the European Commission adopted the Digitalising the energy system – EU action plan, a system-wide digitalisation energy action plan that aims to contribute to the EU energy policy objectives by supporting the development of a sustainable, (cyber)secure, transparent, and competitive market for digital energy services, ensuring data privacy and sovereignty, and supporting investment in digital energy infrastructure[16].

The action plan emphasises many elements which can already be seen in the planning and implementation of the Green Deal Call clean energy projects discussed in this report, including how new technologies can enable greater integration of renewables into the grid, optimise the use of energy, and reduce costs for consumers and companies alike. Examples include the following:

- Developing digital tools, digital twinning, and experimentation platforms which is being carried out by **HYPERGRYD's** Living Labs.

[15] *Digitalization is How Industry Gets Fit for 55, AspenTech, July 2021.*
[16] *Digitalisation of the energy system (europa.eu)*

- Promoting and optimising investment in infrastructure, as is being done by **EU-SCORES**, which is centralising hybrid offshore renewable energy plants, thereby concentrating interconnection infrastructure.
- Improving interoperability, as will be done through **GreenHyScale's** planned use of SymbiosisNet, a smart energy and data network that in the future will allow companies to share their surplus energy and resources.

The Digitalising the energy system – EU action plan further outlines a series of strategies and actions that demonstrate best practices, as well as national initiatives and successful projects. Figure 1 below provides an at-a-glance view of initiatives and support actions, alongside the timeline from research through to infrastructure, and the technology maturity level.

2.2 Research and innovation to support digitalisation of the energy system

Research and innovation are key to developing and deploying digital solutions for clean energy at scale[17]. Unlocking the benefits that digitalisation offers for the clean energy transition requires an exploratory yet systematic approach in order to test, refine, integrate, and optimise solutions across technical, economic, and social dimensions. Horizon Europe, the EU's Framework Programme for research and innovation following the completion of Horizon 2020, supports the development and integration of digital solutions in the energy system, to make it more efficient, resilient, and able to integrate a higher share of renewable energies.

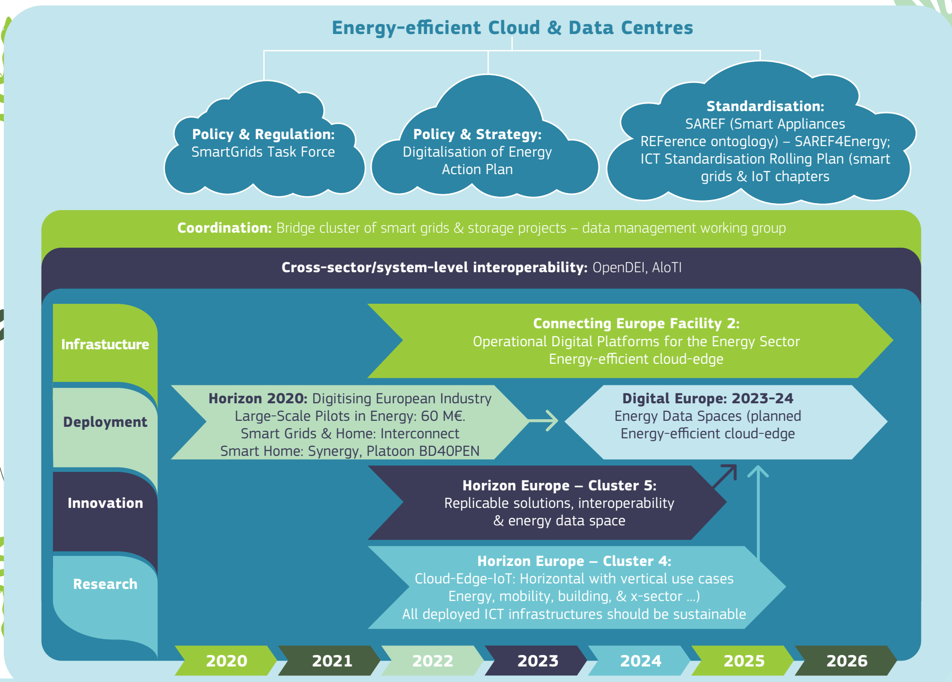


Figure 1: The Directorate-General for Communications Networks, Content and Technology (DG CONNECT) support actions for the digitalisation of the energy system. © European Commission

[17] *Research & innovation to support the digitalisation of the energy system (europa.eu)*

EMPOWERING CITIZENS TO PARTICIPATE IN THE ENERGY MARKET

Energy communities of energy-related citizens' organisations encourage consumers to have a direct stake in producing, using or sharing energy. The COMPILE project is creating a toolset to show the opportunities of remote areas or areas weakly connected to the grid (so-called energy islands) for decarbonisation of energy supply, community building and creating environmental and socioeconomic benefits. These opportunities will be demonstrated at 5 pilot sites.

A EUROPEAN DATA-SHARING INFRASTRUCTURE FOR NEW ENERGY SERVICES

Future energy grids will be more open and participatory, becoming the entry point fro new energy players. CoordiNet is taking the first steps towards a unified European electricity market platform that joins all parties across the entire electricity value chain – electricity carriers, distributors and consumers.

