EnergyVille

Expanding the horizon

Annual Report 2017

Empowered by KU Leuven, VITO, imec & UHasselt

KU LEUVEN vito imec UHASSELT

TABLE OF CONTENTS

COMMITTEES

STRATEGIC STEERING COMMITTEE AND OPERATIONAL STEERING COMMITTEE

Strategic steering committee

President: Walter Eevers
Members: Marc D'Olieslaeger, Luc De Schepper, Ludo Deferm, Gerard Govers, Paul Heremans, Bruno Reyntjens, Paul Van Dun

Operational steering committee

President: Ronnie Belmans
Members: William D'Haeseleer, Geert Deconinck, Giovanni Flamand, Leen Govaerts, Bert Gysen, Jef Poortmans, Marlies Van Bael, Bart Vermang

EnergyVille is a collaboration of four research partners – KU Leuven, VITO, imec and UHasselt - bringing most of their Energy R&D-activities together on the EnergyVille campus in Genk. The transition to a sustainable urban energy system requires a high level of integrated expertise from component over building and district to energy system level. Through the unique collaboration of over 300 researchers of our mother institutes, EnergyVille makes it possible to share expertise and offer integrated knowledge and solutions covering the entire value chain.

PREFACE

Leveraging expertise to accelerate the energy transition

We are proud to present the newest overview of our activities at EnergyVille, clearly illustrating our achievements and research we work on. For a quick overview, I invite you to go through the timeline you can find further on in this report.

Over the past year we had the pleasure of welcoming new partners and of leveraging existing relationships. By signing agreements with different industrial players, we have taken important steps towards bringing our innovative solutions to use in the energy market. One example is the collaboration agreement with ENGIE, one of the important industrial players in the European Energy arena; another example is the joint ownership agreement with NODA, a Swedish company working on sustainable heating solutions. Moreover, through the cooperation with Distribution System Operators Eandis and Infrax for the roll-out of the City Portal, EnergyVille will support Flanders' cities and communities in their low carbon ambitions. These types of agreements offer both parties a unique opportunity to conduct research, develop and provide technical innovations to the market and illustrate how we want to leverage our expertise to reach synergies and generate win-win agreements.

This activity report shows how, over the course of 2017, the partners gathered in EnergyVille have harnessed momentum, fostered multidisciplinary research and pushed sector boundaries. We aspire to hold this upward trend and further position EnergyVille as a top research centre, being a driving force for innovation and energy technology, both locally, regionally and internationally. Together with our partners and making use of the new top-notch infrastructure available in our second building, we will continue and reinforce our efforts in the coming years, sharing our findings with our partners along the way. Together we believe we can increase technology development and valorisation and thus accelerate the energy transition.

I hope you will enjoy reading about our fundamental, applied and industry-driven research.

Walter Eevers,
President Strategic Steering Committee

Our strength is in our people

EnergyVille is built on the energy and drive of its people, whose passion is key to unlocking new technologies and products to bring the energy transition into reality. In 2017, we got to welcome the researchers of imec and UHasselt who joined forces with the founding partners KU Leuven and VITO. Together we continue to shape and work on our ambitions, more specifically an all-encompassing, futureproof and sustainable energy system for the built environment. With the addition of imec and UHasselt whose work mainly focusses on research in solar and battery technologies, we were able to complement our existing roadmaps and enrich our portfolio.

Since joining EnergyVille, individual researchers and entire teams have found each other and have started to leverage the synergies between their disciplines to further enrich and strengthen our work. This process will continue when these new partners physically come closer; in 2018 their photovoltaics research unit will move to our second building where a new lab infrastructure and the proximity to likeminded researchers will surely generate innovative ideas. Our ambition for 2018 is clear: to continue bringing together different stakeholders and to involve partners with different expertise to further enable and exploit a multidisciplinary approach.

The research topics presented in this annual report form a balanced entity and indicate how we see the energy transition: based on sustainable sources and with attention to the entire value chain, to guarantee affordable energy services for all stakeholders involved. Instead of focusing on specific aspects, we aim for a system approach and give preference to the interaction of the different components, making the end user a focal point in the transition. In addition to this multidisciplinary, system driven approach, EnergyVille provides scientific support for decision makers from politics and industry (governments, industry, NGOs, ...). We are happy to continue these efforts on the Thor science park in Genk, where we can build on the rich mining history and link a flourishing past to a green future.

I would like to sincerely thank all collaborators, who work tirelessly and with passion to make our vision reality.

Ronnie Belmans,

President Operational Steering Committee

ENERGYVILLE –

ENERGY FOR LARGE URBAN AREAS

Large urban areas are responsible for a large and increasing part of the energy consumption. As urban populations grow, these areas will need to conform to higher energy efficiency and technology standards. EnergyVille was created to provide an answer to this challenge, ultimately aiming at a sustainable energy system for large urban areas. We work on this in the midst of the ever changing energy landscape.

EnergyVille is a **top research collaboration** to outline the trajectory towards a **market-based, sustainable energy system for large urban areas**. This comprises **Basic, Applied and Industry-driven research**, both theoretical and experimental. EnergyVille serves the community by **developing generic technologies and methodologies** resulting in **new products and services**, by **assisting in human capital development**, and by providing **science-based policy input** from local to global level.

Our challenge: the changing energy landscape

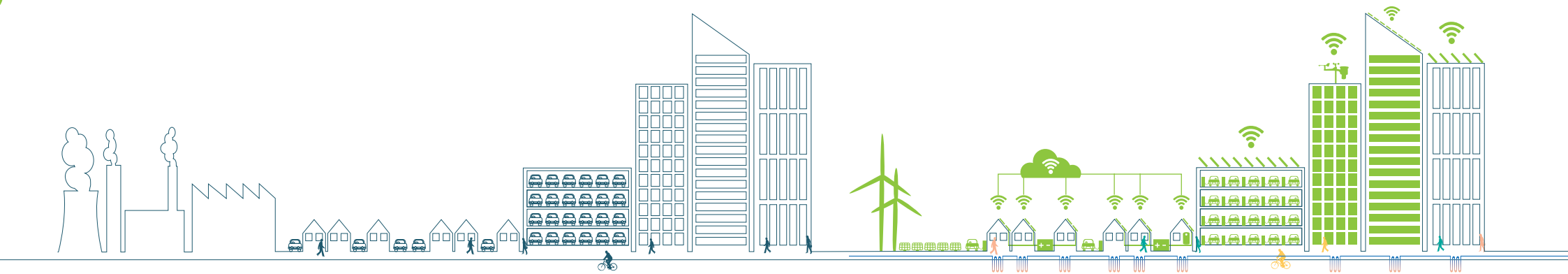
The energy landscape is in full transition. Historically, the electric energy system has been characterized by a centralized production in which electricity is mainly produced at large generation facilities and then shipped through the transmission and distribution grids to the end consumers. Different trends can be distinguished in the overall energy system today. The rise of renewables created a shift from consumers to prosumers, in which everyone can produce electricity and deliver it to the grid. Renewable sources are becoming increasingly competitive and are characterized by intermittency and flexibility. To cope with this intermittency, storage is becoming increasingly important, hence why we witness the emergence of disruptive storage technologies. At the same time there is more electrification, for instance with heat pumps, electric mobility and household appliances. As the biggest demand for energy comes from heating and cooling, thermal energy is getting more attention. This includes thermal networks, storage but also conversion. The energy system of the future will be characterized by interwoven energy vectors where both electrical and thermal energy hold an important place. Coping with the challenges that come with the future system requires innovative solutions for energy optimization, efficiency and renewable energy. The energy transition will have a considerable impact on spatial planning. Sustainable energy harvesting will impact the urban landscape, ranging from small scale installations on an individual level to large scale applications. The challenge lies in equipping the old building stock with new technologies that respond to the requirements of tomorrow, but also in designing brand new energy landscapes. To guarantee a sustainable energy provision, an intelligent management of the energy networks, a flexible way of producing, consuming and storing energy and new business models to support the integration of renewable energy sources are more than ever needed. This is where EnergyVille steps in.

The concurrent technology innovation and cost reduction of both ICT and distributed energy resources creates a unique opportunity for the transition towards a fully sustainable energy system. A multi-scale energy system with a strong and often dominating decentralized presence will be characterized by the pre-eminence of electricity as energy vector, strongly coupled with other carriers such as e.g. thermal energy. The deployment of this energy system in a highly complex urban context, ensuring full sustainability, that encompasses security of supply, resilience, affordability and environmental friendliness, will be a crucial cornerstone of our future energy provision.

Our answer: combining expertise in a living lab

To provide input for a sustainable urban energy system, a broad research scope is needed. EnergyVille offers specialized knowledge of all parts of the energy system and the integration of all systems together, thus covering the entire value chain. We do this by combining the expertise of four partners – KU Leuven, VITO, imec and UHasselt. Through this unique collaboration it becomes possible to share expertise and best practices amongst over 300 researchers.

State-of-the-art lab infrastructure allows to test hardware, software and business models for the combined energy network of the future. Aside from the interdisciplinarity between the different research partners, an important asset is the fact that EnergyVille is being set up as a living lab in which these laboratories and energy systems can be interconnected and data can easily be exchanged. It creates an ideal testing environment to experiment with energy future scenarios, to set up specific simulations and to develop new business models, not only within EnergyVille but also within the entire Thor Park, where the research institute is located.



The Thor Park located at the former mining site of Genk-Waterschei is a high-end business park coupled to a science park. The main building Thor Central is a multifunctional centre allowing workshops, conferences, seminars and much more. The site will be equipped with a technology talent campus opening in 2018, allowing students, job-seekers and employees to be immersed in the world of technology and innovation. In addition Thor Park is implementing a living lab where the newest applications can be tested within the site and simulated in real life. That way, Thor Park serves as a testing ground for research and open innovation around smart grids, new business models and pricing structures and regulation. The park gathers education, research and entrepreneurship in technology and sustainable energy in one location, providing an excellent source for cross-pollination.

Our various labs allow us to perform a wide range of tests and simulations, from materials for PV and batteries to thermal energy and smart household appliances. These top facilities can be interconnected and are complemented by strong multi-disciplinary knowledge, forming the ideal environment to drive the transition to a future-proof sustainable energy system.

