

A large-scale photograph of an offshore wind farm. In the foreground, a massive white wind turbine blade extends vertically from the bottom left towards the top center. Below the blade, the nacelle and part of the tower are visible. Two small figures of workers in orange safety gear stand on a metal platform near the base of the blade. In the background, several other wind turbines are visible, receding into the distance over a dark blue sea under a bright, slightly hazy sky.

CLEANTECH IN FLANDERS 2022



**Cleantech
Flanders**

Powered by **VITO**



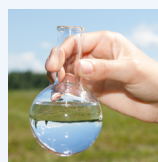
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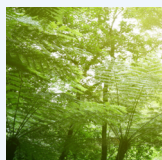
3. Preface

"After all, the transition towards sustainability is taking place in every sector and concerns every citizen."



10. Trends & evolutions

The state of Cleantech in Flanders



25. We know

A major activity of Cleantech Flanders is to inform on developments in the cleantech ecosystem for a multitude of domains



49. We spread

Cleantech Flanders helps to upscale the cleantech business internationally of Flemish cleantech companies.



56. We connect

Cleantech Flanders continuously builds the Flemish cleantech community and offers a platform for promoting and stimulating innovation and accelerating implementation of clean technologies in society.



64. Cleantech Hero

To increase awareness about cleantech solutions, Cleantech Flanders introduced the first 'Cleantech Heroes' in 2021.



MINISTER CREVITS

Vice-Minister-President of the Flemish Government and
Flemish Minister of Economy, Innovation, Work, Social economy and Agriculture

Dear Reader,

As the Flemish Minister for Economy, Innovation and Work, I am delighted to present the annual report of Cleantech Flanders 2022. After all, the transition towards sustainability is taking place in every sector and concerns every citizen. Technology in general and clean, 'green' technology or cleantech in particular are both invaluable on the journey towards a sustainable economy and prosperous society.

The major impact of the coronavirus crisis on the global economy is clear to us all. The 5.7% drop in the Belgian GDP in 2020 compared to the previous year can also clearly be felt in our Flemish economy. Fortunately, a combination of support measures by the Flemish, Belgian and European governments and the economic resilience of our businesses contributed to a strong recovery in 2021.

I am also delighted to see that not only a growing number of companies were registered in the cleantech sector, but also that, in comparison with the previous year, there was significant growth in the total gross profit in the sector (EBITDA +26.61%) and the average EBITDA per cleantech stakeholder (+21.87%). This is in clear contrast with the downward trend compared to 2019. This supports the thesis that companies that focus on sustainability are better positioned to deal with a crisis and to ensure more consistent and therefore more sustainable growth.

Total employment keeps growing in the cleantech sector too. This ongoing trend during a global health crisis only highlights the strength and resilience of the innovative cleantech sector as an enterprising ecosystem. The bulk of investments is focused on renewable energy. Fields such as energy efficiency, sustainable mobility and sustainable buildings also offer a favourable business climate for startups.

Flanders is leading the way in the field of offshore wind energy: Flemish companies have considerable expertise to offer in the value chain when developing offshore wind farms and are preparing to team up with Cleantech Flanders and the Blue cluster to respond to today's opportunities in the field of offshore wind, not only in our coastal regions but also internationally.

Therefore, it is quite logical that Flemish companies are launching more patents in the field of renewable energy. Other fields with a high level of innovation are directly related to reducing greenhouse gases by optimising the use of energy (energy efficiency and green buildings) or through electrification (batteries and sustainable mobility).

So as you can see, a positive wind is blowing through cleantech! I therefore also believe that companies in every sector can benefit from the further integration of cleantech in their business operations. As such, they help to reduce their own ecological footprint and contribute to a green and prosperous future for Flanders.



“The success stories of innovative cleantech companies in Flanders mentioned in our last report keep increasing.”



BRUNO REYNTJENS
Commercial Director VITO

We connect and build knowledge and pass on what we have learned... This sentence captures the very heart of Cleantech Flanders. This Cleantech report confirms what we are seeing and experiencing: cleantech has taken a firm hold in Flanders. Businesses are increasingly aware of the fact that cleantech solutions contain the vital oxygen for the future. Cleantech is not only a guideline for individual companies, but also a global way of working.

The success stories of innovative cleantech companies in Flanders mentioned in our last report keep increasing. Flanders now has 1,980 stakeholders and represents 1.32 billion euros in investments. In just one year, cleantech businesses recruited around 2,000 new employees and the growth in the number of patent requests continued. Companies and the government were not alone in facing the painful consequences of the global energy crisis in recent months; citizens feel it on a daily basis as well? It is a challenge, but also an opportunity to focus efforts on the energy transition, and this report clearly demonstrates how companies are very much aware of this. The evolution in battery technology, the wide-scale integration of renewable energy in our energy supply and research into renewable energy providers such as green hydrogen, the roll-out of heat grids and the realisation that Europe must become significantly more self-sufficient in providing strategic raw materials mean that the energy transition is taking place at a rapid pace. Therefore, it is no surprise that new patent requests focus mainly on renewable energy, energy optimisation and electrification.

The number of applications for clean technologies grows daily. Not only in the field of mobility in all its forms, but also within the building industry, where many efforts are being focused on recycling and maximising the circular economy. Businesses that commit can count on support. Not only from Cleantech Flanders, but also via our spearhead clusters, the European Institute of Technology and – internationally too – from FIT. The Flemish Government is aware of the pole position that Flanders can accomplish in cleantech and is fully supporting a number of initiatives that further reinforce this position.

