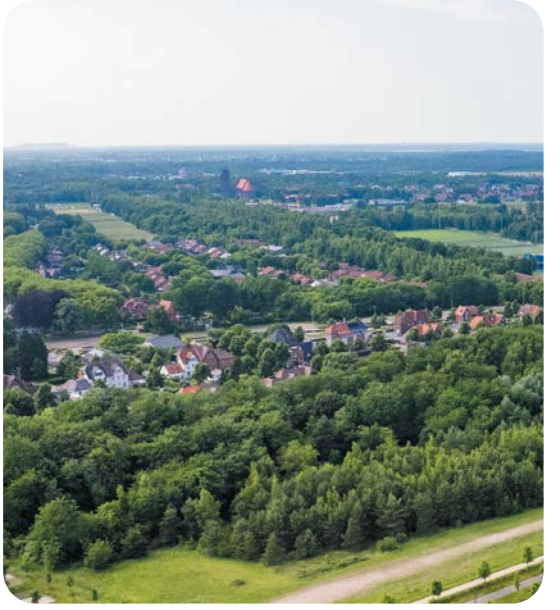
Energy Ville



English

Table of contents

Introduction Walter Eevers

Making the energy transition tangible

The world around us is changing at breakneck speed. Geopolitical, economic, and ecological tensions make the energy transition more urgent than ever. Not only to keep our planet habitable, but also to safeguard our prosperity and competitiveness in Europe. Our chemical and manufacturing industries in Flanders are under pressure. By fully committing to innovation, we can maintain and even strengthen our leading position.

This is precisely where EnergyVille plays a crucial role. We work on energy solutions at *all* levels: from research to application, from model to implementation, from battery to building, from transistor to electricity grid. Above all: we ensure that our knowledge also finds its way into practice. Valorisation is not an afterthought, but a strategic focus.

That means: contributing to concrete energy solutions for a competitive industry, working on affordable and reliable energy, also for those who are struggling today, and focusing on electric mobility. All this technology is built on a strong academic foundation and provides a perspective for clear policy advice. Because a successful transition requires integrated thinking and action.

In 2024, we made concrete progress in all these areas. The collaboration between our parent institutions became stronger than ever with the launch of our Flagship Initiatives, in which we address urgent societal challenges. In the Open Thor Living Lab, we mature innovation to a higher technology readiness level and test solutions in real-life conditions. Innovations can be scaled immediately, at a scale that truly enables the leap to industrial application. Etch links scientific expertise on electricity transmission to technological and social challenges, thus strengthening our role as an indispensable knowledge partner for the grid of tomorrow. In this way, we are building a strong ecosystem in which technological development and economic value creation go hand in hand. It makes EnergyVille a European benchmark.

But technology alone is not enough. The engine of our progress is and remains human capital. And that is a point that I strongly insist on. In a world that is changing ever faster, we must invest in people. We must work on ecosystems that not only attract talent, but also give it the space to grow, develop, and make an impact. That is our greatest strength–and our pride.

In 2025, we will shift into a higher gear. With even closer cooperation between our partners, and with an even sharper focus on tangible impact. Because the future of energy starts today.

Walter Eevers
Chairman of the Board of Directors – EnergyVille

"The engine of our progress is and remains human capital."

"We accelerate technology, lower the barriers to market adoption, and make impact visible and tangible."

Introduction Gerrit Jan Schaeffer

Shaping ambition together

The world is in flux, and energy is increasingly at the centre of the debate. Not just as a climate issue, but also as an economic and geopolitical lever. Anyone looking at the energy transition today sees far more than just a technological shift. Strategic independence, the future of industry, and societal stability all hang in the balance. The stakes have never been higher.

In 2024, we felt this dual reality even more acutely. The costs of solar panels, batteries, and electric vehicles continue to fall. Renewable energy is gaining global traction. At the same time, Europe, and certainly Flanders, remains highly reliant on imported energy—a dependency that is not without risks. In the past, we have been able to rely on cheap energy but that foundation is shifting. And so we must have the courage to rethink how we ensure a robust and sustainable industry, economy, and energy supply.

This is precisely where EnergyVille aims to make a difference. Our unique combination of broad technical expertise, strong collaboration between four complementary partners, and a sharp focus on creating societal value is what sets us apart and makes us successful. In 2024, we turned that ambition even more into reality. Together with our researchers, we launched seven Flagship Initiatives: integrated research programs that align our knowledge areas around major societal challenges. These initiatives emerged from the ground up. Driven by researchers who invested their time out of conviction, not obligation. That's something special. That's what EnergyVille is all about.

Through the Open Thor Living Lab and Etch, we are strengthening our position as a catalyst for industry and a source of inspiration for policymakers. We accelerate technology, lower the barriers to market adoption, and make impact visible and tangible. Our European projects, our valorisation efforts, and our partnerships with companies all affirm that we're on the right track. Internationally, we don't just participate. We are often frontrunners.

Today, EnergyVille is powered by a close-knit collective of people eager to move forward. We have a strong team, a strong network, and above all: a shared ambition. That shared ambition drives everything we do. I'm proud of how our shared motivation has grown over the years. Seeing how much we've already achieved gives me great confidence, because I know there's even more ahead. What we're building here is more than a research organisation. It's a strong, purposeful community.

Gerrit Jan Schaeffer
General Manager EnergyVille

ENERGYVILLE: BRIDGE BETWEEN RESEARCH, INDUSTRY, AND SOCIETY

How EnergyVille translates research into concrete impact

The energy transition is a systemic shift that affects us all. Industry, governments, and citizens all face profound choices. In this complex reality, EnergyVille plays a key role: we bring together science, technology, and policy, and contribute to building concrete solutions. We do this not just by pushing for technological breakthroughs, but especially by putting them into practice. To this end, we actively build bridges between the research world, society, policymakers, and industry. Together, we anchor our knowledge in practice and accelerate the shift towards a sustainable energy system.

In 2024, we leveraged our bridge-building role to work on a series of collaborative projects. In this way, we helped lay the foundation for future-oriented energy policy, e.g. through in-depth energy system analyses and scenario development for Flanders, Belgium, and Europe. We showed policymakers what is possible, under what conditions, and what impact today's choices will have on tomorrow's world.

Companies also relied on our expertise to develop, test, and demonstrate innovative solutions. Together with industrial partners, we brought prototypes to life and propelled technology towards market introduction.

Furthermore, we focused strongly on real-world demonstrations in neighbourhoods, buildings, and industrial sites. Here, we tested not only what works technically, but also what is socially acceptable and scalable.