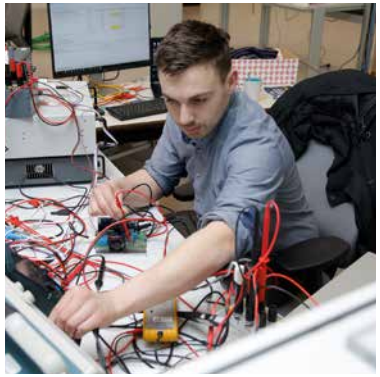
EnergyVille 1

Battery Testing Lab

Performance and lifetime tests are done as well as custom-made test procedures. Each test (self-discharge tests, efficiency tests, calendar life tests,...) can be performed at various temperatures and with several ripple profiles. The battery testing lab is used to evaluate ultra-capacitors, battery cells, components and materials, but also battery management systems.

DC Lab

Technology validation for the new DC distribution systems can be performed: grid architectures, grid components, converters, renewable energy sources, storage, charging for electric vehicles, protection schemes, standards and so on. The DC Lab is embedded in the Home Lab and hosts a DC grid (±500 VDC, 35 kW).



Home Lab

A real life test infrastructure for home energy management systems, residential demand response technologies involving smart appliances and in-home communication systems. More specifically, it enables testing of residential energy management systems, communication systems, novel optimization algorithms etc. in real life conditions.

Matrix Lab

On the one hand it provides the opportunity to measure and test the electric and mechanic characteristics of electro-technical equipment such as electric motors, converters and generators, in different conditions. On the other hand a big part is dedicated to PV module research: both thin-film and crystalline silicon modules, including integration of intelligence in PV modules, simulation tools, reliability, performance and efficiency testing as well as interaction testing with other devices.

Polyline Medium-Voltage Smart Energy System Lab

The efficiency and performance of industrial high-/ medium-voltage components under ideal, realistic and adverse circumstances can be tested.

PV Reliability Lab
PV modules on the roof

EnergyVille has 1070 PV modules in total, connected to 24 PV inverters downstairs. They are north, east, south or west oriented. The tilt angle is 10° to minimize the wind load on the modules and to fit a maximum number of modules on the roof area available. A typical power production at noon on a sunny summer day is about 300 kW.

Smart Grid Infrastructure Lab

A platform for testing smart grid products and systems. It includes a 150 kVA LVAC grid and a +-500 VDC grid which simulates low voltage distribution grids. One of the applications is the integration of renewable energy in the low voltage distribution grids. Furthermore, it also offers the opportunity to investigate algorithms which have to better match supply and demand in real-life conditions.

Smart Grid Lab

A multifunctional lab with grid emulator capabilities. The detailed real-time power system simulators enable testing grid control functionality in close to real-life system conditions. It offers full-detailed system tests to meet the needs of future power systems: from concept over conformity with new standards to full system integration.

Thermo Technical Labo (TTL)

A multifunctional laboratory for static and dynamic testing in order to develop, characterize and optimize a whole array of thermal energy technologies. It includes water pipelines that can simulate a district heating network as well as a circuit with thermal oil and supply lines for gas and electricity.

EnergyVille 2

Battery lab

New battery materials are examined, as well as an improvement of the battery layer build-up. The aim is to further develop cheaper and safe battery types for home batteries. Both coin (for basic research) and pouch cells (for testing applications) can be made up to a capacity of 2 Ah.

Building Integrated Photovoltaic Lab (BIPV Lab)

On the roof of the EnergyVille 2 office building is a BIPV demo room, where test arrangements of life-size demonstration modules can be placed on facades in real weather conditions, facing west, south and east. The interior and exterior climate of the BIPV elements can be monitored continuously, just like the performance and durability of the PV functions.

Dry Room in the Battery Lab

Here batteries can be safely filled with electrolytes and improvements for a full battery manufacturing process can be tested. The dry room has an area of 90 m² and is set to a relative humidity of 0.6%.

Photovoltaic module lab (PV Module Lab)

Research into the improvement of crystalline silicon modules. It can assemble modules up to 1 * 1.6m2. The measuring equipment is specially designed for this size of modules. The aim is to increase the performance and lifespan of the modules. A large number of reliability analyses at module level are possible.

Thin Film Photovoltaic Lab (TFPV Lab)

For the thin film PV applications, two types of materials are investigated: perovskites and CIGS (Cu-In-Ga-Se). The material properties are improved and the interfaces and the different layers in the thin film solar cell structure are studied. The size of thin film cells can range from a few mm (for basic research) up to 30 cm x 30 cm mini-modules (to test applications).

Other Lab Facilities

The entire laboratory in EnergyVille 2 is 2000 m², of which 1500 m² is already fully equipped to connect appliances directly and 500 m² extra expansion can be prepared quickly on request of industrial clients. The dust class in the entire lab is 100,000 (ISO8 standard). There are connections for bulk gases (N2, O2, H2, Ar and forming gas), cooling water, compressed air, DI water and extraction for organic and inorganic vapours. At the request of the users, specialty gases and chemicals can be provided.

Our impact

Embedded in large national and international networks, EnergyVille leverages existing expertise to reach synergies and generate win-win agreements. Within Flanders, EnergyVille is involved in Flux50, the membership organisation that helps Flanders gain international recognition as a Smart Energy Region. In May 2017 this strategic innovation initiative between the Flemish energy industry, research institutes and the government, was officially launched. With support of the Flemish government, a ten year innovation strategy for a smart energy region in Flanders was prepared. EnergyVille, as one of the main co-founders, contributed actively to the concept of this initiative and to make it operational, acting as official board member. Translating the initiative into actions, EnergyVille is involved in seven feasibility studies and new knowledge networks, initiated and financed through Flux50. As such, over fifteen companies started a new collaboration with EnergyVille in the domains of energy harbours, microgrids, multi-energy districts, energy cloud platforms or intelligent renovation. In the broader context, Flux50 allows EnergyVille to interact regularly with about 120 Flemish companies in the field of energy, IT and building currently member of Flux50. During the Smart Energy Academy they organised, as well as the Fall congress organised in the Thor Central building in Genk, energy experts from EnergyVille gave state of the art updates on smart energy. Through Flux50, EnergyVille looks forward to translate its unique knowledge and infrastructures together with Flemish industry and government into specific innovations and impact for Europe and beyond.

On a European level EnergyVille is a shareholder of EIT-KIC InnoEnergy SE and is actively contributing to the European innovation, business creation and education components of the "Smart and Efficient Buildings and Cities" project. Within InnoEnergy, EnergyVille is involved in the development of the educational game Lumen. By using gameplay, Lumen raises interest in STEM topics among children and young adults. Furthermore, KU Leuven as part of EnergyVille is involved in the InnoEnergy Master programs Energy for Smart Cities and Smart Electrical Networks and Systems, and is also involved in the UNI-SET project, that aims to mobilize European universities to contribute to the ambitious European energy goals.

EnergyVille is also working closely with the Global Smart Grid Federation, which provides us with insight in the smart grid activities of various countries around the world. We foster strong relationships with the associations and companies involved in GSGF and in its counterpart ISGAN, which focuses on multilateral government-to-government collaboration to drive the deployment of smart grids. EnergyVille was involved in the organisation of and contributed to the ISGAN public workshop on flexible power systems organised in September 2017 in Thor Central, Genk.

This unique co-localization of talent over the value chain, embedded in a broad network, will help drive the energy transition. We offer scientific support to all parties involved in the energy ecosystem. By providing objective facts and figures, we support not just companies, but also governments, NGO's and municipalities in the energy transition and feed the discussion with scientific data. Such expertise cannot be found in a single organisation, but thanks to the collaboration within EnergyVille we are able to provide an all-encompassing approach.

EnergyVille works together with advanced solution providers to have impact in society via sustainable technological innovation and transition support. In 2017 we signed a Joint Ownership Agreement on the innovative district heating controller technology developed in the European STORM (Self-Organising Thermal Operational Resource Management) project. As a clear illustration of the types of synergies we aim for, the agreement offers both parties a unique opportunity to research, develop and provide technical forefront innovations to the energy market.

TIMELINE 2017

JANUARY 25/01/2017

ENGIE and EnergyVille collaborate on future smart energy systems

Collaboration agreement ENGIE/EnergyVille
Important step towards the development of innovative solutions for the energy market

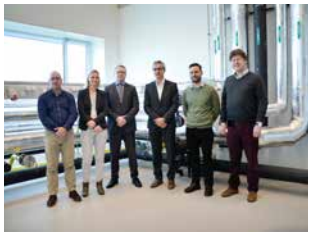
JANUARY 30/01/2017

EnergyVille launches objective preview of Belgian electricity provision in 2020-2030

Unique comparative study of possible future energy scenarios in 2020 and 2030

FEBRUARY 14/02/2017

Joint Ownership Agreement NODA-EnergyVille for STORM controller technology



20/03/2017 MARCH

The Biomass plant in Langerlo: data and alternatives

Study commissioned by Greenpeace, Bond Beter Leefmilieu and local partners in Transitie Limburg
Result: we can produce enough solar and wind energy to replace the plant and save 1 billion in subsidies

02/05/2017 MAY

Festive visit to the EnergyVille 2 construction site

The second EnergyVille building in Thor Park that will open in May 2018

10/05/2017 MAY

Flux50 helps the Flemish smart energy industry realize commercial breakthroughs

23/05/2017 MAY

Business Day

JUNE 12/06/2017

Eandis, Infrax and EnergyVille mark your house on the map

Tool by Eandis, Infrax and EnergyVille for digital data management shaping energy and housing policy