Those who wish to innovate, need the relevant place, space, time and resources. Innovative growth, in cleantech too, means taking risks and testing new paths. Those who take such steps are heroes. Of the many companies who competed in 2021 in the prestigious Cleantech Heroes campaign, three Flemish companies have definitely earned the right to call themselves a Cleantech Hero.

Flanders provides a fertile foundation for cleantech. A fact that is clearly demonstrated by this report. Cleantech Flanders is continuing along the chosen path, namely promoting Flemish cleantech both in Belgium and abroad.



SPEARHEAD CLUSTERS & INNOVATIVE COMPANY NETWORKS

The Flanders cluster policy targets innovative Flemish companies that are open to collaboration with like-minded companies and R&D-actors, with the ambition to grow internationally. It is distinguished between spearhead clusters and the innovative company networks or IBN's.





PUBLIC AUTHORITIES

One can distinguish between public authorities at the European, national (Belgium), regional (Flanders), provincial or communal level. Many Flemish government agencies support companies, allowing them to grow their business through innovation and or internationalization. Flanders had interesting corporate tax rates and awards generous tax exemptions to research-related employment.





COMMUNITIES

Citizens are informed about cleantech innovations through several events and organizations. ao CleanTechPunt introduces the cleantech concept to a wider public by providing educational information to students and citizens.





ACADEMIA

Research and academic education form an important part of the innovation chain. Innovation-oriented research and its potential for valorization are enabled by the research policy. Flemish research centers and universities successfully participate in international networks and projects.





FACILITATORS

Facilitators are actors that enable the connection between industry, academia, government and citizens in order to improve cleantech adoption, innovation and accelerated implementation. Facilitation can happen in the form of networking events, financing, promotion and/or providing infrastructure. A non-exhaustive list of facilitators is provided in the adjacent figure





TRENDS AND EVOLUTIONS

THE STATE OF CLEANTECH IN FLANDERS

Trends in the Flemish cleantech ecosystem are assessed by considering in total 1980 actors. For this year's edition, the analysis is based on data published on 1/11/2021, capturing the year 2020. The number of actors considered in this study has increased (1503 actors in 2020 to 1980 in 2021). Steps have been taken to ensure that the comparisons remain relevant.

The classification in 4 membership types and 9 main domains (see chapter 'Ecosystem') has been retained to allow general comparisons across the sectors and previous reports. An exception is made for the analysis of the innovation of the sector. Here the subdomains for battery and green hydrogen technology is given special attention, given the topical relevance.

Different from previous iterations, this annual returning chapter has been expanded to take a closer look at the investments made into cleantech.



ALAIN DUCHEYNE
Project manager Cleantech Flanders

Actors	>
Geographic distribution	>
Maturity of sector	>
Financial performance	>
Investments	>
Employment	>
Innovation	>



ACTORS

A total of 1980 distinct actors were identified in Flanders' cleantech sector.

Analyzing the size (using staff count) of companies and comparing the relative size distribution, a percentual increase of extra small (XS; 1-10 employees) actors is observed between 2011 and 2020. This observations indicates a continued thriving scene for cleantech start-ups, and strong, competitive market growth.

Stakeholders were divided into 4 categories:

Pioneers: Organisations that apply cleantech within their production process

Enablers: Organisations that enable the cleantech ecosystem

Tech Providers: Organisations that manufacture and sell cleantech that will enable customers to contribute to environmental goals

Implementors: Organisations who help other companies to adopt cleantech

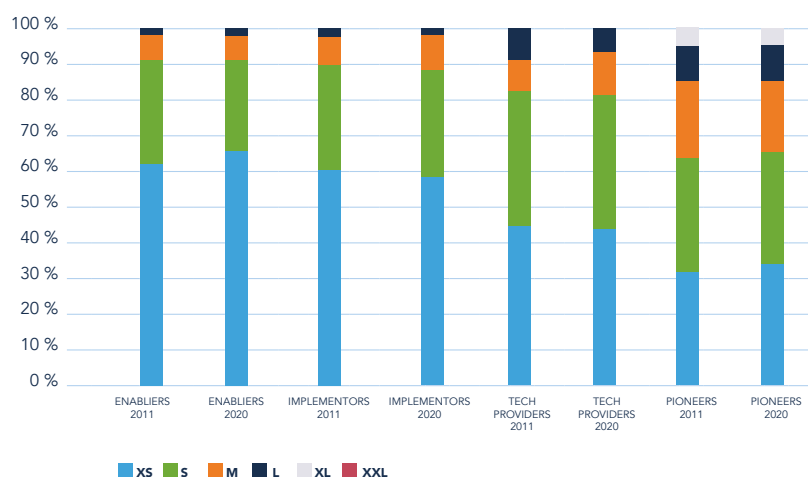
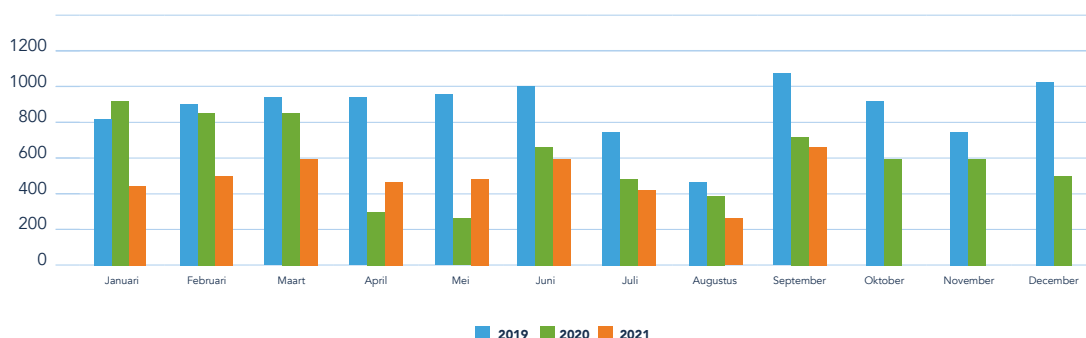