CLIMATE NEUTRALITY IN THE IT SECTOR

Most data centres consume almost as much electricity in their cooling systems as in their servers. At a typical data centre, about 40% of the electrcity is consumed by cooling systems. Data centres. use about 3% of Europe's electricity, and hence the impact on the environment is becoming a growing concern. The BodeTypeDC project has constrcuted, tested and validated a data centre that is both energy and cost efficient. It runs on renewable energy and relies on free air and evaporative cooling technologies without the need for refrigerants.

CYBERSECURITY OF THE ENERGY SECTOR

Digitalisation improves the saftey, productivity, accessibility and sustainability of energy systems, but it also brings new challenges for the sector, in particularr with respect to cyber security. The EnergyShield project has developed solutions to increase resilience against different types and levels of cyber and privacy attacks and data breaches, by adapting and integrating technologies for vulnerability assessment, supervision and protection in a defensive toolkit.

ENHANCING THE UPTAKE OF DIGITAL TECHNOLOGIES IN THE ENERGY SECTOR, AND PROMOTING THE MARKET UPTAKE OF INVESTMENBT IN RESEARCH AND INNOVATIONS

The EU aims to increase its offshore wind capacity from the current level of 12 gigawatts (GW) to at least 60 GW by 2030 and to 300 GW by 2050. Technology improvement and cost reductions are key to the rapid deployment of offshore wind capacity. The ROMEO project has delivered a decision support system to better understan the real time behaviour of wind turbine generator systems under operational conditions, maximising their life span and minimizing operations and maintenance costs.

Figure 2: Five key areas for EU research and innovation relating to digitalisation of the energy sector

Research & innovation to support the digitalisation of the energy system – Publications Office of the EU (europa.eu) [18]

Digitalisation is an ongoing process that is dependent on research and innovation that is rooted in iterative learning and continuous improvement. As digital tools continue to infiltrate the project and business lifecycles, from early-stage research and development through to implementation coordination and post hoc monitoring, reporting, and verification, the need for continued development is ever more critical.

To support this, since 2016 (and before the Green Deal Call) the Horizon 2020 programme has funded 11 research and innovation projects on this topic, for more than EUR 125 million. A thematic collection of innovative EU-funded research results can be found in the CORDIS Results Pack on the digitalisation of the energy system, which explores the results of EU-funded research projects that address five areas that are key to energy and digitalisation.[19] Digitalisation's potential to benefit the clean energy sector in Africa is equally promising, despite the fact that it will need to address a completely different set of challenges. Unlike in Europe, the challenges facing clean energy deployment and adoption in Africa relate mostly to a lack of energy access, availability, and affordability. With over 640 million people on the continent without any access to electrical energy[20], and millions more without access to reasonably reliable energy supplies[21], the need for, role of, and potential impact of clean energy technologies are substantial. Energy poverty in Africa also disproportionately affects certain groups, often including women, low-income households, and those in rural areas.

Digital clean energy solutions can help African countries and projects leap-frog conventional energy development trajectories and avoid carbon-intensive development. Improved operational efficiency, increased system flexibility, and enhanced resilience are just some of the benefits of digitalisation that can help tip the economic balance of energy projects in Africa over the viability threshold. Similarly, digital tools like mobile payments, remote customer support, and system monitoring through smart meters can also increase transparency and drive social acceptance of new technologies, thereby enabling adoption at scale.

The experience of **REFFECT AFRICA**, which is developing sustainable energy solutions based on the valorisation of biomass waste from agriculture and the food industry, provides two notable examples of digitalisation in action:

- a digitally integrated data system that allows researchers to receive results from biomass tests at the demo sites in real-time remotely
- an experimental marketplace app that will match the demand for feedstocks and potential local suppliers

Digital tools enable a range of institutional stakeholders, like investors, governments, and development finance institutions, to streamline policy and planning processes. Recent leaps in digital capability now allow quick and easy integration of actionable insights, from least-cost electrification planning in countries with limited electric grid access to data-driven risk assessment that eliminates the need for complex and expensive investment due diligence. Figure 3 below summarises the utility and impact of specific solutions for a range of sector stakeholders in the African context.

[19] *Digitalisation of the energy system (europa.eu)*

[20] *Light Up and Power Africa – A New Deal on Energy for Africa | African Development Bank (afdb.org)*

[21] *John Ayaburi, Morgan Bazilian, Jacob Kincer, Todd Moss. "Measuring 'Reasonably Reliable' access to electricity services." The Electricity Journal, Volume 33, Issue 7, 2020, 106828. ISSN 1040-6190, https://doi.org/10.1016/j.tej.2020.106828.*

Solutions / Users	Digital planning	Digital platforms	Digital operations	Digital payments
Governments and DFIs	Electrification planning Tender preparation	Tender management Quality assurance	Data on industry performance (indirectly)	Data on industry performance (indirectly)
Investors and banks	Due diligence Strategic financing	Aggregation Due diligence Results-based finance	Due diligence Results-based financing	Due diligence Results-based financing
Mini-grid companies	Site identification Project aggregation for investors Impact measurements	Standardised reporting Access to funding	Lower operating costs Input for future system design	Lower operating costs Less fraud
OGS companies			Lower operating costs Input for future product design	PAYGO business model Lower operating costs Less fraud