SEPTEMBER 12/09/2017

ISGAN Workshop: Building the flexible power systems

ISGAN public workshop on the flexible power system of the future

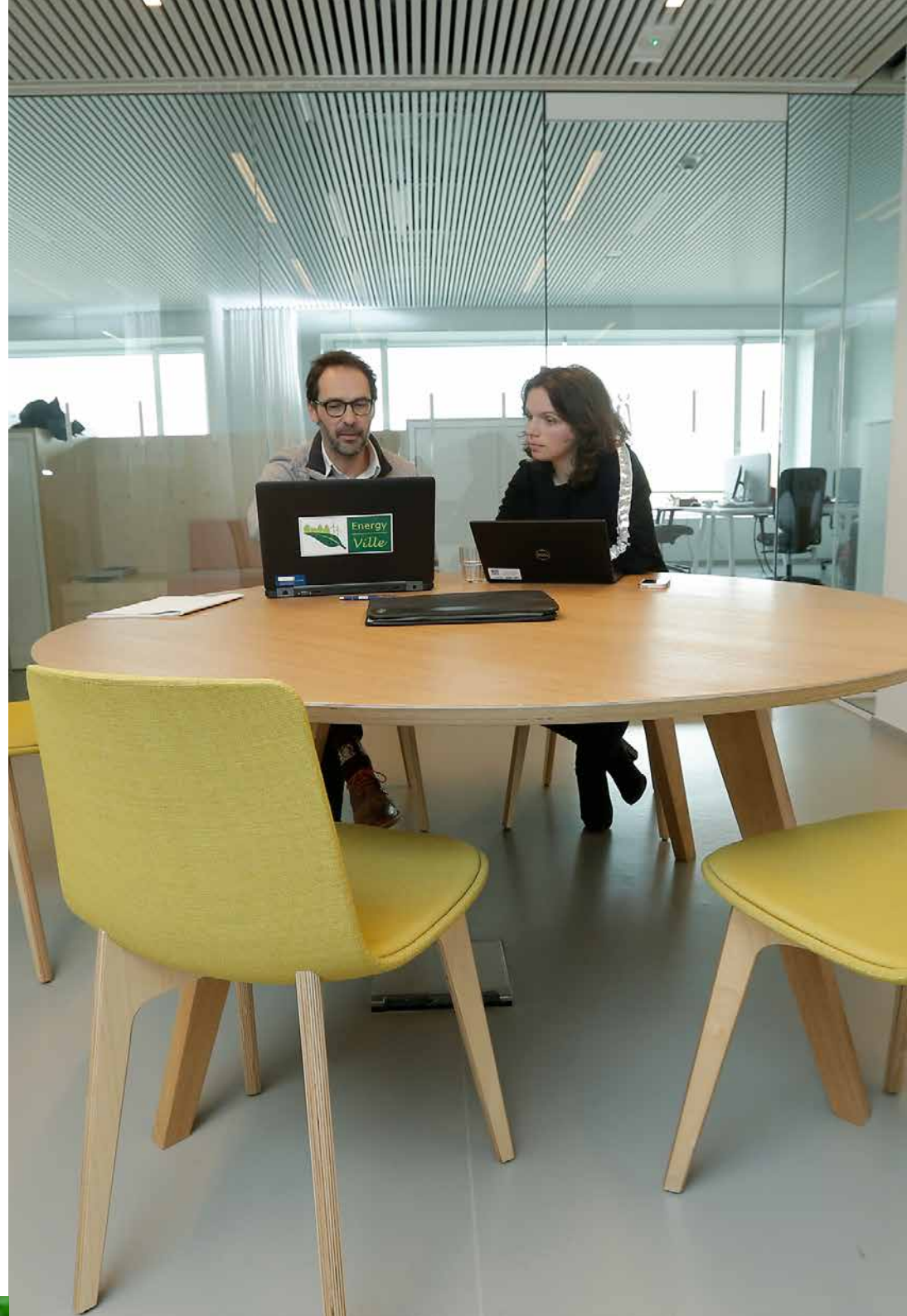
SEPTEMBER 15/09/2017

Festive inauguration Thor Central

NOVEMBER 30/11/2017

EnergyVille links Thor Park to Internet of Things!

ICT-platform integrating the energy consumption of the entire Thor Park



THE ENERGY SYSTEM OF THE FUTURE

To come to a futureproof energy system, there is a need for research covering the entire value chain, from material to market level. EnergyVille aims to answer this need and provides expertise ranging from the smallest to the highest, overarching level. We gather research on solar energy, storage, power control and conversion, networks, buildings and districts and energy strategies and markets. This includes both electricity and heat or cold.

A bright future with solar energy

When it comes to the transition towards renewable energy, solar power is a key part of the equation. Solar technology has improved over the last decade, prices have dropped exponentially and the module efficiency has advanced tremendously. New innovations are paving the way to the next generation of module technologies that will optimize solar efficiency even more.

In the framework of SolSThore (part of EFRO/SALK project), EnergyVille looks into new technologies and strive for a massive implementation of solar energy in a smart city context. To ensure efficiency and reliability, EnergyVille investigates new materials for PV and PV-cell/module technology. For a widespread implementation, the integration of PV in buildings, vehicles or other infrastructure is another topic of research. As these applications require a decent lifetime and reliability, EnergyVille studies PV module ageing and reliability as well as PV module-level convertors. Last but not least, we conduct research in energy yield prediction and forecasting.

New materials and their integration

New thin-film absorber materials, like perovskites, are rivalling with Si on efficiency already. However, stability and upscaling need to be further improved. EnergyVille has built up the infrastructure to investigate such new materials and to develop highly efficient and stable cell architectures. For other materials systems, like CIGS, the absorber interface is meticulously controlled to enhance the output voltage while maintaining very thin films. Understanding and describing the materials properties are crucial to generate high performing photovoltaic devices. This is why EnergyVille enables the demonstration of these new device architectures not only on small lab-scale devices but on full sized (30*30cm²) modules and even full integration in final applications like buildings, vehicles and infrastructure.

One of the critical elements to achieve energy generation is a large scale integration of photovoltaic modules in buildings. More than merely attaching PV panels to the roof (BAPV), EnergyVille also looks into the technology of installing PV panels in the building envelope, such as on the outer walls or in its windows to harvest a maximum of energy in buildings. By simultaneously serving as building envelope material and power generator, BIPV (Building integrated PV) systems can provide savings in materials and electricity costs, and add architectural and aesthetic appeal to the building.

Within EnergyVille, a technology of PV modules for flexible on-demand dimensions is developed. We develop models to predict and forecast energy yield specifically for Building Integrated PV systems. In addition, we study degradation mechanisms and the key influencing parameters, modelling these mechanisms accurately, allowing optimization of the BIPV product and the whole system. This ensures an optimal combination of lifetime and energy yield (E-yield) through adequate monitoring and control.

Optimal energy yield

Nowadays, the energy performance of PV modules is measured indoors under standard testing conditions. However, in reality, outdoor conditions differ significantly from these standard conditions. To bridge the gap between indoor and outdoor performance and to come to highest yield of solar energy, EnergyVille has developed an energy yield prediction model and appropriate testing setups.

The energy yield prediction model is a scenario-based software which accurately predicts the daily energy yield of solar cells and solar modules under varying meteorological and irradiation conditions. The model combines optical, thermal and electrical parameters to provide detailed insight on thermal gradients in the solar module. It integrates the effect of these gradients, resulting in a significantly better accuracy than commercially available software packages for energy yield estimation. It starts from the physical parameters of the solar cells and the used materials, and includes on top of that the variations due to changing external conditions. In this way a 'closer to reality' model is obtained, enabling a more precise assessment of the effects of solar cell and module technology changes on the energy yield of these photovoltaic cells and modules.

A crucial part of the project is to test all of these technological innovations in an all-inclusive test infrastructure. To do this, EnergyVille makes use of a set-up with façade integration (a Building-Integrated PV or BIPV set-up) and a large (also known as commercial-roof) PV installation.

Building integrated PV

Building integrated PV seamlessly integrates solar cell systems in the building envelope. Since they become a prominent part of the architecture of a house, they need to be aesthetically pleasing, should maintain a good performance under non-ideal conditions (e.g. more shadow, reflections, etc.), need a high lifetime and smart ventilations schemes compatible with façades. A full-fledged BIPV installation was designed for the EnergyVille 2 building, to do similar measurement campaigns in Genk for up to 20m² of BIPV modules.

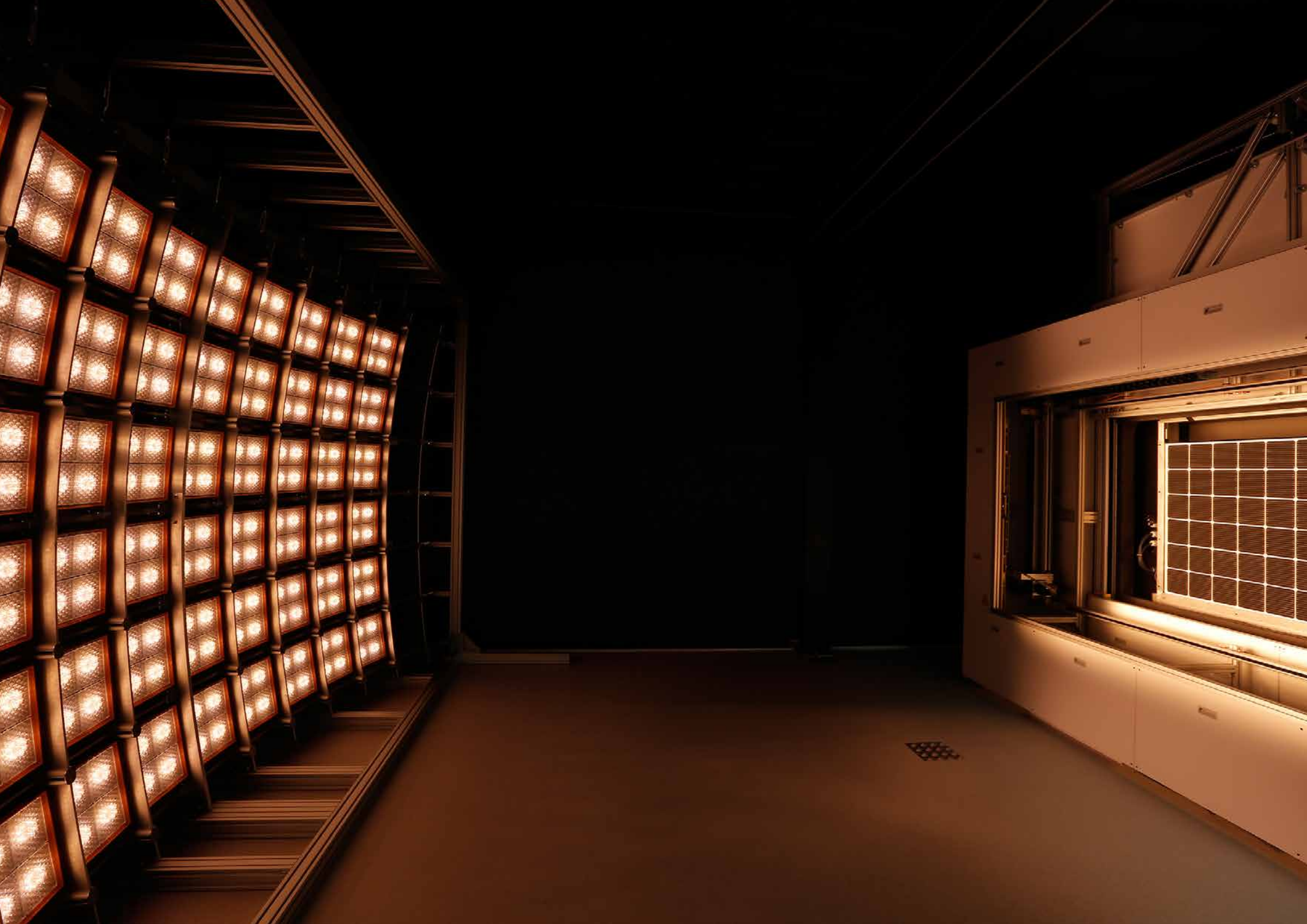
BIPV systems play a twofold role as building element and power generator. In order to evaluate the year-round performance of such concepts, the implementation of BIPV models in building energy simulations (BES) tools is essential. An integrated approach for the simulation of BIPV systems was developed within the open-source environment OpenIDEAS/Modelica. The methodology focuses on thermal-electrical couplings inherent to such systems and on the active and passive effects between the building and the BIPV element. The object-oriented nature provides a flexible tool for fast prototyping and assessment of different BIPV systems and energy scenarios.