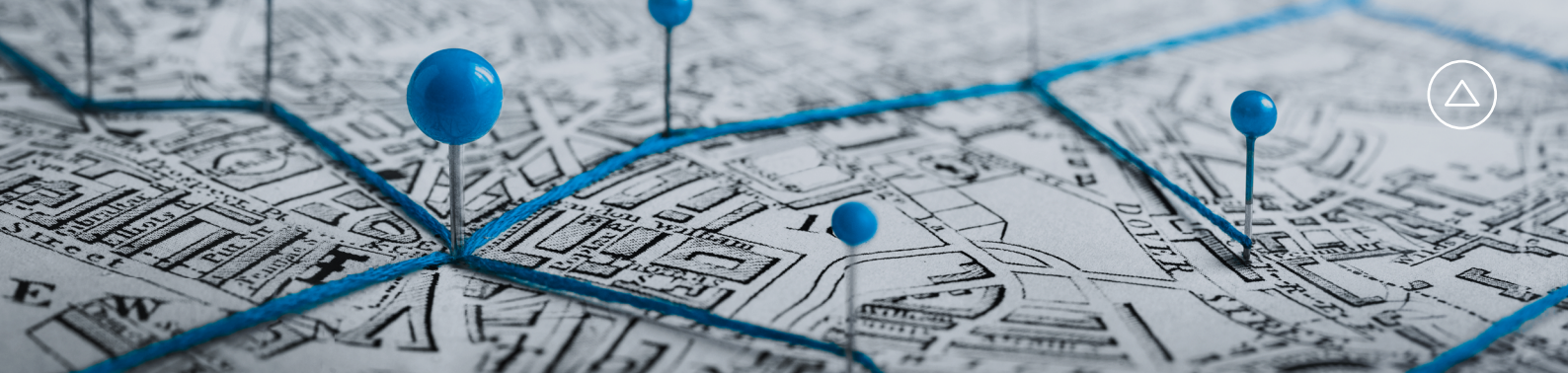
Figure 1 Company sizes per membership over a 10 year period.

This is further evidenced by tracking the changes in juridical status of the bankruptcies. Monthly bankruptcies filed throughout 2020 were lower than in 2019. Whilst the moratorium on bankruptcy, in effect between 18th March and 17th June 2020, certainly influenced this; it is notable that the relatively low number of filings continues well into 2021.



Bankruptcies in Belgium per month





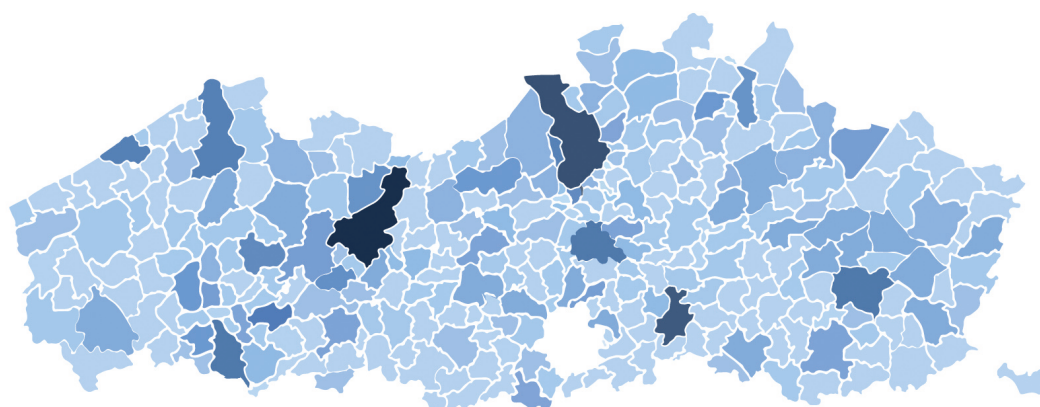
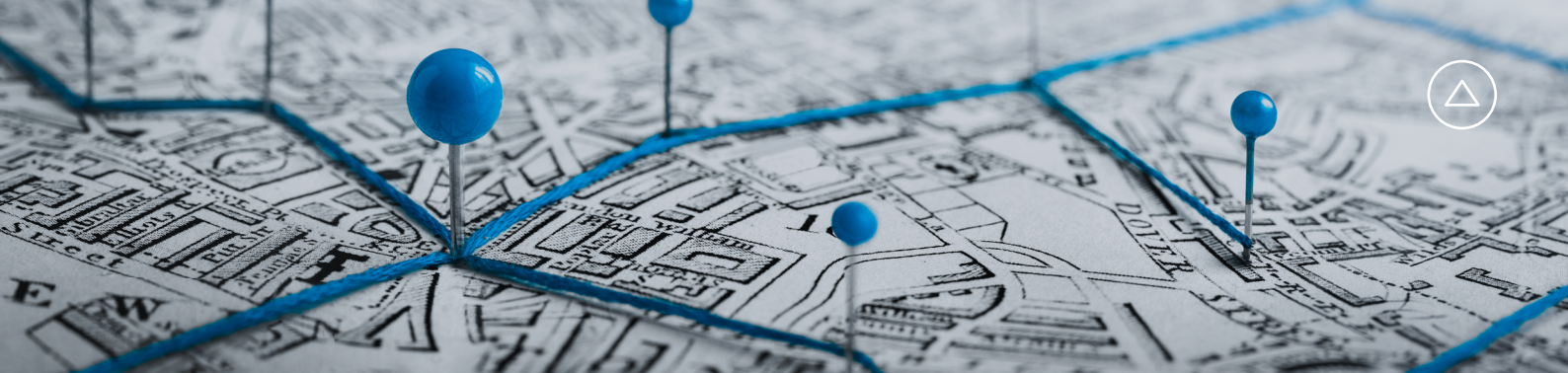
GEOGRAPHIC DISTRIBUTION

