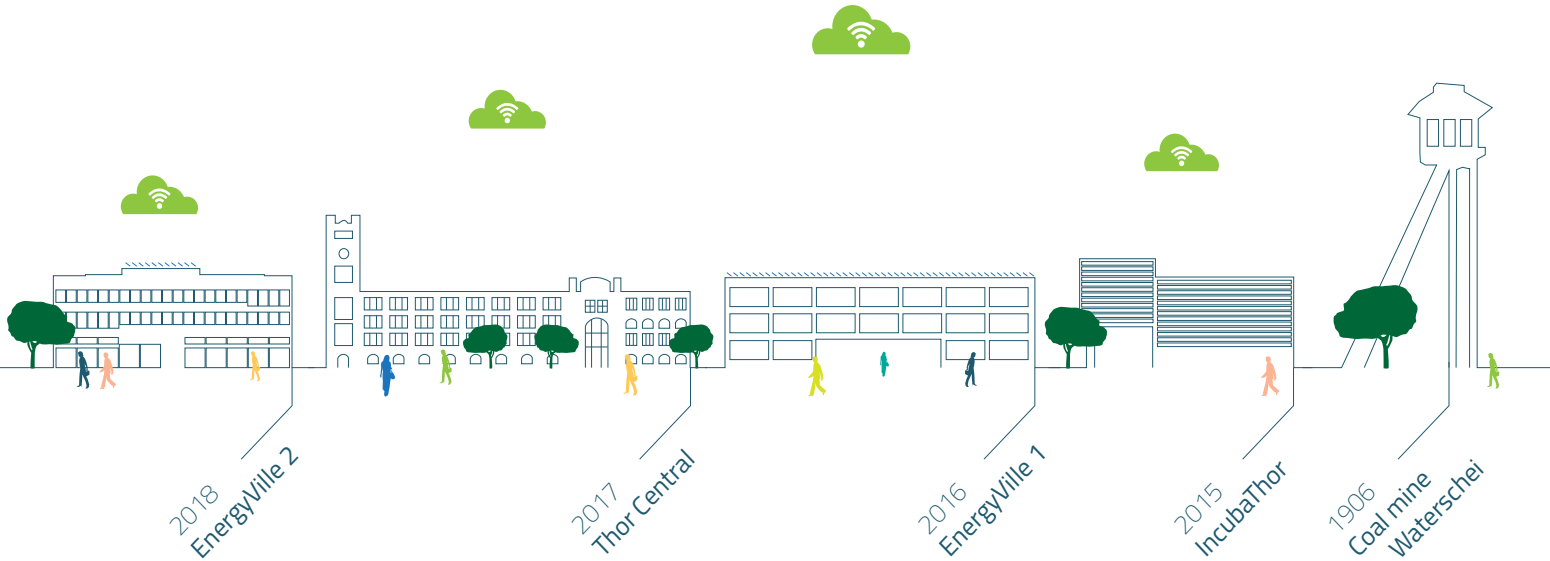
2011-2021



10 YEARS ENERGYVILLE

10 YEARS IN GENK

5 YEARS ON THOR PARK

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2021: A FESTIVE YEAR FOR ENERGYVILLE

EnergyVille is celebrating its ten-year anniversary and is welcoming a new General Manager. Time for a recap of the past years, and a look ahead to ambitious plans for the future by Gerrit Jan Schaeffer and Ronnie Belmans.

In June 2021, Gerrit Jan Schaeffer will officially start as the new General Manager of EnergyVille. A name that rings a bell, doesn't it?

Gerrit Jan Schaeffer: It is indeed not a completely new chapter for me, as I am one of the "founding fathers" of EnergyVille and used to be Group Director Energy at VITO for a period of 8 years. At the end of 2015, I started as an entrepreneur in the renewable energy sector, but it is a happy reunion with EnergyVille. The fact that Ronnie Belmans, current General Manager, is retiring at the end of 2021 does not mean that he will no longer be involved with EnergyVille. He will continue to play a valuable advisory role within the organisation.

Ten years of EnergyVille, a lot has changed over time. What was our position back then and where do we stand now?

Ronnie Belmans: Before EnergyVille was founded, around 2007, the Flemish energy research landscape was highly fragmented. There was a certain competitive drive between the various parties and collaboration was not always easy. Praise goes to Gerrit Jan for bringing these parties together and managing to get them to work together and achieve a synergy. This collaboration also resulted in a more coherent vision on energy in the research landscape, which helped to put energy research on the map. This also helped to make the necessary resources available for research.

Gerrit Jan Schaeffer: Now 10 years have passed and a lot has changed. There is a clear European vision on energy policy, and EnergyVille has proven to be a very reliable partner for both industry and policy makers. All the ingredients are there to sketch a clear framework for the energy future of Flanders and Belgium. If the politicians follow suit, we can leverage our knowledge and really go for a sustainable future.

Not only EnergyVille underwent major changes, so did the entire energy landscape. What expected and unexpected evolutions have taken place?

Ronnie Belmans: It's been an interesting time to be an engineering researcher. Some things have taken me completely by surprise, but that's what makes it so fascinating. The developments in HVDC, for example, are unprecedented: in ten years' time, this technology, which had to be picked up by a fairly conservative sector, has had its breakthrough. I for one, and with me lots of researchers, never thought this would happen so quickly. To a certain extent this also applies to electric cars: I remember I used slides featuring a cartoon about the electric car and what a strange sight such a "plug-in car" would produce. Now I am an avid electric driver, no more fuel cars for me. No more refueling and little maintenance for the car, wonderful. That level of comfort is not to be underestimated.

Gerrit Jan Schaeffer: Nothing has remained the same in ten years. When you're in the middle of it, you can sometimes suffer from boiling frog syndrome: the changes come gradually and don't feel unexpected. It's only when you look back that you see what phenomenal changes have happened. Developments in the field of electricity generation, for example, went very fast. Energy from sun and wind has become cheaper very quickly and

that process is not over yet. At the same time, it also tempts us to look ten years ahead, what would the next few years bring? I predict a similar revolution in the construction sector. If we look back in 2030, the building sector will have taken an incredible leap in terms of sustainable technologies and renovation techniques. And that will be a necessity, because the sector will have to become more sustainable at a rapid pace.

There are technologies that unexpectedly took off, perhaps the reverse also happened: technologies that seemed promising but ultimately will not play a significant role in the energy system of the future?

Gerrit Jan Schaeffer: In my opinion, hydrogen is an eternal promise. The hydrogen car sounded promising, but in terms of efficiency electrification always wins. There are certainly valuable applications for hydrogen and other sustainable molecules in sectors that cannot be electrified. This is what we are going to focus on in the future with EnergyVille. But hydrogen for specific applications such as passenger transport? That's really not in the cards.

Ronnie Belmans: New nuclear has totally collapsed. I remember a project from 2005 in which I was involved regarding a new 1500 MW nuclear power station: Doel 5. Nothing came of it, and looking at the current cost of new nuclear, maybe that's a good thing. In the decentralised energy system of the future where we mainly need flexible sources that fit the intermittent nature of renewable, I do not see a significant role for large power plants that are strong in providing baseload. Other nuclear technologies that are now in the pipeline such as Small Module Reactors sound promising and I am curious to see what they will contribute in the future. As I said before, the energy landscape has changed completely and, as a researcher, you have to be able to adapt to changing preconditions all the time.

Gerrit Jan Schaeffer: We witnessed that 'economy of scale' reflex with the promised revival of nuclear, but also with the revival of coal. With promises of carbon capture, Europe allowed new large-scale coal plants to be built. It ended with only a few plants, and decentralised production now dominates the market. Over 80% of investments in the energy sector are in renewable electricity generation and networks. The challenge will be to overcome further obstacles in these systems on the way to full carbon neutrality.

What obstacles do you have in mind?

Gerrit Jan Schaeffer: The total contribution of renewable sources in the energy supply is still very low. We still need to accelerate and the costs need to come down even further. Innovation will play an important role in this. Lower costs will come from accelerated upscaling, in which policy will play an important role. In addition, the electricity networks and market mechanisms must be adapted in order to become 'smart'. Interoperability is a must, and decentralised can contribute to that. Another thing that must not be forgotten is the inclusion and benefit of citizens in the energy transition. Experiences with solar parks in the Netherlands show that a good dialogue with local residents is essential to get large-scale generation of renewable energy off the ground. We need to pay attention to soil ecology and opportunities to increase biodiversity. Developments in all of these areas are already being supported by EnergyVille and will have an even more prominent place in the future.