Large commercial roof PV systems

To support the owners and developers of buildings with detailed input about the performance and efficiency of larger PV systems coupled to DC nanogrids with battery storage, EnergyVille has equipped part of its PV surface of 300 KWp on its roof for broad testing purposes. The test set-up enables PV modules to be tested on a large scale and in different framework conditions – for example in different tilt angles, east-west configuration – and facilitates to come to the most suitable energy consumption profile for a building. Additionally, this PV system is linked to the DC Nanogrid and battery lab in order to evaluate the design options of such systems.

On 31 May 2018, the second EnergyVille building will be inaugurated.

The building and labs will be dedicated to technology development in thin-film PV, intelligent PV modules, building-integrated PV and new batteries for local storage.

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OTHER PATENTS PENDING
47
50
44

Storage, a key component of a future-proof sustainable energy system

As the fraction of renewable, intermittent energy sources on the grid increases, domestic stationary electrochemical energy storage systems (batteries) can improve the way we are able to use this energy.

EnergyVille's battery research covers the whole application spectrum from micro to macro storage and offers knowledge and expertise along the complete value chain, starting from the synthesis of electrode and electrolyte materials, up to advanced characterization of batteries, ageing studies, post-mortem analysis, and development of battery management systems for estimation of state-of-charge and state-of-health.

At EnergyVille, chemists, physicists, materials scientists and engineers collaborate to overcome the many fundamental and practical hurdles on the road to the development of a new or improved battery technology. Technologies currently under investigation include lithium ion batteries (LIB), solid-state LIB, sodium ion, Li-S as well as Li-air batteries.

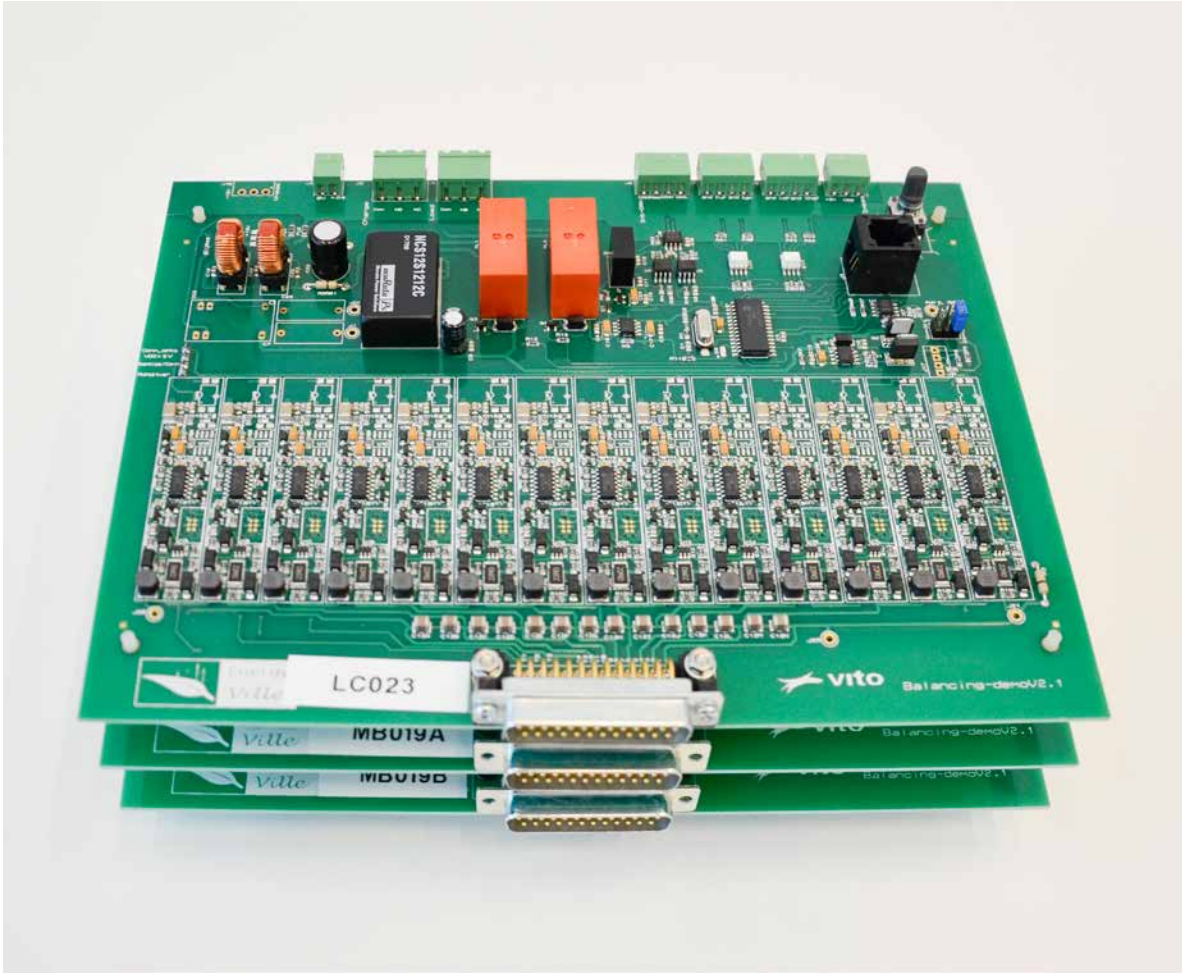
The right technology and battery configuration

Within SolSThore (part of the EFRO/SALK project) EnergyVille has invested in equipment to accurately assess the battery's performance indicators. The Battery Testing Lab combines infrastructure to test batteries at cell, module and pack level up to 1000 VDC from -20°C to 55°C. Those tests can be performed according to existing standards but EnergyVille also has a long-standing expertise in developing and executing application specific test protocols. Using the latter more useful information is gained to translating the evaluation into an advice towards the right technology and battery configuration for the aimed use case.