Thus, 2024 proved once again that our strength lies in connection: between disciplines, between sectors, between vision and action. EnergyVille continues to strengthen that bridge, and in doing so, helps make a difference in the transition to a sustainable, resilient energy system.

Open Thor Living Lab: where the energy transition comes to life

On the former mining site of Waterschei in Genk, where black gold was once extracted, a different kind of wealth is being mined today: progressive solutions to accelerate the energy transition. And these sustainable innovations are being developed and tested in a real-world environment. The Open Thor Living Lab—a collaboration between EnergyVille, the City of Genk and Thor Park NV—is a living laboratory where companies, citizens, policymakers, and researchers work together on a sustainable future.

The Living Lab consists of three zones: a residential area, a science and business park, and the infrastructure of KRC Genk. This combination makes it possible to align the (often complementary) energy needs of different users, and to experiment with shared generation and smart energy control, as well as collective solutions for energy challenges.

In 2024, the Living Lab was established as a separate legal entity and recognised as a social enterprise, an important step to enable long-term impact. Thanks to co-creation with local residents and the involvement of end users, technologies can be adjusted and adopted more quickly. This increases their relevance and accelerates their path to market. In short: Open Thor Living Lab is where the energy transition truly comes to life.

Etch: Shaping the future of the electricity grid

To meet the sharply rising demand for electricity, smart, high-performance transmission networks are needed. That is why we established Etch (Energy Transmission Competence Hub): an expertise centre for underground high-voltage infrastructure, with a special focus on direct current technology.

At Etch we are working on knowledge building, digital testing environments, and new building blocks that are crucial for tomorrow's grid. We do so with support from the Flemish government and in collaboration with grid operators, technology companies, and engineering firms. As always, we combine in-depth scientific expertise with the needs of the professional field—a hallmark of the EnergyVille approach.

Flagships: the power of a shared vision

In 2024, we challenged our researchers to formulate interdisciplinary projects that address the major challenges of the energy transition. Their work will form the basis of the EnergyVille Flagships, due to launch in 2025. These programmes bundle knowledge and expertise from different disciplines and organisations. They translate complex issues into integrated solutions that have the greatest possible societal and technological impact.

This commitment across disciplines and organisations is what defines EnergyVille's strength. With the Flagships, we once again demonstrate how strong our community is, and how naturally we build bridges: not only within research, but also with companies, governments, and citizens. Because the energy transition requires a shared vision and joint action.

PATHS2050: strategic scenarios for a climate-neutral Belgium

The transition to a climate-neutral society hinges on strategic choices—technologically, socially, and economically. With PATHS2050, EnergyVille/VITO develops possible future scenarios for Belgium that couple scientific depth with practical applicability.

For instance, in 2024, EnergyVille/VITO solidified its collaboration with major industrial players in the PATHS2050 Coalition. This co-creation makes our analyses sharper and better attuned to the reality of companies and policy. PATHS2050 also strengthens EnergyVille's role as a bridge between research and strategic decision-making, offering a robust framework to help shape Belgium's energy future.

Research domains

SOLAR ENERGY

Better solar cells that last just as long

Solar energy remains a key technology in the energy transition. In 2024, EnergyVille made significant strides in making solar cells more efficient, durable, and adaptable for a wide range of uses. One of the most talked-about results comes from TESTARE, a European project focused on improving the lifespan and performance of promising new solar technologies.

Silicium in tandem with Perovskite

Solar cells are becoming more efficient. The latest generation can generate significantly more electricity per square meter than those from ten years ago. But that progress is approaching its limits. Traditional silicon-based solar cells are nearing their theoretical maximum efficiency, meaning there's little room left for improvement using silicon alone. To break through that ceiling, our researchers are exploring new approaches. One of the most promising is perovskite, a material that absorbs parts of the light spectrum that silicon doesn't.

By layering perovskite on top of a silicon cell, researchers have created tandem cells that can convert more sunlight into electricity. This could lead to a significant improvement in solar panel performance. However, there's a catch: perovskite cells are not as durable (yet) as silicon ones. Conventional solar panels typically last 25 to 30 years with minimal efficiency loss (less than 1% per year). In contrast, perovskite cells degrade much faster, which currently makes them unsuitable for commercial use.

That's why researchers at EnergyVille/imec, working within the TESTARE project, are focused on improving the lifespan and stability of perovskite cells. They field-tested their mini-modules under real-world conditions in sunny Cyprus. After a year exposed to sunlight, wind, and heat, the new modules retained up to 78% of their initial efficiency. In the lab, tweaking the cell architecture led to an efficiency retention of over 80% after 8,000 hours of thermal stress. This breakthrough raises the prospect that tandem cells could soon match the longevity of today's commercial solar panels.

More applications, greater impact

Integrating solar cells into new types of systems remains a key focus. EnergyVille/imec/Hasselt University developed semi-transparent perovskite modules on glass substrates which have an efficiency of 16.3%. When combined with silicon cells, the total efficiency reached 22.8%. This technology is particularly well suited for agrivoltaic systems, in which solar panels are installed above crops not just to generate energy, but also to protect plants from harsh weather, such as intense sun or hail.

A good example is the HYPERFARM project, coordinated by EnergyVille/KU Leuven and completed in 2024. Field trials in Belgium, Germany, and Denmark showed that vertical panels offer a good balance between crop protection and energy generation. The trials also highlighted the importance of carefully selecting crops to minimise yield loss. To support this, the team developed an advanced simulation tool.

Another example comes from the IN2PV project. Here, researchers from EnergyVille/imec/Hasselt University are combining Copper Indium Gallium Selenide (CIGS) cells with perovskite cells to create fully thin-film tandem modules. These are lightweight, flexible, and visually appealing, making them ideal for applications where traditional panels don't work well. We are therefore also setting up an R&D CIGS process line at EnergyVille/imec/Hasselt University.

Finally, the spin-off company Enfoil made headway in 2024. This young startup, which develops flexible solar cells, secured its first strategic investor.

These milestones underscore EnergyVille's role in pushing solar energy forward—combining cutting-edge technology with tangible benefits for society. Thanks to TESTARE and other initiatives, the vision of powerful, durable, and versatile solar power is coming closer to reality.