Scalability   Cost reduction   Risk reduction

Figure 3: Possible impacts of digital solutions on energy access in Africa[22]

Africa's enabling environment for digital-enabled clean energy is steadily improving, yet there remains a need for concerted action and support. With promising policy reforms, a wealth of clean energy potential, and, more recently, a rapidly developing digital ecosystem, the continent is well-positioned to leverage the dual development symbiosis of energy and digital infrastructure. Large projected increases in population, urbanisation, and income are set to increase energy demand by a third between 2020 and 2030. However, without the digital tools to scale the deployment and decrease the costs of meeting this demand with clean energy sources, there is a real risk that decision-makers will revert to conventional carbon-intensive options. Projects that promote cooperation and frontier innovation, like those discussed in Section 4, are therefore vital in order to drive the global clean energy transition.

[22] *"Energy access, data and digital solutions", TFE Africa, 2020.*

3

Opportunities and challenges of clean energy projects, and potential response strategies

Clean energy, and the digital development that underpins it, offers a range of benefits and opportunities; however, several challenges remain that can impact the effectiveness of its implementation. With careful consideration and planning, many of these challenges can be effectively mitigated and most of the opportunities can be unlocked. This chapter highlights some of the most difficult challenges faced by the cohort of Green Deal funded clean energy projects, and discusses mitigation strategies, including those that rely on digital tools and infrastructure.

3.1 Common challenges among the Green Deal Call clean energy projects

3.1.1 Energy system integration remains a challenge for many projects due to complexities at the technical, organisational, and regulatory levels

Energy system integration (ESI) is the process of coordinating the operation and planning of energy systems across multiple pathways and/or geographical scales to deliver reliable, cost-effective energy services that have minimal impact on the environment[23]. Barriers to effective ESI vary widely, depending on the technology and local operating context, though most relate to the following issues:

- Grid interconnection or feed-in is simply not allowed, as is the case in non-liberalised energy markets or vertically integrated and monopolistic utilities.
- Authorities lack appropriate application procedures and technical standards, limiting the ability of energy suppliers and prosumers[24] to supply energy to the grid.
- Complex coordination and burdensome bureaucracy increase costs and cause delays, which erodes the feasibility of projects, especially during the development stages.

The importance of ESI is recognised globally and forms a central theme of the European Commission's Strategic Energy Technology (SET) Plan. ESI is critical to achieving a low-carbon energy system with affordable, efficient, and secure supplies of energy.

Mitigation strategy

Creating an environment in which system integration serves as an enabler rather than a barrier requires stakeholders to understand the value, applications, and impact of system integration. In order to create this understanding there is a need for concerted effort to do the following:

[23] *Energy Systems Integration: Defining and Describing the Value Proposition (nrel.gov)*
[24] *Prosumers refers to energy consumers that generate their own energy and can sell excess energy.*

- **Communicate the importance of ESI to all stakeholders**

Effective communication that highlights the significance of integration will help focus attention and resources on related challenges and opportunities across different levels, from households to communities to the national grid, and throughout project lifetimes. Part of the communication strategy should include identifying and emphasising the benefits of robust integration, such as unlocking additional revenue from grid feed-in or improving the security of supply by diversifying energy sources.

- **Encourage and support dedicated education programmes to help produce the human resources that are required to deliver on the potential of ESI**

Developing internal capability, and deploying this capability throughout the project planning and implementation stages, will ensure design decisions are made with ESI in mind. A proactive approach to ESI-related education and capacity building requires that a range of DER technology options be considered, and that technical and operational configuration can be easily optimised. A case in point is the SESA project, which will develop a course titled Smart microgrid and system integration, that will be available on its platform for capacity development.in early 2024 alongside five other courses.

- **Highlight the importance of breakthroughs in ESI and promote knowledge creation and transfer.**

The extent to which energy systems can be successfully integrated does not depend only on one energy system or project, but rather on all the systems in a network, up to and including the grid network itself. Therefore, understanding the context-specific enabling elements of the network makes it possible to better plan for and execute integration strategies. Important enabling elements include regulatory, financial, and technical factors.

Because many of these factors tend to change over time it is useful to stay abreast of developments. For example, new regulations or mass rollout of smart meters can dramatically improve the ease with which energy systems can be integrated with one another. Remaining vigilant and sharing successes with peers and other participants in an energy system can thus help drive ESI, and therefore clean energy adoption.

Integration-related knowledge sharing is neatly exemplified by **HYPERGRYD's** forthcoming output Regulation Inventory and Guidebook to a Proper Grid Integration, that can serve as a guide for subsequent projects.

3.1.2 As projects develop, financing needs will change, due to the changing risk return profile of a project at different stages of development

Projects often struggle to raise the follow-on funding that is needed to bridge the financing gap between early-stage development and the growth and commercial stages. As projects progress through the development cycle, from early-stage concept to full commercial solution, it is imperative to find and structure finance appropriately. This means balancing large, occasional capital expenditures like machinery and buildings, with smaller but regular operating expenses like salaries and overheads.

Seed funding usually provides an initial capital injection to kickstart the project and provides a sufficient runway to develop a proof-of-concept. The proof-of-concept, in turn, can be used to raise follow-on funding from investors to support continued development and upscaling. The more developed a project is, the higher its chances of success, the less risky it becomes, and the more likely investors are to invest.