As per the previous years, the key cleantech hubs remain in areas with prominent institutes of higher learning and locations with high economic activity. Very little movement is seen in the overall ranking of cities with most cleantech actors this year.

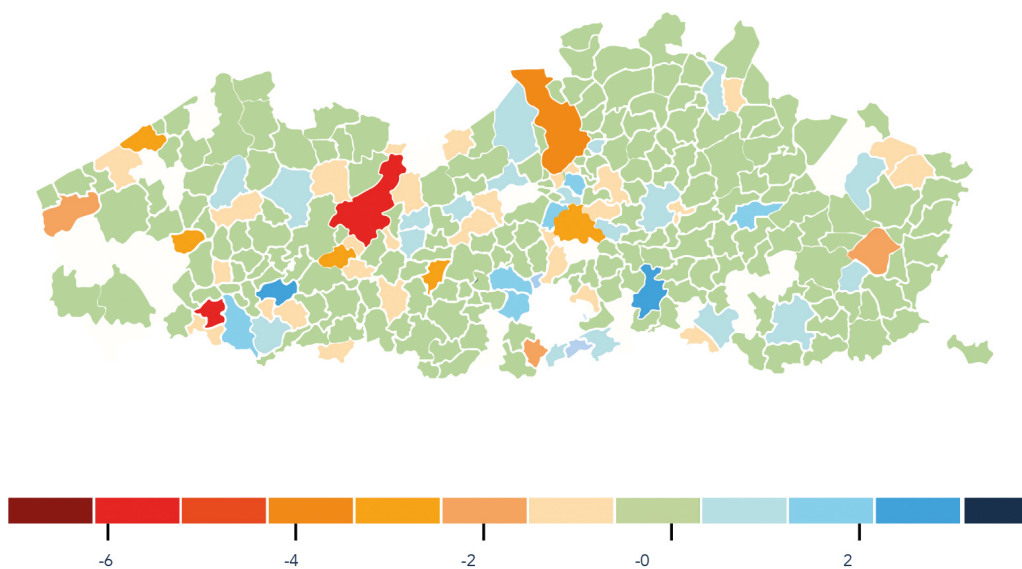
However, a notable observation in 2020 is the decentralization of the cleantech actors. Whereas previous years saw a consolidation of actors in the main economic hubs, 2020 saw a reversal of this. For the first time, many of the cities in the top 10 ranking saw a decrease in the number of registered actors, where many smaller communities saw an increase. The cause of this change is speculative, but possibly related to the change in work conditions induced by the COVID19 pandemic.

2020			2019				
Rank	City	# Actors	Rank	City	# Actors	GROWTH	CHANGE
1	Gent	170	1	Gent	175	-2.8%	-
2	Antwerpen	134	2	Antwerpen	138	-2.9%	-
3	Leuven	84	3	Leuven	81	+3.7%	-
4	Mechelen	38	4	Mechelen	40	-5.0%	-
5	Hasselt	31	5	Hasselt	31	0%	-
6	Brugge	30	6	Oostende	31	0%	↑1
7	Oostende	28	7	Brugge	30	-9.7%	↓1
8	Kortrijk	27	8	Kortrijk	25	+8%	-
9	Genk	22	9	Genk	24	-8.3%	-
10	Waregem	22	10	Roeselare	20	+15.8%	↑1

Ranking of cities with most cleantech actors registered.



