



An energy transition for all

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PROLOG:

2022 THROUGH THE LENS OF GERRIT JAN SCHAEFFER, GENERAL MANAGER ENERGYVILLE



2022 was an extraordinary year in many ways, and certainly in terms of energy. Partly due to the terrible war in Ukraine and the subsequent sanctions against Russia, energy prices soared. The high prices led to many government measures to protect families against sky-high energy costs. Politicians and the general public gave much more attention to our energy system and the functioning of the energy market. Sales of solar panels, insulation, energy conservation measures, heat pumps and so on skyrocketed. We all turned down our thermostat a degree or two, which together saved a lot of gas. Industrial production processes were temporarily halted because the raw material, natural gas, was too expensive. And the realization grew that we could bring together sustainability and a structural reduction of our energy dependence and our energy bill in an accelerated energy transition.

Accelerating the energy transition, that's what EnergyVille stands for and what we, as the leading innovation center in this field in Flanders, are contributing to. Thus, we strengthened our research infrastructure, created new spin-offs and helped advance the discussion on a carbon-neutral Belgium in 2050 by publishing our science-based energy scenarios.

The **Open Thor Living Lab**, our infrastructure where we can work with businesses and citizens to develop and test innovation in a real-life environment, is growing. This can be taken literally, as in 2022, work began on two test homes and a fifth-generation heating network at Thor Park. The two test homes are identical, similar to existing homes and are equipped with techniques and a set of measuring equipment to test retrofit solutions, indoor air quality and façade elements. They are part of the **Thoreaq** project, in which a technical hall and a site lab will also be realized in the coming years. A second piece of the puzzle in the Open Thor Living Lab is the construction of the **CollectThor** heat network, with which buildings can be heated and cooled sustainably and energy can be exchanged. EnergyVille is therefore collaborating in the **oPEN Lab** project with residents of the garden

districts of Waterschei and the New Texas neighborhood, and will also collaborate with KRC Genk in a later phase. More than thirty homes are being retrofitted with new technologies as part of this project. Finally, preparations



were made for **ConstrucThor**, a climate-neutral building in which renovation solutions and new installation techniques can also be tested.

A number of spin-offs saw the light of day in 2022, including **SOLiTHOR**. SOLiTHOR focuses on the development, production, and commercialization of innovative solid-state batteries and raised €10 million in capital. It aims to play a key role in the European battery value chain, supplying the global market and thus making a significant contribution to European exports and the decarbonization of the transport sector. With this technology, the electrification of transport is not limited to passenger cars, light trucks and buses, but we can also consider long-haul trucking, inland shipping, sea ferries and short-haul aviation.

Making a significant contribution to Belgium's energy transition by providing insight into routes to carbon neutrality is the goal of the **PATHS2050 platform**. The platform, on which more than 200 EnergyVille researchers have collaborated, is available via its own website (<https://perspective2050.energyville.be>) and shows at a glance the outcomes of different roadmaps, across different sectors - industry, electricity, buildings, transport and hydrogen.