A SHORT HISTORY: HOW IT ALL STARTED

/ EnergyVille in 2009

2009

The story of EnergyVille starts in 2009 with a collaboration between ELECTA, the research group within KU Leuven that works on electrical energy systems, and the Energy Technology Unit of VITO (Flemish Institution for Technological Research). In more detailed terms, there is a growing awareness that the current energy system is undergoing major changes and that, in view of the proposed climate objectives, there is a need for new technologies and system integration. Strengthened by developments such as Internet of Things, which was not even in its infancy at the time and took the form of classic automation, the rapid growth of competitive renewable energy and a great demand for more sustainable systems, the research collaboration EnergyVille was launched.

2009-2014

Between 2009 and 2014, the first joint research project as EnergyVille was launched: Linear. This project with a large social impact investigated ways in which households can adjust their electricity consumption to the available solar and wind energy. This large-scale living lab, which was tested among 250 Flemish households and in collaboration with 20 companies, scored highly as a European reference project of an applied smart electricity network. As a recognition, it received the European EEGI label (European Electricity Grid Initiative) and the global ISGAN Award, which rewards innovation in smart grids. And it did not stop there: various products and services are still being further developed by the Linear partners today. In addition to Linear, many industrial, applied and fundamental research projects were initiated and carried out together.

2010

Campus EnergyVille NV was officially founded in 2010. The investors, which are the research institutions KU Leuven, VITO and imec, and LRM, POM Limburg and the City of Genk, gave the starting signal for the construction of the first innovative research building. A research building that is also striving for the highest level of sustainability and was awarded a BREEAM Outstanding certification in 2020. With the construction of EnergyVille 1, the home base of EnergyVille officially becomes Thor Park in Genk (the former Waterschei mine site), where new technologies are developed in cooperation with industry in state-of-the-art labs. The starting signal for EnergyVille 2.0 is given.

2016

The first building was commissioned in 2016 and gathers 250 energy researchers in Flanders under the same roof. The research themes are expanded to "energy for the sustainable urban environment". In this period, imec brings its research into the system applications of PV and grid connection into the EnergyVille collaboration.

2016-2018

In 2016, the construction of the second research building on the site was started, primarily housing researchers from imec and UHasselt. EnergyVille now unites the largest part of energy research in Flanders in a collaboration of 400 researchers, making it the only research collaboration in Flanders that can offer solutions across the entire value chain. This ranges from materials and components (new solar cells or battery materials) to the level of entire energy systems, business models and strategies. This allows the EnergyVille collaboration to play a unique role in the energy transition, the role of an accelerator for the advancement of innovative basic technologies for energy production and storage to the system level.

2016 - 2018

This knowledge was further developed between 2016 and 2018 in an important ERDF-SALK project: Thor Park as a living lab and the start-up of the SmarThor platform to exchange energy between buildings take shape within this project called 'Towards a sustainable energy supply in cities'. The ambition is to turn the Thor Park into a large-scale living lab where technologies can be fed into the infrastructure in real time. This makes it the ideal testing ground for new energy technologies on a large scale and to simulate and develop business models. In 'Towards a sustainable energy supply in cities', the building blocks were laid to convert the EnergyVille Campus and by extension the entire Thor Park into a real living lab. This ambition is still being worked on today. Thanks to the ERDF-SALK project, an important step forward was also taken towards the establishment of a beyond state-of-the-art facility for the development, upscaling and analysis of new PV and battery systems in the EnergyVille labs at Thor Park.

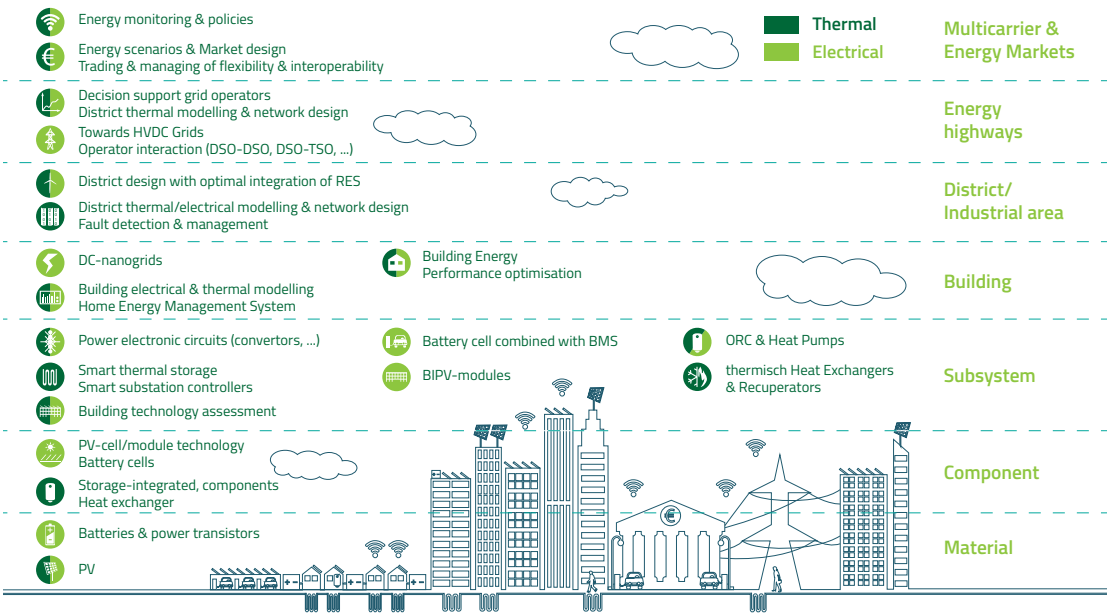
The ecosystem at Thor Park is also growing. Both education (T2-campus), research (EnergyVille) and business creation (IncubaThor) were given a place on the premises. Campus EnergyVille NV became a shareholder of IncubaThor NV, creating a tight cluster. Thor Central, the main building on the site, was thoroughly renovated into a majestic business & event center.

Campus EnergyVille @ Thor Park: from black gold to green gold

Research into renewable energy requires the necessary infrastructure and cannot happen in a vacuum. Thor Park, located on the former mining site of Genk-Waterschei, offers this infrastructure in the form of a high-quality business park linked to a science park. On the same Thor Park, the main building of the former mine site, Thor Central, was renovated and transformed into a multi-purpose center for workshops, conferences, seminars and much more. In addition, the park was complemented by a technology and talent campus (T2-campus) that opened in 2018. Thus, the three factors of training, research and entrepreneurship around technology and sustainable energy are brought together in one location: an ideal source for cross-fertilisation.

WHERE ARE WE NOW AND WHAT ARE THE AMBITIONS?

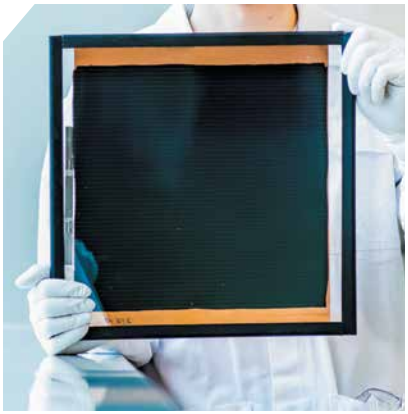
/ From 2016 to 2021



In the meantime, EnergyVille exists for 10 years and the Thor Park in Genk has been the home base of the research collaboration for 5 years. The research roadmaps and mission have taken shape over the years, with integration being key. EnergyVille covers the entire value chain of energy research. At the component level, research groups develop the basic technology for solar cells, batteries, electrodes for sustainable fuels such as hydrogen and thermal components. These teams work together with research groups at the module and system level: they study the electrical systems for electricity generation and storage as well as the thermal systems, including heat storage and recovery. This way, we live up to our promise: accelerated system integration based on innovative basic technologies and value creation that gives the companies we work with a sustainable competitive advantage. There is a close collaboration with the teams that embed the sustainable solutions in specific sectors, energy infrastructures and business models: transmission and distribution grids, microgrids, heating networks, sustainable buildings and positive energy districts, e-mobility, smart industrial processes, demand management... Finally, there are teams that complete the integration. They integrate all elements of the energy transition into the national and international energy system and provide knowledge on sustainability from a broader perspective. They provide scientific knowledge to companies and local, regional and international governments to underpin their policies and strategies.