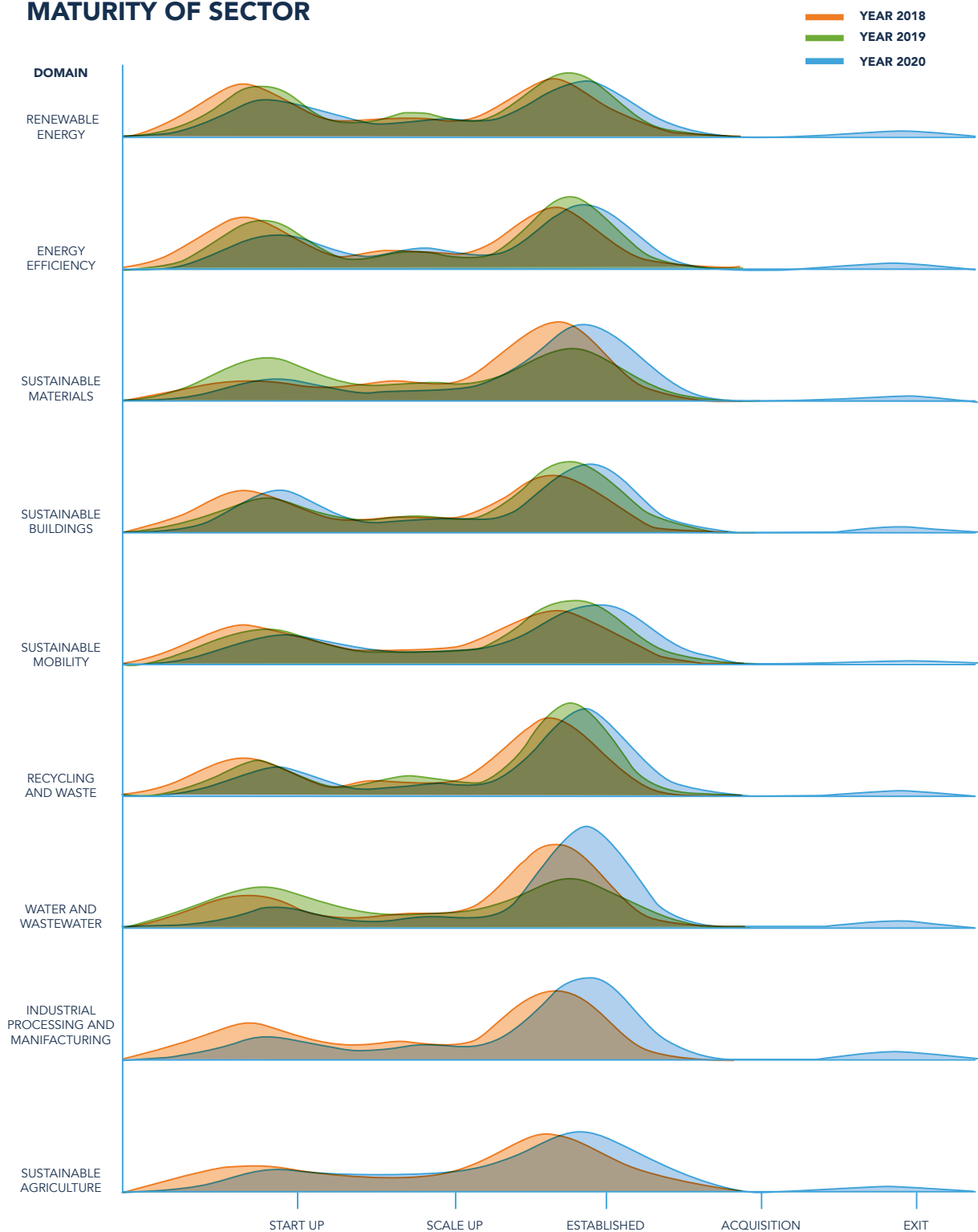
Map of cleantech actors in Flanders



Difference in number of cleantech actors per community in 2020 versus 2019



MATURITY OF SECTOR



Evolution of maturity across the 9 cleantech domains over the past 3 years.

