INNOVATION STRATEGY 2024 - 27

Transforming challenges into opportunities

December 2023

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FOREWORD

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Loïc Tilman,
Head of Innovation at Elia Group

Global events over the past three years have caused disruptions across society, including the European gas and electricity markets, leading to extreme energy prices. These events occurred at a time of great transformation for the energy sector. Indeed, the energy transition is entering a new phase: one in which all areas of the energy landscape are shifting at a phenomenal speed, with changes ranging from the growth in renewable energy and phase-out of nuclear power through to the decentralisation of energy sources. New futures are consequently being shaped for transmission system operators (TSOs).

To achieve our goal of providing an energy system that is sustainable, secure, and affordable, business as usual is not the answer. The scale of the challenges we are facing requires us to quickly adapt our ways of working, upgrade the technologies we use, and modify our processes. We must act now to ensure the energy transition is a success.

In addition to working with partners from across the energy sector, innovation will be key for successfully navigating the disruptions, challenges and shifts mentioned above. It is innovation that will allow us to transform these into opportunities for society - opportunities that will ensure that we reach net zero in time. We view innovation as a mindset which must be embedded across the whole of our organisation, opening doors to more effective processes, products, and ideas.

With this in mind, Elia Group has developed this Innovation Strategy. It aims to give stakeholders a holistic view of external trends and their impact on our mandate. This document outlines our strategy for the next regulatory periods which will affect our TSOs in Belgium (2024-27) and Germany (2024-28). It describes each of the innovation areas we are working on in line with the latest developments in the energy sector. In addition to outlining our priorities for the next few years, we are also cultivating a network of internal and external innovators who will help to transform Elia Group and prepare it for meeting the challenges ahead.

We look forward to receiving feedback from our readers and are keen to hear from organisations who want to partner with us in future.

I hope you find our strategy to be insightful and inspiring.

Loïc Tilman,
Head of Innovation at Elia Group

1. THE CONTEXTS IN WHICH WE OPERATE

1.1 Why we innovate

As the owner of two TSOs in Belgium and in Germany, Elia Group provides society with a robust electricity grid, ultimately supporting socioeconomic prosperity. We ensure that the production and consumption of electricity are balanced around the clock, supplying over 30 million end users with power.

Since our grid forms the backbone of the Belgian and German electricity systems, we are also a driver of the energy transition in both countries - and Europe more widely. We are helping to meet social, political, and economic goals by integrating increasing amounts of renewable energy into the system, supporting the latter as it gradually encompasses smaller, more dispersed, and localised energy sources. In doing so, we aim to address the three dimensions of the energy trilemma: sustainability, security, and affordability.

This task is no easy feat. Its difficulty is well expressed in the German word '*Energiewende*'. Literally translated, the expression means energy turn, or turnaround, making the challenges linked to the transition quite explicit: we must turn away from current methods of producing and consuming energy towards a drastically different way of working. This drastic change is putting a great deal of pressure on the existing system, which must keep evolving if it is to continue serving society's needs. The system and our role within it are becoming increasingly complex, requiring us to consider trends such as the acceleration of electrification, the move away from fossil fuels, the rise in prosumers and the difficulty of obtaining local acceptance for the construction of infrastructure. Building the system of the future is therefore an intricate process that requires us to completely rethink the way we develop and run it, to be flexible, to be open to learning and collaboration, and to be innovative.

We consider innovation to be crucial for transforming the challenges we are facing into opportunities. It is through the harnessing of these opportunities that we will be able to successfully navigate our way to net zero.

1.2 Our legal mandate as a group of TSOs

Our four main societal tasks are defined by the legal obligations we have. They are outlined below.

GRID MANAGEMENT

We plan, build, and maintain our transmission grid in accordance with society's long-term needs. We invest heavily in the integration of renewable energy sources (RES), the development of a meshed offshore grid and the construction of interconnectors to facilitate the integration of the European energy market. This task comprises our business activities of System Planning, Infrastructure Design and Construction, and Grid Operations and Maintenance.

SYSTEM OPERATIONS

We monitor the electricity system in real time, maintaining the balance between supply and demand across our control areas and managing grid congestions on a continuous basis. This requires specialist knowledge, close working with local and national partners, and the use of sophisticated tools and processes.

MARKET FACILITATION

As market facilitators, 50Hertz and Elia have ultimate responsibility for ensuring that the balance between demand and supply is maintained across their control areas. We do this by developing and implementing market mechanisms to integrate RES, harmonising energy markets across Europe, incentivising flexibility, and operating different market platforms that employ flexibility and ancillary services.

TRUSTEESHIP

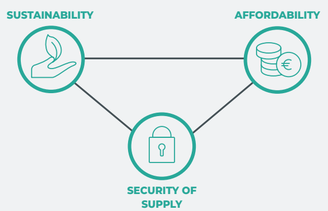
The German and Belgian legislators have transferred the responsibility for coordinating and processing legal levy systems that promote environmentally friendly technologies to the TSOs in their respective countries. Elia and 50Hertz therefore act as trustees, collecting levies from consumers in Belgium and Germany and playing an important organisational role in the remuneration of green energy producers.

1.3 The Energy Trilemma

In carrying out our business activities, our goal is to effectively facilitate the management of the energy trilemma. Proposed by the World Energy Council, the term is used to describe the three elements that national energy systems should seek to successfully balance, namely affordability, security of supply and sustainability.

Every decision we take is guided by this goal. As the owner of two regulated businesses, we perform our activities with societal impact firmly in mind: we are a driver of the energy transition and are helping society to establish affordable, secure, and sustainable energy systems.

Figure 1: The Energy Trilemma



Affordability

consists of providing inclusive access to affordable energy, thereby ensuring that basic power needs are met, and that socioeconomic prosperity is supported.

TSOs play a crucial role in ensuring the affordability of electricity. We plan out our grid in a way that optimises socio-economic gains, building infrastructure which integrates all the necessary energy sources into the system and avoiding the risk of stranded assets. By maximising the amount of available transmission capacity for the market, the exchange of energy between different bidding zones can be optimised leading to price convergence – ultimately benefitting consumers.

Sustainability

covers avoiding or mitigating environmental harm and the impacts of climate change as energy is generated, transmitted, and distributed to consumers.

TSOs are responsible for integrating RES into their grids and coping with the impacts of these on the management of the system. In addition, we must minimise the impact that our assets have on the environment by, for example, reducing the harm caused to wildlife and lowering the use of harmful gasses. We must assess different possibilities related to reducing the environmental impact of our operations by, for example, sourcing ancillary services or covering grid losses through the use of RES.

Security

involves meeting current and future energy needs in a reliable manner, through the availability of energy sources and the dependability of proper infrastructure.

As a TSO, we have no final say over what a country's energy mix is. However, we are responsible for the maintenance and availability of our transmission grid, for using all of our assets within their operational limits, for balancing the demand and supply of electricity across our control areas, and limiting market exchanges where necessary to avoid outages or blackouts.

EXAMPLE

NATURE INCLUSIVE DESIGN USED FOR THE PRINCESS ELISABETH ISLAND

The Princess Elisabeth Island is the world's first energy island that will connect wind farms and interconnectors to the Belgian electricity grid. A nature inclusive design (NID) approach has been adopted for its construction. NID aims to foster the growthand health of marine biodiversity. The island will become a global benchmark for NID approaches in offshore development, demonstrating that the provision of renewable energy and biodiversity can coexist.

The seven key features of the island that will encourage nature to thrive are:

- ledges attached to the island's storm walls for kittiwakes to nest in;
- relief panels for marine organisms and small fish to benefit from;
- oyster baskets supporting the growth of European flat oysters;
- chaotic scour protection, creating diverse habitats in which organisms can forage, shelter or rest;
- gravel beds;
- oyster tables for additional oyster reef support;
- large-scale boulders for increased marine habitat complexity.

"Elia Group's ActNow program enables us to be more sustainable in our activities. Innovation is a key aspect to realize some of the ActNow objectives, for example to find innovative solutions to protect birds from colliding into our lines."

Olivia Geels,
Environment Expert

1.4 The four megatrends shaping the energy sector

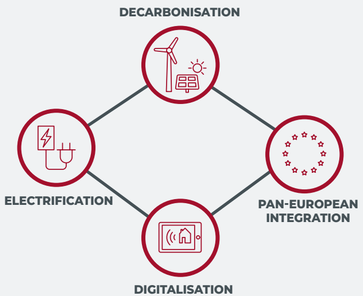
The energy sector is changing at a tremendous speed, driven by political factors, societal expectations and ever-increasing opportunities which are enabled by innovation.

From the range of social, economic, technological, and political developments that are taking place, we have identified four major interconnected trends that are playing a key role in shaping the future of the energy sector (Figure 2). These trends are increasing the complexity of the power system, triggering a need for increased flexibility and technological breakthroughs.

The four megatrends are:

- Accelerated decarbonisation and electrification to fast-forward the green transition
- Increasing international cooperation to harness Europe's full RES potential
- Digitalisation and new technologies to deliver system efficiency
- Flexible electricity consumption to integrate more renewables and lower consumption costs

Figure 2: The four megatrends shaping the energy sector



1. Accelerated decarbonisation and electrification to fast-forward the green transition

The Russian invasion of Ukraine in February 2022 returned a sense of urgency to the European energy debate. The geopolitical crisis and record-breaking energy prices have prompted the European Union to take stronger ownership of its energy production and more rapidly fulfil its commitments to renewable energy, decarbonisation and electrification.

The European Commission published its 'RePowerEU Plan' (May 2022), which builds on the 'European Green Deal' (2019) and 'Fit for 55' legislative package (2021). The plan aims to reduce Europe's dependence on fossil fuels. It focuses on the diversification of Europe's energy supplies, energy saving measures and increasing clean power.