/ Solar technology

/ Bifacial crystalline silicon PV modules

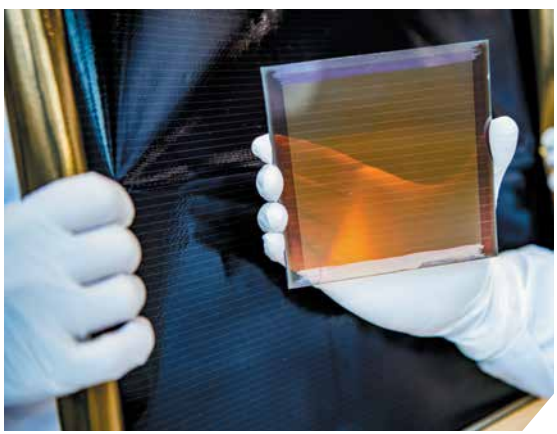


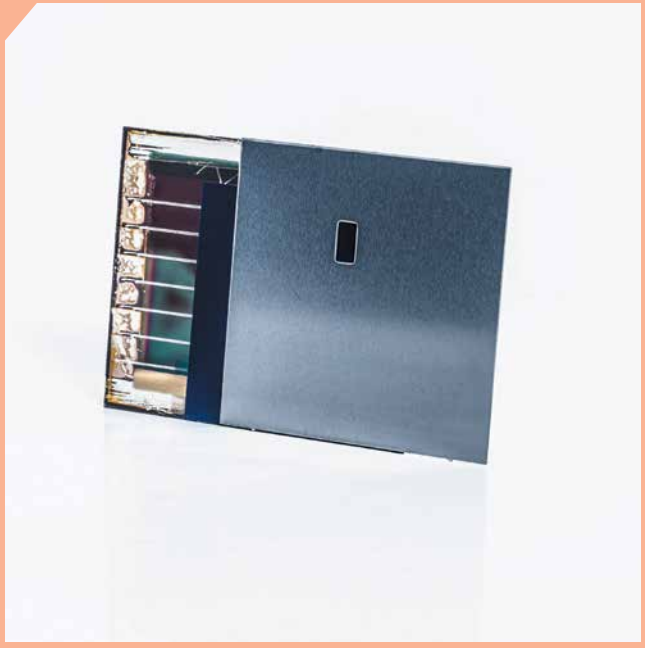
Bifacial modules absorb light on both sides, making them the ideal match for a transparent or reflective back of a PV module. EnergyVille/imec takes these highly efficient bifacial cells and combines them with optimised cell metallisation techniques and multi-wire interconnection technologies. This achieved a record efficiency of 23.2% with bifacial n-pert solar cells. More important than pure efficiency, however, is the fact that this metallisation and interconnection technology will be an important catalyst for applications of photovoltaic integration in buildings and, more specifically, in the façades of buildings where aesthetics play an important role.

/ Thin-film cells: interesting for integrated applications

Currently, 95% of panel production is silicon-based and only 5% is thin film. Thin-film cells are environmentally friendly due to their lower material and energy input in production, have gained strongly in reliability in recent years, offer full recyclability capabilities and have gained strongly in cost efficiency. In addition, they often provide superior performance in diffuse light conditions and at high temperatures and are lightweight and flexible, including in size and color, which offers important advantages for applications in building elements, for example. Within the labs of EnergyVille/imec/UHasselt, research is being carried out on different types of thin-film solar cells. Thanks to the investments in beyond-state-of-the-art labs, we are at the top of the pack for perovskite-based cell technologies, both in terms of performance and in scalable structures for cells and modules. ESPResSo is an exemplary project within the perovskite research line, developing new materials and cell concepts to overcome the current limitations of this technology. Both thin-film materials can also be combined in tandem applications. This is happening in PERCISTAND, where performances are being obtained that are higher than existing commercial PV technologies.

In the Rolling Solar project, a 13-meter-long test assembly of noise barriers with integrated solar cells is being installed at Thor Park. This uses both bifacial silicon cells and thin film cells and allows EnergyVille/UHasselt researchers to develop and validate the necessary modules and materials to eventually integrate solar panels into footpaths, bike lanes and other road infrastructure.





/ Double benefit: tandem cells

Also promising is tandem cell research, in which perovskite solar cells are placed on top of traditional silicon solar cells. This will pave the way for effective industrialisation of these low-cost tandems. Scalable processes are being developed and step-by-step integration into selected applications is expected to accelerate market launch in the coming years. Tandem technology is explored in the Sundrive project, which aims to integrate solar cells into the roof of electric vehicles. Solliance partners TNO, EnergyVille/imec and Eindhoven University of Technology recently realised a tandem breakthrough. They developed an infrared-transparent perovskite solar cell with 18.6% efficiency. Combined in a 4-terminal configuration with a highly efficient crystalline Si tandem or with a flexible Miasolé CIGS tandem, this yielded a new record efficiency of 28.7% and 27.0%, respectively.

/Better prediction of PV yields

As the amount of solar energy in the power system continues to grow, accurately predicting the energy efficiency of solar cells and modules becomes increasingly important. Therefore, EnergyVille/imec developed a simulation framework for PV systems that can accurately calculate the energy yield of Si bifacial PV systems, among others, but is perfectly extensible to other configurations such as tracking systems and thin-film technologies. The TRUST-PV project also supports the development of low-maintenance and grid-friendly PV components and solutions in large portfolios at distributed and utility scale.

/ Batteries

/ Liquid vs. solid-state lithium-ion batteries

Lithium-ion batteries are state-of-the-art and have the highest efficiency, energy and power density. Li-ion batteries with graphite as an anode and liquid electrolyte have been on the market for a while and are used in the current generation of electric vehicles, bicycles, laptops, home batteries, etc. Li-ion batteries with lithium as an anode and a solid-state electrolyte, a core part of EnergyVille's battery research, are the next step. Solid-state batteries will enable electric cars to match or eventually exceed the driving range of internal combustion engine cars. To achieve this, EnergyVille/imec is working on the development of lithium anodes in combination with a nano-composite solid state electrolyte with the aim of enabling an energy density of 1000Wh/l. Currently, the development of solid-state battery cells is at TRL (technology readiness level) 3, EnergyVille/imec has demonstrated values above 400 Wh/l in the lab. The goal of the H2020 SOLiDIFY project is to elevate it to TRL 6: demonstration of prototypes in a pilot line. This way, we expect to meet the roadmap for introduction of these types of lithium metal solid state batteries in 2030. The XL-Lion project seeks to improve safety, energy density and power in advanced lithium-ion batteries as well, this time by using dually conductive core-shell particles as electrodes.

/ Battery rollout in developing countries

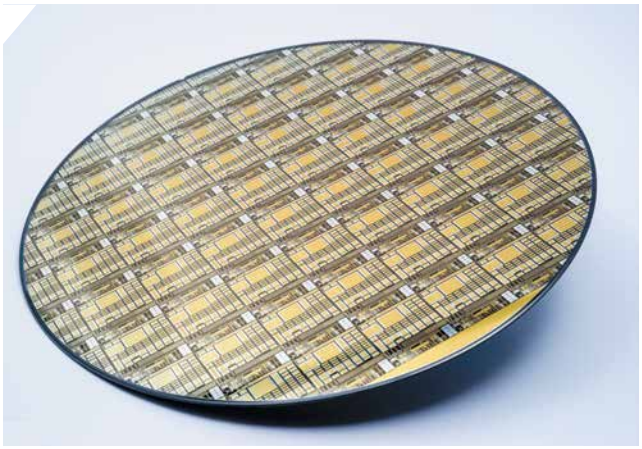
Since December 2020, EnergyVille/VITO and the South African CSIR have been rolling out a "battery test bed" in South Africa. The test lab will provide an opportunity for South Africa to test new battery technologies adapted to local climatic and technical conditions. The combination of electric storage with increasing investments in renewable energy, will on the one hand lead to a more sustainable and stable energy supply and on the other hand can also provide access to electricity for a larger part of the population. The project came about as part of the World Bank's Energy Storage Partnership (ESP), a major program to promote energy storage in developing countries. Both energy and sustainability aspects are addressed.

/ Continuing to improve battery technologies

In addition to research into new battery materials, we are also investigating how existing and new battery technologies can be optimally used. The ultimate goal is to improve the range, lifetime, charge rate and performance of batteries without sacrificing safety. To this end, EnergyVille/VITO brought to market the BattSense battery management system (BMS) technology, a flexible solution suitable for different applications and battery types. The technology was derived from the CellSense technology for monitoring fuel cells. This BattSense battery management system not only continuously monitors individual battery cells, but also manages the system to maximise their intrinsic capacity and extend their lifetime. Several large-scale European projects such as Current Direct and NAIMA are looking at how this BMS technology can be further perfected.