BATTERY STORAGE

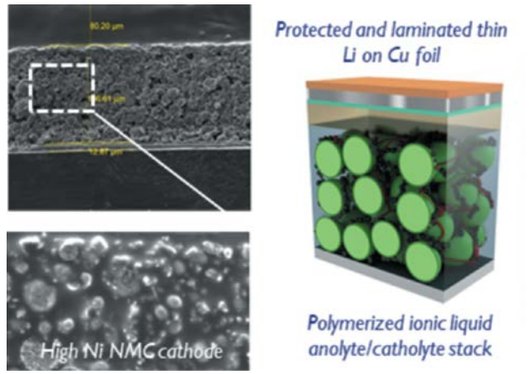
Higher energy density, smart control, and sustainable alternatives

Batteries play an essential role in enabling the energy transition. At EnergyVille, we are pursuing two parallel innovation tracks: developing new materials and cell technologies that are more sustainable and high-performing, and designing smart systems to manage batteries efficiently, safely, and cost-effectively.

In 2024, we made progress on both fronts. Within EnergyVille, battery cells with unprecedented energy density were developed, and ultra-light lithium-sulphur technology was successfully tested. We also concluded a licensing agreement for BattSense, a battery management system that enables precise, cell-level performance monitoring and control. These advancements reflect our impact at both the material and system levels.

SOLiDIFY: three times higher energy density for the batteries of tomorrow

Within the SOLiDIFY project, which was completed in 2024, EnergyVille researchers from imec and Hasselt University, together with international partners, achieved a significant breakthrough in the development of solid-state lithium-ion batteries. By integrating innovative components, they succeeded in developing a prototype battery cell with an exceptional volumetric energy density of 1,070 Wh per liter, three times higher than current batteries for electric vehicles. This paves the way for batteries that are more compact, lighter, and significantly more efficient.



The development and evaluation took place in the state-of-the-art battery labs and dry room at EnergyVille, where the performance of the cells was maximised and avenues for further improvement were mapped out. EnergyVille's unique infrastructure made it possible to test the technology under relevant conditions, ensuring it is ready for the next steps toward industrial scale-up.

Fugels: batteries with maximum energy, minimum mass

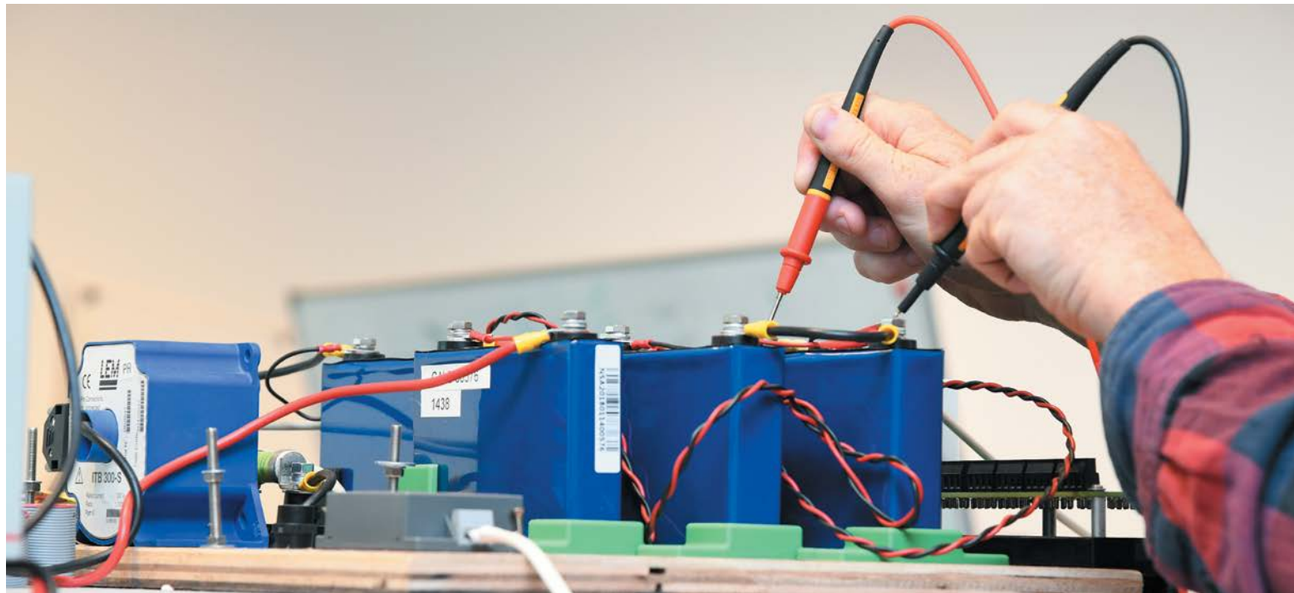
Where SOLiDIFY focuses on compact power, the Fugels project offers a different answer to the energy challenge: ultralight lithium-sulfur batteries (LSBs). Thanks to their unique chemistry, LSBs can be more than twice as light as traditional lithium-ion batteries, while retaining the same energy content. Reducing the weight of a battery is particularly important for applications in aviation and aerospace.

Within Fugels, EnergyVille/Hasselt University/VITO/imec researchers developed a working pouch cell (a compact battery cell with a flexible housing) that demonstrates the potential of this technology. Furthermore, because sulfur is abundant and inexpensive, production costs can be kept low. This step opens the door to more efficient and economically attractive battery solutions for the future.

BattSense: smart battery management on its way to the market

In addition to innovations in battery chemistry, investments are also being made in intelligent control and monitoring systems. At the end of 2024, a license agreement was signed with the Belgian company DVC for the commercialisation of BattSense battery management technology. This flexible technology platform, developed by EnergyVille/VITO, makes it possible to measure and adjust the status of each cell individually, leading to better performance, longer lifespan, and increased safety. Thus, BattSense is not only a commercial breakthrough but also a foundation for future smart applications in areas such as charging infrastructure and integrated energy systems.

DVC will further refine BattSense and make it cost-competitive, so that it can be widely deployed in the market. At the same time, EnergyVille/VITO will remain closely involved as a research partner for future innovation opportunities.