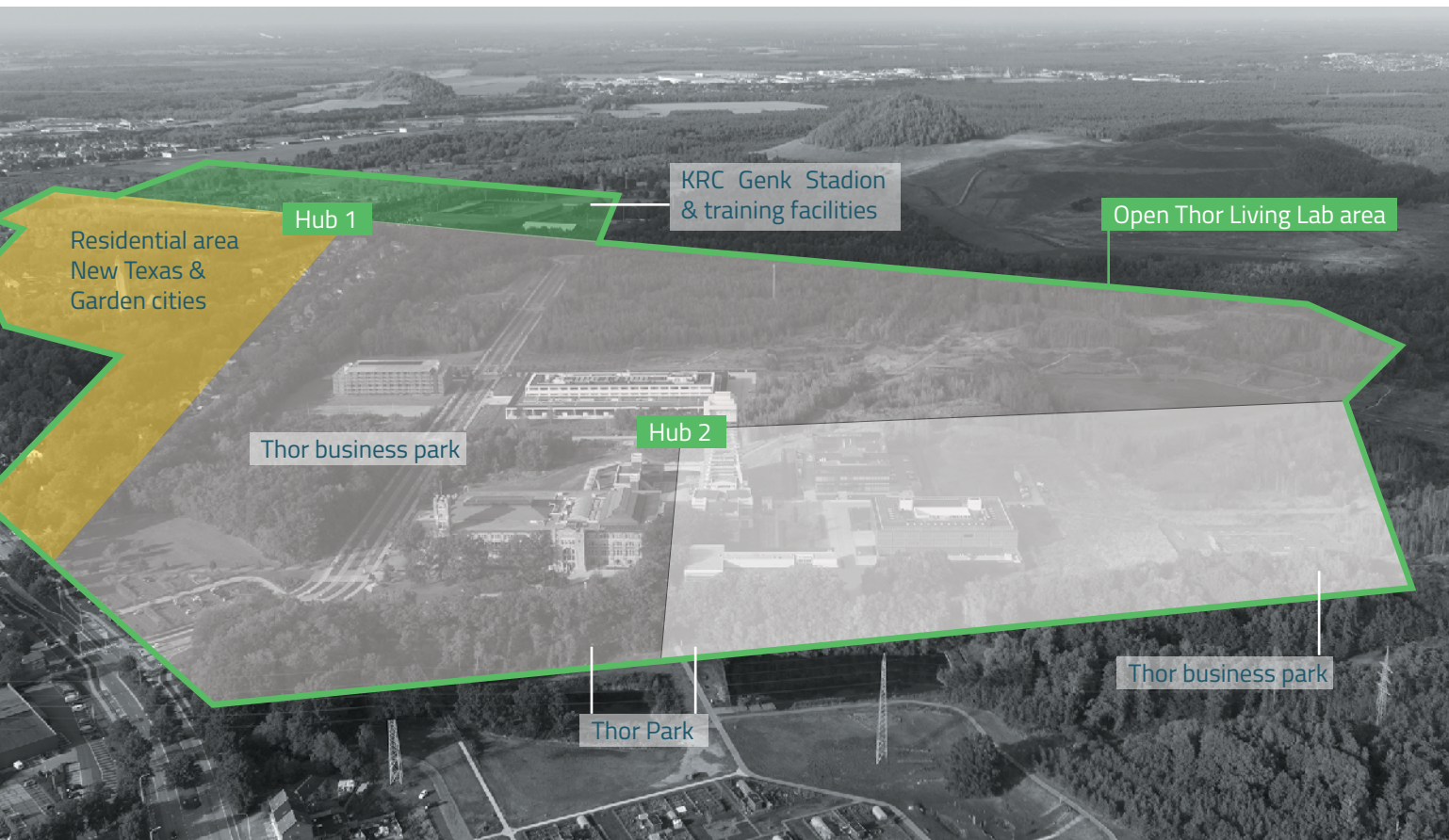
Clearly, we are working on the future in several areas. In addition to the small selection of highlights above, you will find a more extensive overview of our activities on the following pages. Highlighting concrete steps is a start, but rest assured that there are many activities in addition to these highlights and that hard work is also being done behind the scenes to further accelerate the transition to a market-based, sustainable energy system for urban areas.



OPEN THOR LIVING LAB - A LARGE-SCALE LIVING LAB WHERE SUSTAINABLE AND INNOVATIVE ENERGY SOLUTIONS COME TO LIFE

Built on the black gold of the past and with an innovative vision for a green future, that is the Open Thor Living Lab: a top-level European innovation environment that focuses on innovative solutions for the energy transition on the one hand, but also wants to provide solutions for smart manufacturing and smart city applications on the other.

To achieve this, EnergyVille, Thor Park and the City of Genk have joined forces to create an unparalleled ecosystem – with a state-of-the-art infrastructure in which innovative energy solutions are developed and tested and ensure an accelerated market entry in unique interaction with scientific institutions, companies, education, governments and local citizens.



Within the Open Thor Living Lab collaboration takes center stage

The Open Thor Living lab is a story of many assets. It is a unique infrastructure environment where innovation comes to life, but also where governments, companies and citizens are actively involved to interact and exchange knowledge. It is a living lab where issues related to social topics are specifically tackled via co-creation, open innovation and collaboration, making Thor Park a unique test environment to provide meaningful answers and solutions to the climate objectives.

Geographically, the Open Thor Living Lab is equally a unique location to stimulate and valorise initiatives. The Open Thor Living Lab includes the Thor science and business park, the New Texas social housing estate, the adjacent Waterschei garden suburbs, and the buildings and training complexes of KRC Genk. These five areas each have a different context and challenges, but together form a valuable ecosystem of industrial companies, researchers, entrepreneurs, end users, citizens and governments to develop innovative solutions for a sustainable future.