Accelerating the energy transition will reduce our dependence on fossil fuels, strengthen Europe's energy sovereignty and ensure more stable and affordable energy prices, helping to mitigate high inflation in gas and electricity markets. Offshore energy, generated in Europe's seas, is set to become a cornerstone of its future energy system.

However, the sharp rise in renewable energy and in electricity demand are triggering important consequences. Building new grid infrastructure is critical for matching society's ambition to accelerate the transition. Since areas with high amounts of RES are often remote, the need for long-distance electricity transmission is rising. Moreover, areas with complementary production patterns need to be connected as the availability of RES is not equally distributed across Europe.

To ensure the secure and efficient operation of such a renewable and volatile electricity system, more flexibility should be unlocked from households and industry across all levels of the electricity system and via different electricity markets. The consequences of this trend are integral part of the second megatrend.

KEY NUMBERS

RES capacity is due to drastically increase in the run-up to 2030. In the Ostend declaration on the North Seas as Europe's Green Power Plant, the goal of increasing offshore wind generation from 32 GW today[1] to 120 GW by 2030[2] was put forward.

Similarly, in Elia's 'Adequacy and Flexibility Study for Belgium (2024-2034)'[3], Elia outlined that the country should expect an average yearly increase of around 880 MWp of solar power between 2022 and 2034 in the 'Central' scenario. This would lead to an installed capacity of 14.5 GWp by the end of 2030, and up to 18 GWp by 2034.

Since electrification is a clear way for households and industry to decarbonise their energy use, industrial processes and the heating and transport sectors are set to experience significant rises in their demand for electricity.

Driven by the increasing ambitions of the Belgian government, Elia's 'Adequacy and Flexibility Study (2024-2034)' predicts that there will be 2.6 million EVs in circulation in Belgium by the end of 2035, up from about 250,000 EVs in 2022 (both all-battery electric and plug-in hybrid electric EVs).

Moreover, industry's transition to net zero is accelerating, as demonstrated by Elia Group's 2022 study 'Powering Industry Towards Net Zero'[4]. This highlights how industry's electricity consumption is due to increase by 40% and 50% by 2030 in Germany and Belgium, respectively. Belgium's total demand (industrial, households and tertiary sectors) for electricity is therefore due to reach 113 TWh in 2030[5] (up from 82.1 TWh in 2020; a 38% increase). In Germany, demand will reach 750.7 TWh in 2030 (up from 526.7 TWh in 2020; a 30% increase)[6].

1. Offshore wind investments recovering but still "way to go" - including on supply chain | WindEurope – last accessed Nov 2023
2. Ostend Declaration on the North Seas as Europe's Green Power Plant | Alexander De Croo (premier.be) – last accessed Nov 2023
3. Elia (2023), 'Adequacy and Flexibility Study for Belgium (2024-2034)
4. Elia Group (2022), 'Powering Industry Towards Net Zero'
5. Federal Development Plan 2023 and International Energy Agency (IEA)
6. Langfristanalysen 2030 (Version 2022), Eingangsdaten für 2030 and IEA

2. Flexible electricity consumption to integrate more renewables and lower consumption costs

Our sources of energy are increasing in both number and type. We are moving away from traditional, centralised sources of electricity like nuclear and fossil fuel plants to much smaller, decentralised and renewable sources such as solar farms, on- and offshore wind farms, and solar panels on the rooftops of our houses. Our grid must therefore be adapted and expanded to accommodate these new green energy sources.

In addition to this, new ways of balancing the production and consumption of electricity on a continuous basis must be adopted, since the need of adapting the grid to accommodate these new green energy sources, this growth in intermittent renewables means that production patterns are becoming less predictable. Flexible consumption is becoming increasingly important both for supporting the grid as electrification spreads and renewable energy levels rise and for keeping system costs under control.

Industrial electrification and the rise of electric vehicles (EVs), heat pumps and batteries are fundamentally changing the way consumers are interacting with the electricity system. Sector convergence is offering new opportunities for unlocking flexibility, meaning it is becoming an important accelerator for an efficient energy transition.

These new flexible appliances will allow households to consume more electricity at lower costs when there is lots of wind and sunshine available.

KEY NUMBERS

The 4UeNB (coalition of four transmission system operators of Germany) has outlined that 20 million EVs will be able to provide demand side management in Germany by 2030[7]. In Belgium, the national and regional climate plans assume 1.9 million of EVs by that same year. In addition to these, other technologies such as heat pumps and electric boilers, electrolysers and batteries will emerge in the flexibility market. Elia's 'Adequacy and Flexibility Study for Belgium (2024-2034)' projects that by 2034, as much as 1000 MW of fast acting flexible devices that can stop consuming within 15 minutes, such as home batteries, electric vehicles, and heat pumps, will be available to ensure grid stability. Similarly, about 700 MW worth of flexibility will be available more than 80% of the time to start consuming within 15 minutes.[8] These numbers increase to 2100 MW and 1200 MW, respectively, in a 'High flex' scenario.

Elia Group's Consumer-Centric Market Design[9] (2021) aims to facilitate this shift. Once rolled out, existing and new energy service suppliers will be able to provide their customers with better products and incentives, allowing them to monetise their flexibility and lower their electricity costs. As households become more educated about the opportunities available to them, they will come to expect different possibilities for using this flexibility in a way that serves the grid and delivers economic value.

Industry will become a key provider of flexibility as it electrifies and decarbonises some of its processes. The flexibility potential held by different industrial sectors was outlined Elia Group's 'Powering Industry Towards Net Zero' viewpoint[10]. Today, the business case is mostly focused on industry providing ancillary services to the power system. However, much broader opportunities will be offered up in electricity markets provided we further develop these, allowing industry to better align its consumption with renewable generation patterns and optimise it against dynamic electricity prices and grid fees.

3. Increasing international cooperation to harness Europe's full RES potential

As described in Elia Group's 'Road Map to Net Zero' study, published in 2021, Europe's direct electricity demand can be met in 2050 - but only if we accelerate RES expansion by a factor of three, increase efficiency, and build more on- and offshore interconnectors to balance out the uneven distribution of RES across Europe.

To make optimal use of the continent's RES, Europe needs to set up frameworks for partnerships between countries with different levels of RES potential. Moreover, the full potential of the North and Baltic seas will need to be harnessed through an international approach. The rise of hybrid interconnectors and energy islands will allow electricity to be exchanged between countries whilst also connecting them to offshore wind farms. These interconnectors and energy islands are forming the first building blocks of a European meshed offshore grid.

The increasing integration of the European power system is requiring Member States to adopt a supranational approach to the construction of their grids. Regional Coordination Centers (RCCs, such as Coreso and TSCNET) facilitate cooperation between different European regions, whilst ENTSO-E facilitates continent-wide cooperation between 39 TSOs from 35 countries across Europe. Its ten-year network development plans (TYNDP) are aimed at securing a fully integrated European grid and energy markets.

TSO coordination through RCCs increases the efficiency of system operations, minimises the risk of brownouts or blackouts spreading across large areas, and lowers costs through maximising the availability of transmission capacity for market participants[11]. RCCs push national TSOs to adapt their ways of working and adopt a pan-European decision-making approach, rather than just national approaches, in their work.

End customers will only begin to directly benefit once all voltage levels are taken into consideration and consumers from across all levels are enabled to play a role in the system.

7. Langfristanalysen 2030 (Version 2022): Eingangsdaten für 2030
8. Adequacy & flexibility study for Belgium (2024-2034) by Elia Group
9. CCMD (eliagroup.eu)
10. Elia Group study on "Powering Industry towards Net Zero"
11. https://eepublicdownloads.entsoe.eu/clean-documents/SOC%20documents/RSC%20Factsheet.pdf

Different and unique obstacles are present at lower grid voltage levels. For example, end users will be satisfied if they are able to use the electricity they produce at home or use their energy contracts while charging their EVs abroad. This is one of the advantages that international cooperation should deliver. Elia Group's Consumer Centricity Moonshot[12] is a step towards addressing and solving this challenge, since it explores the possibility of enabling cross-border energy transactions to occur.

KEY NUMBERS

The TYNDP 2022 (ten-year network development plan, published in May 2023)[13] posits that the socioeconomic value of adding 64 GW of additional capacity on over 50 European borders between 2025 and 2030 would be positive, hence that such significant investment plan is economically interesting for society. Such increase of capacity represents a surge of 55% in cross-border capacity compared with the 2025 grid. Beyond 2040, another 24 GW of cross-border capacity increase would likewise yield positive socioeconomic returns. These numbers show an incredible economic and societal potential of increased cross-border collaboration.

In June 2022, the PICASSO platform was launched in some European countries (Germany, Czech Republic and Austria). The platform, which was built to enable the exchange of frequency restoration reserves with automatic activation, aims to reduce the cost of flexibility in Europe. ENTSO-E states that the socioeconomic gains that PICASSO has delivered for consumers was €375 million in 2022[14]. These are set to increase significantly in future, as PICASSO will be launched across all the control areas belonging to the 26 TSOs that are part of the PICASSO project.

4. Digitalisation and new technologies to deliver system efficiency

The development of new technologies and digitalisation has led to the power sector being increasingly coupled with other sectors, such as heating, transport and industry. The owners of flexible appliances like heat pumps, EVs and small batteries can be encouraged to shift their electricity consumption in time, so contributing to a more efficient operation of the system.

The rise of new technologies that are used for monitoring and maintenance purposes is also contributing to system efficiency. The internet of things and artificial intelligence are leading to the establishment of smart grids, automated decision-making, enhanced risk prediction and incident analysis. The decentralisation of the system is leading to the exploration of blockchain and self-sovereign identity technology. Both have the potential to change the interactions between end user devices and grid operators, so facilitating the safe integration of small assets into the system.

Access to the right data and using it as part of real-time decision-making will be necessary for managing this more complex electricity system. In turn, this will lead to data security and consent management becoming key areas of responsibility and concern.