POWER ELECTRONICS

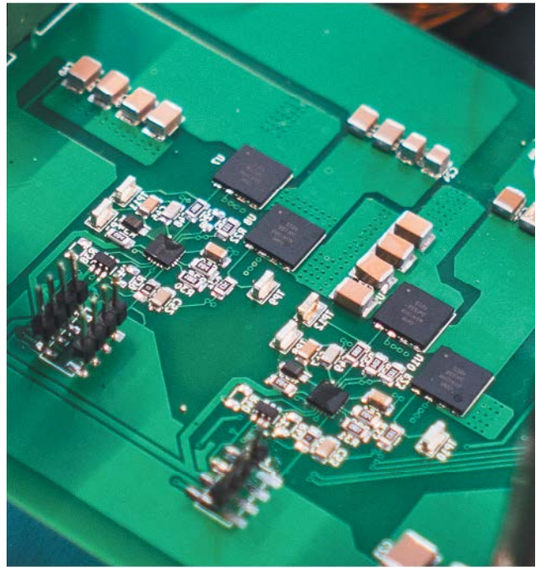
Every kilowatt counts

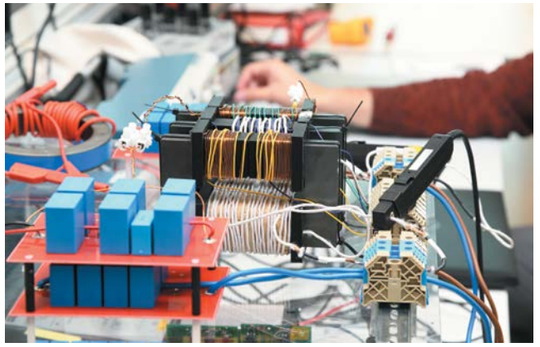
The rapid electrification of our mobility and energy demands more than just efficient solar cells and powerful batteries. Innovation is increasingly found in what happens around those solar cells and batteries; namely, in power electronics: the circuits, inverters, and charging technology that convert and manage energy. In 2024, EnergyVille made significant progress in making these systems smarter and therefore more efficient and sustainable.

Gallium nitride for compact switching

While an electric car's primary function is as a means of transport, it also has enormous potential as a mobile battery. The average car battery is eight to ten times more powerful than a classic home battery. However, a significant amount of energy is lost during the charging and discharging of such a battery, often up to 20% in each direction. Therefore, we need efficient and flexible inverters and charging systems that can handle a variety of usage scenarios and power capacities.

That is why EnergyVille researchers from KU Leuven, imec, and Hasselt University are working on smart, mobile power electronics that automatically adapt to achieve the highest possible efficiency, for example within the European project PowerBrain. They focus on gallium nitride (GaN), a material that allows energy to be processed much more compactly and efficiently. In 2024, EnergyVille/KU Leuven researchers developed a liquid-cooled, compact built-in charger, based on a GaN Dual Active Bridge Converter. Thanks to this technology, a much greater amount of power can be processed in a much smaller housing, with a capacity of up to 2.2 kilowatts per litre. This means, for example, that a compact 10-litre charger, about the size of a small shopping bag, can supply sufficient power for a smooth charging process at home. Moreover, the combination with liquid cooling ensures better heat dissipation, which benefits the performance and lifespan of the system.





Detecting, preventing, and predicting wear and tear

High temperatures are detrimental to the lifespan of power electronics. That is why at EnergyVille, we are looking for ways to better manage this heat and to better estimate its effects. Simulations have shown that ignoring thermal capacity can shorten lifespan by up to 70%. EnergyVille/KU Leuven scientists investigated how shadow flicker from wind turbines affects the temperature of inverters in solar cells. As a result, we can now more accurately estimate how temperature differences affect the system. Thanks to another breakthrough at EnergyVille/KU Leuven/ Hasselt University, we can monitor the wear and tear of MOSFETs in real-time; these are compact, powerful switches in charging systems and solar energy converters. Using a double-extended Kalman filter (an analysis method from the world of predictive algorithms), we can detect wear and tear at an early stage through subtle changes in electrical resistance. This allows any defects to be resolved before they can cause real damage.

Smarter design, broader deployment

Software is playing an increasingly important role. Tools such as PowerBrain and BriskSIM (developed by EnergyVille/KU Leuven) enable designers to simulate, optimise, and validate power electronics systems faster and more accurately, even before the first prototype has been built.

The applications extend beyond mobility, and build on the knowledge and expertise of EnergyVille researchers at KU Leuven, as well as imec, Hasselt University, and VITO. In projects such as SolarEMR, MarineSpots, Nautical Sunrise, and INCREASE, power electronics contribute to the efficient conversion of solar energy on land, on roofs, and on water.

Finally, there is also innovation in the building blocks themselves. Thanks to planar magnetics, with compact, thermally optimised coils and transformers, power converters become even smaller, more powerful, and more reliable. This breakthrough won awards at APEC 2024 and ECCE 2024.

With all these achievements, EnergyVille is strengthening its role as a pioneer in smart electrification and energy conversion. Ready for a future in which every kilowatt counts.

POWER-TO-MOLECULES

Towards a carbon-free industry

The transition to a sustainable industry requires innovative technologies that reduce the dependency on fossil fuels. Within EnergyVille, the research line 'Power-to-Molecules' plays a crucial role in this development by focusing on the production of green hydrogen and the conversion of CO_2 into valuable chemicals. The emphasis in 2024 was on upscaling, sustainability, and systems thinking.

Scaling up green hydrogen production

Green hydrogen is a promising energy carrier that can replace fossil fuels in sectors where electrification is difficult, such as heavy industry and chemistry. That is why EnergyVille focuses on more efficient, affordable technologies for hydrogen production via electrolysis.

Since 2021, researchers from VITO and imec have been working within EnergyVille on advanced membrane electrode assemblies (MEAs) for alkaline hydrogen production via electrolysis, a cost-efficient method to produce hydrogen. This collaboration, with companies such as DEME, Bekaert, and John Cockerill, previously led to the establishment of HYVE.

In 2024, the focus was on scaling up and commercializing this technology, with special attention to production costs and sustainability. Thanks to investments from the Flemish Resilience recovery plan, new research infrastructure was built at EnergyVille/imec/VITO, such as a membrane casting machine, a PVD system, and a wet chemical production line for nanomesh electrodes. Strategic investments were also made at EnergyVille/Hasselt University, including in a high-pressure PEM electrolysis installation and additional characterisation infrastructure. This allows researchers to test and optimise electrolysis systems even better. The manufacturability of nanomesh electrodes was successfully evaluated on this semi-automatic pilot line. In the future, this process will be scaled up further to films measuring 30x30 cm. At the same time, work was carried out on hydroxyl exchange membranes (HEMs), with a focus on lifespan and gas tightness. This infrastructure and these innovations form the basis for a new generation of high-performance and scalable electrolysis systems. By linking these electrolysis systems to renewable energy sources, we can produce green hydrogen on an industrial scale.

In addition, EnergyVille researchers from Hasselt University and imec are developing innovative photo-electrochemical (PEC) systems, in which sunlight is directly used for hydrogen production via specially developed semiconductors. PEC systems could, with further research into aspects such as efficiency, scalability, and co-production of value-added chemicals, evolve into a competitive technology for solar-driven water splitting.