2022: A SMALL SAMPLE OF OUR BIGGEST ACHIEVEMENTS

|| SOLAR ENERGY

Perovskite solar cells are hundreds of times thinner than silicon solar cells, which are currently widely used. They are therefore much cheaper and more sustainable. In 2022, EnergyVille has demonstrated a perovskite solar cell with an efficiency of over 24%.

Perovskite has been an important material under investigation for several years as an absorption layer. On the one hand, this material has enormous potential for thin-film PV, with high efficiency, but also to realize transparent and flexible solar cells. By having as few defects as possible on both sides of the perovskite absorption layer with specific treatments, we could realize PV cells with efficiencies of more than 24% by 2022. On the other hand, the perovskite material is also crucial for a new generation of tandem solar cells in which

a perovskite top cell is applied over a bottom cell based on silicon or a polycrystalline semiconductor material, such as chalcogenides. Thanks to the development of process technology for the perovskite cells and modules, this has also allowed us to make tandems at larger sizes (~800cm²). This shows that this new PV technology will also be relevant and possible for large-scale, industrial applications.

Bringing together the expertise of the crystalline-Si and thin-film teams, a 2-terminal tandem module was fabricated using a perovskite/silicon tandem cell with a large surface area of 4x4cm² and multi-wire connection, achieving a module efficiency of 18.6%. This is the largest tandem cell made in-house to date.





|| BATTERY STORAGE

In 2022, SOLiTHOR, a spin-off from imec, saw the light of day. SOLiTHOR focuses on the development, production, and commercialization of innovative solid-state (Li) batteries. Solid state batteries can take the performance of classic battery systems to the next level by improving energy density, charging speed, weight and volume. SOLiTHOR is also

looking for components that are compatible with the current assembly process of Li-ion batteries to make a large-scale production process much easier and cheaper. The goal? To become a world leader in solid-state batteries and use this technology to reduce carbon emissions in our society.

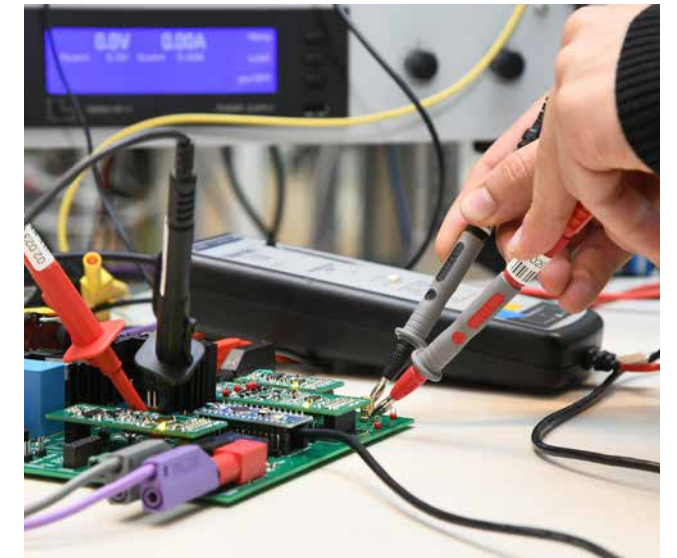
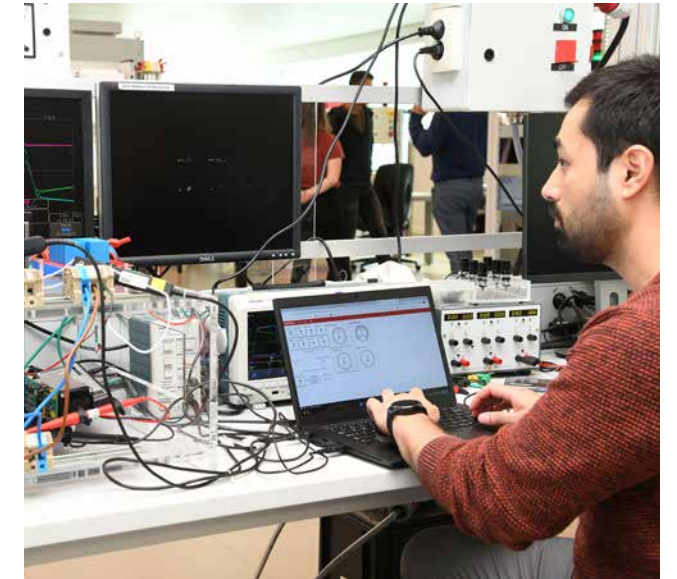
|| POWER ELECTRONICS

Power electronics ensure the switching, control and conversion of large electrical capacities, such as inverters of solar panel installations, energy management systems or charging systems for electric vehicles. As such, they are indispensable for a global roll-out of renewable energy sources and they are an essential part of batteries of electric vehicles. Due to the need for power electronics, it is important to make them as efficient and sustainable as possible. Since power electronics are used in the conversion, storage and end use of all electrical energy, even a small increase in efficiency has a big impact.