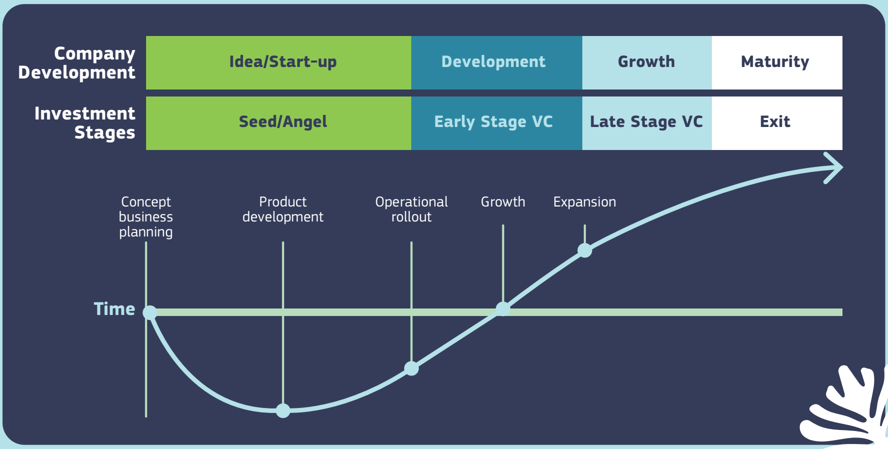


Figure 4: Funding requirements throughout the project development cycle

The factors underpinning the challenge of obtaining follow-on funding include the following:

- **Many strong projects are competing for limited pools of capital.** Clean energy projects using complex technology usually have high capital requirements and long timelines. This may deter risk-averse investors, who usually prefer a lower investment quantum and quick payback periods on their investment. At the same time, clean energy projects are competing with a wide range of sectors, companies, and geographies, all chasing a limited number of funds. Even with initial seed funding like that provided through the Green Deal Call, without additional investment or sufficient revenue projects struggle to finance their operations, development, and eventually upscaling.
- **Long timelines that are sometimes misaligned with financing requirements.** Due to the technical complexity of many innovative clean energy projects, it can take several years to develop a working prototype or to achieve proof-of-concept. As a result, early-stage seed capital may not be enough to cover costs over such a long period, and follow-on investors might be hesitant to invest before seeing a functional model. This risks funding drying up before key milestones are reached and greatly jeopardises the project's chance of success.
- **Financial requirements change as projects develop.** Balancing financial outflows with the appropriate incoming investment, in terms of size, type and timing, is difficult but is critical to the successful implementation and operation of clean energy solutions. For example, early-stage projects may need to invest heavily in hardware while making do with only a core team. This means high capital expenditure, which can be financed through a loan and repaid over time, and low operating expenditure. Conversely, a project in the growth stage may need to undertake rapid recruitment to meet the increase in workload. More employees will significantly increase the project's operating cost base, but at this stage the project should be generating some revenue that can help cover these additional costs.

Mitigation strategy

Solving the financial equation of any project is often the most challenging – but also the most critical – part of ensuring effective implementation and long-term sustainability and impact. Raising investment is further complicated by a rapidly evolving energy landscape in both Europe and Africa, and is exacerbated by the complexity of frontier technologies. However, some proven principles can help projects better mitigate and navigate these challenges, such as the following:

- **Match the structure and timing of funding to the project needs at that stage**

To do this, it is important to understand the types of finance that are available and appropriate at each stage, as well as the likely implications each have for the project. For example, grants are usually low risk as they don't need to be repaid like loans but they may involve strict reporting requirements. Equally important is to plan timelines appropriately, noting that funding applications and associated due diligence processes can take months or even years. For example, **EU-SCORES** experienced deliverable delays due to restructuring and due diligence proceedings when preparing for an equity funding round, but ultimately succeeded in creating an optimal financial structure for its purposes.

- **Diversify financial resources leverage by leveraging partnerships and positive climate impacts**

To mitigate the risk of financial shortfall and resultant disruptions it is prudent to develop a robust resource base from which funds can be withdrawn as and when needed. In addition to innovation funding, such as Horizon 2020 and Horizon Europe grants, a wide range of types and sources of financial resources are available that can be tapped over the different phases of project development. These include research grants paid to academic partners for research and development (R&D), private commercial investors, ranging from early-stage venture capital to infrastructure-focused pension funds, to impact investment supporting climate-positive outcomes.

Non-financial support like technical assistance or contributions in kind can also free up financial resources that can be reallocated to more capital-intensive activities. Similarly, many support programmes like the Green Deal Projects Support Office provide targeted tools and advisory services to help projects and companies access finance. **Bio-FlexGen** provides a great example: to maintain its development and operations it partners with several universities across Europe, and taps into co-financing from private investors.

- **Focus on transparency, efficiency, and robust financial management**

Employing strong financial controls and following best practice management principles creates a robust financial operating system and signals to investors a project's ability to attract and effectively deploy investment. Other useful protocols include developing a financial management plan, maintaining a contingency fund for use in the event of unforeseen expenditure or cost overruns, embedding sufficient redundancy to account for possible system failure, and ensuring adequate financial controls are in place (e.g., requiring sign-off from various partners to approve large expenses).