Getting started with CO_2

A second line of research focuses on the electrochemical conversion of CO_2 into high-quality molecules, such as synthesis gas or syngas (a mixture of carbon monoxide and hydrogen). Syngas serves as an important raw material in the chemical industry and can be used for the production of e-fuels for aviation and maritime transport. EnergyVille researchers at imec, Hasselt University, and VITO are developing advanced materials for this purpose, including gas diffusion electrodes, plasmon (photo)catalysts, and nanomesh catalysts, and are optimising electrolysis cells.

These efforts led, among other things, to the development of silver-based electrodes that efficiently convert CO_2 into carbon monoxide. It also resulted in an integrated solution for CO_2 capture combined with the production of hydrogen and oxygen, the technical feasibility of which was successfully demonstrated.

At the same time, at EnergyVille/imec/UHasselt, we are exploring innovative concepts such as photoelectrochemical conversion, in which sunlight is used to convert CO_2 into valuable molecules. For this purpose, we developed innovative catalysts based on gold and ruthenium, which can convert CO_2 into syngas or methane under the influence of light. With this, we are taking a promising step towards sustainable, light-driven conversion technologies.

Systems thinking and integrated technologies

Finally, we look at the bigger picture. We seek solutions that are effective across the entire energy system and within industrial applications. For example, we are investigating how we can establish complete value chains for the production of e-fuels, such as by reusing process heat. In doing so, we consider economic feasibility, market opportunities, and European regulations.

We combine, model, and test innovative processes and components on a pilot scale, with the aim of optimising them together. To this end, EnergyVille brings together internal experts from various disciplines, including chemistry, process technology, and energy systems to develop sustainable solutions.

BUILDINGS AND DISTRICTS

Smarter, sustainable, and zero-emission buildings and neighbourhoods

The energy transition does not stop at the generation of renewable electricity. Our buildings and neighbourhoods must also become smarter, more sustainable, and energy-neutral. At EnergyVille, we work every day on solutions that help transform the construction sector and the broader energy system. We look beyond the individual building and develop solutions at different levels: from advanced materials and energy-efficient building components to integrated neighbourhoods and smart energy networks.

Our real-life test environments in the Open Thor Living Lab are unique in Europe in this respect. Thanks to co-creation between public authorities, companies, and the involvement of end users, we are able to collaborate on new ideas and thus arrive at solutions that better meet actual needs. By combining complementary methods, both model- and data-based, we create a strong synergy.

ConstrucThor: building the future, today

On 29 March 2024, the first shovel went into the ground for ConstrucThor, a new research building for climate-neutral construction. Here, various research groups from EnergyVille/KU Leuven will test and demonstrate new construction technologies and construction methods on a realistic scale. The structural work phase of the main building has started and, in addition, three typical houses from the 1920s, 1950s, and 1970s are under construction as representative renovation cases. This makes ConstrucThor a living laboratory where the construction sector gains insights that contribute to an accelerated energy transition.

THOREAQ: ready for the next step

In 2024, EnergyVille/VITO took major steps towards making the THOREAQ test buildings fully operational. The technical study and tender for the building technologies and monitoring setup were completed, and the THOREAQ test setups were officially inaugurated. THOREAQ consists of two identical test homes in which energy consumption, heat emission, and emissions from residents can be simulated and controlled. This allows the effect of specific interventions, such as a different heating systems, to be accurately measured.

In 2025, the test homes will be further equipped with technologies, interior finishing and 'virtual residents'—devices that mimic human behaviour. All this makes THOREAQ a crucial environment for testing innovative energy and building technologies. The insights from real-time monitoring will contribute to smarter and more sustainable buildings.

Official inauguration of THOREAQ with (from left to right) mayor of Genk Wim Dries, Flemish Minister of Economy and Innovation Jo Brouns, General Manager EnergyVille Gerrit Jan Schaeffer, VITO CEO Inge Neven, VITO Valorization Director Water & Energy Transition Marlies Van Holm, LRM General Manager Tom Vanham, and representative of the European Commission Marie-Pierre Jouglain.

Robotics in construction: innovation with precision

Automation is making its entry into the construction sector, and we are exploring this evolution in our dedicated robotics workshop. In 2024, the workshop was equipped with a robotic arm to support EnergyVille/VITO researchers in studying how robotics can enable faster, more efficient, and more sustainable construction processes.

oPEN Lab: from renovation to transformation

Renovation is a cornerstone of a sustainable future. Under the coordination of EnergyVille/VITO, 32 partners from seven countries, including KU Leuven and imec, are collaborating in the oPEN Lab project to upgrade urban areas across Europe and accelerate the shift toward energy-positive neighbourhoods.

From the start, the city of Genk has played a pivotal role, working alongside other partners to transform a social housing estate (Nieuw Texas) and a former mining district (Tuinwijk Waterschei) into energy-positive communities. In total, 33 homes (27 rental units owned by 'Wonen in Limburg' and 6 private homes) are being equipped with 16 innovative technologies. In parallel, researchers are exploring how energy can be shared and managed collectively within these neighbourhoods.

The goal extends beyond improved energy performance. oPEN Lab is building a future-proof, affordable, and socially inclusive renovation model. One that could inspire similar transformations in urban areas across Europe.

Hybrid methods: the power of data and models combined

Within EnergyVille, we combine the best of both worlds: physics-based modelling and data-driven methods. EnergyVille/KU Leuven is continues to build on this expertise in (physics-based) model development, for example via the Modelica IDEAS library, and links it to cutting-edge data-driven approaches to develop optimal control strategies and digital twins.

By seamlessly integrating these methodologies—such as data-enriched models, physics-informed algorithms, or hybrid control techniques like Reinforced Model Predictive Control (which blends MPC with reinforcement learning)—we create a powerful synergy. This innovative approach is gaining international recognition and is paving the way for smarter, more resilient, and more efficient energy systems.

ELECTRICAL NETWORKS

A strong and smart power grid

From high-voltage cables to low-voltage distribution, a future-oriented energy system requires grids that are robust, flexible, and smart. In 2024, EnergyVille worked on technological, digital, and organisational solutions to realise this ambition: from the new Etch expertise center to smart software tools such as PIRI and eMoPHs. Together they help grid operators move forward towards a reliable and resilient energy system.

High voltage: underground, offshore, and smartly managed

The energy transition requires a drastic expansion of the electricity grid, both onshore and offshore. High-voltage direct current is essential in this regard to efficiently bring offshore wind energy inland. Underground high-voltage cables can be a solution for social resistance to new above-ground routes.

Therefore, the expertise centre Etch (which stands for Energy Transmission Competence Hub) was officially launched in 2024. From its base in Genk, Etch focuses on three pillars: research, industrial development, and training. Together with transmission and distribution grid operators, technology companies, engineering firms, and large consumers, the centre develops new methods for planning, protecting and controlling hybrid (AC/DC) grids. In this way, it contributes to projects such as Princess Elisabeth Island, a future energy island 45 km off the Belgian coast.