A battery management system for better batteries

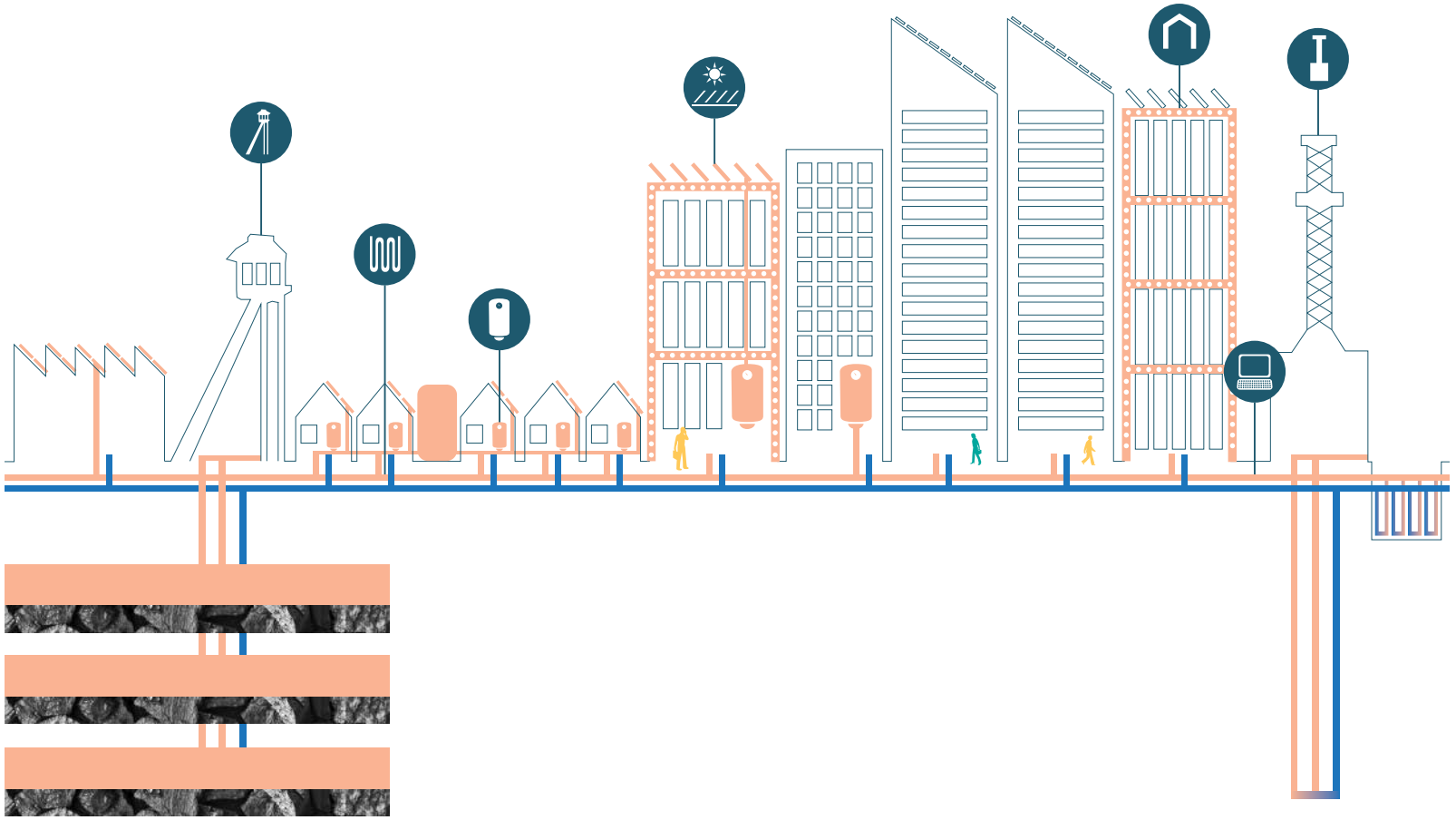
To ensure a safe, reliable and high-performant operation of the battery in the end application, it has to be connected to a battery management system (BMS). Over the last year and in the scope of the SolSThore project, EnergyVille has focused on the development of an advanced cost-efficient and modular BMS for mobile and stationary battery packs. The resulting BattSense technology (www.battsense.eu) is a combination of hardware and software features that not only continuously monitors the individual battery cells but also manages the system so that its intrinsic capacity is used to the maximum and its lifespan is increased. The permanent dynamic cell balancing and the definition of a dynamic safe operating area in terms of voltage (V), current (I) and temperature (T) are only some of the outstanding enabling features of the system. Due to the constant measurement of the three parameters, the battery's exact status is known at any given moment. This status can be expressed through the battery's state of charge (SoC), referring to its energy content, and the state of health (SoH), referring to its condition compared to a fresh battery. Both state estimates can be combined to provide an estimate of the ability of the battery to deliver a specific service, expressed by the state of function (SoF).

The EnergyVille researchers are combining their testing and analysis expertise to feed different kinds of battery models which serve the software features developed for the BattSense BMS. As this BMS works model-based, it is a very flexible solution, ready when new technologies are entering the market. Together with an increased lifespan of the battery, this can make the difference in the balance for a business case for battery deployment in a given application.



From technical challenges to market uptake

Aside from technical challenges, attention should be paid to policy. This is why EnergyVille is involved in the BATSTORM project on developing a roadmap including implementation plan for electrical storage in Europe. The BATSTORM project supports the European Commission and the European Technology and Innovation Platform (ETIP) for SmartGrids and Storage in their progress to identify and support RTD&D needs and market uptake of battery based energy storage. The project aims to improve the competitive position of Europe in the battery market as well.



Storing heat and cold

Aside from electrical storage and within the framework of GeoWatt (another part of the EFRO/SALK project), EnergyVille conducts research on thermal energy storage technologies. With these technologies excess heat or cold can be stored to be used when needed: the delivery of heat or cold is made independent of demand. It provides a solution to the daily mismatch between heat demand on a domestic level and supply from renewable sources (such as solar collectors or PV coupled heat pumps). There are different ways of storing heat and cold, from activating the building mass to phase change materials or thermochemical storage.

EnergyVille is involved in the incorporation and integration of thermal energy storage into the thermal grid to create more flexibility. Key to access this flexibility is the accurate energy content estimation or state-of-charge (SOC) of the storage device at any moment in time. SOC methods were developed and/or improved for a series of thermal storage technologies like phase change materials, thermochemical materials, water buffers, concrete core and (shallow) geothermal applications. To better align the thermal storage available, these states are linked in an optimization framework to determine the optimal technology in specific situations, its dimensions and the most optimal implementation with respect to its specific geographic conditions. It results in another step in energy efficiency and share of renewable energy sources.

Power control and conversion to manage the energy transition

This area is characterized by research in power electronics and conversion. On an electrical level, the main research topic is Low Voltage Direct Current or LVDC. On a thermal level, we study conversion technologies in order to make optimal use of renewable energy sources.

A building-level DC nanogrid in EnergyVille

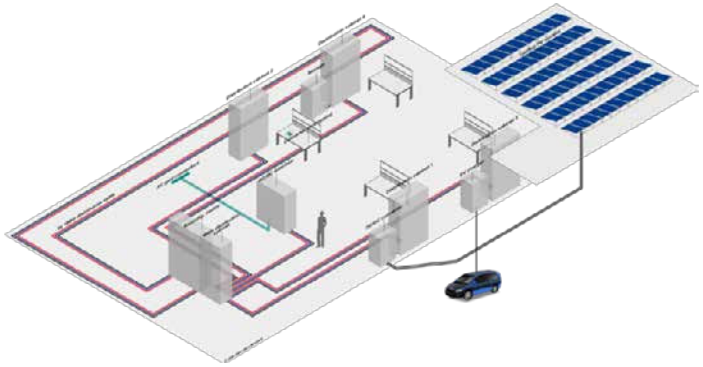


Fig. EnergyVille DC nanogrid schematics with 4 substations and central AC/DC converter + connections to PV test roof and vehicle/battery charging.

One of the highlights is the implementation of a building-level DC nanogrid in the EnergyVille 1 building developed in the framework of the SolSThore project. Although electrical power networks in buildings and districts have been for about a century equipped with AC technology at 50 or 60 Hz, the energy transition is putting into question whether that is still the right choice. The transition to decentralized production, energy-efficient technologies and the electrification in heating and transportation all contribute to the question whether the current "lock-in" of AC technology for building technologies is justified.

EnergyVille studied the expected gains for new buildings and conversions, to conclude that there are limited operational efficiency gains in the order of single-digits percentages possible (average 5%). However, large quantifiable gains are to be expected in investment costs as less cabling and a lower count of conversion hardware are needed and storage can be integrated more efficiently, indirectly also leading to an improved space utilization. Even more, improvements in reliability of the power supply are projected. Despite the fact there currently seems to be an economic rationale, it is necessary to prove in practice that low-voltage DC technology works on a wide scale, and that safety concerns are overcome. However, due to a lack of market, except for niches such as data centres, the necessary electrical components are not widely available and no unified standardization nor safety practice exist yet.

Therefore, EnergyVille decided to set up a representative building-level "DC nanogrid" (as opposed to the wide area microgrids). To realize this, a portfolio of technology was developed using high-performance power electronics including wide-bandgap semiconductors, non-linear modelling and control methods, and protection philosophies. As a milestone, in December 2017, this system underwent the compulsory external "safety approval" according to the Belgian AREI-code (note that this code is intended originally for AC) making it the first building-level DC power system in the country.

A preliminary study for the Flux50 Cluster industrial partners has been concluded end of 2017, showing that the LVDC concept can be deployed to demonstrations in the public domain, as the relevant standardization and safety codes can be met, opening the possibility to move on the next stage of "Living Labs" and be at the forefront of LVDC research and development.

Thermal Energy Conversion

The extensive development of renewable, distributed energy sources will lead to major changes in the energy networks. Trends include a higher level of interaction between different energy vectors. By using more extensive energy conversion systems like heat pumps and Organic Rankine Cycles (ORC), more efficiency can be obtained in the global energy system. In periods of high electricity prices heat-to-power systems like ORC's could produce electricity starting from heat. During periods with low electricity prices heat pumps could pump up heat at low temperature to higher temperatures to be used by consumers.

Conversion systems will play an important role in the optimal use of renewable energy sources and in the interaction between energy networks. They need to be flexible, efficient and equipped with new components in order to be used as energy hub between networks and to deliver extra services to one or more networks. Over the past year, EnergyVille has focussed on heat pumps, ORC's and heat exchanger concepts.

Towards a sustainable electrical and thermal grid

In the electricity sector, the switch to an electricity production primarily based on renewable sources causes a 'paradigm shift' in planning and operation of our electricity grids. On a thermal level, district heating and cooling networks have major potential to increase energy efficiency and the share of renewable energy in the urban environment.

Strengthening the transmission system

On the pan-European level, major connection investments are needed to strengthen the transmission system. These reinforcements enable transporting growing amounts of energy coming from renewable energy sources, not only within countries, but also across borders. On the long-term, the large-scale integration of offshore wind energy, and opportunities brought by increasing interconnection capacities will lead to the construction of offshore grids and so-called 'electricity highways' interconnecting the continent. At the same time, distribution systems are undergoing tremendous changes all around the world. The digitalization of the smart grid allows to prepare the distribution networks for the large scale integration of renewables (e.g. photovoltaic installations), battery storage and electric vehicles. Over the past year, the EnergyVille activities marked important milestones towards making our electricity grid ready to face these challenges, with research centred on HVDC technology and decision support for grid operators.

HVDC technology

High Voltage Direct Current (HVDC) has become a key technology in the energy transition. It offers new perspectives for cross-border infrastructure investments and at the same time, it is the only technically feasible solution for connecting remote offshore wind farms. In the coming decades, meshed HVDC grids will enable even higher levels of renewable energy integration by unlocking the full potential of the technology. EnergyVille's activities to move towards HVDC grids are centered on control and protection of such systems, as well as on planning aspects.

In the past year, the HVDC group has performed high-quality research to provide insights on a system, component and policy level. As a reward for her high-quality research, researcher Mian Wang has been awarded the CIGRÉ Winnipeg 2017 Colloquium Best Student Paper Award with her paper on AC and DC Protection Equipment and Technologies. In addition, our active involvement in the international CIGRE working group sets the scene for the pre-standardization of the control principles for future HVDC grids.