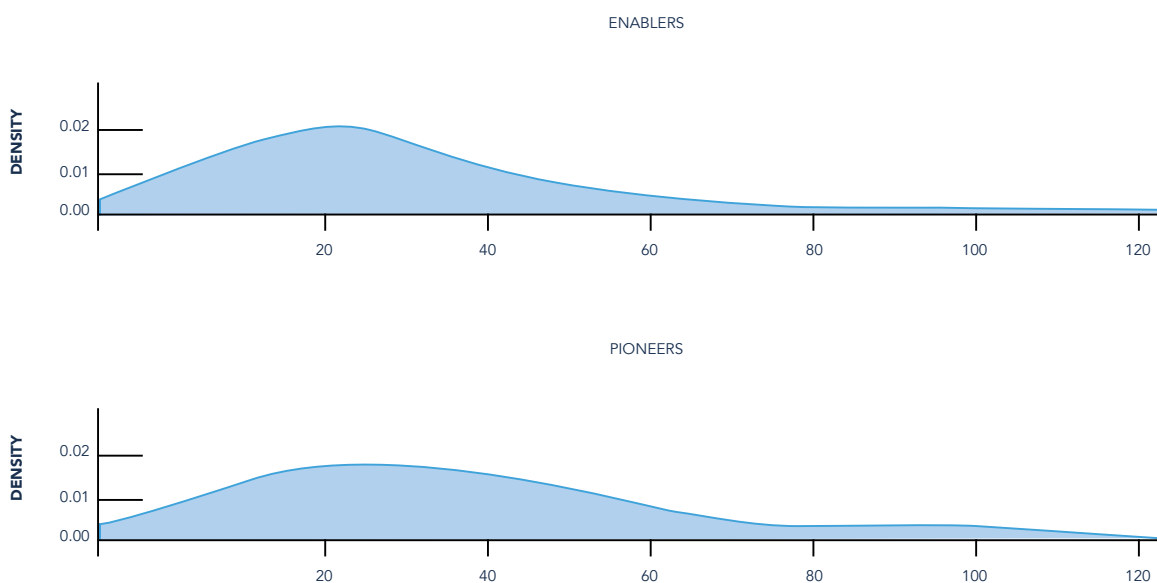




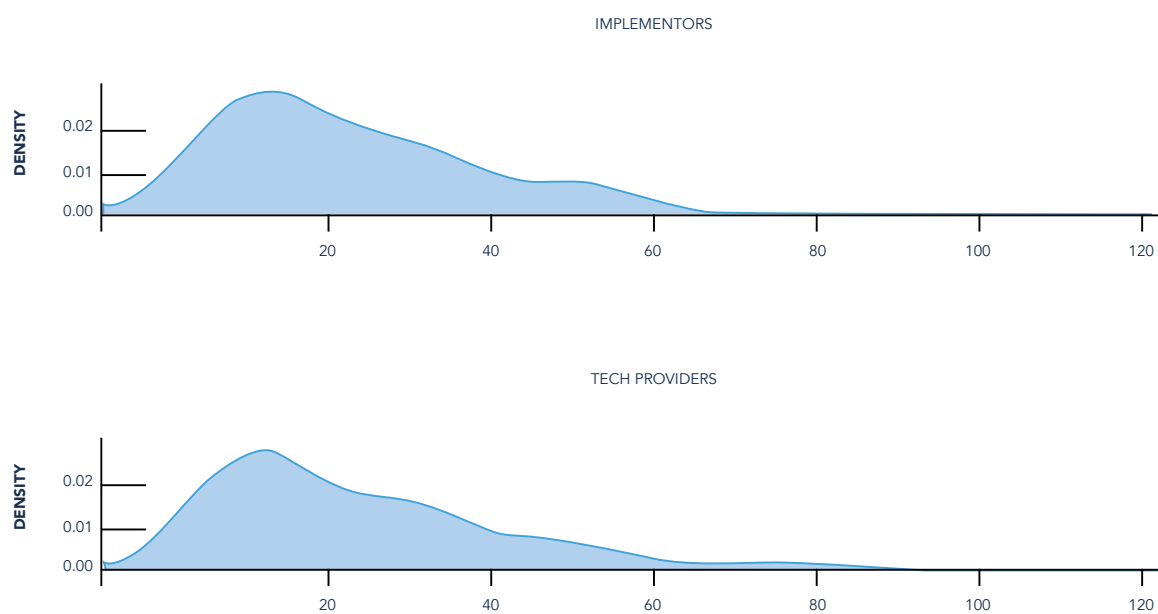
The diversity of the activities encompassed under the label cleantech make it difficult to assess its overall level of maturity. Looking at the 9 identified subdomains however, one can assess that most domains have reached some degree of maturity in Flanders. This is evidenced by a fairly stable distribution of startups and established actors when comparing historic data.

In contrast to previous years there does seem to be an overall trend of a reduction in fraction making up startups across the sector. Most domains see a further increase in the fraction of established companies, indicating further maturing of these domains.

The reduction of the fraction of startups across all domains may be an indicator that innovation by these younger, and often dynamic, companies will get hampered in the years to come. This decline is regrettable, especially considering the recent drive from governing bodies at COP26 stressing the importance of innovation and technology in reaching their net zero targets.



Age (in years) distribution of Cleantech actors, split by membership



Age (in years) distribution of Cleantech actors, split by membership

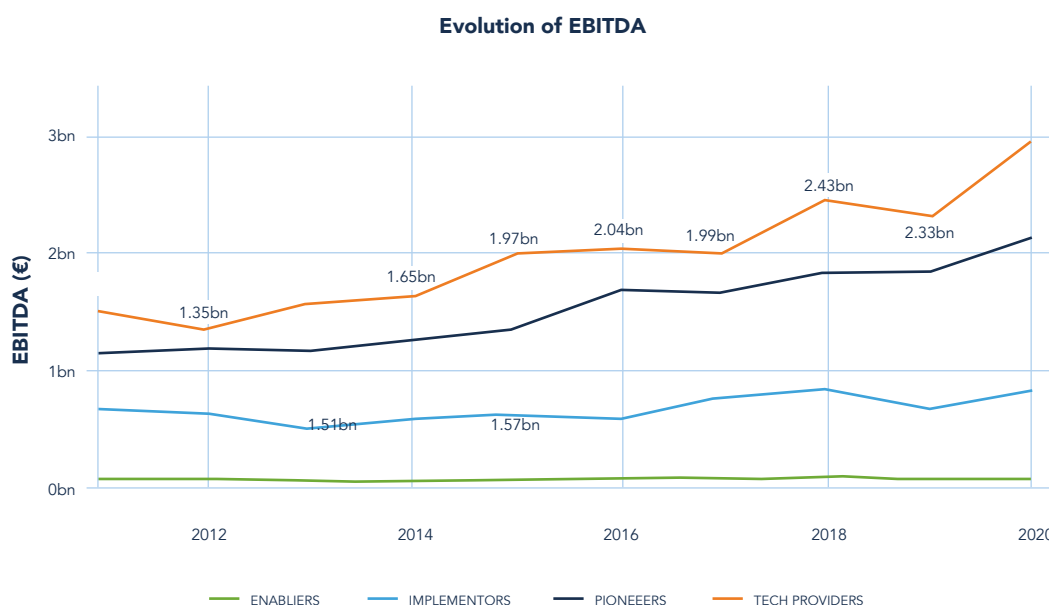
Despite the fractional decline of start-ups across nearly all domains, the age distribution of cleantech actors show continued influx of new actors for all 4 actors. As expected, the relative new number of pioneers is on the lower end of the spectrum, as these companies usually require large capital investments to start operations. The distributions also show that the pioneers (whose core activities are not necessarily cleantech related) are the eldest faction, followed by enablers who are crucial as a foundation to build the cleantech industry upon. The implementors and tech providers each show a notable increase in new actors approximately 35 years ago (coinciding with the foundation of most early Enablers) but saw a spectacular growth of new actors about 10 years ago. They continue to show growth with a substantial number of new actors every year since.