Financial efficiency and reporting are also critical elements that can cause serious concerns if they are neglected and that can play a pivotal role in gaining investor confidence and accessing finance if they are done correctly. Financial efficiency refers to how successful a project is at turning expenses into revenue or results. Tracking and reporting financial performance demonstrates a project's ability to manage and deploy resources effectively. This is closely linked to transparency: the practice of sharing financial information with stakeholders including funders and partners. All of these processes can be significantly improved by using appropriate accounting or other software to minimise costs and enable coordination among stakeholders.

The **SophiA** project demonstrates this well. It initially considered using a financial management platform before deciding to opt for a more streamlined option to minimise cost and ensure compatibility with the developing context of its pilot sites. Financial reporting is done internally every six months when the project budget is transparently shared among all partners, including details on how the budget was spent between partners and activities.

3.1.3 Deploying sophisticated data management systems despite limited data availability, and without adding undue complexity

Smart and digital systems operate on the principle of intelligently responding to inputs, whether that means dynamic responses to changing weather conditions, real-time energy load balancing or automated payment for solar energy fed into a smart grid. However, in many cases, the input data needed to program the algorithms that govern the system's intelligent response is imperfect or does not exist. In other cases, available datasets and the suite of analytical tools that underpin them may be so vast and complex that deriving meaningful insights from them becomes unmanageable or even impossible. This is particularly true for legacy systems where the back-end data control process was developed iteratively and reactively to meet the needs of the project, rather than being holistically and proactively embedded into project design.

Mitigation strategy

The task for project proponents is, on the one hand, to overcome the challenge of inherently scarce or imperfect data, and, on the other hand, to develop fit-for-purpose digital solutions that are able to leverage the desired benefits of digitalisation without overcomplicating project operations. Striking this balance is not easy, yet the integration of digital systems and the effective use of data-driven insights can mean the difference between success and failure. How data is captured and used by digital systems can be highly context-specific and needs to be tailored accordingly. The following principles offer practical mitigation mechanisms to help overcome the challenges of imperfect early-stage data while ensuring system simplicity:

- **In a data-scarce environment, infer insights from proxy datasets**

Early-stage projects may not have a robust dataset upon which to base design decisions. In such cases, it may be necessary to rely on proxy datasets that provide a starting point for design parameters. Parameters can then be refined over time as more accurate information becomes available.

A case in point is the **SophiA** project. Since on-site solar measurements and relevant meteorological data were not available for the sites selected in the project, data from three different global climate databases (Meteonorm 8, PVGIS, and POWER NASA) was considered. Comparisons were made to obtain reliable information for the design of the SophiA systems.

- **Continue optimisation efforts through using feedback loops and as more data becomes available**

The ease and expediency of digital systems mean that feedback loops can be introduced in near real-time and with limited human involvement. This allows for rapid fault detection, dynamic response to system changes, and performance monitoring. Critically, short feedback loops that are rooted in accurate data allow continuous optimisation by adjusting operating configuration (which can often also happen remotely) and measuring input and outputs.

One example is **REFFECT AFRICA**, which uses digital tools to monitor the quality of biomass feedstock and to allow researchers access to receive results from tests at the demo sites in real-time remotely.

3.2 Opportunities to leverage digitalisation in support of clean energy technologies

Despite the challenges and the need for mitigation efforts, digitalisation, and the capabilities it unlocks, hold immense potential for streamlining planning and operations, driving down costs, and enabling rapid iteration and course correction. Better insights also mean inefficiencies can be minimised and redundant costs can be cut. Finally, well-designed digital systems mean decisions can be made based on robust data and the impacts of decisions can be tracked much more accurately, both in real time and over months and years.

Digital tools and smart energy systems also enable solutions to scale much more rapidly. Analytical tools primarily based on software and open-source data can be replicated almost infinitely with low or no marginal costs.[25] For example, an app can be downloaded by 10 or 100 or 1,000 users without adding to the cost of creating the app. Similarly, an integrated smart electricity grid can allow any user with a smart meter and generating capacity, such as a solar panel on the roof, to connect seamlessly and feed electricity back into the grid. Couple this with an automated digital payment system, and the user can receive income for energy generated by the solar panel as the sun shines.

The following subsections share highlights and examples of opportunities from the emerging clean energy digital evolution.

3.2.1 Digital systems for social and environmental monitoring

One defining feature of digital systems is their ability to capture, process and analyse large volumes of data. As a use case, this capability is indispensable when trying to monitor progress or evaluate impacts in complex interconnected systems like local marine ecosystems or socio-economic changes for a certain region.

Datasets generated by tracking large volumes of data over time can be interpreted by intelligent algorithms like those increasingly used by machine learning and artificial intelligence to derive meaningful, actionable insights. Moreover, the more high-quality data we have, the better these algorithms become at tasks like predictive fault detection and maintenance, smart grid integration, and load optimisation.

EU-SCORES is an excellent case in point: it uses digital tools to conduct a baseline characterisation of marine mammal communities, through visual and acoustic surveys, as well as to characterise the existing ambient noise. The project's aerial monitoring campaign, which seeks to provide data on the bird, marine mammal, and other marine megafauna populations, is ongoing.