Decision support for grid operators

Transmission and distribution system operation and planning are becoming ever more complex, due to uncertainty caused by renewables and new sources of flexibility provided by demand side management, storage and flexible, non-linear grid elements. Currently, system planners and operators have to process large amounts of information and make a decisions in a short span of time, resulting in suboptimal utilization of equipment or over-investment in system planning. With the research on Decision Support Tools for Grid Operators, EnergyVille provides new computational methods and tools, helping the grid operator to take decisions proactively and to allow optimal integration of all service providers in the market, making use of various optimization techniques.

Within the Garpur project EnergyVille is involved in, such an optimization tool was developed to compare reliability decisions by TSOs: the Garpur Quantification Platform (GQP). In 2017, EnergyVille has started a structural research partnership with distribution system operators, focusing on congestion detection and management in low-voltage distribution grids. Various machine learning approaches and optimization techniques are explored for congestion detection, state estimation and optimal control of low voltage networks. This helps to detect congestions in advance and to schedule flexibility such as demand side management and electrical vehicles to proactively relieve the congestion. These activities all mark important milestones towards making our electricity grid ready for the future.

DHC+ Summer School

In 2017 the 5th edition of the International DHC + Summer School was organised in collaboration with EnergyVille. It took place from 27 August to 2 September 2017 and was a perfect occasion for students and professionals to explore the functioning of the newest installations for energy research in Belgium and participate in the discussions on district heating and cooling development. Diverse lectures were combined with guided site visits to real installations, such as the newly developed district heating network *Nieuw-Zuid Antwerp*, the highly advanced 4th generation network *Mijnwater in Heerlen*, and the first *deep geothermal well in Mol*. The DHC challenge was hosted by Mr. Ralf-Roman Schmidt (AIT Austrian Institute of Technology) and required participants to work together in small groups to conduct feasibility studies for district heating in or nearby Genk. Under the guidance of district energy experts from EnergyVille, representatives from the city of Genk and the province of Limburg, participants with different backgrounds shared their knowledge and came up with great ideas for the transition towards a more sustainable heating and cooling future in Flanders.

District heating and cooling networks

Thermal energy plays an important part in the energy landscape. Fourth-generation thermal grids therefore have major potential to increase energy efficiency and the share of renewable energy in the urban environment. EnergyVille therefore focuses on the optimization of entire thermal systems, ranging from component to system level, simultaneously making sure the supply for heat and cold is balanced with the corresponding demand of user groups.

District heating and cooling (DHC) networks can be of great help in rendering our heat and cold supply more sustainable. Fourth-generation thermal grids especially have major potential to increase energy efficiency and the share of renewable energy in building heating and cooling. A fourth generation thermal network is mainly characterized by a lower temperature compared to its predecessors. The lower the temperature needed for the thermal network, the more energy sources like residual heat can be used. In addition, there are less losses in lower temperature networks, which results in more efficiency.

DHC networks are an important part of EnergyVille's research, as they can be combined with energy storage, flexibility in demand or other measures to form one of the foundations of a sustainable future energy system. EnergyVille aims at implementing innovative concepts and demonstrators for smart substations, thermal storage and thermal grids with low return temperature. We also develop tool kits for designing fourth-generation thermal grids and geothermal plants. All technological developments are tested in a prototype fourth-generation thermal grid in the Genk region.

Energy for the built environment

Buildings are responsible for approximately 40 % of energy consumption and 36 % of CO^2 emissions in the EU. This is no surprise as about 35% of the EU's buildings are over 50 years old. As 9 out of every 10 of the existing buildings in the EU will still be there and occupied in 2050, improving the energy performance of the existing building stock is a key challenge. EnergyVille supports various stakeholders in the transition to smart, energy efficient, low-carbon buildings and cities by means of innovative software tools and algorithms, both at building and city level.

City Portal

The City Portal is an interactive portal with building data for collective energy efficiency measures of the residential building stock, from building to regional level. While the first applications are developed for the Belgian residential building stock, an expansion towards non-residential buildings can easily be set up. The City Portal can be used jointly by several stakeholders including managers of city services, DSO's, urban strategy advisors and solution providers. The portal serves the purposes of joint data management, planning and roll-out of energy efficiency measures and monitoring of the implemented measures in terms of annual energy consumption, renewable energy production and resulting lowered CO_2 emissions. In 2017 the first contracts were signed to roll out this innovative solution on the Belgian market.

EBECS – EnergyVille Building Energy Calculation Service

EBECS is a tool for giving home owners comprehensive renovation advice. It combines input from the owners on simple questions related to the state of the house and its systems in order to better understand and analyse the current situation of the house (construction, systems, people and their behaviour, energy consumption). The purpose is to identify the possibilities for improvement via renovation. Consequently, the tool offers complete renovation packages and reflects on how much the energy consumption is reduced. In addition, EBECS reveals how much the home owners can save on the energy bill and gives insights in the total investment costs, including subsidies and government incentives. Furthermore, the home owners can select and investigate the effect of different renovation measures to the energy bill of their house in order to choose the renovation package that best fits their needs.

In the course of 2017 the product was launched for three different clients in the energy, financial and technical services sector.

Renovation pact and VLAIO Living Labs

At national level, EnergyVille is involved as knowledge partner in initiatives such as the Renovation Pact and the VLAIO funded living labs for dwelling renovation.

The Renovation Pact is an initiative of the Flemish government together with regional stakeholders with the objective to increase the depth and renovation rate of the existing buildings stock. Under the framework of the Renovation Pact, EnergyVille was commissioned by the Flemish Energy Agency (VEA) to update the calculation method for Energy Performance Certificates (EPCs) of existing buildings. The prototype of the new generation of EPCs (EPC+) were presented by the Flemish Energy Agency at the end of 2017.

The VLAIO living labs for dwelling renovation are ten demonstration pilots of home renovation in Flanders that EnergyVille contributes to. One of the pilots is Ecoren, in which renovation concepts for social housing are tested and implemented, taking into account the comfort of the inhabitants during and after renovation. EnergyVille monitored not only the technical aspects of the renovation such as thermal comfort, indoor air quality and energy performance but also the social aspects such as user engagement and interaction. In December 2017, four residences were renovated to nearly zero energy (NZEB) level in just twenty days.

Smart Cities Information System

Since the Autumn of 2017, EnergyVille leads the consortium which manages the SCIS database, bundling more than 100 EC funded projects from 200 cities in Europe. The platform showcases projects' technologies, best practices and barriers/ solutions in order to stimulate replication across Europe. With a focus on smart cities, energy efficiency, transport and mobility and ICT, SCIS showcases solutions in the fields of sustainable building and district development, renewable energy sources for cities, energy efficiency and low-carbon technology applications.

Managing and modelling energy strategies and markets

To come to an all-encompassing, future-proof energy system, not just technological aspects but also economic and behavioural aspects need to be studied. EnergyVille monitors energy demand and supply, carries out evaluations and provides advice on energy efficiency, renewable energy and flexibility for companies and local, regional and European policy makers. To underpin choices, cost-efficient trajectories to a new energy system are calculated, taking into account climate objectives and energy policy.

In addition, to absorb ebbs and flows in the intermittent supply and demand of renewable energy and to optimally use the energy produced, an integrated and balanced system approach is needed which takes into account the different energy vectors, electricity, gas, heat and cold and interconnects them via different conversion technologies, operated by different actors. This work is crystallized in SmarThor, the third part of the EFRO/SALK project.

Scenarios for the Belgian electricity provision

The transition to a sustainable, affordable and reliable energy system has an important social impact. There is a need for substantial investments and therefore the choices that have to be made must be substantiated by facts and figures. Last year, EnergyVille was asked by various parties to provide input by calculating various scenarios for electricity supply. Febeliec, the Federation of Belgian Industrial Energy Consumers, Greenpeace, BBL and IEW have asked for such calculations. For each of them, the Belgian TIMES model was used, a model developed by EnergyVille in different research projects in recent years. The studies provide insight into what our electricity supply might look like in 2020 and 2030 and what effect this will have on energy production and costs for society, an insight without specific preference for certain technologies. Unique to the use of the TIMES model, is that in all calculations, given the chosen preconditions, the best economic solution, or the lowest costs for society, are sought for the entire system. External funding of technologies like subsidy schemes are considered a way of financing, i.e. a cost for society, and are therefore not included in the model.

EnergyVille has been 'contracting party' for more than 20 years of the ETSAP (Energy Technology Systems Analysis Program) technology collaboration program of the International Energy Agency (IEA). Within this network, together with research groups from all over the world, we are working on the development and use of the TIMES model. The Belgian TIMES model has been used many times in Belgian and European research projects, such as for 'Towards 100% renewable energy in Belgium by 2050' (commissioned by the 4 Belgian energy ministers) and 'ESTMAP: Energy Storage Mapping and Planning' (commissioned by DG Energy). As a result, the model is continuously updated: economic growth projections are aligned with the latest forecasts, new technological developments are incorporated with their efficiency, cost, etc.

All scenarios show that by 2030 natural gas based generation (gas power plants and combined heat & power plants) and better interconnection capacity will be crucial in combination with the increasing renewable generation. Taking into account the nuclear phase-out by 2025, the TIMES model invests in new CHP's and gas power plants to a total capacity of more than

6 GW by 2030. Growth of renewable electricity production is barely hampered in scenarios with a lifetime extension of 2 GW of nuclear capacity. Given the past and still ongoing price declines in renewable technologies like photovoltaics and wind (especially offshore), they are becoming more and more cost competitive. Renewable capacity grows from a current 5,35 GW to 17 GW in all scenarios.

Although the electricity system cost in 2030 (investments, operational and fuel costs) is lower in the scenarios with an extension of 2 GW of nuclear capacity, the long term gas price uncertainty plays a dominant role in the eventual system costs. The difference in system cost due to gas price variation is larger than the difference between scenarios with or without a 2 GW extension of nuclear capacity. The average marginal cost of electricity production will slightly decrease from the current 44 €/MWh to 40 €/MWh in 2020 due to the growth in renewables. By 2030 the TIMES model calculates an increase up to 69 €/MWh taking into account the phase-out of nuclear and to 63 €/MWh with a 2 GW nuclear extension. This difference is limited as gas-based production is in most cases the marginal technology and thus determines price setting when renewable production cannot completely meet demand.