In collaboration with European grid operators, EnergyVille/KU Leuven published open-source tools such as CbaOPF and Z-Tool. CbaOPF helps to simulate the financial and stability impact of new high-voltage direct current installations, while Z-Tool analyses the stability of grids with multiple active sources and simulates small disruptions. Within the Horizon Europe project PROSECCO, various tools are further refined and will be tested on the hardware of grid operators such as the Dutch TenneT.

Within Etch, practice-oriented training courses are also set up to strengthen the labour potential around high-voltage infrastructure. In close collaboration with partners across the sector, EnergyVille wants to create not only technological, but also social and economic added value.

Low voltage: smarter measurement and better control

The low-voltage grid must evolve to keep pace with the growing number of electric vehicles, heat pumps, and solar panels. In 2024, EnergyVille/VITO, in collaboration with Fluvius, conducted large-scale data analyses showing that most electric vehicle owners in Flanders tend to charge their cars in a grid-friendly manner. Their charging patterns are diverse, which helps spread the load effectively across the network. The data also revealed a trend: owners of electric vehicles or heat pumps tend to have more solar panels on average. These interconnections are important to monitor closely, as they could significantly impact grid performance in the years ahead.

Additionally, EnergyVille/VITO developed the software tool PIRI, which can reconstruct the structure of the low-voltage grid based on digital meter data, even if administrative data is missing or inaccurate. This helps grid operators to draw up realistic grid models and to manage them proactively. PIRI was delivered to Fluvius as a Minimum Viable Product and is now also attracting interest in Germany.

For the German grid operator Mitnetz Strom, EnergyVille/VITO researchers also developed the eMoPHs tool. This tool analyses the measurement data from the connection points of low-voltage circuits and, for example, maps out how many solar panels or electric heating are connected to these circuits. The results are sometimes surprising: the actual load often turns out to be higher than expected. In 2025, eMoPHs will be rolled out operationally by Mitnetz Strom.

Infrastructure and models in harmony

From smart tools to infrastructure projects, the electricity grid research line proves that preparatory work and modelling are just as essential as hardware innovation. While Open Thor mainly offers room for experimentation, Etch is a programme with clear technological objectives. Together, they strengthen EnergyVille's role as a knowledge centre for a reliable, flexible, and smart electricity grid in Flanders and Europe.

ENERGY STRATEGIES AND MARKETS

Smarter choices for a sustainable future

The energy transition goes beyond technological innovation. How we organise, trade, and regulate energy also determines how smoothly and affordably the transition to a climate-neutral future proceeds. At EnergyVille, we put our expertise to work to help companies, policymakers, and researchers make well-considered choices.

To achieve this, we take a comprehensive approach—ranging from long-term scenario planning and policy analysis to flexible market mechanisms and the social dimensions of energy use. In 2024, in close collaboration with our industrial partners, we advanced the development of these tools while addressing the growing challenges of an energy system marked by increasingly volatile prices.

PATHS2050: Building a climate-neutral and industrially resilient Belgium

How do we make Belgium climate-neutral by 2050, in a way that is both technically feasible and economically sensible? With PATHS2050, we develop potential future scenarios based on the insights of 200 EnergyVille researchers, outlining not only the broad strokes but also concrete applications for policymakers and companies.

In 2024, EnergyVille/VITO enriched the PATHS2050 results platform with sensitivity studies that increased the robustness and policy relevance of the scenarios. At the same time, we established the PATHS2050 Coalition: a partnership with (currently) five leading industrial players (ArcelorMittal, BASF, Elia, Fluxys and Luminus), all co-authoring the different strategic scenarios. This enhances not only the relevance but also the applicability of the insights in practice.

To make the platform more widely accessible, we improved outreach and user-friendliness. EnergyVille researchers at KU Leuven and VITO developed a new method to better model the import and export of electricity with neighbouring countries for more accurate simulations.

PATHS2050 has become an indispensable source for anyone who wants to work on a coherent energy policy. Its well-thought-out scenarios offer support for strategic decisions that take into account changing economic, technological, and industrial challenges. With the right policy choices, Belgium can accelerate the energy transition while maintaining its industrial competitiveness.

Smarter markets for a reliable energy supply

A future-proof energy system requires markets that can cope with ever greater fluctuations in supply and demand. In 2024, our scientists at EnergyVille/VITO/KU Leuven investigated ways to exchange electricity more efficiently between countries, with an increasing emphasis on offshore wind farms, and how long-term contracts could stimulate investments in renewable energy.

The future energy system will also need to be more flexible. In 2024, extensive research was conducted into new products, services, and market models that could unlock flexibility more effectively, particularly at low voltage levels. These innovations will make it easier to coordinate supply and demand in the short and long term. This included investigating how coordination between grid operators can be improved and how different energy carriers—such as electricity, gas, heat, and molecules—can be efficiently aligned in an integrated energy system.

At the same time, interest grew in dynamic electricity prices, which vary by the hour. Although this offers advantages at the system level, it can lead to challenges for individual districts or buildings. That is why governments and grid operators such as Fluvius and Elia were advised on smart solutions, including local energy management systems that can automatically respond to price fluctuations.

Looking further: from industry to consumer

In the energy transition, two stakeholders are crucial: industry and end-users. In demonstration projects with industrial partners, teams from EnergyVille/VITO/KU Leuven investigated the barriers to electrification and demand-side response, and worked on solutions to better unlock industrial flexibility. At the same time, they mapped out how energy communities and consumer behaviour influence the adoption of solar panels and batteries.

Additionally, they investigated how hydrogen and the capture, reuse, and storage of CO_2 (CCUS) can contribute to a more sustainable energy system. By linking technological progress to economic and social insights, market and technology are better aligned. This helps make the energy transition feasible and affordable for everyone.

THERMAL SYSTEMS

Smarter use of heat

In the energy transition, the focus is often on electricity, but heat accounts for more than 60% of our total energy needs. That is why at EnergyVille, we are working on smarter heating networks and more efficient heat exchangers—solutions that are less visible, but indispensable. By maximizing the use of residual heat and refining the design of thermal networks, we lower CO_2 emissions and make sustainable energy solutions more technically and economically feasible.

CollecThor: a modular heating network within a living lab

EnergyVille/VITO is taking sustainable heating and cooling at Thor Park to a new level with CollecThor: a fifth-generation heating network. Construction began in 2024, and the network was launched in February 2025. It will be fully operational by the end of 2025, providing heating and cooling for existing and future buildings at Thor Park using shallow geothermal energy and residual heat exchange.