FINANCIAL PERFORMANCE

The statement that 2020 will be a year for the history books is no exaggeration. The COVID-19 pandemic has had a profound impact on the world's economy. The Belgian GDP shrank by 5.7% in 2020 (year-on-year), which dwarfs the decline experienced during the Great Recession of 2009 (-2% of GDP).

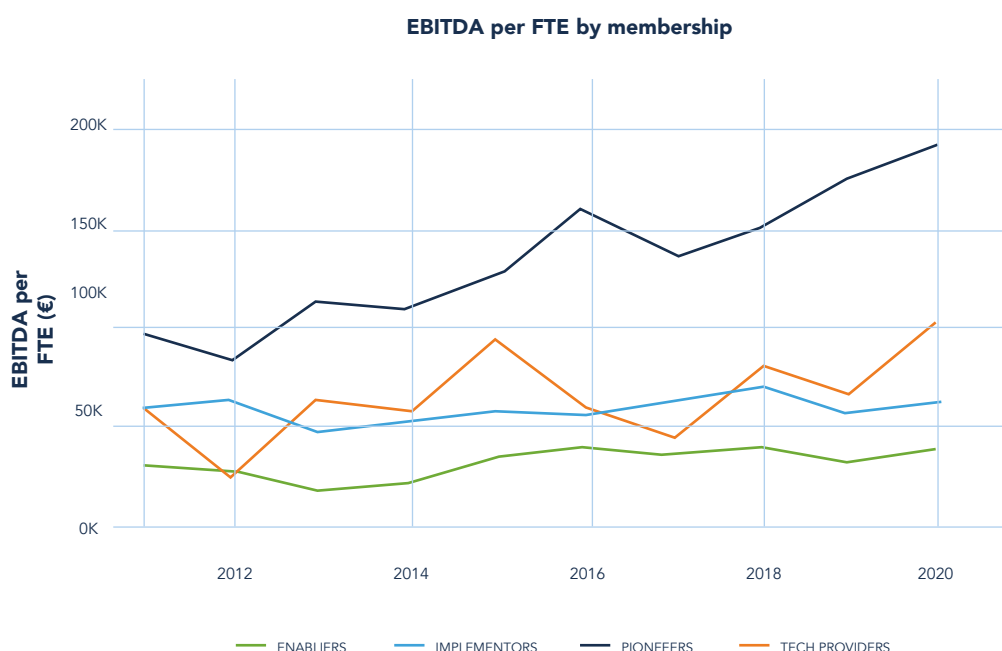
Framed within this context, it is notable to observe not only an increase of number of registered companies in the cleantech sector, but also a statistically relevant increase in both total EBITDA growth (+26,61% YoY) and average EBITDA growth per actor (+21,87% YoY), bucking the downward trend seen in the previous report for the data of 2019. It also lends additional credibility to the statements issued during the 2020 pandemic that businesses with a focus on sustainability were better positioned to deal with the crisis. The impact of fluctuations in annual financial reporting caused by large tech providers and pioneers was a critical factor observed throughout the decade. And it is a factor worthwhile to consider given the exceptional performance of the sector versus the overall economy.



EBITDA of the cleantech actors in Flanders, split by membership with identified outliers removed.