Tariff structure of the distribution grid tariffs

In the context of a future reform of the tariff structure, The Flemish Regulator of the Electricity and Gas Market (VREG) allocated a study on the revision of the tariff structure of the distribution grid tariffs to EnergyVille.

The current distribution network tariffs are based on the assumption of a "traditional" use of the network, based on a centralized large-scale electricity production and a pure purchase of electricity. They do not take into account recent evolutions in the energy system and in the energy markets. The combination of the increased integration of renewable energy generation and the principle of the backward rotating meter for prosumers also led to distribution system operators having to deal with a decrease in the net purchase of electricity, the parameter currently determining the consumer invoice.

The VREG therefore commissioned EnergyVille to conduct an additional study with regard to future distribution grid tariffs for consumers and small commercial grid users. The study focuses on the design of future-proof, regular distribution grid tariff structures and their impact on consumers and small commercial grid users and distribution system operators, so that the intended energy policy and challenges of the energy transition can be tackled, both in the short and long run.

The study concludes that for the classical meter customers, a tariff structure based on the technical connection capacity (kVA) is the best option. For digital meter customers, there are two options: one based on the technical connection capacity, monthly peak power and purchased energy and one based on consumption and capacity, where higher rates apply to a higher peak demand. With the data from this study and in collaboration with various stakeholders, the VREG can draw up a proposal for a new tariff structure.

SmarThor: research platform for multi-energy systems and markets

Since November 2017, the first version of the SmarThor ICT Platform developed by EnergyVille is up and running at Thor Park in Waterschei, Genk. SmarThor is the combination of Smart and Thor and integrates energy generation and –usage, both thermal and electric, of the entire Thor Park into one ICT-platform and is based on Internet of Things Solutions. By means of advanced regulation and control algorithms, the SmarThor ICT Platform balances both demand and supply, and will enable in the future to interchange energy remainders by means of a virtual electricity heat and cold market.

The SmarThor ICT platform makes use of the latest developments in cloud technology and Internet of Things to gather relevant data. It not only measures the energy production of solar panels but also the energy use of heat pumps, gas boilers, charging stations, offices and lighting. By means of self-learning techniques the computers look for specific relations between these data and set up automatic and self-learning patterns that take into account weather forecasts and changes in user behaviour.

The first version of the SmarThor ICT-platform monitors the energy production and use of EnergyVille I and will be gradually expanded towards IncubaThor and Thor Central. It is expected that EnergyVille 2 and T2-Campus, which will open in 2018, will join the network, generating a virtual electricity-, heat and cold market at Thor Park.

OUR VISION:
A LIVING LAB TO SUPPORT THE ENERGY SYSTEM OF THE FUTURE

Ronnie Belmans, Bert Gysen and Jef Poortmans give a short overview of the current energy landscape and the role EnergyVille aims to play in the transition towards a future-proof energy system. Ronnie Belmans is CEO of EnergyVille and professor at KU Leuven, Bert Gysen is COO of EnergyVille and unit manager at VITO, Jef Poortmans is R&D Strategy Coordinator at EnergyVille and Programme Director at imec.

Solid support for the energy transition

The Belgian energy landscape was characterized in 2017 by some remarkable changes. For instance, the cost price of offshore wind has decreased significantly, marking a transformation for the sector. This will also have consequences for the connection between Belgium and its neighbouring countries, which has greatly improved last year. There was the inauguration of the Stevin connection, which will bring the electricity from the aforementioned offshore wind farms to land. The construction for NEMO also started, the very first direct power connection ever between the British and the Belgian grid. With the Alegro line between Belgium and Germany currently under construction and Brabo II and III on the rise, it is clear that there will be substantially more and improved interconnections. "This will make it easier for Belgium to balance green energy at European level," says Ronnie Belmans.

At the political level, efforts were made to bring solar energy and other renewable energy sources into the mainstream, efforts that are clearly paying off. "In 2017, a favourable energy climate could be perceived in Belgium for the very first time ", says Ronnie Belmans. "Both through technological developments and through political efforts there is now a solid social basis for the energy transition, which is perceived as feasible and affordable. This is a hopeful sign".

In 2017 awareness also grew that the energy transition is not just an electricity transition. More and more attention is being paid to green heat, a trend that will continue in 2018 and which we would like to contribute to within EnergyVille. We see steps in thermal networks and deep geothermal energy, but this will only yield results in the long run. "In the short term we can probably expect further improvements to batteries, with accelerated production and lower prices," says Bert Gysen.

Regarding novelties in 2018, Ronnie Belmans also mentions the smart meter. "Last year Minister of Energy Tommelein brought solar energy into the mainstream without any technological breakthrough, this year should be the year that we finally get the opportunity to bring demand response into this process via smart meters. We have to think at system level, no longer in terms of individual technologies. "This system also includes electric vehicles that require more charging stations. They too can be expected in the coming years. In every area it is becoming clear that technology is driving political progress.

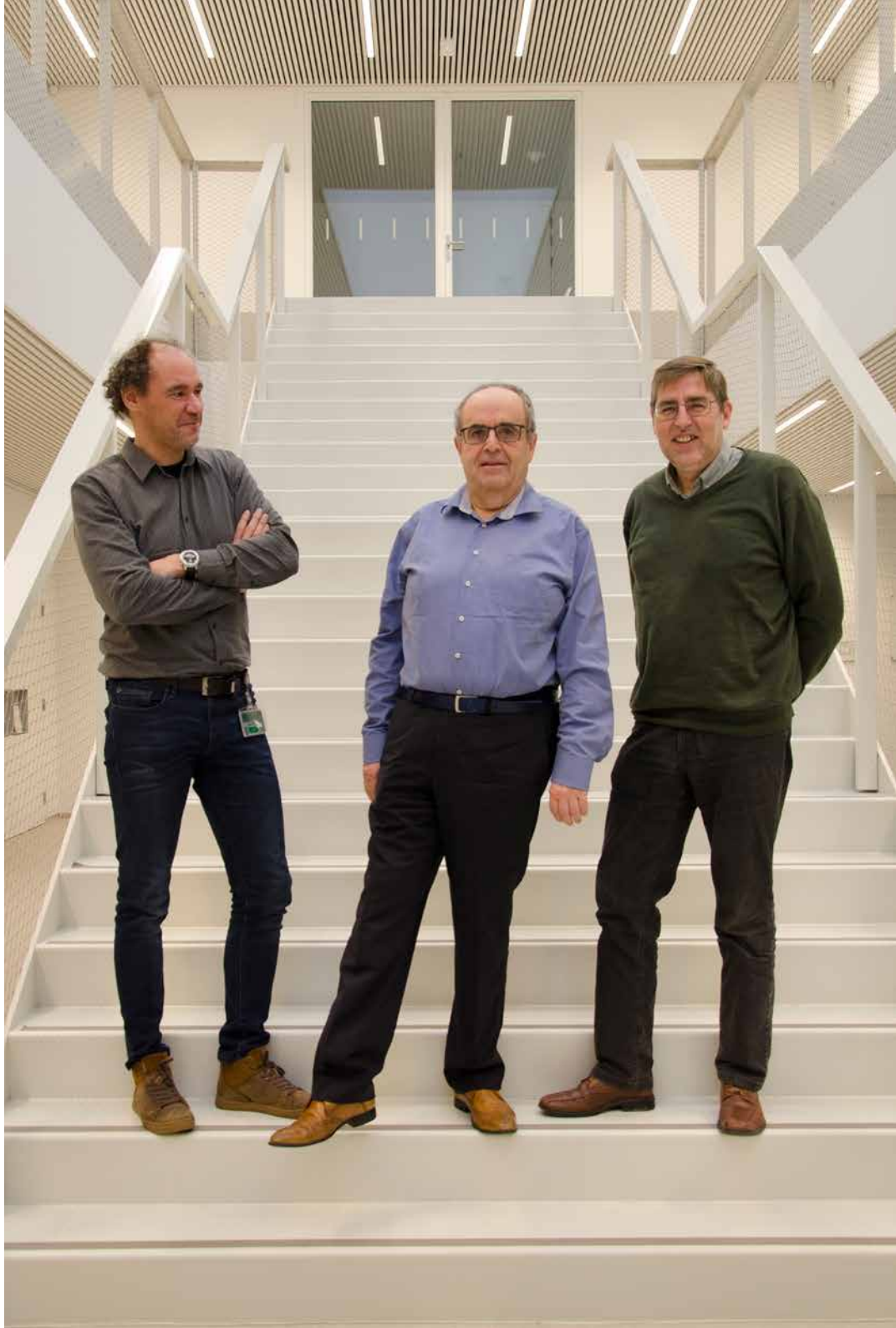
Not only in Belgium things are moving, but internationally as well the transition to green energy is continuing. Jef Poortmans: "When visiting international fairs and conferences, it quickly becomes clear that Europe is not an "Einzelgänger" with their efforts in the field of energy: all the great global powers are becoming part of the energy transition. In the US, too, individual states are trying to do their part. "

EnergyVille 2: new top notch laboratories

Another milestone in 2017: the completion of EnergyVille 2. The second research building will be opened in May 2018 and will focus mainly on research on (building-integrated) PV and storage. The proximity of all researchers will promote internal cohesion, and our international image will further grow as well thanks to the new excellent laboratories. "Last year we received many on-site visitors, both from the policy level as from companies. We want to continue this in an upward trend in 2018. Thanks to EnergyVille 2 these possibilities will increase substantially", confirms Jef Poortmans.

A new building with top notch laboratories is one thing, but the strength of EnergyVille still lies in the cooperation and alignment of the research topics of the various partners. Jef Poortmans: "In 2017 we managed to further coordinate the research of KU Leuven, VITO, imec and UHasselt and we have great confidence in the detailed roadmaps. Now it is time to bring everything together in a living lab environment. The backbone for this has just been released in 2017, with the roll-out of the SmarThor ICT platform at Thor Park. The next step is to add the necessary hardware."