/ Power electronics

/ Semiconductor switches: from silicon to gallium nitride



At the heart of all power electronics are semiconductor switches. Until now, these were primarily components based on silicon. By switching to GaN (gallium nitride) materials, these switches can become even more efficient and switch even faster. However, because of their complicated cooling requirements and other physical challenges, more development is needed for the wide acceptance of GaN technology. By leveraging EnergyVille/imec's flexible GaN technology platform for power devices, the SloGaN project aims to increase GaN circuit integration and component packaging suitability to improve efficiency and size.

/ LVDC: a range of applications

Within EnergyVille/KU Leuven, power electronic converters are being developed using state-of-the-art GaN and SiC technology for, for example, the rollout of the LVDC grid. LVDC (or low-voltage DC) offers increased compatibility, which translates into lower costs (in terms of investment and operation). A range of applications is possible: data centers, industry, electromobility, commercial buildings and also providing electricity in developing countries. The ICON BIDC projects are working on hardware and software components, an overall system protection strategy and a grid code to develop the low-voltage DC networks needed in the future energy landscape.

/ Energy networks

/ HVDC grids

The development of renewable energy and in particular wind energy has made offshore wind increasingly cost-effective but has also led to the construction of increasingly large wind farms, which are placed further from the existing grid. This comes with additional challenges. The research activities on HVDC grids are leading in Europe and beyond, with a diverse team of specialists investigating what the future transmission grid will look like when we complete the transition to a 100% renewable system. The rapid development of offshore wind is a clear driver here. The specific expertise of EnergyVille/KU Leuven lies in the development of models and tools that correctly and efficiently characterise the system aspects of this new and complex technology. The core of the research consists of three topics: how to design the future transmission network, how to secure that network and how to ensure that it interacts with all other network elements as efficiently and stably as possible.

The PROMOTioN project investigated how these challenges could be overcome. The final results are clear: the technologies for an offshore meshed HVDC transmission grid are ready for use within Europe. EnergyVille/KU Leuven played a crucial role here, particularly in the development of new security concepts for HVDC grids. These concepts were also successfully tested in the EnergyVille labs: both the first open HVDC and the first commercial protection relay were tested for the first time in Genk, and this according to newly developed test standards. The results of the project were received very positively by both industry and European policymakers.

/ Decision support for grid operators

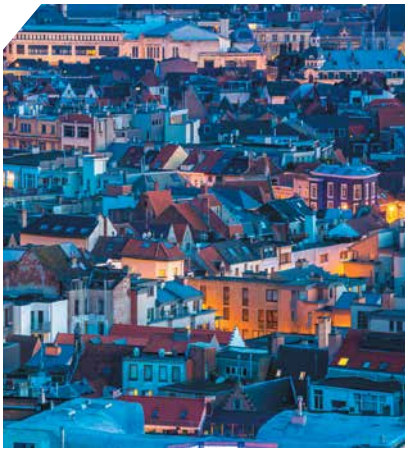
To support grid operators in optimising the operation and planning of transmission and distribution systems, EnergyVille/KU Leuven is developing algorithms and tools to proactively make decisions and to guarantee optimal network exploitation. These tools allow the network operator to guarantee a cost-efficient and reliable energy supply under extreme uncertainty, and this without distorting the market. They use the latest mathematical techniques and the increased availability of measurement data to navigate the network operator through the ever-changing operating conditions in the network.

For example, in the Adrian project, EnergyVille/KU Leuven, in collaboration with Fluvius, looked at how more renewable energy or more electric vehicles could be integrated into the electricity network without additional expensive network investments. For this purpose, new tools were developed that can quickly and accurately calculate the entire Flemish distribution network and, as a result, can make detailed recommendations for the operation and development of their system.

/ Buildings and districts

/ Energy renovation of buildings

Energy renovation of the existing building stock is a key area of action for achieving the energy and climate targets. In the DITUR (Digital Twins for Upscaled Retrofits) project, the digital twin concept will be investigated as a catalyst to support informed decision making for different stakeholders (cities, social housing companies, building owners,...). The Urban Energy Pathfinder application will be used for opportunity detection, looking for a match between supply and demand of no-regret renovation measures in the residential sector. The digital twin is a virtual representation of the building stock, based on innovative top-down and bottom-up data analysis. New data sources (Lidar, digital meters, in-house sensors, IR drones, ...) and data processing techniques (profiling, clustering, filtering, ...) will be used, with a focus on the reliability of the data and the resulting insights (e.g. calculated payback period of the renovation) in terms of data quality and attention to data protection and privacy.



/ Local energy communities

A sustainable and active participation of the end consumer will be characteristic of the energy system of the future. This can be achieved through local energy communities. Such a community groups buyers/producers and allows them to exchange energy locally between buildings. EnergyVille explores the concept of collective activities in the Thor Park regulatory sandbox. In the ROLECS project, local energy communities are being tested at ten locations in Flanders, including Thor Park.

/ Sustainability Assessments

Life Cycle Analysis or Life Cycle Assessments are critical when talking about sustainability. In a life cycle assessment the total environmental impact is calculated, from production to use and waste disposal. EnergyVille/VITO researches methods for evaluating sustainability and circularity on the one hand, and on the other hand the researchers also carry out sustainability assessments to make buildings, technical installations and renewable energy systems more environmentally friendly and energy efficient. In the CSP+ project, a long-term analysis of an innovative PV-CSP system is carried out. Research into the sustainability of battery technologies is also being conducted in the aforementioned battery test bed in South Africa. To meet the increasing demand from building material manufacturers for sustainability consultancy, EnergyVille/VITO launched the spinoff Enperas in 2021.

/ Thermal systems

/ Fifth-generation heating networks

Building on their track record in technologies for district heating networks, EnergyVille is strongly committed to fourth- and fifth-generation district heating networks. Fifth-generation grids are low-temperature controlled with decentralised generation, integrate both thermal and electrical energy (conversion), and have closed thermal energy circuits that allow for heat and cold exchange within and between buildings. In the D2Grids project, researchers have the ambition to industrialise the 5G DHC (Fifth Generation District Heating and Cooling) concept and evaluate the results. They provide the technical guidance for the implementations of the district heating networks at the various sites. Based on the knowledge acquired over the years in thermal and electrical networks, EnergyVille/VITO has access to the latest technologies and provides advice right from the design phase.

/ Digitalisation of heating networks

Extensive digitalisation is of great importance in both the design and the operational management of district heating networks. In an automated self-learning way, a district heating network will become more reliable, more profitable and greener. The STORM District Energy Controller from EnergyVille/VITO uses the thermal mass of buildings to flatten or shift the heat demand, so that on the production side the peaks are also flattened or shifted. This results in less use of expensive fossil fuel - such as oil, for example - in favor of cheaper greener base fuel - such as wood chips.

The platform FLEXharvester has been developed to harvest energy flexibility in an open and standardised way. On this platform, the STORM District Energy Controller is the first application.

/ Heating and cooling of buildings

GEOTABS are the "perfect marriage" of technologies for heating and cooling buildings. "GEO" refers to geothermal heat pumps, "TABS" (thermally activated building systems) include technology such as concrete core activation, i.e. pipes embedded in concrete floors or ceilings through which hot/cold water is pumped to heat/cool the thermal mass of a building. Together, GEOTABS ("Geothermally Activated Building Systems") offer huge energy savings over conventional systems. In the hybridGEOTABS project, researchers at EnergyVille/KU Leuven are further developing this concept. In the project, the hybrid concept, consisting of GEOTABS and secondary production and/or emission systems, is further expanded with optimal control via Model Predictive Control (MPC). This way, the hybridGEOTABS concept can be deployed very broadly.

/ Strategies and markets

/ Designing energy markets

The transition from an energy system traditionally dominated by large conventional generation units to one with many variable renewable technologies results in challenges to safe and reliable energy system operation at both the transmission and distribution levels. Innovations in product and market design support the current evolution where system operators want to implement a more active system management approach. EnergyVille/VITO is conducting extensive research on innovations in product design, market design and coordination between system operators. For example, the EU-SysFlex project is devising new types of services that will meet the needs of a system with over 50% renewables. The project seeks the right mix of flexibility and system services to support safe and resilient operation of the transmission and distribution system. Additionally, research is being conducted into the possible market and business models for organising collective flexibility, for example through an energy community. In addition, we are looking at how, next to flexibility markets, other flexibility mechanisms such as dynamic network tariffs can play a role within the energy transition.