CollecThor is a very low temperature network (VLT network), which means that users can connect their water-to-water heat pump directly without additional geothermal drilling. This makes the system particularly suitable for densely built-up areas seeking viable alternatives to natural gas.

CollecThor is more than an infrastructure project: it is part of the Open Thor Living Lab, our real-life test environment where technology and practice converge. The network has a modular design and we can expand and optimise it in phases. With a smart management system, we can efficiently control the entire energy chain, from production to consumption.

Heat exchangers: innovation behind the scenes

Heat exchangers play a critical but often overlooked role in recovering energy from industrial processes and various energy systems. In 2024, EnergyVille/VITO built upon the methods developed in previous years, with the aim of making heat exchangers even more compact and efficient.

By optimising the internal fin structures, they improve heat transfer while simultaneously limiting pressure loss—essential for efficiency and applicability. The new designs can be rapidly manufactured using 3D printing techniques.

A significant milestone was the construction of a complete test setup in our thermotechnical lab. The end of 2024 marked the start of the 3D printing of an initial optimised prototype, which will also be tested in this new setup.

Behind the scenes, we are making tangible progress in what at first glance seems purely mechanical engineering but which plays a key role in more energy-efficient energy systems for buildings and industry.

Smarter heating networks for better energy performance

Thermal networks are an important link in a sustainable energy system. Therefore, at EnergyVille, we develop advanced software tools to make heating networks more efficient, sustainable, and profitable.

With the STORM District Energy Controller, EnergyVille/VITO researchers smartly manage heat demand: it shifts consumption to times when sustainable energy is available and inexpensive. This increases both the sustainability and the profitability of the network.

Additionally, with FAST FDD (Fault Detection & Diagnostics), they analyse where operational improvements are possible in a heating network.

And with PATHOPT researchers from EnergyVille/VITO/KU Leuven calculate the most cost-efficient design for each project—from a small neighbourhood to an entire city. The tool also allows scenarios to be compared and adjusted, which ensures a flexible and future-oriented design.

Smart control for heat pumps

Heat pumps play a key role in the energy transition for heating and cooling. To smoothly integrate them into smart networks (Smart Grids), it is important that they are ‘smart grid ready’, i.e. flexible and remotely controllable. That is why we are working on improving the intelligent control of heat pumps, including via new control interfaces and the development of digital twins, to facilitate communication with energy management systems.

The future of thermal systems

Whether it concerns innovative heat exchangers, heat pumps, smart algorithms, or integrated networks such as CollecThor, our innovations in thermal systems ensure that heat, just like electricity, plays a full role in the energy transition.

WITHIN INDUSTRY

Regional anchoring, international ambition

Industry is a key sector in the energy transition. Not only as a major energy consumer, but also as a driver of innovation for sustainable solutions At EnergyVille, we work intensively with companies of all sizes to drive this transition. Through joint research, demonstration projects, and technological support, we help industrial players to move towards a low-carbon, competitive future.

In 2024, we further strengthened this collaboration, both locally and internationally. By maintaining close contacts with companies and sector organisations, we were able to better align our research infrastructure to their needs, accelerating technology transfer. The Open Thor Living Lab played a pivotal role in this capacity as a shared innovation hub.

Anchored in the local ecosystem

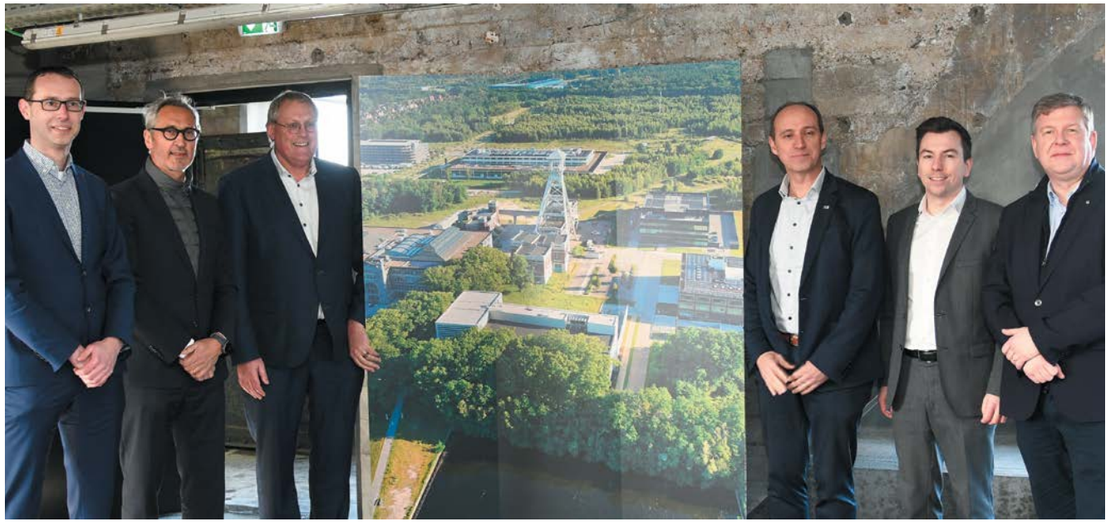
In 2024, our focus on the Limburg ecosystem became even stronger. We were present at local network events such as Get-2-Know-You at Thor Park, SMAFACC, or demonstrations related to the Einstein telescope, and we welcomed companies such as Nitto, Facil, and ARaymond to our site. The ties with regional partners such as VOKA, Embuild, and POM Limburg were strengthened.

Open Thor Living Lab as a catalyst

The Open Thor Living Lab also continued to grow. As part of the largest European oPEN Lab project, the renovation of the test homes in 'Nieuw Texas' and 'Tuinwijk' in Waterschei was largely completed, and THOREAQ—including its test site for construction robotics—is being prepared for use. The first phase of ConstrucThor, a unique test environment with real buildings, was launched. In the meantime, the collective heating network CollecThor, which will be available for test setups by companies and researchers from 2025, was also constructed. In 2024, the Open Thor Living Lab was officially established as a cooperative social enterprise. This allows us to further develop our infrastructure, coordinate investments, and support partners.

Thor Park on the European map

In March 2024, the European Council for Industry met at Thor Park in Genk. Flemish Minister Jo Brouns and Federal Deputy Prime Minister Pierre-Yves Dermagne, together with EU Commissioner Thierry Breton, welcomed around thirty fellow European ministers. The summit focused on the future of European industrial policy, highlighting the green and digital transition. The choice of Thor Park underlines the strategic relevance of this innovation campus. For EnergyVille, it is a confirmation of both our strong regional anchoring and our role as a leading knowledge centre within the European energy system.