In 2022 the EnergyVille researchers developed a first prototype of an isolated inverter for EV battery charging based on GaN (Gallium Nitride) instead of the traditionally used silicon technology. By switching to this material, semiconductor switches can become even more efficient, smaller and faster.

Other highlights include our work on failure mechanisms of PV inverters, which will help identify the indicators of reliability and integrate them into a monitoring system that can accurately predict inverter failures, ultimately extending the lifetime of PV inverters. When it comes to charging of electric vehicles, bi-directional chargers are increasingly making their way to the market. Nissan, Hyundai and Kia paved the way, other car manufacturers will soon follow.

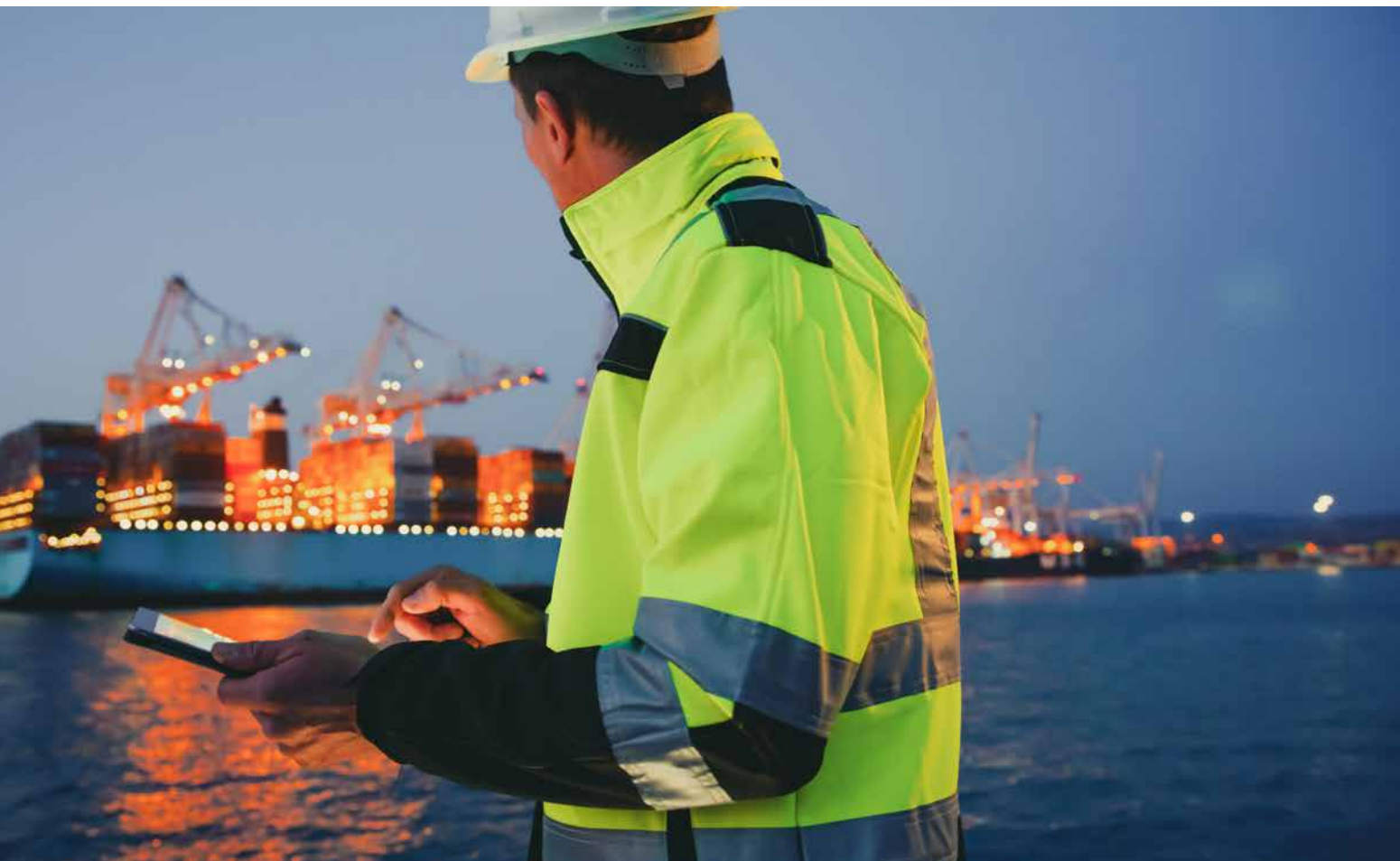
At EnergyVille we analyze and improve the efficiency and power density of the available bi-charging systems, as these systems will be essential to relieve the electricity grid at peak times.