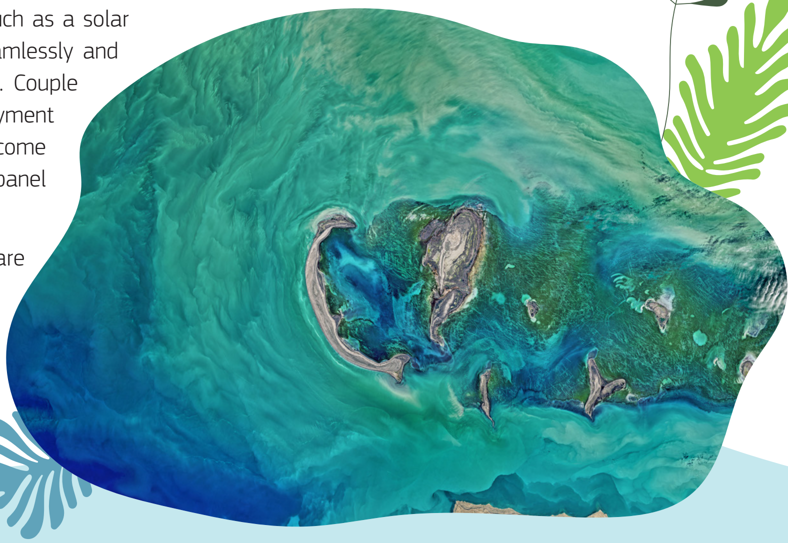


Figure 5: Aerial picture of marine algae[26]

[25] *Marginal cost is the cost added by producing one additional unit of a product or service.*

3.2.2 Impact demonstration

Similarly, digital data and analytics are key to measuring and communicating impact. Robust empirical data helps researchers and innovators better understand the dynamics between energy and natural systems, and their relationship with consumers. For example, commercial energy consumption can be shifted to times when renewable energy is abundant and prices are low, thereby reducing the need for storage. Data is also a powerful tool for storytelling, through its ability to capture and convey the real-world impacts of projects like those under the GDC to policymakers and the wider public.

3.2.3 Coordination and transaction across producers, consumers and other stakeholders

Enabling stakeholders to interact in myriad meaningful ways is another key feature of digital transformation. Digital platforms allow a wide range of participants to coordinate and collaborate with one another, while blurring the lines between energy producers and consumers (collectively 'prosumers') and other stakeholders. They also create a mechanism for instantaneous financial transactions and even microtransactions, without third-party intermediaries and therefore at very low costs.

HYPERGRYD offers an example of this: its goal is to develop a system for smart energy exchange and trading in local energy communities. Using digital-enabled technologies, the project plans to create local grid-aware energy (electricity and heat) marketplaces, interfacing with grid operators and energy assets (generation and consumption) to facilitate automated and decentralised peer-to-peer transactions.

Similarly, **REFFECT AFRICA** plans to develop an app-based digital marketplace to create a circular trade system that allows agricultural and food producers to 'sell' biomass in the form of waste or by-products, and to 'buy' biochar products which can be productively used in farming or food production processes. Being app-based will make the marketplace accessible to many people as it will be able to be downloaded freely and will allow dealmaking to happen without the need for travel or undue transport of goods.

3.2.4 Insights and flexibility for increased sustainability

As more energy systems become digitised and the use of data becomes more standardised, systematic integration between various systems and processes will become increasingly robust and streamlined. Data sharing between projects will become commonplace, and projects that take a data-centric approach will have a competitive advantage by being able to leverage existing tools and services to drive their solutions. Data from apps that allow users to observe and regulate their energy consumption will help inform system sizing if they ever decide to install solar panels or battery storage. Service providers will be able to easily connect these user smart meters to district heat and energy systems, which will allow them to feed excess energy back into a local smart grid, while automated payment will ensure fair and accurate tariff billing.

Technological tools like apps and platforms, through user interfaces and experiences, also help to retain engagement and raise awareness. Improving engagement and fostering a sense of ownership helps to catalyse and drive not only acceptance of clean energy but also active adoption, as well as initiatives like energy communities. Deploying clean energy at scale requires projects to be scalable and replicable, which will not happen without the digital tools and infrastructure needed for upscaling.

4

Examples of Green Deal funded clean energy projects

Several of the Horizon 2020 Green Deal funded projects are using digital solutions to overcome a number of challenges and barriers across the project lifecycle. From early-stage R&D to mid-stage implementation through to commercialisation and replication, the projects' creative use of digital technologies demonstrates the role these technologies can play as key enablers underpinning technical, economic and social project components. The challenges the projects face, which have prompted them to develop different strategies and formulas to address them, also highlight the opportunities for and barriers to research and innovation identified by the project coordinators.

This section presents some of the Horizon 2020 Green Deal funded projects that are leveraging and deploying digital tools, not only to address many existing implementation and monitoring challenges but also to innovate new models for delivering clean energy.