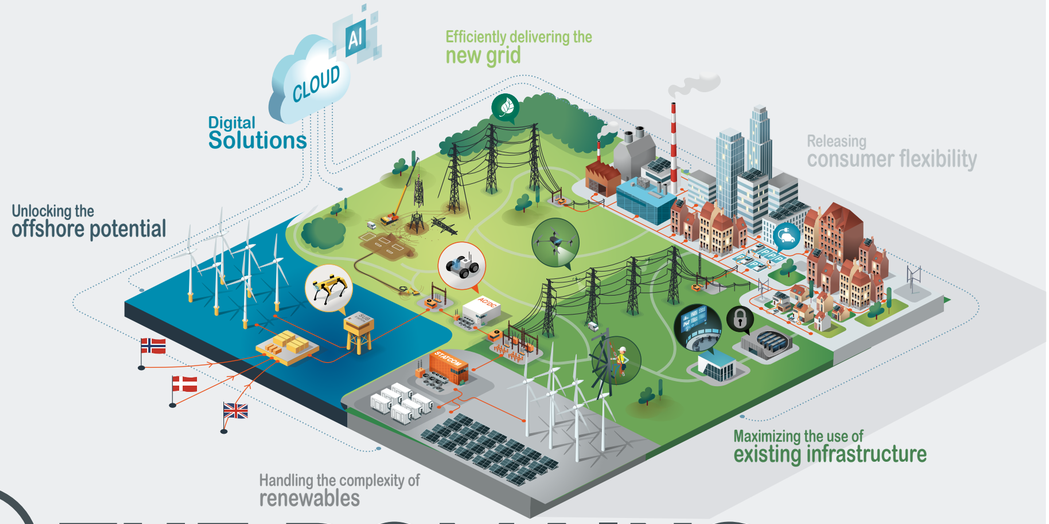
In a 2019 survey of European TSOs, ENTSO-E established that many high-voltage grid operators see numerous digital opportunities arising in future – in particular related to grid and system cost efficiencies, and system risk management, security of supply and safety. According to BloombergNEF's New Energy Outlook[15], published in 2023, in the lead-up to 2050, 24% of investments in grid infrastructure will relate to digitalisation. In absolute numbers, this represents more than $5 trillion worldwide. The biggest share of these investments will go to the automation and control of the power system and increased monitoring and situational awareness.

ASSET DATA MEASUREMENTS IN BELGIUM

Digitalisation is allowing us to improve the reliability of our networks through optimised maintenance practices: the use of digital sensors, for example, means that assets can be continuously monitored from a distance, reducing the time, danger and difficulty associated with manual inspections. In Belgium, more than 218,000 unique assets from across Elia's transmission grid are being monitored via its Asset Condition and Control Platform. This allows an estimated 600 million measurements to be carried out of Elia's assets every year, and about 2.5 million calculations and analytics to be carried out every week. Thanks to these measurements, we are now more aware of the state of our assets and their maintenance needs, allowing us to predict their health. Furthermore, opportunities with regard to automating decisions in system operations will allow speed to be improved and human errors to be decreased. Ultimately, the availability of high-quality real-time data will unlock the possibility of creating digital twins of our physical infrastructure.

The challenge lies in keeping pace with these digital developments and to benefit from them, rather than being overwhelmed by them. As more complex technologies and applications continue to replace traditional operations, questions of interoperability, data storage, computing and management emerge. Issues relating to effective consent management and data security are also surfacing.

12. See Section 3.2 for more information on the Moonshot programme
13 Update on Balancing Platforms, March 2023
14 https://about.bnef.com/new-energy-outlook-series
15. See Section 3.2 for more information on the Moonshot programme



2. THE DOMAINS OF ELIA GROUP INNOVATION

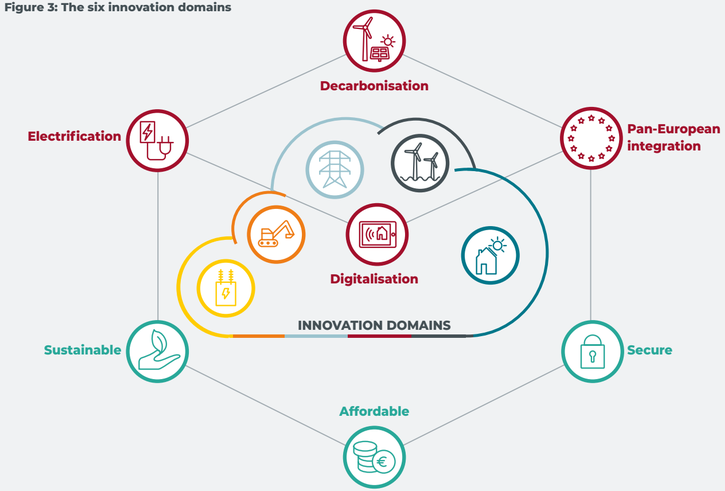
We have identified six core innovation domains that we need to concentrate on to keep creating value for society. These domains, outlined in Figure 3, are all supported by one transversal domain: the digital backbone. This reflects the fact that digitalisation cannot be treated as a separate domain: it is becoming increasingly ubiquitous and has the potential to shape and accelerate all of our other innovation domains.

The six innovation domains are outlined below. Each of these is followed by concrete examples of some of the work we are undertaking within these domains, providing readers with tangible explanations of how our projects are addressing the associated challenges. For an in-depth exploration of our approach to innovation, including an overview of our Moonshot programme, please see the section entitled "How we innovate".

"Our Innovation Strategy aims to ensure that our innovation portfolio remains focused on responding to the challenges we identified, and transforming them into opportunities. This way we can ensure that the energy trilemma is efficiently balanced and we are driving forward the energy transition in our home markets."

Thijs Vral,
Business Innovation Elia Group

Figure 3: The six innovation domains

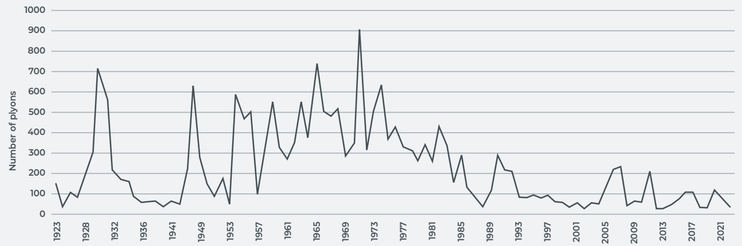


2.1 Maximise the use of existing assets

The complexity of our asset maintenance and operations activities is linked to the broad range of assets that we own. 50Hertz owns and operates 9,672 km of overhead lines, 658 km of underground and submarine cables and 76 substations and high-voltage direct current (HVDC) converters, with voltages ranging from 150 to 400 kV. Elia owns and operates 5,575 km of overhead lines, 3,292 km of underground and submarine cables and 809 substations and HVDC converters. The voltage of the Belgian grid ranges from 30 to 400 kV, and it includes onshore and offshore infrastructure and both AC and DC lines.

Belgium's electricity infrastructure is amongst the oldest energy infrastructure in Europe. Figure 4 shows the number of pylons which are still in use in Belgium alongside the years they were installed. It clearly demonstrates that many of Belgium's pylons were installed in the 1930s and 1960s. These aging assets need to be maintained and operated in a way that is efficient, safe, and cost effective.

Figure 4: Pylons in use in Belgium and their installation date



Source: (Elia internal data)

Elia Group aims to minimise the construction of new infrastructure, so reducing unnecessary impacts on the environment, communities, and consumer energy bills. The best way to achieve this is by maximising the use of existing assets. This first domain therefore covers the improvement of monitoring and inspection activities, using the resulting data to assess the current condition of our assets and predict their future health or behaviour, ultimately enhancing the performance and lifetime of an ageing grid.

Having an exact, real-time image of our grid and assets is therefore crucial. Harnessing both existing and emerging digital technologies - such as drones, robots, and real-time data sensors - is facilitating the adoption of more efficient, cheaper and safer remote monitoring and inspection activities. Projects and approaches such as this will help to optimise the grid's availability and ensure that maintenance-induced outages don't result in congestions. In addition to cost efficiencies and the optimisation of asset use being achieved, safety and sustainability will be bolstered; for instance, unmanned technology is being used to monitor SF_6 leakages. Improved monitoring and data gathering are helping to predict the condition and behaviour of our assets and equipment. For example, hyperspectral inspections are providing us with detailed overviews of corrosion conditions in the field, and assessments of the aging of linear assets will provide us with greater insights into the aging of copper conductors.

Our success in this domain will be able to be measured through the fact that we will minimise outages using AI-driven planning and will embark on the integration of digital twins for a more complete view of the system.

HYPERSPECTRAL CAMERA FOR RUST DETECTION BEHIND PAINT

Corrosion is a major source of infrastructure damage. Traditional ways of checking our pylons for such damage have involved staff climbing onto them. Although this is a reliable method for detecting corrosion, it is resource-intensive and involves a high amount of risk for our staff.

We are therefore currently exploring the use of a hyperspectral camera to carry out this work. This technology will allow us to 'see through' paint on the pylons (meaning it is a non-invasive method) and, in the long run, we hope to be able to use AI to classify the severity of the damage that is present.

ASSET MANAGEMENT MOONSHOT: QUICK INCIDENT UNDERSTANDING

This Moonshot[14] is a highly ambitious project which forms the basis of our innovation portfolio. It aims to build up our ability to quickly analyse and verify grid incidents using highly accurate fault localisation and visual information. We are aiming to allow operators to understand the exact nature of grid incidents within ten minutes and whether or not it is safe for them to re-energise a line. We are aiming to reach this goal through the use of remote sensors and drones and the automatic analysis of new and existing data sources.

TECHNOLOGY FOR ASSESSING THE AGING OF LINEAR ASSETS

This project aims to address the aging of overhead line components by using aeolian vibration sensing to predict the age of copper conductors. By establishing a correlation between the age of our assets and vibrations from broken strands, we are aiming to enhance the efficiency of incident detection in copper conductors. Ultimately, the project seeks to enable earlier incident prediction and intervention before failure occurs by detecting aging that is not visible to the naked eye.