Bert Gysen: "In 2018, we must further operationalize the laboratories and our activities in EnergyVille 2 and bring all of our knowledge together in a living lab environment." Jef Poortmans adds: "At the same time, that living lab is not the end point. We must continually inject new technology and introduce IP. We have the ambition to make EnergyVille a focal point of the energy transition".



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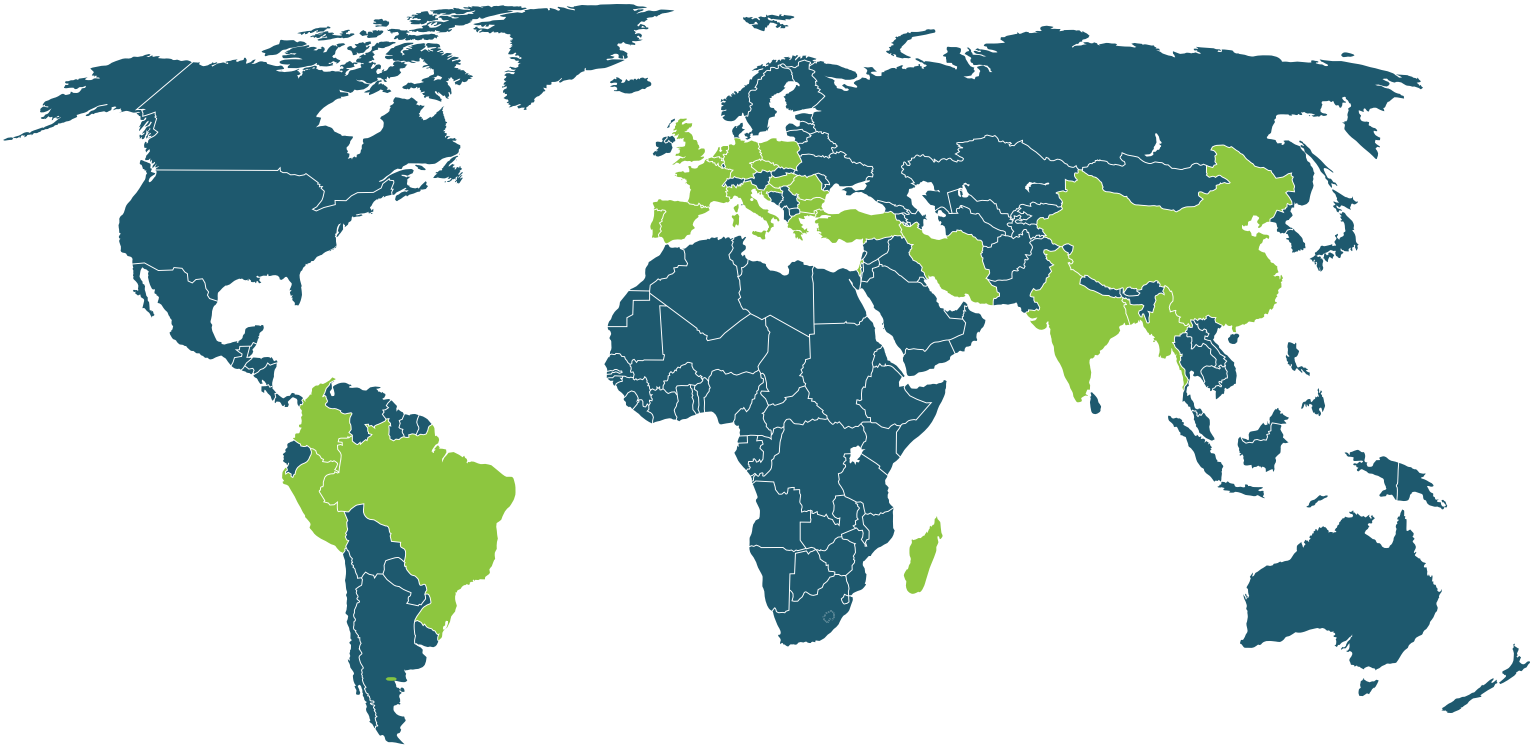

Personnel

92

264

\+

356

PhD students

103

Publications
262

Patents
15

Press
329

Events
48

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- Building Physics
- Energy Conversion &
- Thermal Fluid Engineering

vito

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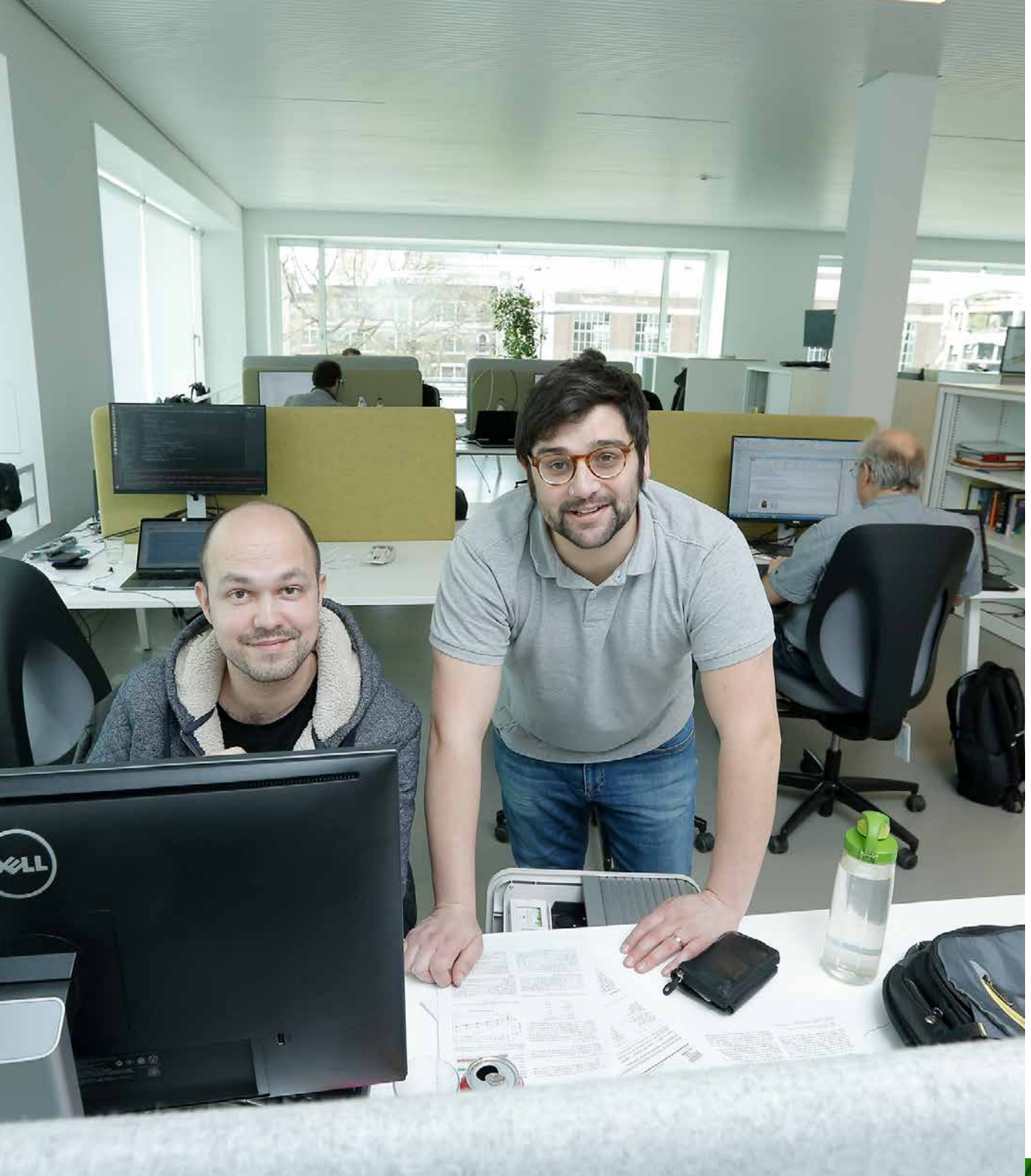
Award Marcel Herman
Annelies Vandermeulen &
Luckas Vandeplas

PROJECTS

Name	Period	Website
SolSThore	01-06-2015 until 31-05-2018	http://energyville.be/project/solsthore-onderzoek-naar-gebouwgeintegreerde-pv-systemen
PVopMaat	01-01-2016 until 31-12-2018	http://pvopmaat.eu/home
MATChING	01-03-2016 until 31-08-2019	http://www.matching-project.eu/
SmartNet	01-01-2016 until 31-12-2018	http://smartnet-project.eu/
Garpur	01-09-2013 until 31-08-2017	http://www.garpur-project.eu/
PROMOTioN	01-01-2016 until 31-12-2019	https://www.promotion-offshore.net/
FHP	01-11-2016 until 31-10-2019	http://fhp-h2020.eu/
STORM	01-03-2015 until 31-08-2018	http://storm-dhc.eu/
GeoWatt	01-06-2015 until 31-05-2018	http://www.energyville.be/project/geowatt-onderzoek-rond-thermische-netten-van-de-vierde-generatie
EVERLASTING	01-09-2016 until 31-08-2020	http://everlasting-project.eu/
GEOTeCH	01-05-2015 until 30-04-2019	http://www.geotech-project.eu/
SPICY	01-05-2015 until 30-04-2018	http://www.spicy-project.eu/
Request2Action	01-04-2014 until 31-03-2017	http://building-request.eu/
City-zen	01-03-2014 until 30-11-2019	http://www.cityzen-smartcity.eu/
hybridGEOTABS	01-09-2016 until 31-08-2020	http://www.hybridgeotabs.eu/
SmarThor	01-06-2015 until 31-05-2018	http://www.energyville.be/project/smarthor-ict-platform-voor-geintegreerde-sturing-van-multi-energiesystemen
IndustRE	15-12-2014 until 31-12-2017	http://www.industre.eu/
BATSTORM	11-12-2015 until 10-02-2018	http://www.batstorm-project.eu/
Ecoren	01-08-2014 until 31-07-2018	http://www.ecoren.be/
SCIS	20-10-2017 until 20-10-2020	https://smartcities-infosystem.eu/

For more projects, check out http://www.energyville.be/en/projects



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