HYPERGRYD

HYPERGRYD is developing, piloting and building hybrid coupled networks for thermal-electric integrated smart energy districts. Developing Smart Energy Grid solutions empowered by new ICT tools and services is the key for the evolution towards the digitalization of these networks. These innovative tools are designed to improve planning and optimization of the districts. One of the targets consists of creating a 'digital twin' of these energy districts which will enable HYPERGRYD to simulate the system and validate its functioning, while dynamically integrating a range of data tools and techniques, as described below. Also, the focus will be on creating modelling tools to enhance assessment, alongside creating a specialized tool to enable energy exchange and trading within LECs.

Digital innovation and enablers

Other digital innovations include the design and development of a HYPERGRYD platform that utilises smart systems that include:

- •data analytics and artificial intelligence for predictive anomaly detection and suggesting preventive maintenance in supply and distribution.
- data analysis and machine learning tools to forecast energy generation and demand.
- an open API[26] to enable market-aware demand response management with self-adapting trading strategies.
- internet of things-enabled sensing technologies that allow real-time remote access and monitoring for modelling, control and optimisation.

[26] *API stands for Application Programming Interface and refers to a set of rules and protocols that allow different software programs to talk to each other and share data or functionality.*

Bio-FlexGen

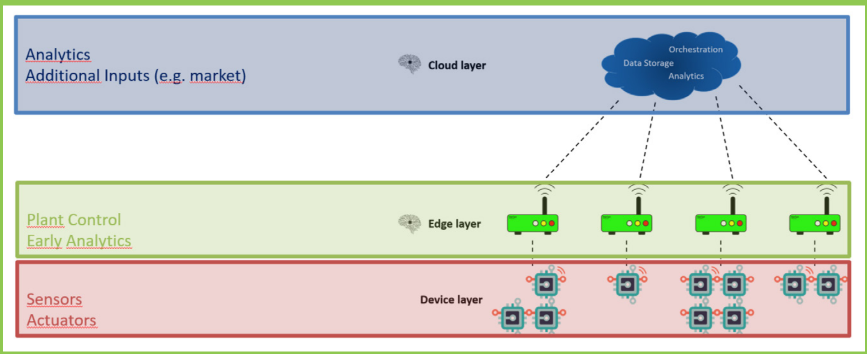
Bio-FlexGen is an acronym of the detailed project description: Highly-efficient and flexible integration of biomass and renewable hydrogen for low-cost combined heat and power generation to the energy system. The project is developing efficient and flexible integration of biomass and renewable hydrogen for low-cost CHP generation to the energy system. It seeks to develop a CHP system with hourly, daily and seasonal flexibility through producing hydrogen from biomass. This includes the flexibility to switch from CHP mode in winter to hydrogen production when needed.

Digital innovation

The digital infrastructure that supports Bio-FlexGen's solution is built around a three-layer architecture which connects device, edge and cloud layers, as demonstrated in Figure 6 below.

- The device layer will collect the variables from sensors and the setpoints for the actuators and send them to the edge layer.
- The edge layer is where the plant may be controlled and can carry out some early analytics if required. It will also communicate with the cloud.
- The cloud layer will incorporate additional I nputs, such as market data, which may be used for more advanced analytics and decision-making.

This digital architecture allows for on-demand digital optimisation, and when combined with appropriate hardware and biomass feedstock means that the plant can flexibly and efficiently generate four different products for the broader energy system or industrial applications: electricity, heat, hydrogen and/or CO_2.



EU-SCORES
European Scalable Offshore Renewable Energy Sources

EUROPEAN SCALABLE OFFSHORE RENEWABLE ENERGY SOURCE (EU-SCORES) is a demonstration project that seeks to demonstrate the combination of offshore wind with wave and offshore solar photovoltaic energy. The project aims to pave the way for bankable multi-source offshore parks across Europe by 2025. These multi-source parks will use offshore space more efficiently and will balance the electricity grid to achieve a resilient and cost-effective 100% renewable energy system.

Digital innovation

Developing an offshore energy supply system that integrates a combination of wind, solar and wave energy sources require a myriad of diverse yet connected systems that all work in tandem. With the use of digital tools, EU-SCORES has achieved the following:

- Undertook a levelised cost of energy (LCoE) baseline assessment for wave and solar energy to demonstrate the benefits of co-location of hybrid projects and support a number of business cases. The analysis was done using Exceedence financial analysis software (ExFin). Currently ExFin allows for four different types of project configurations: offshore/on-shore wind farms, tidal farm, wave farm, or a combination of any of the first three technologies.
- Conducted a wind, wave, and solar resource assessment using open-source coarse data, primarily using the ERA5 dataset which spans the 30 years between 1990 and 2020 over the entire Europe covering the region between 30° N to 69.9° N, and 19° W to 41.9° E.
- Performed a baseline characterisation of marine mammal communities, through visual and acoustic surveys. The project will also employ a high-resolution digital video monitoring system to monitor of animal population size, density, seasonality, etc., along with other information, such as bird flight heights, sex, age, and activity.
- Demonstrated the powering of an island system with 100% renewables in the Maldives using the EnergyPLAN model, including manual iterative optimisation of costs. This demonstration provides a unique opportunity to refine and integrate lessons into the EU-SCORES project.

SMART ENERGY SOLUTIONS FOR AFRICA (SESA) is a collaborative project between the EU and nine African countries (Ghana, Kenya, Malawi, Morocco, Namibia, Nigeria, Rwanda, South Africa and Tanzania) that aims to provide energy access technologies and business models that are easily replicable and that generate local opportunities for economic development and social cohesion in Africa.