2.2 Efficiently deliver the new grid

As our current infrastructure becomes too old to sustain, as the need for electrification increases, and as new decentralised generation sources need to be connected to our onshore grids[16], we must build new infrastructure. We must therefore construct new assets with enhanced capabilities to cope with increasing demands, including avoiding both congestion along our lines and the curtailment of renewable energy sources.

In Elia's federal development plans outline a solid number of projects which will enhance the 'horizontal system' (380 kV grid) to efficiently transmit electricity across Belgium and improve cross-border connections. Similarly, in Germany, 50Hertz collaborates with Germany's three other TSOs to deliver the country's federal grid development plans. Currently, 50Hertz is undertaking more than 15 onshore projects which aim to reinforce the grid[17]. *Its 100 percent by 2032* initiative, which is the cornerstone of its strategy, aims to match 100% of electricity consumption across its control area by renewable energy by 2032[18]. Massive investments in our high-voltage grid will therefore need to be undertaken.

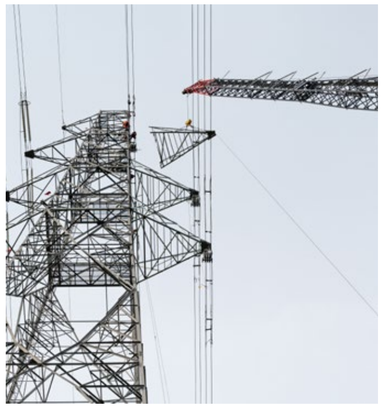
The work in this domain will be focused around three core pillars. Firstly, improving the modelling of assets and equipment; this will improve the lead time for the construction of infrastructure and decrease unforeseen costs associated with new assets. Alongside our Engineering Department, we will aim to improve our assets by redesigning them or using new materials for their construction. Through standardisation, optimised operations, and adaptations to the full infrastructure delivery process, we will work on ways to more quickly and efficiently build our infrastructure.

Success markers in this domain will include the enhancement of newly built infrastructure through innovative materials and methodologies, and the broadening of capabilities of our new assets. The speed of our construction activities will increase, enabled by revised permitting approaches, whilst the impact on our operations activities will be reduced. Additionally, comprehensive grid analysis techniques will ensure we optimise solutions which take into account both capital and operational costs, rather than initial asset expenses alone.

SYNAPSE AND PROOF

In the future, creating an outage plan for maintenance work will become more and more difficult due to the volatility of external factors. The synergy between agile planning and stable execution (Synapse) tool will allow us to carry out planned outages across the grid whilst coping with the uncertainty of renewable generation and highly dynamic load and market behaviour. In turn, this will limit the risk of RES curtailment and the risk of further outages.

As part of the Predictions of Renewables Optimised for Offshore using Forecasting (PROOF) project, we aim to optimise the planning of offshore maintenance work, in order to maximizes the production of renewable energy, optimise work and costs, and have a positive impact on local communities and stakeholders.



NEW STEEL TO REINFORCE GRID

Given that our pylons need to carry increasingly heavy weights - due to the use of higher-performing conductors and higher cables, and higher wind loads - S355 steel is no longer best suited for their construction. We are therefore assessing whether S460 steel could be a good replacement for it, allowing new pylon structures to be designed and speeding up the delivery of new grid projects. The main difference between both steel types is their yield strength (355 MPa and 460 MPa respectively).

This new steel will be used as part of an optimised design of the current 380 kV lattice design with insulated cross-arms to further reduce their visual impact on surrounding environments and, potentially, their electromagnetic fields.

16. Offshore development will be a priority in the coming decade, leading us to select it as a separate domain in this strategy, See Section 2.5
17. Onshore projects (50hertz.com)
18. Details 100 Prozent Erneuerbare bis 2032 (50hertz.com)

2.3 Enable the secure integration of renewable energy and future components

Europe is set to double, or even triple, its RES capacity by 2030[19]. Our primary objective is to seamlessly integrate these renewables into the electricity system.

However, this higher amount of renewable energy sources is challenging the system's stability, and, ultimately, security of supply in Belgium and Germany. Traditional fossil fuel generators, which offer crucial grid stability through inertia[20], differ from RES which use power electronics. As we incorporate more RES into the system, the grid's inertia will decrease, posing risks to its stability. Given the increasing adoption of new HVDC and converter technologies across our grid, it is imperative that we proactively address this matter to prevent future incidents, cascading effects, and blackouts.

In recent years, there has been a noticeable increase in incidents related to the integration of power electronics. For instance, one of the earliest and most prominent cases was the Bard Offshore Project[21]. This project involved a 400 MW HVDC link that aimed to deliver offshore wind to Germany. This link was initially connected to the German onshore grid in 2013 but had to be disconnected due to harmonics issues. This disconnection resulted in the project being delayed by one year and led to significant costs being incurred by the project owners. The primary cause of such problems can be attributed to the use of innovative technologies like HVDC without sufficient consideration being given to grid interaction and stability issues.

A more recent incident occurred during the summer 2023 in Glasgow, where dozens of traffic lights in the city unexpectedly went out[22]. This case is still being investigated, but preliminary expert discussions suggest that converter-driven interactions may be involved in the problem.

Other significant events have also resulted in more severe issues, such as continental Europe's electricity system splitting in January 2021[23] and a blackout in Australia[24].

In the long term, an increasing share of RES in the system means the production of electricity will become more volatile. In turn, this will require a different approach to the real-time management of the grid, given that energy fluctuations will become more pronounced. In the coming decade, rapid shifts in load are anticipated, especially during peak hours. During the summer months in Belgium, for example, an evening upward ramp of 5 GW between 17:00 and 20:00 is to be expected[25]. This will put an enormous amount of stress on system engineers, who will need to keep the grid stable and within operational limits during such fast and significant ramping events. They must maintain grid stability despite the increase in dispatchable resources, moving from dozens today to potentially hundreds of thousands in the future.

Moreover, the growth in offshore wind energy will result in extreme flexibility demands, particularly during storms. Significant fluctuations in wind energy occur during periods of turbulent weather, emphasising the need for accurate system predictions during such events. For instance, by 2028, we expect that shifts of up to 2.5 GW within an hour will appear[26]. The same trend holds for solar generation; in Belgium, for example, shifts of 500 MW were recorded in early 2021, whilst they were 860 MW in mid-2023[27].

In this domain, we aim to maintain grid stability despite the rise in electronic devices by harnessing existing opportunities through measures like grid-forming control loops and virtual grid inertia (see examples below). Our focus also lies in refining forecast accuracy, enhancing our situational understanding, and fortifying our decision-making through advanced tools. We will be shifting towards the use of automated processes in system operations; equipping ourselves to deftly handle rapid and complex changes; and the enabling of informed and autonomous decisions.

19. Fit for 55 - The EU's plan for a green transition - Consilium (europa.eu)
20. An explanation about grid inertia can be found here: Grid inertia: why it matters in a renewable world (renewableenergyworld.com)
21. Harmonic Propagation and Production in Offshore Wind Farms - Audun Matre Meinich, July 2018
22. Traffic lights across Glasgow go down following power surge | STV News, accessed Nov 2023
23. System separation in the Continental Europe Synchronous Area on 8 January 2021 – 2nd update (entsoe.eu), accessed Nov 2023
24. The Anatomy of the 2016 South Australia Blackout: A Catastrophic Event in a High Renewable Network – Ruifeng Yan et al., 2018
25. Elia Adequacy and Flexibility study for Belgium (2024-2034)
26. Elia MOGII System integration study – Final study report
27. Solar-PV power generation data (elia.be)

MCCS AND VOLTCONTROL

50Hertz is developing a new grid control system, the Modular Control Centre System (MCCS). This platform will support the grid operators of the future through the use of algorithms and by automating system operation processes. The MCCS will be comprised of different modules, supporting the development of fast and differentiated solutions for different areas of system operations.

One of the use cases of the MCCS project is VoltControl. Decision-making regarding the management of the grid's voltage is becoming increasingly complex due to decentralisation, decarbonisation, and increasing market dynamics.

The VoltControl project aims to provide AI-based decision-making support to system operators. Its end goal is a human-out-of-the-loop type of grid management, where voltage-related actions can be implemented automatically by the system.

THE INTEGRATION OF POWER ELECTRONICS (INPOWEL)

RES storage systems operate in 'grid-following' mode. In other words, in order to inject power into the grid, they synchronise to the grid's frequency and voltage levels, requiring steady levels themselves to do so effectively. As renewable energy levels rise, and rotating machines used by fossil fuel plants are eliminated from the system, the grid has less inherent stability and strength. Eventually, this will result in a lock-in: renewables will not be able to inject their power into the grid any longer.

The goal of the Inpowel project is to run a demonstrator based on 'grid forming' technologies, which involve RES storage systems actively controlling the frequency and voltage output of the grid they are connected to. This will enable static devices, which many RES are, to provide system strength, successfully playing the role that conventional rotating machines have until now.

"Inpowel is a key project that will help us to better integrate renewables energies in a safe way on our grid despite the phase out conventional sources such as nuclear power plants."

Martin Crappe,
Future Grid Integration Innovation

2.4 Support consumers to benefit from the energy transition

To meet Europe's clean energy goals and enable end consumers to play an active role in the system, we are working on placing end consumers at the heart of the energy transition. As devices like solar panels and EVs are becoming common, we are opening up ways for people to actively interact with our electricity grid. This lets them use their own energy resources in a way that helps to keep the energy system balanced. The aim is to establish a system in which consumer consumption patterns naturally matches production patterns. We want to establish a consumer-centric system through a market design that will give consumers full freedom and advantages for participating in energy markets.