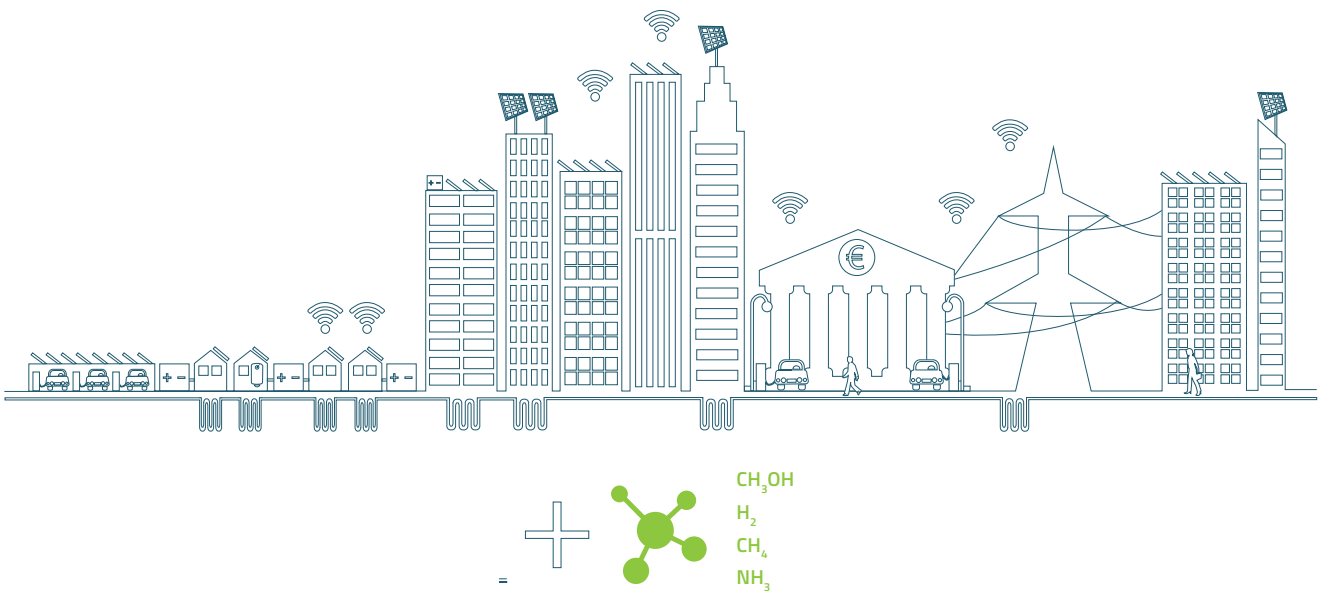
/ Towards a sustainable 2050

A lot of ink has already flowed about the energy future of Belgium. EnergyVille supports the debate with fact-based insights based on scenario and modelling work. The EPOC 2030-2050 project combines the expertise of the Belgian research community by linking the different energy models, updating them with state-of-the-art knowledge and applying them to the Belgian situation. This will support policy makers in their decisions regarding the energy future in Belgium. In that respect, EnergyVille recently published several studies with a long-term perspective on the Belgian electricity supply in 2030 and 2050. This was built on the insights of the various companies and stakeholders (Febeliec, Greenpeace and ENGIE) with whom we have been working over the past few years. These studies provide insight into a number of specific energy scenarios for Belgium, and thus try, without specific preference for certain technologies, to provide an answer to the question of what our electricity supply could possibly look like in 2030 and beyond, and what effect this would have on the energy production and costs of this electrical energy system. In this context, we are also working with Dutch and German research partners to map the cross-border aspects of the energy transition, with a focus on making this industrialised region CO_2-neutral.

Through the European Topic Centre on Climate Change Mitigation and Energy (ETC/CME), EnergyVille/VITO supports the European Environmental Agency in its activities by providing policy-relevant data, information and knowledge on greenhouse gas emissions, renewable energy and energy efficiency in Europe. For example, we examine whether the European Union and individual member states are achieving the various climate and energy targets. EnergyVille also supports local governments in their ambitious climate and energy plans. To give an example, we are a strategic partner in the "No Coal"-collaboration of the City of Genk for the implementation of innovative energy projects with a view to lowering the climate footprint.

ENERGYVILLE 2021 & BEYOND: WHAT ARE THE FUTURE PLANS?

Decarbonising the electricity supply is seen as the most important element in the energy transition. It is not easy to replace the current energy source with renewable electricity for all energy services. Therefore, in EnergyVille 3.0, an additional dimension is added to the research: the study of chemical energy carriers based on sustainable electricity. In the future, molecules will be needed for different parts of the value chain, and those molecules will be made available through a technique called "power-to-gas." Power-to-gas is an energy storage technique that converts electrical energy into chemical energy in the form of gas. This can be hydrogen, methane, methanol, ammonia, etc. For example, in the Catalisti Moonshot SYN-CAT project, researchers at EnergyVille/imec/UHasselt are developing a combination technology based on direct sunlight and renewable energy to selectively convert CO_2 to methanol. The PROCURA project, in turn, looks at the role of power-to-X in multi-energy systems and markets. Scenario studies around the world show that Power-to-X (gas (e.g. H2, methane), chemicals, liquid fuels) and Carbon Capture and Utilization (CCU) can become critical technologies to decarbonise our energy system by 2050 and to increase security of supply. This project will provide a roadmap for these new technologies for all sectors in Belgium, with a clear picture of the steps needed by 2030 to achieve carbon neutrality by 2050.



THOR PARK AS A LIVING LAB

Thor Park as a living lab is taking shape and offers new opportunities. In 2020, for example, Thor Park was recognised as the very first regulatory sandbox for energy in Belgium. We are one of the largest regulatory sandboxes for energy in Europe. And the ambitions reach high. In the coming years, this living lab will be further developed into a unique test environment of 93 ha in size. New partners are also expected on the site: for example, recently a smart manufacturing campus was announced that will provide 600 extra jobs in the future. The cooperation with companies settled at Thor Park also provides new opportunities. For example, Azteq is building a concentrated thermal solar installation at Thor Park, and sound barriers with integrated solar cells are being installed as part of the Rolling Solar project mentioned earlier.

The approval to make Thor Park the first regulatory sandbox in Belgium marks the start of many new experiments to prepare our energy system for the future. The ambition of the regulatory sandbox is to develop Thor Park into a place where EnergyVille can experiment with new technologies and services in collaboration with industrial partners. The ultimate goal is to develop an energy system that is as efficient as possible, where user comfort, sustainability and cost are three key elements.

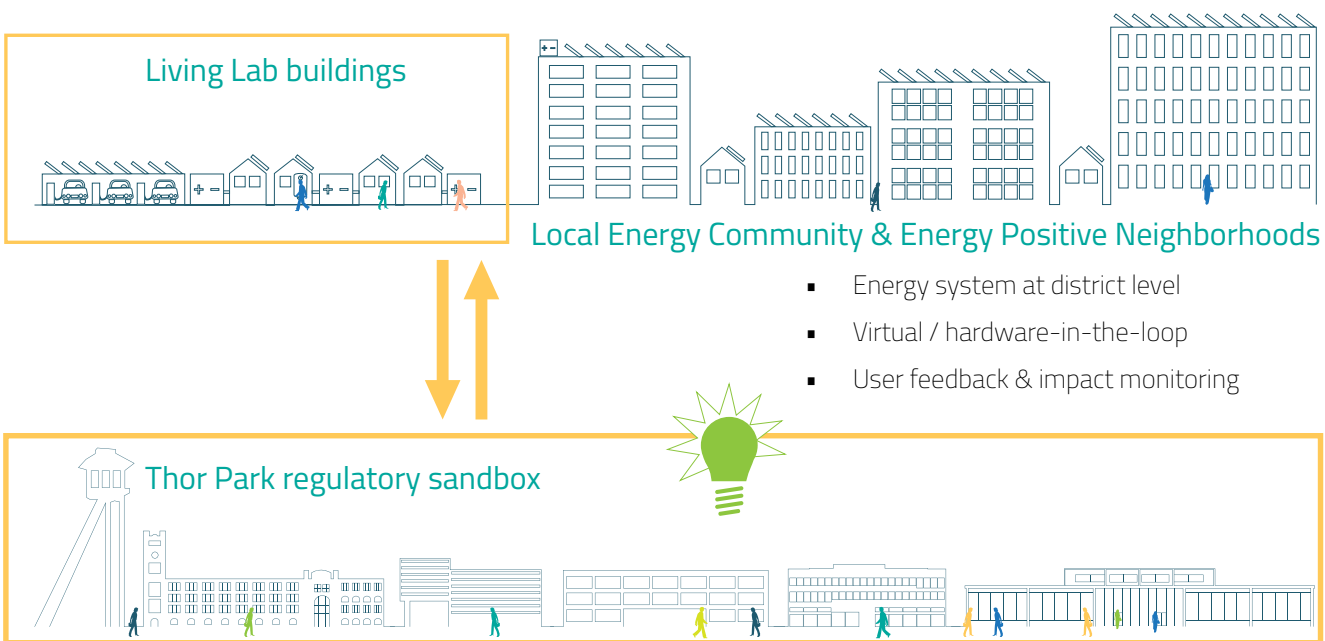
Within the regulatory sandbox, the aim is to produce as much renewable energy as possible locally and to exchange surpluses as efficiently as possible. For example, the new parking lot at Thor Park has a large roof area suitable for solar panels, but relatively low consumption, especially now that the number of electric vehicles is still limited. On Thor Central, the historic main building of the mine, no solar panels can be installed but the building consumes a lot of energy. An exchange between buildings is not permitted under the current regulations, but an experimental regulation will be developed in consultation with the Flemish government, VREG, Fluvius and a local market operator, which will be tested in practice for a