|| POWER TO MOLECULES

Green hydrogen is essential to decarbonize certain sectors where electrification is not a solution. By combining the imec nanotechnology for the electrodes and electrolyte with the VITO system knowledge and technology for cells and membranes in the Hyve consortium, we are using the joint knowledge of the EnergyVille partners to develop more efficient and sustainable electrolyzers. This consortium was founded in 2021 together with industrial pioneers Bekaert, DEME, Colruyt Group and John Cockerill.

In a first phase, Hyve is focusing on the proof-of-principle demonstration of the nanomesh electrode and the hydroxyl exchange membrane that make up the Membrane Electrode Assembly (MEA). Both the nanomesh structure and gas separation membrane were significantly improved, indicating the tremendous potential of the technology. The next phase of the project focuses on scale-up and manufacturability so that the product can be brought to market in a final stage.



|| BUILDINGS AND DISTRICTS

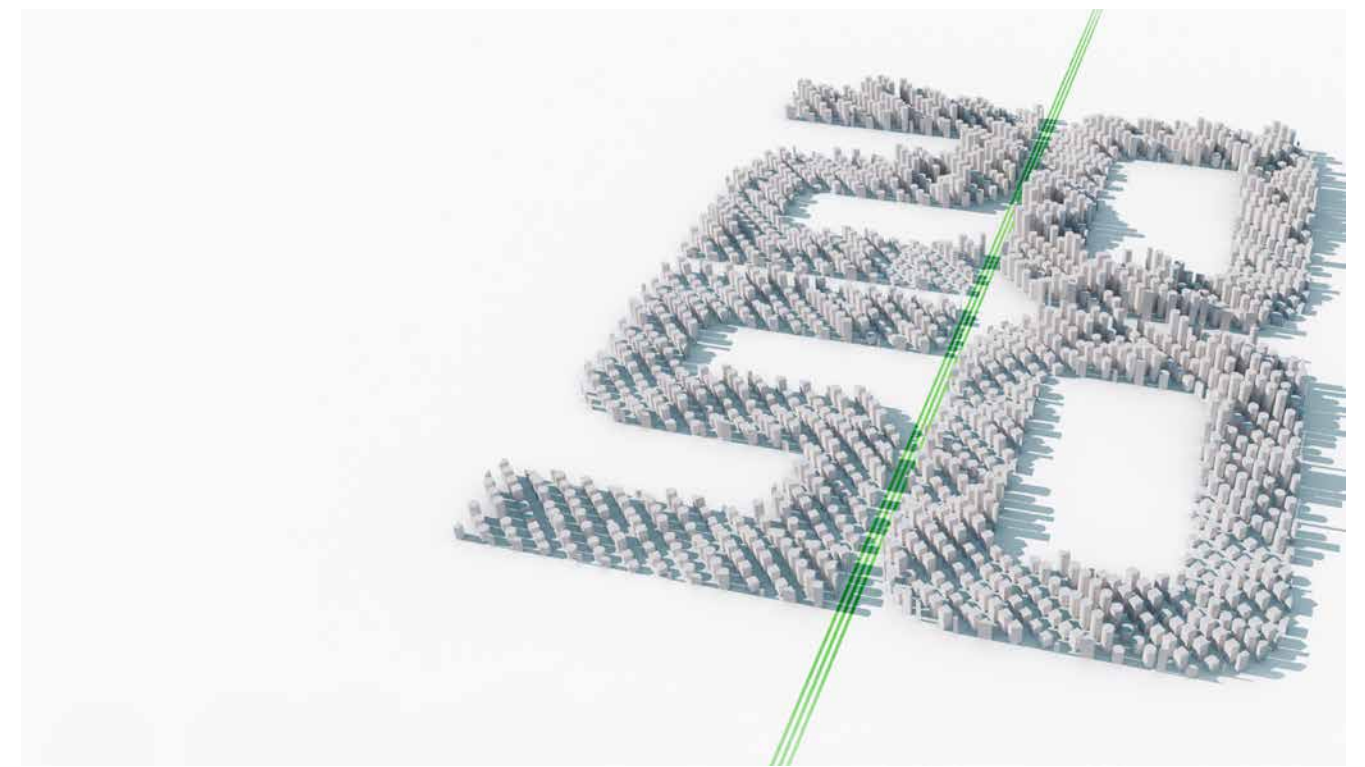
In the Open Thor Living Lab infrastructure, a lot of our ambitions come together. In the living lab, we gather data to validate models and to test innovative concepts. The Thoreaq and ConstrucThor research infrastructure will enable us to test new materials and methods of building, and new retrofitting strategies. Not just that, because we will also be able to test the interaction between buildings and energy systems. This is the system approach that makes our work unique.