The energy system of the future will require the potential of decentralised assets to be harnessed for both immediate and anticipated energy deviations. Our Consumer-Centric Market Design[28] will help users to consume electricity and make the most of their electric devices. This could mean using electricity when it is abundant or even selling it back to the system when it needs it most.

To empower consumers and promote their engagement, we need to set clear rules, make it easy for these devices to cooperate across the system, predict energy needs accurately, and encourage users by making it worth their while, all in the easiest and most user-friendly way.

Success in this domain will mean that residential and business consumers will actively take part in energy markets and maintain the balance of the grid. They will benefit from new rules and digital tools that help them to change how they use energy, save money, and enable new business opportunities. Success in this domain will be marked by strong collaboration with all energy players, from traditional ones to newer participants like energy service providers and original equipment manufacturers.

ENERGIZECONNECT

This project aims to integrate end users and their data into the grid. It therefore explores different ways to integrate both households and their assets into the system through the use of the right data and tools that support seamless and secure data exchanges.

The EnergizeConnect project will investigate possible solutions for integrating this vast amount of new data into the system. It will explore the creation of a decentralised asset registry, supported by blockchain technology, which will have the ability to integrate decentralised assets into the system in a secure, transparent and scalable manner. As part of a second phase, the project will consider Solid Pods (Personal Online Data Store), which allow consumers to store their data in a secure and sovereign way. Lasty, the use of energy wallets will be assessed. Their useability, inclusivity and overall potential for flexibility and community use cases will be examined.

The success of EnergizeConnect will lie in its ability to foster collaboration among diverse stakeholders. This collective approach (which will involve distribution system operators, universities, municipalities, and end consumers) will ensure that every actor is aligned with the broader vision of a consumer-centric energy transition.

CONSUMER-CENTRIC MARKET DESIGN

The next decade will be characterised by a fast rise in renewables and the widespread electrification of industrial and residential appliances. Since 2020, Elia Group has been working on its CCMD, which addresses how flexible appliances can be integrated into the system, so helping to balance the grid.

We are convinced that the keys to unleash further flexibility lay in:

- giving consumers a leading role in the system across all voltage levels;
- providing energy service providers with easy access to data and digital platforms to support them as they develop new consumer services.

The CCMD comprises two main features:

- the development of an Exchange of Energy Blocks hub, through which consumers could exchange energy with other market parties on a fifteen-minute basis (for uses in energy communities and for supplier switching purposes);
- through our Smart Balancing Controller product, we want to evolve the imbalance price to a real-time price, which would reflect system conditions in real time, giving consumers a reference for their consumption and the value of services offered by third parties.

28. WG Consumer Centric Market Design (elia.be)

2.5 Unlock the potential of offshore energy

In our role as TSO, we connect offshore wind farms to our grids in Germany and Belgium. Offshore wind is essential for bolstering the EU's energy sovereignty, resilience, and journey to climate neutrality. During the 2023 North Sea Summit in Ostend, for example, nine countries set themselves the offshore wind capacity targets of 120 GW by 2030 and 300 GW by 2050 in the North Sea.[29]

To use infrastructure in an optimal manner, Elia Group is developing new and more efficient grid connection concepts with international partners. For example, hybrid interconnectors link two countries together whilst also being connected to an offshore wind farm. Hybrid interconnectors and multi-terminal, multi-vendor solutions will be increasingly adopted, potentially leading to the establishment of meshed offshore transmission systems[30]. Moreover, Elia is working on the world's first offshore artificial energy island, whilst 50Hertz is working on energy island in the Baltic Sea These islands will serve as central hubs which will collect offshore electricity produced by wind farms and deliver this energy back to the mainland grids they will be connected to. Elia Group and its subsidiaries are front-runners in the development of highly complex offshore infrastructure.

Besides developing such large infrastructure projects, we work on using new technologies such as virtual and augmented reality for remote inspection and maintenance activities. This will allow us to minimise the number of physical sites visits we have to undertake, saving costs and increasing the safety of our employees. Furthermore, we will develop new approaches to the operation of complex meshed offshore systems by developing operation algorithms tailored to hybrid offshore grids, to enhance energy flows, reduce congestions, and ensure a reliable electricity supply. The importance of protecting our physical assets from intended or unintended intrusions has also become an area of focus for us. Damage to our assets can directly impact security of supply, which requires us to develop advances monitoring solutions, including radar, acoustic monitoring and even satellite surveillance. Last but not least, we want to minimise the environmental impact of our offshore activities through the adoption of nature inclusive design approaches and new sustainability. Lastly, we aim to build our offshore assets in a faster way, to keep up with society's growing need for electricity.

In Germany, 50Hertz and its Danish counterpart Energinet built the world's first hybrid interconnector: the Kriegers Flak-Combined Grid Solution. This connected Germany to Denmark to each other and to two offshore wind farms. Over the coming years, 50Hertz will continue to build innovative multi-terminal solutions such as the Heide Hub and Bornholm Energy Island. The Heide Hub will connect offshore wind farms through DC links to an onshore converter station, where electricity will be made available to electrolysers for hydrogen production and will be further transmitted via DC links.[31] The Bornholm Energy Island, a project Energinet is working on with 50Hertz, is a future offshore hub that will connect offshore wind farms and transmit energy between the 50Hertz and Energinet bidding zones.

In Belgium, Elia is a key player in the North Sea. In 2019, Elia built the Modular Offshore Grid, which is located 40 km off the coast. The MOG bundles the electricity generated by four offshore wind farms together and transmits it to the mainland through joint subsea cables. Furthermore, to further enhance the efficiency of integrating renewable power into the Belgian electricity grid, Elia is building the Princess Elisabeth Island – the world's first artificial energy island. The artificial island will serve as an electricity hub onto which cables leading to Belgium's second offshore wind zone (Princess Elisabeth Zone) and future interconnectors with other European countries such as the United Kingdom and Denmark will land.

These infrastructure projects are crucial elements in the development of a future European meshed offshore electricity grid. They will require further innovation related to the use of HVDC and multi-terminal–multi-vendor (MTMV) links. Elia Group is on the way to developing the first MTMV DC link, which is due to be operational by 2030.

29. European countries aim to turn North Sea into green power engine
30. Elia Group white paper on promoting hybrid offshore interconnectors for reaching Europe's goal of 300 GW of offshore wind capacity by 2050
31. New europawire

Success in offshore development will be evident through our deep understanding of and expertise in innovative concepts and technologies, such as offshore platforms, floating and hybrid interconnectors, and advanced HVDC technology. Additionally, we will deploy digital solutions tailored to offshore maintenance purposes that can endure tough marine conditions and tackle connectivity challenges. We'll also implement operation algorithms tailored to hybrid offshore grids, aiming to enhance energy flows, reduce congestions, and ensure a reliable energy supply.

OFFSHORE GRID OPTIMISER

Whilst the construction and operation of wind farms has already reached a very high level of maturity, their integration into the grid requires innovative approaches to be adopted to facilitate the efficient and flexible transportation of the clean energy they generate to onshore demand centres. The construction of point-to-point interconnectors therefore needs to be replaced by hybrid, multipurpose offshore interconnectors.

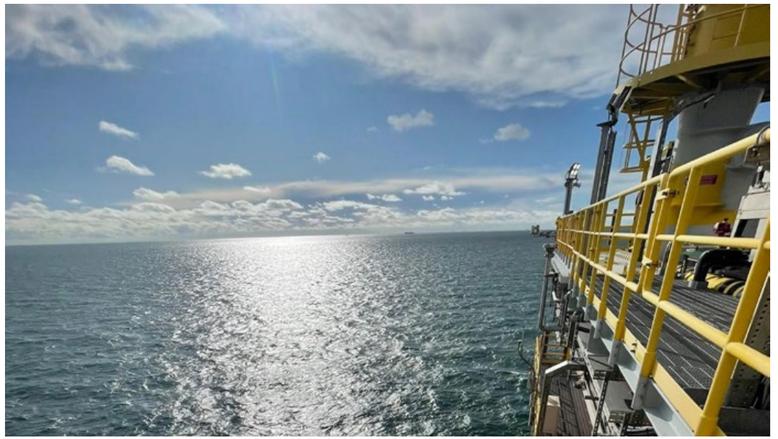
To successfully operate these sophisticated hybrid offshore interconnectors, dynamic models will be required to control active and reactive power flows through the interconnector. The objective of the offshore grid optimiser project is to work on such models.

SUBSEA PINPOINTING:

Pinpointing is a critical technique employed to precisely locate faults along offshore cables. Given the rise in such infrastructure, and the associated rise in possible cable failures, this need is rising. Elia Group intends to establish a common standard for pinpointing AC/DC subsea cable faults, aiming to mitigate the significant downtime such faults cause and associated security and financial repercussions. This will be achieved through dedicated research, the rigorous testing and assessment of faults and technologies, and by encouraging market progress in this area.

"We are building increasingly complex and sophisticated offshore assets that cannot be operated manually with static models. We are therefore developing the offshore moonshot optimiser that will support the operation and optimisation of these assets with dynamic models."

Arya Fazilat,
Advisor digitalisation of System Operations



2.6 Digital excellence of the energy system

In the past, information technology (IT) was seen solely as an enabler: a means to handle the operational technology (OT) and deliver our core operations. However, IT is increasingly emerging as a standalone component alongside OT, meaning it is becoming an important pillar of our business. We are realising that IT should be given the same level of importance and attention as traditional infrastructure.

The shift towards a world in which IT and OT hold similar levels of importance is not without its risks and challenges, primarily when it comes to cybersecurity. Our increasingly digitalised operations and the rise in devices connected to our grid makes us increasingly vulnerable to cyberattacks.

We need to become faster and more flexible at introducing new requirements and tools across our organisation, as the complexity, cost, and work for maintaining our current technology stack will increase exponentially. For this reason, Elia Group is Implementing the Elia Digital Platform (EDP). This platform approach allows us to provide functionally grouped capabilities, which will accelerate product development.