certain period. This way, the impact and any unexpected side effects can be visualised and, based on this, the global, new regulations can be adjusted before they become generally applicable. Industry can test and validate new technologies or market models in the living lab and bring them to the market later.

Within the regulatory sandbox, EnergyVille will exchange energy for the first time via a direct current connection between different buildings on the site. In addition, researchers will experiment with an innovative thermal network (CollecThor) to optimally integrate renewable sources. For example, the consumption of heat pumps will be tuned to peaks in solar and wind energy to then simultaneously produce heat or cold, store it and then efficiently deploy it where and when needed.

With the future expansion of the Thor living lab into the nearby residential area in Genk, we also want to offer a residential experimentation zone for companies that provide technologies and services for upgrading existing homes and neighborhoods to energy positive districts.

There is no doubt that the regulatory sandbox and living lab infrastructure offer many opportunities for industrial players. With the expansion of this unique environment and infrastructure, we are laying the foundation for a strengthened collaboration with industry and governments for innovation and upscaling. Industry will be actively involved in the innovation chain and will help shape the energy transition within the living lab.




Parking lot
T2-Campus
Rolling Solar
EnergyVille 2
Thor Central
EnergyVille 1
IncubaThor

THE DIGITAL TRANSFORMATION IN THE ENERGY TRANSITION

Thorough digitisation is a necessary lever for a successful energy transition. Because of the high proportion of intermittent renewable energy sources, system flexibility is becoming extremely important. In addition, digitisation also provides solutions for the optimal design of energy services and infrastructure. EnergyVille supports the digital transformation in several ways.

/ Supporting digital meter rollout

EnergyVille was one of the first labs in Belgium where companies could go to test their innovations linked to the digital meter. Energy suppliers and technology companies active in Flanders can go there to test just about any energy innovation regarding the digital meter in a realistic context. This may involve specific representations or warnings about energy consumption at home, the control of smart household appliances, but also applications that, for example, make the most efficient use of the power generated by solar panels. The rollout of the digital meter in Flanders was supported in this way.

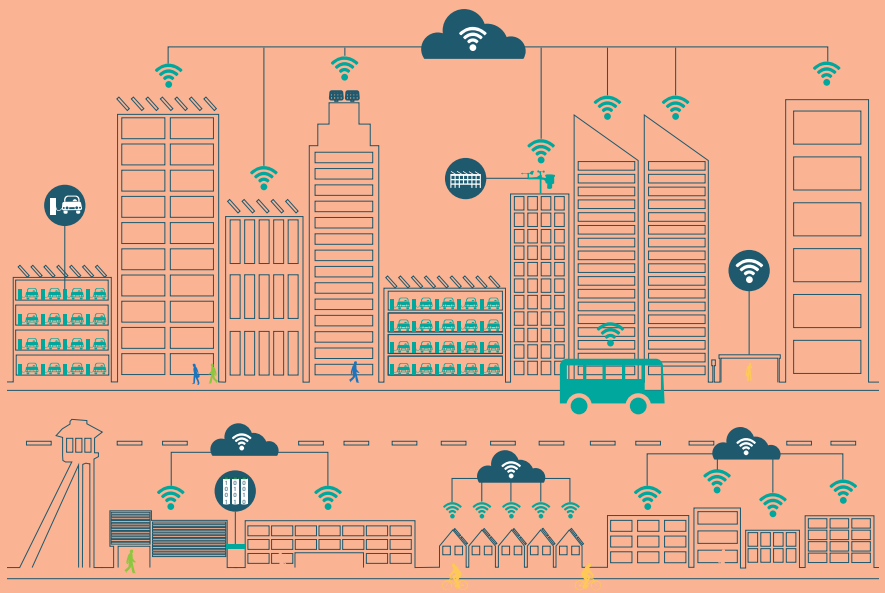
/ Smart buildings

Integrating smart technologies into buildings can be a particularly effective way of moving towards healthier and more comfortable buildings. They can also help to reduce energy consumption and CO_2 emissions and are essential for integrating buildings into future energy systems with high levels of renewable energy through smart controls. The European Commission therefore launched the Smart Readiness Indicator (SRI), a methodology to assess how smart buildings are and their readiness to interact with their users and with connected energy grids. EnergyVille/VITO coordinated two technical studies for the development of the Smart Readiness Indicator on behalf of the European Commission with the involvement of more than 800 stakeholders, and is working on a third study. The first building on which the SRI was tested is the EnergyVille 1 building, with a very nice score of 77%. Meanwhile, the methodology was already tested in more than 100 buildings. At the end of 2020 the methodology was approved in the European Parliament and thus becomes an official tool to support the digitisation and modernisation of buildings in Europe.

/ EnergyVille as European Digital Innovation Hub Energy in the Built Environment (EDIH-EBE)

EnergyVille's ambition is to coordinate a European Digital Innovation Hub Energy in the Built Environment (EDIH-EBE), making a sector connection between construction, energy and digitisation. It focuses on successful digital transformation of companies (start-ups, scale-ups, SMEs and midcaps) and governments in Flanders. To this end, EnergyVille works with partners T2-Campus, Thor Park, Incubathor, Flux50, Vlaamse Confederatie Bouw, Confederatie Bouw Limburg 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. In particular, the EDIH-EBE focuses on the use of artificial intelligence, high-performance computing, cyber security and other digital technologies (i.e. IoT, cloud, big data, etc.), this with application areas in energy at the level of smart buildings and urban districts. The preparatory phase of EDIH-EBE is ongoing (2021) with expected implementation from 2022, pending approval from the Digital Europe Programme call of the European Commission for European Digital Innovation Hubs co-investment support through grants.

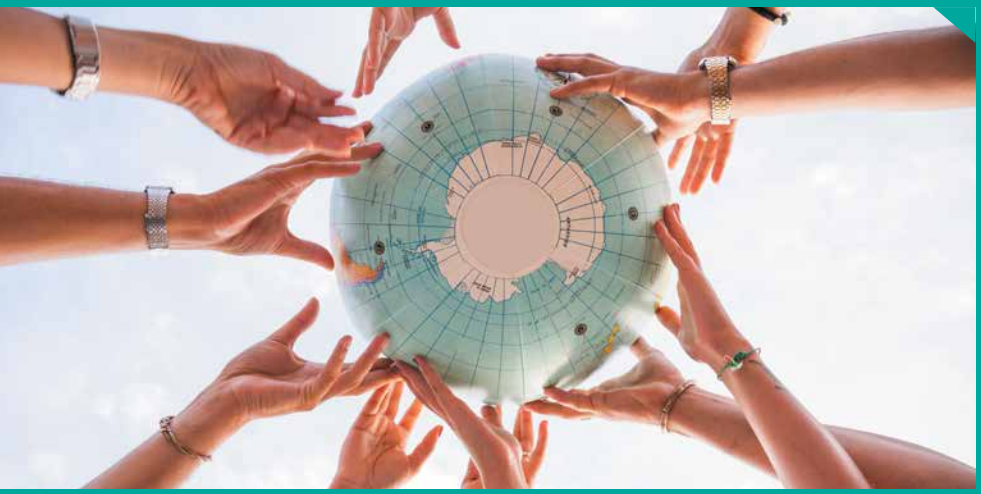
/ The EnergyVille Cloud Platform



EnergyVille has its own Cloud Platform, the SmarThor ICT platform. SmarThor integrates the data on energy generation and consumption, both thermal and electrical, of the entire Thor Park into one platform, using Internet of Things solutions. The platform also balances supply and demand using advanced control and steering algorithms and will allow to exchange energy surpluses in the future, through a virtual electricity, heating and cooling market.