WITHIN THE DIGITAL WORLD

Digital innovation as a lever for a resilient energy transition

The digitisation of the energy system is no longer a distant dream. It is a necessary accelerator of the energy transition. Without smart control, connected infrastructures, and data-driven insights, the full potential of renewable energy and flexibility cannot be realised. EnergyVille plays a pioneering role by conducting research that strengthes grid management, boosts energy efficiency, and advances system intelligence.

In 2024, EnergyVille made significant progress in the digital transformation of the energy system. The SmarThor platform grew into a powerful digital nerve centre for monitoring, analysis, and real-time control. With new tools, improved accessibility, and international visibility, EnergyVille strengthens its position as a digital pioneer in the energy transition.

A flexible and smart data platform as the digital backbone

In 2024, EnergyVille again took important steps in the integration of digital technology within the energy system. The SmarThor platform, our central digital infrastructure, further developed into a high-performance and flexible environment for monitoring, data analysis, and smart control. For example, the Smart Charging platform was redesigned into a scalable, standardised data architecture. This enables the management and interconnection of charging stations on different sites, each with their own optimisation.

The platform's accessibility received extra attention: users now have central access via a revamped portal, with dedicated dashboards for the renovated homes in the Open Thor district, smart charging, Fluvius data, and more. Furthermore, new links with external systems and control signals enable real-time adjustments based on data, bridging the gap between analysis and action.

We invested in the quality and reliability of the data. Historical data was integrated, incorrect measurements were filtered and missing data were retrieved via adapted APIs (Application Programming Interfaces). Moreover, data from the weather station on the EnergyVille campus was added, along with a day-ahead forecast based on ENTSO-E data, as input for the energy management systems.

From demonstrations to international visibility

Finally, EnergyVille also ensured international exposure with live demonstrations of the platform during events such as FTI Genk and the Agoria Belgian Data Spaces Day. With these efforts, EnergyVille is strengthening its position as a digital pioneer in the energy system of tomorrow.

WITHIN A POOL OF TALENT

The future of energy? People!

The energy transition is above all a human one. Innovation arises when people collaborate—not because they have to, but because they want to contribute to a better world.

We saw this mindset in action when our researchers shared their vision on the defining challenges and opportunities that lie ahead. Joining forces across disciplines and universities, they bundled their insights into new Flagship programs, where collaboration and multidisciplinarity are central. This open, team-driven approach is what sets us apart. It is this extra dimension, on top of the expertise of our people, that makes EnergyVille a leader on the international stage.

To prepare the employees of tomorrow, we reinforce this ambition with three strong pillars: inspiring young people with STEM initiatives, training talent through specialised master's programmes and anchoring top research through a strong doctoral programme.

STEM: passing on knowledge to the next generations

Inspiring young people and teachers with science and energy remains a priority. In 2024, we organised the Energy Masterclass, an in-depth session on current energy themes for teachers, policymakers and the business world. In March, the FTI Energy Festival took place, where visitors of all ages could discover energy through interactive workshops and demonstrations. Additionally, we reached young people through the KU Leuven Children's University, school visits with EducaThor and the 2024 Science Day. STEM projects such as Power IT Up, the Learning Ecosystem T2, and TATOE brought technology and energy into the classroom in a tangible way. These are all examples of how we spark people's interest and involve the next generations in our search for solutions to the energy challenges.

Master's programmes: preparing talent for the energy transition

To close the gap between future labour needs and available skills, we actively contribute to master's programmes that focus on energy innovation. In addition to relevant engineering and science programmes at KU Leuven and Hasselt University, the latter also started the International Master Energy Engineering Technology (iMEET) in 2024–2025. The second year of the Master in Materiomics started with a strong focus on energy and materials. In 2023–2024, students gained hands-on experience through summer schools, internships, and theses at the EnergyVille labs focusing on solar energy, battery storage, and power-to-molecules.

Doctoral programme: EnergyVille as a breeding ground for top research

With more than 280 doctoral students from around 60 countries, EnergyVille remains a magnet for international talent. Our doctoral programme helps to anchor knowledge in Flanders and to pass on expertise to the next generations of energy experts.

In 2024, PhD students again had the opportunity to deepen their research and connect with industry through Energy Talks, the EnergyVille PhD Days, networking events with Hasselt University, and company visits to the Port of Antwerp and Umicore. Additionally, several young EnergyVille researchers gave lectures at UCLouvain on energy systems and modelling.

Thanks to these initiatives, we continue to attract, train and inspire talent and contribute to a sustainable and innovative future.

WITHIN COMMUNITIES (OUTREACH)

Connecting energy with society

A successful energy transition is one that is both technically sound and socially supported. Citizens, governments, and communities all play a crucial role. EnergyVille therefore focuses strongly on outreach and open dialogue. This allows us to share knowledge, learn together, build together, and accelerate progress.

In 2024, this role expanded, but the goal remained the same: to bring the energy transition closer to people.

In 2024, that ambition first took shape with a complete rebranding. We refreshed our corporate identity, launched a new logo, and built a brand new website. All because we want to make our message clear, attractive, and accessible to everyone.

We stepped out into the world, and invited the world in. We organised international events at Thor Park, including a visit from the European Council of Ministers. We also attended fourteen Flemish and international trade fairs, congresses and events. These were great opportunities to share our expertise and build bridges with other players in the field.

Through blog posts, expert talks, and position papers, we made our knowledge tangible for a broad audience. We addressed current themes: from solar panels and circular construction to heat pumps, CO_2 prices, and energy policy. In this way, we helped to make complex themes understandable, without sacrificing content.

In short: EnergyVille does not retreat into an ivory tower. We go outside, engage in dialogue, and make the energy transition visible and tangible. Because only together we can truly drive that transition forward.

ENERGYVILLE IN NUMBERS

657*
Colleagues

281
PhD students

2
International events at Thor Park

14
EnergyVille representatives at international and national fairs and events

53
Companies active in our Living Lab

6
New European projects awarded to two or more EnergyVille partners

58
Publications in international journals with two or more EnergyVille partners

*April 2025

CONCLUSION

This annual report provides a look back at EnergyVille's main achievements in 2024. It is not a complete overview but a representative insight into where we, as a knowledge centre, have made a difference: in research, in collaboration with industry, in societal dialogue, and in international projects.

We thank all researchers, stakeholders, and colleagues who have contributed to this success. Their dedication and expertise are the driving force behind our progress. In the coming years, we will continue this work unabated, with the same dedication and ambition.

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