By doing so, we will create building blocks such as a data platform or IoT platform which will serve multiple use-cases.

The rise in the volume of data we will need to manage alongside the growing variety of tools and mechanisms to balance power and frequency in real-time will make system operations and planning more complex. We will need advanced computational power to process vast datasets quickly and efficiently. The implementation of advanced computing infrastructure, both hardware and improved tools, will be essential to meeting our time constraints.

Success in this area will be clear once we have managed to integrate both IT and OT into our systems with the same level of importance, strengthen our cybersecurity defences, streamline our tech stacks through a platform strategy, and enhance our computational capabilities.

"We will increase the amount of loadflows we can calulate per second from just 100 to over 60 million, by exploiting GPU power and code optimization."

Christian Merz,
Project Manager AI

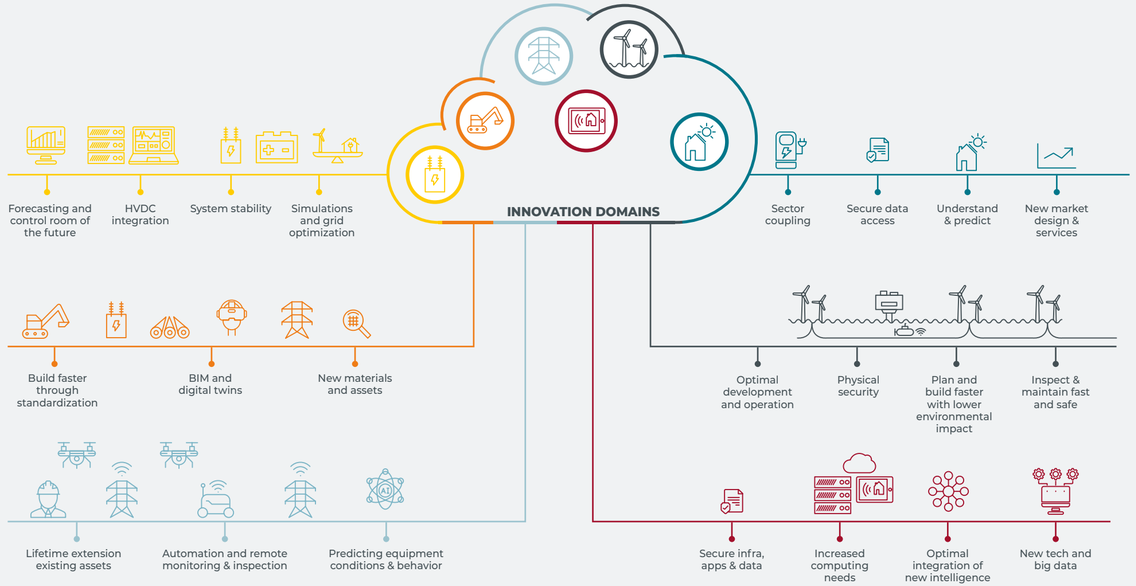
ADVANCED COMPUTATIONAL POWER

As system operation and planning processes become increasingly complex, the scalability of classical computing concepts will reach its limits. We are therefore exploring alternative computing paradigms, including quantum computing, reinforcement learning, and novel processing units. This project's objective is to comprehend and experiment with specialised functionalities, such as parallel processing, to enhance solving times and reduce sub-optimal results in complex calculations.

GRIDSHIELD

Cyberattacks on power grids have significant consequences and are considered severe threats due to their ability to cause equipment damage, load loss, system instability, and even widespread blackouts. The GridShield project aims to establish a resilient power grid, enhancing its security and defences against these threats - particularly in terms of decentralised energy resources. Leveraging power grid digital twins and an OT cyber range, we'll test real-time cyber-secure functions like intrusion detection and prevention. Our main goal is to model future grid scenarios, assessing the security of the expanded attack surface (created by decentralised energy resources), and develop practical solutions to address emerging challenges.

Figure 5: The innovation domains with focus areas



3. HOW WE INNOVATE

Instead of having a single centralised innovation department at Elia Group, we are working towards embedding different initiatives across the organisation empower all employees to participate in the innovation process. At the core of this approach lies the belief that innovation is a shared responsibility: all members of staff can contribute to innovation across the Group.

Our approach to innovation can broadly be split up into four different areas, as follows.

- Incremental innovation: providing all employees with the tools and methods to implement small but continuous improvements in their daily work.
- Disruptive innovation: running ambitious programmes that aim to create breakthrough solutions for future challenges.
- Open innovation: engaging with different external entities, such as start-ups, universities, and peers, to co-create innovative solutions and share best practice.
- Emerging technology: tracking the evolution of technology and preparing for technological shifts by exploring potential new capabilities for the future of the energy sector.

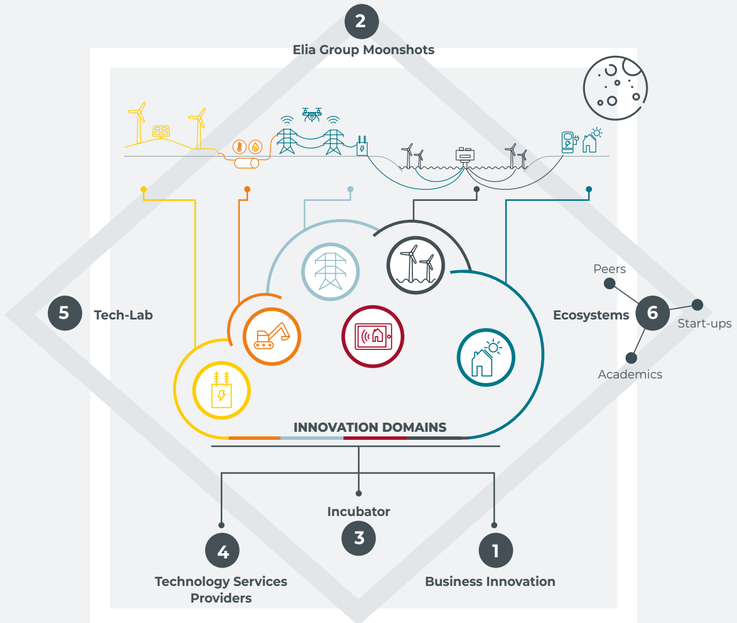
Different initiatives covering these four pillars will be introduced throughout the next few sections of this publication. These initiatives collectively form the building blocks of our innovation strategy and will allow us to achieve our stated goals and objectives.

Overview

Innovation activities are encouraged and undertaken by the following core interconnected actors across the Group:

1. **Business innovation:** Innovation is first happening in every business department. In every part of Elia Group (system operations, asset management, market...), teams are solving business challenges with new ideas supported by innovation team.
2. **Moonshots:** as resources are limited, innovation without focus will certainly miss the real impact. For that reason, Elia Group has launched in 2021 the moonshot program which aims at delivering a list of ambitious demonstrators. These demonstrators will articulate a series of new innovation for which the business value will be tested.
3. **The Nest**, our internal incubator, supports employees to develop digital ideas. It is especially focused on incremental innovation.
4. **Our Technology Services Providers (TSPs)** focus on advanced technology like AI, IoT and robotics, fostering knowledge-sharing across Elia and 50Hertz and driving both incremental and disruptive innovation to occur.
5. **Our Tech-Lab** serves as our innovation radar, evaluating disruptive technologies in terms of their potential impact, value, and risks, ensuring our company stays ahead of changes across the energy sector.
6. Through our **Open Innovation**, we actively engage with start-ups, leverage academic partnerships across Belgium and Germany, and foster industry-specific eco-systems to drive research and set new benchmarks in the energy world.

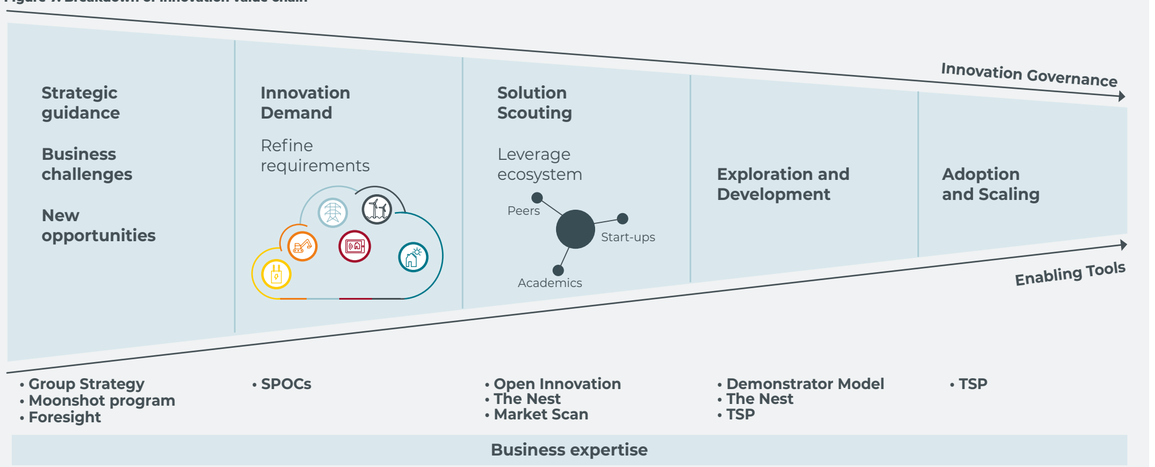
Figure 6: Innovation decentralisation pillars



Elia Group Decentralised Innovation

Generally, the mentioned actors work together in many different ways to identify a need and then develop a solution to this problem. Although different interactions between the units above may occur, one possible example could begin with business need or requirement being spotted by one of our SPOCs. Along with business experts, this SPOC will then scout out a solution to this need by interacting with the Open Innovation ecosystems. A partnership with an external stakeholder may well be established to help design a solution. In cases where no off-the-shelf solution exists, The Nest steps in, leading to the solution being created in-house.