Furthermore, by using Internet of Things technology, smart systems can be linked to the SmarThor ICT platform, regardless of their location. As a result, this platform can also be used in future living lab projects testing the impact of new solutions in households and businesses.

HUMAN CAPITAL



In its mission, EnergyVille pays attention to actively disseminate collected knowledge and skills to society. For example, out of a growing awareness of the societal importance of the energy transition, it was decided in 2019 to make additional efforts to better inform second and third grade students and their teachers about the science behind the energy debate. In collaboration with Thor Central, T2-campus, and IncubaThor, EnergyVille organised **Energy Unplugged**, a crash course on energy for teachers and students between the ages of 16 and 18. More than 450 students and their teachers were introduced to the energy system of the future. The underlying idea is also STEM-related: the energy transition comes with a lot of new technologies. In order to implement these, skilled scientists and technicians are needed. For this reason, it was decided that Energy Unplugged would not be a one-off course but would be repeated every year, so that pupils and teachers will always be able to look at the energy transition with the most recent knowledge. The collaboration with T2-Campus is not limited to Energy Unplugged or participation in events such as the Day of Science, but rather there is an extensive collaboration in the battery training courses organised by T2-Campus. The necessary content for these courses is provided by EnergyVille.

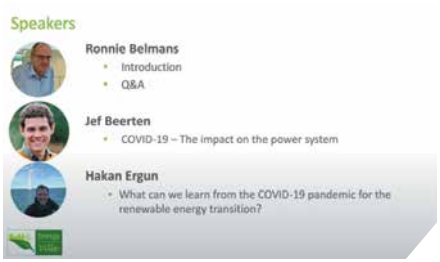
Various activities are organised to promote the exchange of knowledge between researchers. Of course, there is a direct link to the bachelor and master programs of KU Leuven and UHasselt. Regular internal 'lunch talks' take place in which researchers share insights derived from their work. **PhD Days** are organised annually for doctoral students to strengthen the mutual dynamics, to improve their skills and to exchange knowledge. During these days, workshops are interspersed with presentations by PhD students. This initiative will also be further expanded in the coming years.

OUTREACH

In addition to the development of human capital, EnergyVille has also taken on an essential societal role: facts and figures, which are regularly updated, are made available to the general public via the website. Expert Talks were launched in which each month, a socially relevant theme is examined. A recent example includes the effect of the COVID-19 pandemic on our electricity supply.

Energy Mission

The Day of Science



Expert Talks

Events are also organised on a regular basis for a wide audience. By participating in the Day of Science, we literally open our doors and offer a glimpse of our research. Thanks to our track record in top research, we were also able to welcome several international conferences to Limburg, such as the IEEE Smart Grids for Smart Cities conference in 2018. The Energy Mission conference, organised by EnergyVille, IncubaThor, Flux50 and POM Limburg, aims to bring together decision makers from industry, policy and knowledge institutions and present innovations and cases around 3 missions: built environment, industry and electrification. The Energy Mission took place for the first time in 2020 and will have a follow-up in 2021.

The Energy Encounters, a series of debates on the implementation of the energy transition, were organised for the first time in 2021. The first series included sessions on onshore wind, PV, offshore wind and gas and concluded with a summary session for policy makers. The second series includes sessions on the built environment and renovation, smart cities and districts, mobility, industrial decarbonisation and heat. The goal was to bring different parties together, put opportunities and drawbacks on the table, and map out realistic ambitions regarding the energy transition. With not only over 600 unique participants who took part in the livestreams, but also a clear enthusiasm for making the energy transition a success story, the Energy Encounters proved to be a great success.

A positive story that we also want to continue in the future. After all, energy transition is a complex puzzle that requires a scientific foundation that must continuously interact with society as a whole.

ENERGYVILLE IN FIGURES

NATIONALITIES 2020

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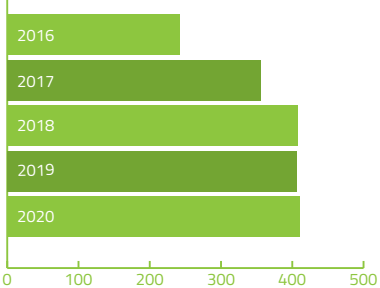
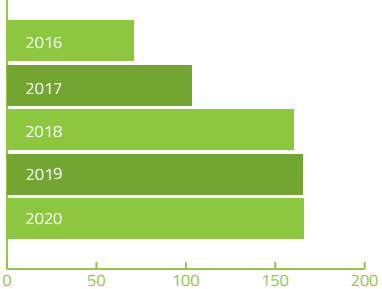
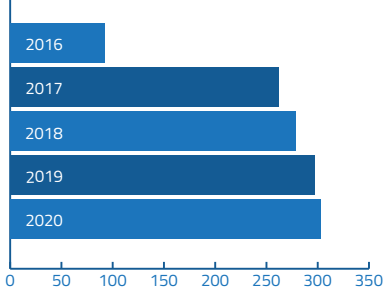
COLLEAGUES

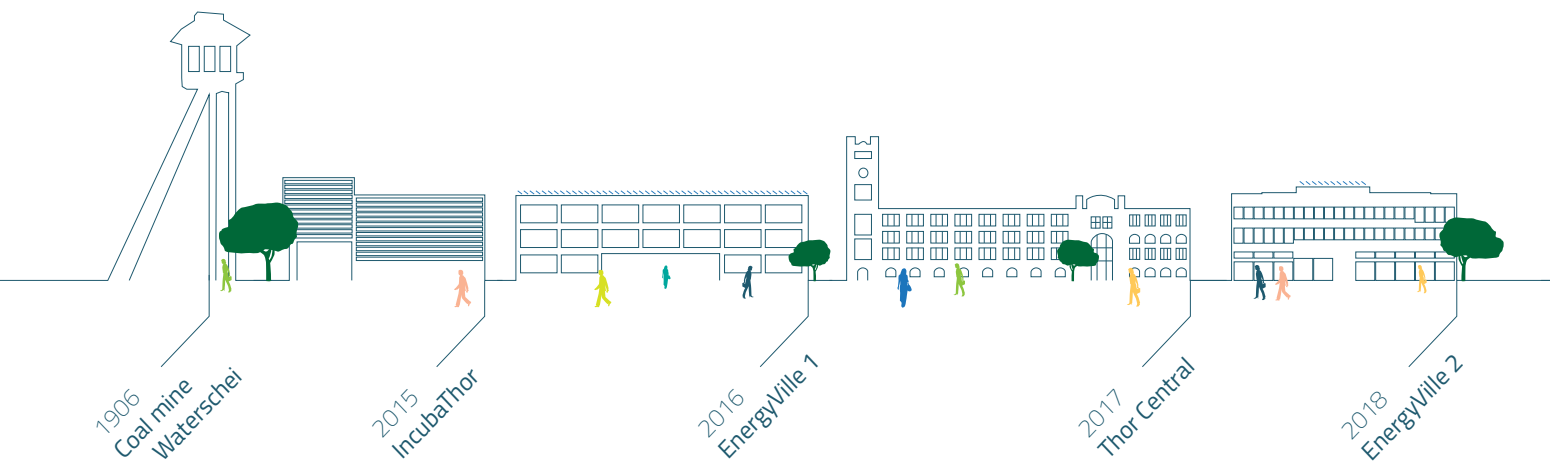


PHDS & POSTDOCS

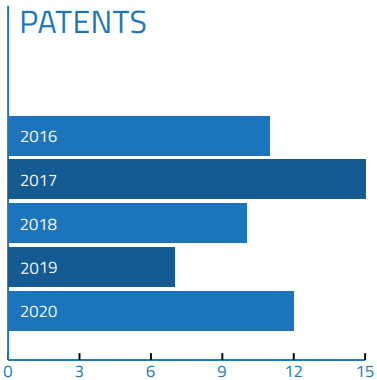


PUBLICATIONS

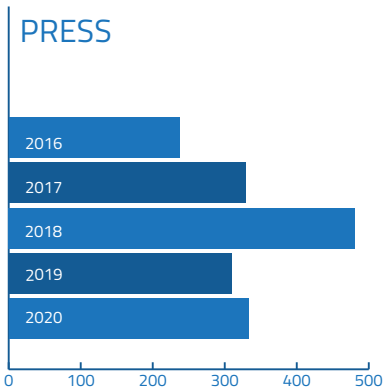




PATENTS



PRESS



AWARD HIGHLIGHTS

2016: ABB Research award
Jef Beerten

2016: Award for research excellence in district heating and cooling
EnergyVille and NODA