Our system approach brings together scientific expertise on several research topics, as well as strong connections to market actors and policymakers. The output provides opportunities to complement models and data in other lines of research, allowing them to estimate the impact of buildings more correctly. Conversely, insights from the other research lines provide more in-depth understanding of the broader energy context (with, for example, knowledge about energy markets), energy systems (both thermal and electrical) as well as more in-depth knowledge about the behavior of components such as PV, batteries and thermal and electrical devices.

|| ELECTRICAL NETWORKS

In the near future, HVDC or High-Voltage Direct Current connections will form the backbone of the pan-European transmission network. HVDC technology is ideally suited to transport these large amounts of electrical energy over long distances (e.g., from offshore wind farms to load centers inland). However, current systems are mostly point-to-point and the transition to an HVDC network will bring many new challenges from a technological, management and planning perspective. From a social perspective, it is not easy to find support for new, overhead high-voltage lines in a densely populated area such as Flanders, as demonstrated in the discussions on the Ventilus project. In recent years, EnergyVille has developed considerable expertise on electric transmission networks, and in particular HVDC. This technology – given the necessary development – will be able to be applied widely for long, underground connections with high powers.

The know-how of EnergyVille will be leveraged in the HVDC Competence Center (HCC), a center of expertise for and with Flemish and Belgian transmission and distribution system operators, large energy users, technology suppliers and engineering firms. Within this center, EnergyVille will conduct research on underground high-voltage connections and their integration into existing grids.



|| ENERGY STRATEGIES AND MARKETS

EnergyVille has investigated the most optimal way to achieve a climate-neutral Belgium by 2050, and this at the lowest societal cost. We took the current high prices into account, and looked at the horizon towards 2030 and 2050. Is it at all possible for Belgium to become climate neutral by 2050? And, if so, will climate policy towards 2050 be affordable for our society? Our results were poured into a platform that allows for these results to be viewed at a glance, and this across different sectors – power, industry, transport, hydrogen and residential & commercial.

For the platform, baptised PATHS 2050 - The Power of Perspective, more than 200 EnergyVille researchers collaborated to plot data-driven roadmaps for three different scenarios - each of them describing another possible route for our journey towards Belgian carbon neutrality by 2050. The full set of assumptions, model descriptions and detailed results can be found on the website <https://perspective2050.energyville.be>. The model development behind the study was funded by the Energy Transition Fund of FPS Economy and by Febeliec.

|| THERMAL SYSTEMS

The STORM District Energy Controller of EnergyVille is a technology that optimizes operation and therefore improves the profitability and sustainability of district heating networks. The STORM District Energy Controller is a well-established technology that builds on scientific research conducted previous research projects. The energy efficiency and energy flexibility at the district level were tackled by developing an innovative district heating & cooling (DHC) network controller. It was tested and implemented in real life DHC networks in Mijnwater BV in Heerlen (NL) and Rottne in Växjö (SE), both demo cases. In each of the demo sites, a CO2 emission reduction of approximately 11,000 tonnes/year or equivalent to the emissions of approximately 1,400 households was achieved. In 2022, the controller was further developed and tested in the heating network of Brescia (Italy). The STORM District Energy Controller is a market-ready product, with future developments and new features on the horizon. Additional control features such as supply and return temperature optimization, are currently under development. These new functionalities will open up new avenues for the optimization of district heating networks.