Figure 7: Breakdown of innovation value chain



3.1 Business innovation and exploration

As Elia Group aims to fully decentralise innovation activities across the entire company, we are seeking to empower individual business departments to outline their own innovation roadmaps. Different experts from Innovation department hold key responsibilities for the most innovative projects that are being pursued by our organisation. Some of these initiatives were started by the central innovation team (including in the case of autonomous drones, hyperspectral cameras, and AI models for incident detection).

In other cases, business departments themselves led on the project, with or without support from their Innovation department contact. As example, the Group's departments have been instrumental in tackling first-hand challenges, giving rise to solutions like the automatic SF_6 reader, and versatile IoT sensors.

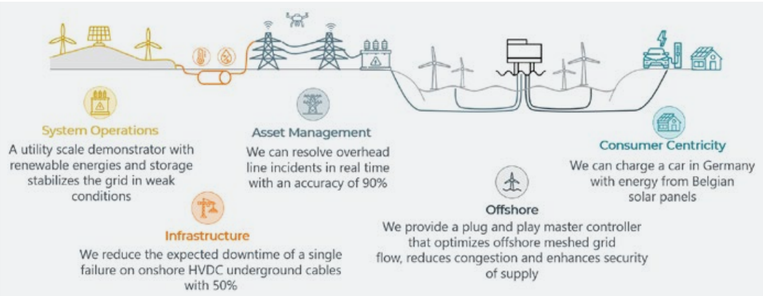
As the energy landscape undergoes a rapid transformation, the line between routine projects and innovation activities becomes increasingly blurred. Projects such as the energy islands, multi-terminal HVDC, and even sustainability-focused measures like drones highlight this evolution. It is clear that innovation is no longer an isolated activity but a fundamental trait of every business initiative and will shape the future of the energy system.

For that reason, Elia Group is actively investing in orchestrating its innovation across departments. The goal is to enable complete transparency of all innovation initiatives arising in the company and channel the new ideas through an aggregated innovation funnel. This collaboration is notably managed by key innovation team representatives for each business, who ensure that they exchange with the business on a regular basis to push and acquire new ideas.

3.2 The Moonshots: our focus on big challenges

Innovation is only useful when its focus is clear. As the challenges in our field continue to grow, so the emergence of innovative solutions grows. This led to the launch of our Moonshot programme, which aims to solve the biggest challenges faced by the energy sector. The Moonshot programme provides a clear way for the Group to prioritise its innovation portfolio whilst inspiring our co-workers and peers.

We started the programme in 2020 with five different Moonshots - one per innovation domain: Asset Management, Infrastructure, System Operations, Consumer Centricity, and Offshore. Through the Moonshot programme, we want to disrupt our industry and accelerate innovation, so strengthening our position as a leading TSO in Europe.



3.3 The Nest, our internal incubator

The Nest is our internal incubator. The main goal of The Nest is to foster innovation, digital transformation and change across the entire organisation. It offers a nurturing environment in which employees, or 'idea owners', can transform their digital visions into tangible products. We have two physical Nest spaces at both our Belgian and German headquarters where teams can come together to co-create and work on solutions.

The Nest approaches innovation in a bottom-up way, by encouraging every staff member to put forward digital or innovation ideas. Once an idea is accepted by The Nest team, the idea owner is provided with coaching, mentoring, and access to resources. To ensure their ideas come to fruition, they are backed by a dedicated team of software engineers and designers, with up to 70 working days allocated for each project. The employee is required to contribute their business knowledge to the solution.

The Nest fosters the creation of digital prototypes for solving business problems and acts as an organ for learning and change. Each idea owner becomes an ambassadors of The Nest's 'new way of working', so spreading the tools and methodologies that have learned across the organisation.

"The Nest acts as a catalyzer offering to Elia Group's employees in-house capabilities for rethinking, designing and building scalable digital solutions that shape the future of the energy ecosystem."

Oz Ural,
Nest Manager

The Nest

EXAMPLES

Selection of ideas that have been explored in the Nest

1. **Dynamic forecasting and financial closing**: Development of a tool to support financial processes to detect improbabilities earlier and more accurately using an algorithm and presenting them via a convenient user interface.
2. **Get on-board:** Improvement of the onboarding process through a digital platform for new joiners and managers. The project will provide users with a better experience through pre-defined checklists and gamification.
3. **Advanced Analytics for Topology Optimisation (AATO):** Providing system operators with quick and sensible suggestions for solving bottlenecks across the grid as part of the day-ahead process. AATO quickly provides multiple suggestions for a selected day to solve the predicted "power congestion".
4. **Offshore Grid Navigator:** Development of a navigation system for the sea that can perform multi-criteria routing optimisation for new interconnectors, hybrid assets and energy islands.
5. **eCO2grid:** Generating a real-time visualisation of where electricity comes from and how much CO_2 was emitted to produce it.
6. **Green Tracking project:** Producing a system architecture that shows where green electricity comes from. The aim is to create transparency beyond guarantees of origin and to track the source of this green energy in near real-time. Energy Track and Trace evolved out of this project., an initiative for green proofs in collaboration with Energinet and Elering[32]

3.4 Technology Services Providers

Our Technology Services Providers (TSPs) are specialised hubs designed to disseminate specific technological capabilities across the Group. These TSPs are more than just a testament to the Group's expertise; they are a proactive response to the evolving demands of the digital age, ensuring that we remain at the forefront of established technological fields.

The AI TSP is a beacon for artificial intelligence prowess within the Group. Armed with a dedicated team of data scientists and analysts, this centre delves deep into the nuances of AI technology. They don't just theorise; they have a tangible platform at their disposal to develop cutting-edge solutions. Further enriching their capabilities is a strategic partnership, ensuring that the group has access to the latest AI trends and tools.

Parallel to this sits the Internet of Things (IoT) TSP which-boasts an advanced IoT platform, paving the way for innovative applications and solutions. With capabilities including sensor development and IoT network connections, this centre ensures that Elia Group is always interconnected, optimising operations, and enhancing service delivery.

Finally, the Group has an Innovation Coaching Centre. Home to experts in innovation methodologies like design thinking, this centre focuses on fostering a culture of innovation. It empowers teams across the business to approach challenges with fresh perspectives, tools and techniques.

32. www.energytrackandtrace.com

3.5 Technology exploration: The Tech-Lab

Staying on top of the constantly evolving technical landscape is key. By constantly monitoring emerging technology trends, we're able to identify the most impactful technologies that will allow us to tackle current and future business challenges, mitigate risks, and disrupt the way we do business. Our dedicated technology lab stands at the forefront of this exploration. Beyond this, the lab is also instrumental in testing and offering specialised knowledge on avant-garde technologies such as quantum computing, exoskeletons, and blockchain to staff across the Group.

We assess different technologies based on several factors, such as their potential influence on Elia Group, their potential value and their projected time-to-market.

If a technology is deemed relevant for Elia Group, we enter a testing and analysis phase to determine its level of maturity and potential benefit. We continuously check how we can apply the new technology – with the ultimate goal of solving the business challenges of today and tomorrow.

"In recent years, we have demonstrated that technological advancement, such as the innovative implementation of a machine that repairs pylons directly on site, lead to increased efficiency, cost reduction, and a safer working environment for our agents. Our commitment to this tech-driven transformation is pivotal in reshaping both our operations and our impact on the energy world."

Kris Laermans,
Technology Innovation

"The Technology Vision Radar informs and inspires discussions and potential partnering opportunities outside the scope of our corporate boundaries. Additionally, this tool helps us to promote technological awareness across the Group and encourage the exploration and adoption of emerging technologies to to address organizational challenges."

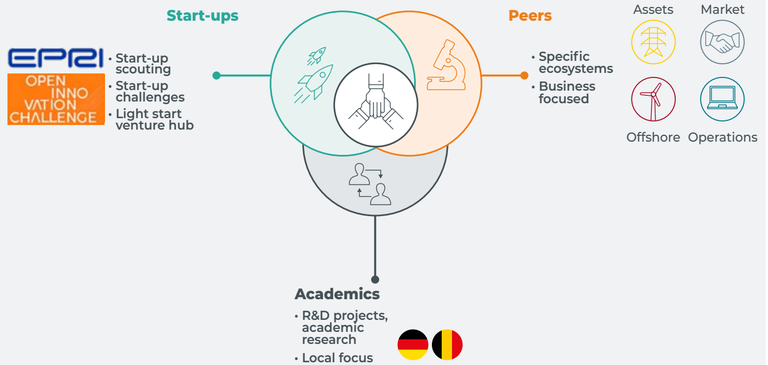
Eva Schramm,
Technology Innovation Elia Group

The pylon unbending machine under test in real conditions

3.6 Open Innovation: the Ecosystems

We cannot innovate alone – we therefore seek out partners with whom to innovate in an open manner and foster the creation of ecosystems with a range of actors. We are constantly on the look-out for potential synergies and partners, from start-ups through to more established organisations such as the Electric Power Research Institute (EPRI). We have established two academic boards in Belgium and Germany, bringing together the brightest minds from top-tier universities, to shape the future the energy landscape. We have also built specialised ecosystems tailored for our industry peers and others in areas such as system operations, asset management, consumer centricity, and offshore. These communities not only inspire but also catalyse innovation, ensuring that we keep learning and keeping us ahead of the curve.