2017: ERC Grant
Bart Vermang

2017: Encon Energy Award
Thijs Peirelinck

2018: Febeliec Energy Award
Johan Driesen

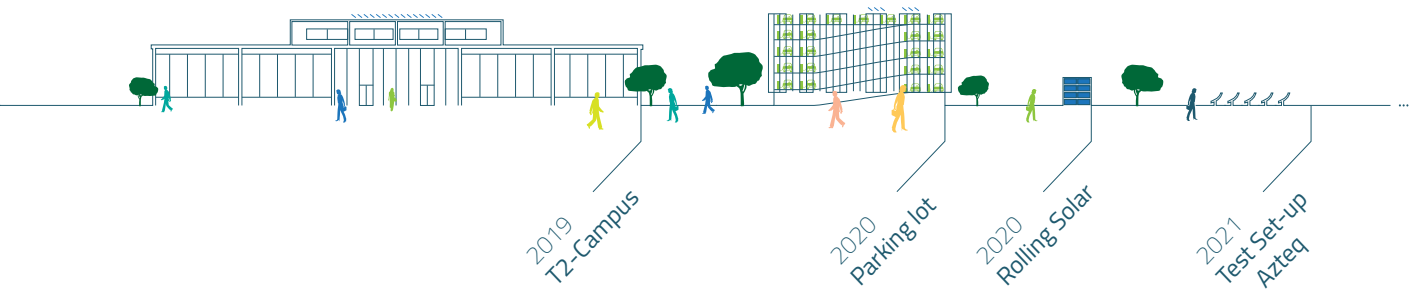
2018: Encon Energy Award
Arthur Schillemans

2019: ERC grant
Koen Vandewal

2020: Encon Energy Award
Anne-Claire Legon

2020: Sinave award from the Royal Belgian Society for Electricians (KBVE)
Willem Leterme

2020: BREEAM outstanding certificate
EnergyVille 1 building



2022 AND BEYOND

The topics above already gave a brief outline of EnergyVille's future plans. In this epilogue, Ronnie Belmans and Gerrit Jan Schaeffer link the role of EnergyVille to the broader energy system.

The previous chapters show that science has come a long way and many technologies are already available, while other things are set to arrive later. However, the energy transition is in full swing and new technologies must be implemented as soon as possible. What is still missing?

Ronnie Belmans: My estimation is that with the new technologies that are now on the market we can already accomplish a lot in the ten years to come. If we optimise everything that is on the market and implement it in systems, we can achieve a considerable reduction in greenhouse gases. At the moment, the process of becoming more sustainable is moving too slowly, and this is not due to a lack of new technologies but due to the lack of a clear framework. Without a correct and stable policy framework, investments and new developments are held back. However, Europe is showing itself to be a powerful leader, and if local politics were to follow, I have high hopes for our energy future.

Gerrit Jan Schaeffer: Technologies such as heat pumps, district heating, batteries and solar panels will have to improve significantly over the next ten years, both in terms of performance and cost. EnergyVille has assets to play on all these fronts. Beyond 2030, we still need many developments, especially in the field of materials. In the field of heating and cooling for buildings and in industrial processes, there are still major advances to be made.

What role do you see for EnergyVille?

Gerrit Jan Schaeffer: As far as the implementation of new technologies in the electricity supply and built environment is concerned, the role of science is becoming increasingly supportive: the actors in the market are working on it and have a lot of practical knowledge themselves. Many innovations along the value chain are already taking place in the market. Innovation centers such as EnergyVille should connect to these value chains and, through access to their experimental environments (such as labs and living labs) and through deeper scientific knowledge, deepen and accelerate these innovations. For example, we need to look closely at what it takes to make a solar farm with storage controllable, so that it delivers energy to the grid at the right times, with the lowest system cost. An integrated solar panel/battery/energy management module can play an important role in this. Market mechanisms in the electricity sector need further adjustment. It must become easier to supply electricity to the grid and to purchase it at the right times. To automate this, a great deal can still be developed technologically. Think Artificial Intelligence and Digital Twins of buildings in the built environment sector, but also universal automated access to electricity markets that match supply and demand.

Ronnie Belmans: Inextricably linked to the research itself is the science-based input we provide to policy makers. We are also strongly committed to facilitating dialogue between researchers, industry and policy makers. We carried out this vision in our Energy Encounters. It was great to see different market players came together and how this was taken up by politicians. The trust between academia, industry and politics is necessary to accelerate the process of making our energy sector more sustainable. We also see it as our task to motivate young people and arouse their interest in science, ranging from children University to engaging high school students through various initiatives such as Energy Unplugged. With all the changes that are coming, we have a great need for a new batch of academics, but also for skilled technicians who can deal with new technologies. We must not lose sight of the fact that certain 'established values' are going to have a difficult time. How, for example, do we deal with garages or petrol stations, which are ubiquitous today but will be

less needed in the future? Their business model will have to be completely transformed. These are questions that we need to ask ourselves and for which policy frameworks need to be drawn up.

And what about the consumer?

Ronnie Belmans: The consumer is still a rather passive player today, but in the future they will actively participate in the energy market. That doesn't mean that they have to spend two hours a day looking at network tariffs, or taking care of the control of their electrical appliances themselves. No, the control will be automated and consumers will be relieved of their worries. At the same time, they get more comfort and a healthier living environment.
Gerrit Jan Schaeffer: A lot can already be done, as people are both citizens and consumers. As consumers, they can pay attention to energy labels when making purchases and with large purchases (solar panels, heat pumps, electric cars) they can think ahead and futureproof their investments. As citizens, they can join energy cooperatives, which are increasingly taking an active role in sustainable energy generation. As such, consumers can really make the energy transition their own.

In other words, there is still some work to be done.

Gerrit Jan Schaeffer: Exactly. I'm ready for another ten years of EnergyVille!
Ronnie Belmans: And I'm happy to hand over my seat to Gerrit Jan. With 30 years of experience in the energy sector and his link to the early history of EnergyVille, I couldn't have imagined a better General Manager. I am very curious to see what the future holds, but can already reveal that our research for and collaboration with the industry will be greatly intensified.
Gerrit Jan Schaeffer: A stronger commitment at the European level in function of the Green Deal is paramount. A new line of research is also being added to EnergyVille's research program: research into molecules to make processes that cannot be electrified more sustainable. Exciting times ahead!

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Energy Ville

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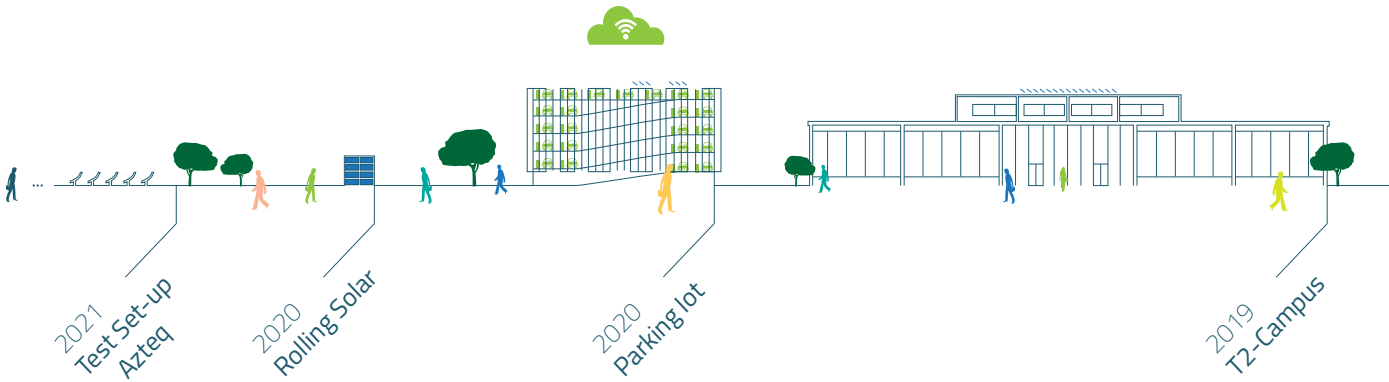

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