These solutions will include decentralised renewables (solar photovoltaics), innovative energy storage systems, including the use of second-life electric vehicle batteries, smart micro grids, waste-to-energy systems (biomass to biogas), climate-proofing, resilience and adaptation, and rural internet access.

Digital innovation

The project's digital strategy includes the following elements:

- Providing rural internet access coupled with e-learning opportunities, through SESA wireless information spots ('InfoSpots').
- The utilisation of data and data tools for internal project planning and management, including a data management plan, a data storage repository, and a toolbox for ensuring efficient and sustainable energy use, from which insights can be drawn in regard to supporting the replication and upscaling of initiatives.
- Developing as part of its capacity building plan a dedicated course titled "smart microgrid and system integration" to teach communities what smart energy technologies means and how to adopt and deploy them in their context.

THE SUSTAINABLE OFF-GRID SOLUTIONS FOR PHARMACIES AND HOSPITALS IN AFRICA (SOPHIA) project provides sustainable off-grid energy supplies and clean drinking water for rural and remote health facilities in Africa by deploying containerised solutions using natural refrigerants, solar thermal energy, and photovoltaics.

Digital innovation

The harsh operating conditions of rural Africa and the lack of local data creates a need for creative digital solutions. These include the following elements:

- Seasonality and solar irradiance analysis of weather data to assess daily solar irradiance, hourly maximum temperature, daily maximum precipitation, and annual energy yield – to inform system design and specifications.
- Implementing a smart and robust control system that integrates real-time weather forecasts to optimise charging and storage using an energy management algorithm.
- Designing and demonstrating a smart yet low-cost Internet of Things-based control system for water treatment processes to produce safe and cool drinking water, as well as soft water and steam for facilities.

REFFECT AFRICA

RENEWABLE ENERGIES FOR AFRICA: EFFECTIVE VALORIZATION OF AGRI-FOOD WASTES

Renewable energies for Africa: Effective valorisation of agri-food wastes **(REFFECT AFRICA)** is developing reliable and adapted sustainable energy solutions based on the valorisation of biomass waste from agriculture and the food industry through biomass gasification. In doing so the project is developing renewable energy sources and providing solutions for on-grid and off-grid communities, and their integration into the existing energy system. It also aims to close the water-energy-food loop by redistributing biochar – a by-product of the gasification process – back to farmers and food producers to be used in their processes.

Digital innovation

- Remote monitoring and quality management of water testing facilities that allows researchers access to results from tests at the demo sites in real time. This short feedback loop also allows for early detection, rapid response to problems, and rapid iteration of solutions.
- Programming and testing a marketplace app that will match the demand for feedstocks and the potential local suppliers, creating and organically growing market for waste products.

5 Summary and conclusions

Digitalisation is enabling a wealth of new technologies, operating models and social innovations that continue to drive the global transition to clean energy. Digital tools have become indispensable across the energy value chain, from early-stage R&D of new component materials to revolutionary new implementation methods through to remote system management and post hoc environmental monitoring. The benefits of digitalisation for increasing efficiency, reducing costs, and diversifying our sources and uses of energy are proven, as demonstrated through the Green Deal funded clean energy projects presented here. Moreover, these benefits – and critically their impacts – will continue to improve and shape our energy systems as the technologies and the solutions we build around them develop.

Digital transformation is at the core of the energy transition, yet it is not without its challenges and risks. Digital technologies are inherently complex, involving the computing of thousands or even millions of bits of data in nanoseconds and connecting millions of devices globally. They are also increasingly employed in energy systems and other spheres of infrastructure, from security to communications and finance. Because they are both complex and critical, it is imperative to ensure digital technologies function as intended and maintain the stability of the societies that depend upon them. It is for this reason that initiatives like the Green Deal Projects Support Office support pioneering energy projects and help them develop within an ecosystem of learning, integration, and collaboration. Documents like this one that shed light on common challenges and proposes shared solutions do so in the spirit of a coordinated approach to problem-solving.

There is an ongoing debate about whether modern technology can be considered neutral. Some claim the use of technology requires human action, which itself is never neutral, while others argue that technology itself is always neutral and depends upon human intentionality for its ordering and purpose. How this applies to digitalisation and energy, and particularly clean energy, is worth reflecting upon, as these systems are so intrinsic to our daily life. From reading the news to buying or cooking food, there are very few things we don't use energy or digital tools for. What is clear, however, is that as much as we shape technology, technology also shapes us. When we design and build our energy systems, we are also building the world we will live in, and by extension defining the impact it will have on ourselves. When we build them it therefore makes sense to build our energy and digital systems to be as clean and sustainable as possible.

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This report explores the critical linkages between clean energy technologies and the digital tools and systems that underpin so much of the innovation in the sector. It highlights the opportunities, drivers, and challenges of digitalisation in the context of the clean energy transition and discusses practical strategies and actions from selected Green Deal Call Clean Energy Projects to address these. Finally, the report presents a set of principles, insights and lessons for cross-integration for developing and implementing clean energy projects across Europe and Africa.

Studies and reports

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