Figure 9: Overview of the different ecosystem approaches



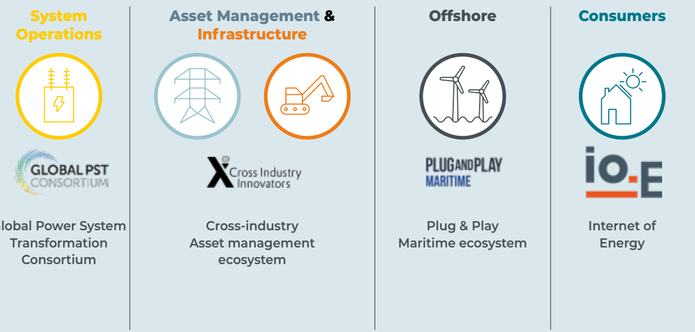
3.6.1 ECOSYSTEMS WITH OUR PEERS

The power of collaboration cannot be understated, especially when it involves learning from our peers, both within the energy sector and beyond it. We aim to both share our knowledge with and benefit from the collective wisdom of diverse industries. By doing so, we will increase the pace of innovation and substantially reduce its costs. We are therefore part of distinct partnerships, or ecosystems, as outlined below.

ECOSYSTEMS

1. **Cross-Industry Asset Management Ecosystem:** A newly established partnership that brings TSOs, DSOs, railway companies, and other companies operating vast life-essential infrastructures across Europe together. This collaborative platform aims to pool resources and insights, with one of its pioneering projects being a cross-industry image database sourced from drone imagery. This is instrumental in enhancing the AI algorithms used in maintenance.
2. **Internet of Energy (IoE):** Launched in 2019, the IoE explores cross-industry use cases, fostering the integration of consumers into the energy market. Engaging participants that range from EV start-ups to prominent building developers, it explores innovative use cases such as smart home and EV charging optimisation, as well as the introduction of new flexibility services. Beyond mere demonstrations, IoE offers insights into technological hurdles and barriers in consumer onboarding, enriching the overall market design.
3. **Maritime Ecosystem with Plug and Play:** We work with industries like dredging companies and ports to enhance our offshore activities. Initiatives here focus on securing offshore assets, so ensuring their longevity and operational efficiency.
4. **Global Power System Transformation:** The G-PST facilitates the exchange of knowledge about intricate topics, including the development of grid-forming techniques. Leading TSOs from across the globe are part of this ecosystem.

Figure 10: Elia Group is a part of various innovation ecosystems with peers



3.6.2 COLLABORATION WITH ACADEMIA

We recognise the value of academic input. We are actively collaborating with Belgian and German academic institutions through our Academic Board in Belgium and Scientific Advisory and Project Board in Germany[32]. These academic boards allow us to apply academic learning in solving the challenges faced by our sector. They allow us to discuss the challenges and issues which are crucial to the future of the energy sector and launch studies and research projects with the academic community.

"For us, this is an ideal opportunity to make sure that the theories and the science that we develop are validated, and bring them to the industry and apply them at the actual operations in a TSO. Through this academic board, we can jointly develop research and innovation roadmaps that will lead to an acceleration of the energy transition in Belgium."

Prof. Van Hertem, KU Leuven

"This collaboration helps us to focus our research activities on the right problems, and to teach the right things to our students."

Prof. Cornélusse, ULiège

Figure 11: Elia's Academic Board

Figure 12: Virtual meeting with the 50Hertz Scientific Advisory & Project Board

32. Scientific Advisory & Project Board (SAPB) (50hertz.com)

3.6.3 COLLABORATIONS WITH START-UPS

For years, Elia Group has thrived on its collaborations with start-ups. These have spanned multiple projects across our value chain, and have explored a wide range of areas, from harnessing the capabilities of autonomous drones, robots, and sensors, through to exploring the potential of block-chain.

"Understanding the unique challenges faced by start-ups, we are working on ensuring swifter contractual processes for our work with them, so aligning these with their operational realities. This approach will accelerate our innovation activities and will encourage start-ups to flourish within our ecosystem."

Lora Ivanova,
Open Innovation at Elia Group

Every year, we host the Elia Group Open Innovation Challenge[33] (OIC). Each of our challenges have attracted the attention of close to a hundred start-ups from around the world, including front-runners like TideWise, a Brazilian start-up that designed an autonomous boat that carries drones and can be used to inspect offshore infrastructure.

Our collaboration with EPRI and (more specifically) our participation in their Incubatenergy Lab programme, has allowed us to access a vibrant innovation ecosystem. Through this, we collaborate with start-ups and technology innovators on the creation and testing of cutting-edge solutions in real-world environments.

EPRI's global reach and deep-rooted understanding of innovation in the utility sector have enabled us to identify promising start-ups with whom we can work. As an example, through EPRI we began working with ALD Technologies, which offers innovative carbon wrapping solutions to reinforce poles and overhead lines.

33. Open Innovation Challenges (eliagroup.eu)

Figure 13: Tidewise (Winner OIC 2021) autonomous boat on a mission

CARBON GRIDWRAP TO REINFORCE THE GRID

Concrete poles typically have a lifespan of 70 years, with replacements involving high costs, difficult risk mitigation measures, and a week of outage. In the south of Belgium, strict pole replacements are in place (5% of poles can be replaced annually, whilst 20% can be replaced every four years). ALD Technical Solutions LLC's "GridWrap" is an innovative solution that reinforces aging or damaged poles, extending their lifespans and reducing replacement needs. The technology involves a composite repair wrap made of carbon fibre and epoxy resin, boasting high tensile strength, low weight, excellent durability, and rapid, on-site application. This aligns with the goal of mini-mising maintenance outages and can increase a pole's lifespan beyond the average of 70 years.

4. CONCLUSION

The energy landscape is being drastically transformed due to changing societal expectations, the emergence of new technologies, and the pressing need to address climate change. We at Elia Group are a front-runner in this transformation. We have an important role to play in accelerating the energy transition and seek to ensure that the needs of the energy trilemma are met: we are working to establish energy systems which are secure, affordable, and sustainable. To succeed in this, we must continuously innovate across a broad range of fields and transform our ways of working.

Our Innovation Strategy outlines the ways we plan to tackle the challenges that are being raised by the shifts above and transform them into opportunities. Our strategy focuses on six key domains – defined in line with our ambitions – that span the entire value chain. Tangible examples of our work within each domain are included, providing readers with examples of key projects and the way they are addressing the associated challenges. This is followed by insights into the formal structures and channels we have put in place across the Group to facilitate innovation and reach our ambitions. We have successfully established a cross-company and cross-functional decentralised innovation model within the organisation, involving multiple actors that carry distinct areas of focus and collaborate to reach common goals. Together, these six domains and our approach to innovation demonstrate our commitment to the energy transition and position us as a leader in the shaping of tomorrow's energy sector.

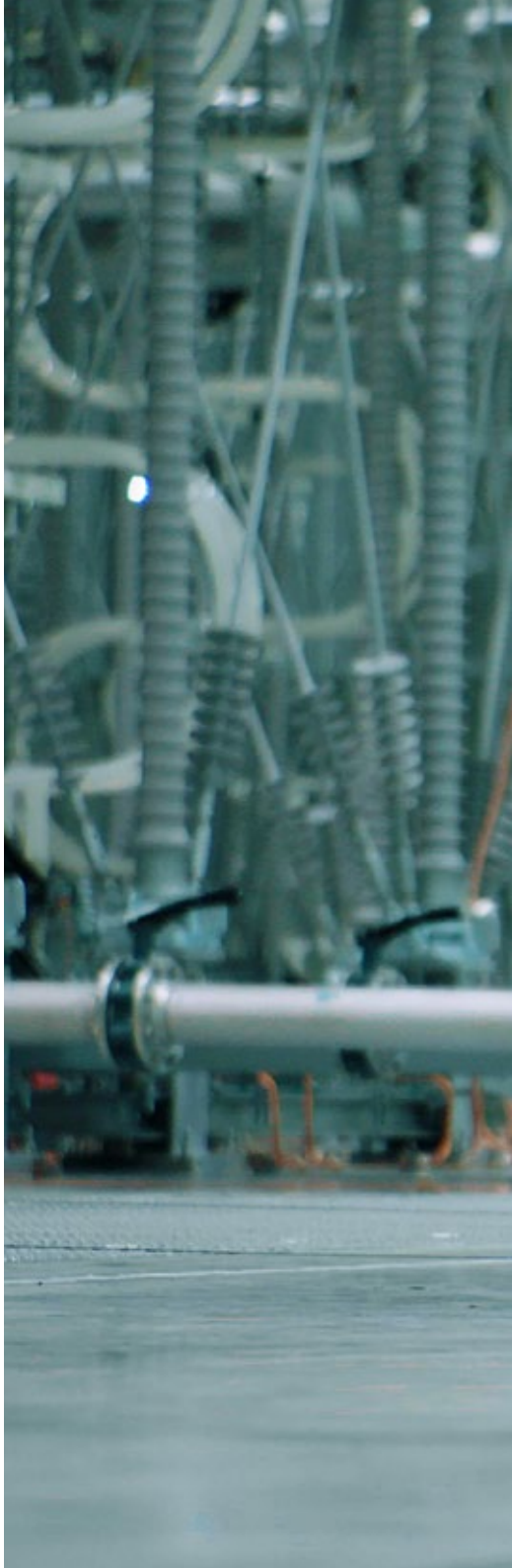
Our task, as a Group which comprises two of Europe's leading TSOs, is to inspire, lead by example and enable innovation in energy sector. We work in the interest of society and ensure that our work matches society's evolving needs and expectations. This is why our innovations are more than technical solutions: they are commitments to societal wellbeing, operational excellence, and proactive consumer engagement. Through our work, we are setting new benchmarks for efficiency, sustainability, and societal value.

We recognise that our ambitions are impossible to reach without using insights from or collaborating with our stakeholders. Their role is instrumental and we would like to invite them to actively engage with us. We would therefore like to ask readers of this strategy to share their insights or feedback with us, challenge our current perspectives or initiatives, and partner up with us to work on future joint projects.

Let's turn challenges into opportunities together.

"The nature of the energy transition brings more volatility and uncertainty requiring continuous technology evolution. In that context, efficient innovation is crucial to adapt fast, necessitating concerted coordination among all our stakeholders internally and externally. That's why Elia Group puts collaborative innovation as priority to fulfil our mission to decarbonise society."

Michael von Roeder,
Chief Digital Officer



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