CollecThor – the 5th generation district heating network launched at Thor Park in 2022 – aims to explore the maximum potential of intelligent district heating networks. The intention is to heat and cool buildings sustainably, and to exchange and store a maximum of residual heat and cold via an underground district heating network. In the first phase, the existing buildings of Thor Park (Thor Central, IncubaThor, EnergyVille 1 and 2) and 8 additional vacant plots will be connected to this network.



|| WITHIN INDUSTRY: A GLOBAL ENERGY SECTOR'S SHIFT

Through industry collaborations, we aim to integrate market feedback into our research from the start. Vice-versa, industrial companies can integrate innovation into their processes. Thanks to our living lab, they can test innovations in a real-life environment, ensuring smooth operation once they are commercialized. More than 50 companies now work with us in our labs, including our Open Thor Living Lab.

The Open Thor Living lab forms a unique infrastructural environment where innovation comes to life, but also where governments, companies and citizens are actively involved to interact and exchange knowledge. Here, specific societal issues are addressed through co-creation, open innovation and collaboration, making Thor Park a unique test environment to provide meaningful answers and solutions for climate goals.

We aim at expanding the industrial ecosystem of Limburg by connecting to the many players active in the province, such as [city of Genk](#), [Thor Park](#), [VOKA](#), [POM Limburg](#) and [Embuild Limburg](#). We do this not just through the Open Thor Living Lab, but also through direct consultation with these partners or through participation in their events.

Last but not least, we remain in close contact with the spearhead cluster [Flux50](#) and its Walloon counterpart [Cluster Tweed](#). Regarding the industrial chains, EnergyVille adopts a joint market approach. Internally, the partners share information about industrial contacts and opportunities for innovation projects or bilateral research, pooling the knowledge of the EnergyVille partners to offer companies an integrated approach.



WITHIN THE DIGITAL WORLD: DRIVING FORWARD THE DIGITAL TRANSFORMATION OF THE ENERGY ECOSYSTEM

To facilitate companies wishing to demonstrate new services or products to connect to our ICT platform, work continued on [the SmarThor platform](#) and related cloud services. A coupling was made with the data platform in Ghent, gaining access to the data gathered in the HomeLab there.

Digital Europe has launched a network of over 100 digital innovation hubs focusing on artificial intelligence, high performance computing and cybersecurity as well as digitalization in the broad sense. EnergyVille is leading the [EDIH-EBE](#) set up in 2022 for delivering services to companies (in particular SME's) and public sector organizations directly or indirectly active in the field of energy and the built environment (building, districts, cities). The aim is to accelerate the adoption of digitalization in the construction sector. To this end, EnergyVille works with partners T2-Campus, Flux50, Embuild Limburg, Embuild Flanders and POM Limburg, in close collaboration with stakeholders from the Flemish innovation ecosystem, and with connections throughout Belgium, its neighbouring countries and more broadly in Europe.



WITHIN OUR POOL OF GREAT PEOPLE: EMPOWERING PEOPLE TO RAMP UP THE ENERGY TRANSITION

A coordinated effort is needed to develop the necessary human capital pipeline to meet the needs of the fast-growing renewable energy sector. At EnergyVille we are working on various initiatives to instil a taste for science in children and young adults. The [Children's University of KU Leuven](#) organized at our premises attracted over 100 children between eight and thirteen years old with lectures and workshops about our research. Our annual [Day of Science](#) has an offer program tailored to kids and young adults alike. Teachers from the third degree of secondary school were invited to join [Energy Unplugged](#), our annual crash course on energy that is offered in collaboration with T2 Campus. Aside from these efforts, a [series of seminars](#) were organized targeting young researchers. Other annual initiatives include the [EnergyVille PhD Day](#), to connect young researchers from the partner institutions.

In September 2022, UHasselt launched the new [Master in Materiomics](#). In this programme, physics, chemistry, and engineering students will be trained to realize material and technological innovations for, among other research pillars, energy.

With these initiatives, we aim to resolve the mismatch between future employment requirements and the supply of skills in the energy sector, creating a talent pool for Flemish industry. Moving forward, the focus will be on continuing and expanding existing collaborations with T2 Campus and exploring new opportunities in STEM education.



WITHIN COMMUNITIES: A JUST TRANSITION FOR ALL

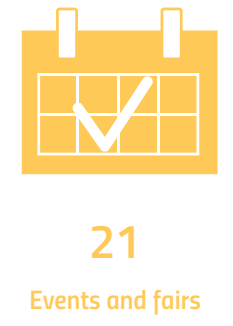
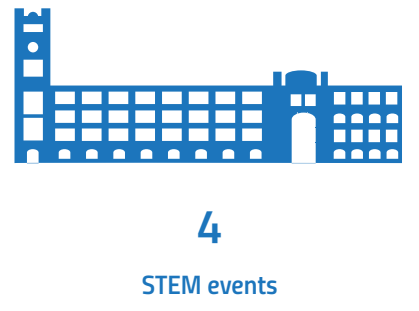
In 2022, the world was confronted with high energy prices. After a global pandemic, the war in Ukraine put the affordability of energy on the agenda. Once again it became clear the transition to clean energy is the way forward. We must move away from expensive fossil fuels, towards local energy production based on renewables/renewable energy sources. Special attention needs to be paid to the affordability of the energy transition, which was the theme of **Energy Mission 2022**. The energy crisis also created a high demand for expertise in energy markets, the potential of renewable energy and energy saving, which led to a prominent media presence. Examples include participation in a live Q&A session organized by VRT, development of an online simulation tool for energy savings at home by De Standaard, and numerous interviews for radio, TV and print media, on various topics such as energy saving, digital metering, the Ventilul project, the capacity tariff, ...

We further reinforce our position as knowledge institute by sharing insights through Expert Talks and position papers, both on technological innovations (for instance on perovskites) and on socially relevant themes (for instance with a position paper on the optimal building renovation measures in the framework of the Flemish 2050 ambitions).

Through all of this – presence at national and international fairs, hosting company visits at our premises, providing experts as guest speakers, sharing expertise through media presence, we aim to share our knowledge and stimulate support for the energy transition.



ENERGYVILLE IN NUMBERS



257
Belgian colleagues



85
European colleagues

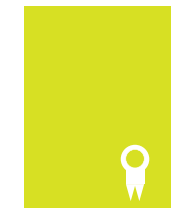


136
International colleagues



208
PhDs

69
Post-Docs



6
Patents



260
Scientific publications



42
Science Citation Index entries with two or more EnergyVille partners

EPILOGUE BY GERRIT JAN SCHAEFFER: NAVIGATING THE SHIFTING FRONTIERS OF THE ENERGY TRANSITION

▶▶ *although there are many disruptions,
we sail a steady course*

The direction we need to take has not changed, even as obstacles appear. The disruptions we encounter are not small. We are still seeing the after-effects of the pandemic, which disrupted the supply chain and created shortages of components such as microchips. The war in Ukraine has put our geopolitical dependence back on the map. These disruptions do not change our course, quite the contrary. They only highlight what we already knew: we must make the shift from fossil fuels to zero-emission sources. The only way to structurally get out of high fossil prices is to accelerate from fossil to carbon-free technologies. Renewable electricity can be generated domestically, which also provides an answer to geopolitical dependence. We are therefore pleased to welcome a production facility



like SOLTECH to Thor Park, and hope that more industrial parties will follow soon.

While homegrown production facilities may be part of the solution, we must be careful that the energy transition does not become more expensive than necessary. A cost-effective energy transition is the ambition, backed by innovation and research. EnergyVille's role in this is clear. There is still work ahead of us, not only in terms of research but also in terms of communicating with and engaging citizens. OPEN Lab is an excellent example of a project in which we communicate bottom-up with citizens who will feel the impact of our research. What questions are they facing and what needs are there? These questions were answered before our researchers got to work. The results speak for themselves: a path of co-creation where innovation is not seen as imposed, but welcomed. The resulting solutions closely match user needs from the outset, requiring fewer adjustments along the way. Innovative solutions can answer concerns in society. In response to the discussions surrounding the Ventilus high-voltage line, we are going to set up a research program on underground long-distance high-voltage networks in the coming years. In this way, our research closely matches the needs of the market, but also the needs of end users.

The direction is clear, but does that answer all the questions? Of course not, there are still plenty of question marks. One of the key questions: what positive future is there for industry in Europe? How easily will we get



access to carbon-free renewable electricity? Aren't investments going to move to countries that have easier access to zero emission electricity? What is clear is that a huge manpower will be needed to meet the requirements of the future labor market. With EnergyVille we are responding to this by putting extra effort into (STEM) training, and also towards robotization or prefab solutions for the construction sector, just to name a few. These will all be pieces of the puzzle.

Within EnergyVille, we developed a robust strategic research programme that addresses the needs of public and private stakeholders in their transition to an energy efficient, decarbonized and sustainable urban environment. In the coming years, we will continue with solid research, supported by intensive collaboration with the industry and an additional focus on digital applications and training the right people for the job. We will also do this with an open line of communication to the wider population, because the energy transition belongs to everyone.



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