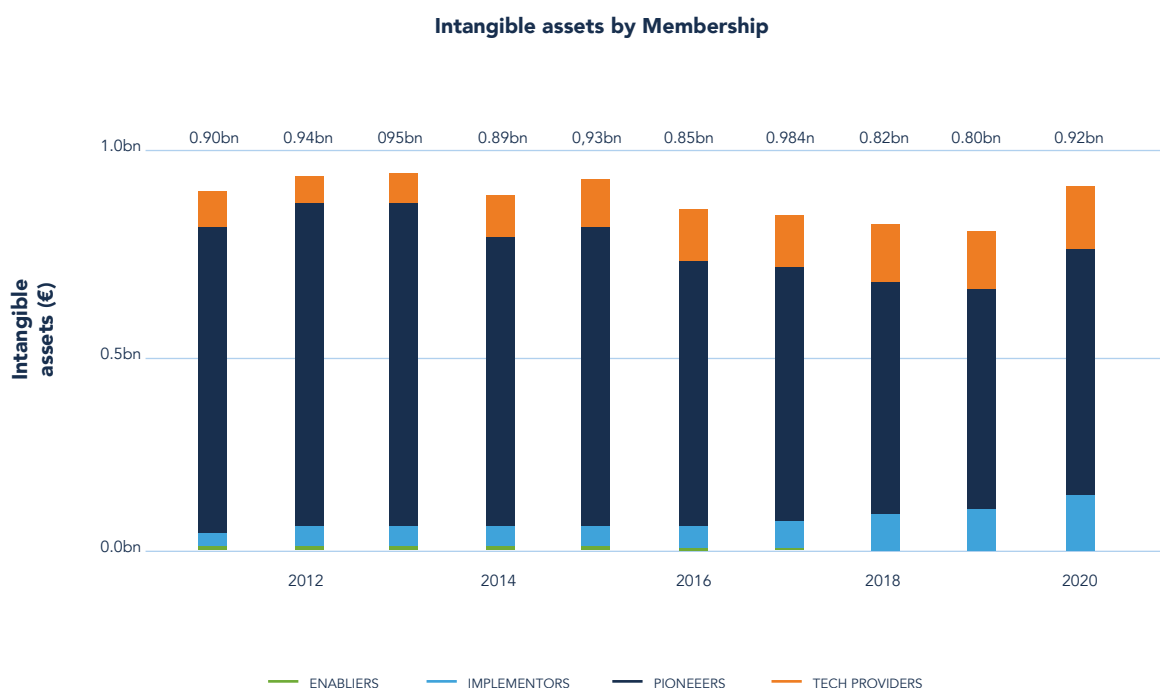
The evolution of EBITDA over the past decade has shown a steady increase, despite significant year-to-year fluctuations. A closer look at the data attributes the source of these fluctuations within the financial reporting of large tech providers. Large acquisitions, investments, or the sale of a subsidiary in a select number of companies can skew the data. Implementors or pioneers realized more stable and significant growth throughout the past decade, continuing to prove that there is a market demand for cleantech.



Evolution of average EBITDA realized per FTE, split by Membership



Another trend which changed in 2020 was the Intangible assets held by the cleantech sector. The term is nebulous at best but is typically considered to be a metric closely associated with investments in R&D, innovation, and patents held. This asset class has been on the decline since 2013. In 2020 it bounced back to near record levels. All membership types expanded their intangible assets, but notably the Enablers hold a negligible amount compared to the rest of the sector. This is not unsurprising, as enablers typically facilitate the adoption of technologies by other actors, not develop them.



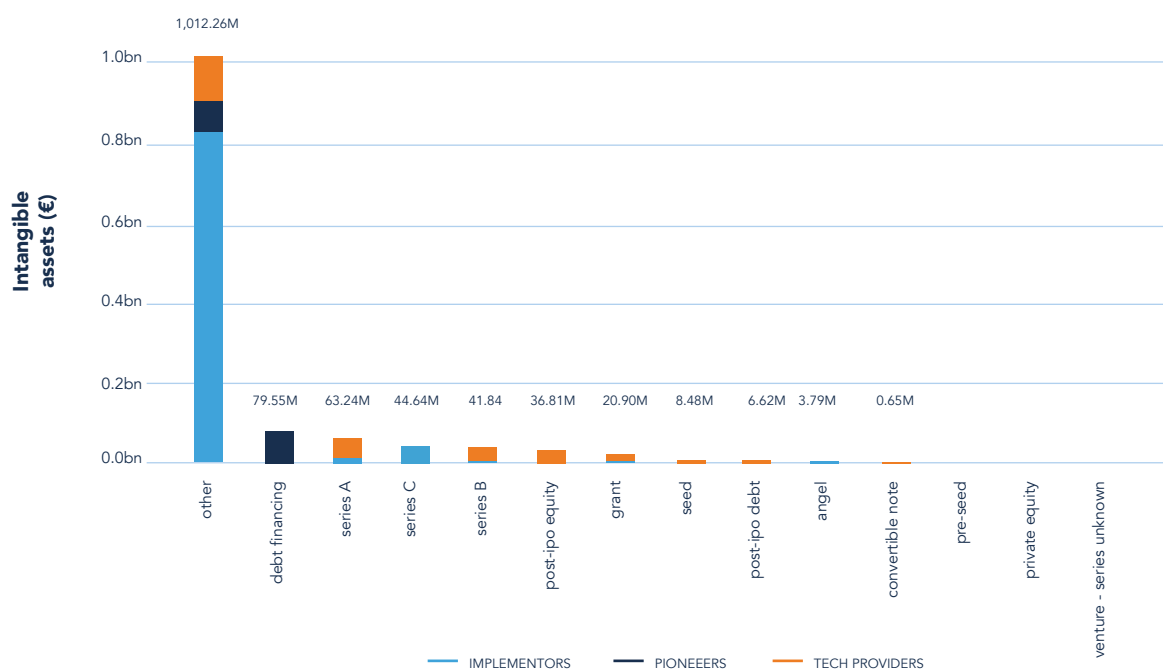
Intangible assets reported by Flanders' cleantech actors, split by membership.



INVESTMENTS

In 2020, the cleantech sector reported 125 funding rounds initiated by 61 actors. This led to a total of 1,32B€ of investments. This relates to an average of 10,56M€ per funding round, but this varies wildly between the different membership types. Pioneers raised 158.4 M€ over 9 rounds (or 17,6 M€ on average) by 8 actors. Tech providers featured 33 actors launching 68 funding rounds, raising 260,69 M€ (Avg. 3,83 M€/round). The implementors raised the bulk of the capital. 19 Implementors raised approximately 900 M€ over 48 funding rounds (or 8, 74 M€ on average per round). In contrast, Enablers raised no funds.

Funding raised per type by Membership

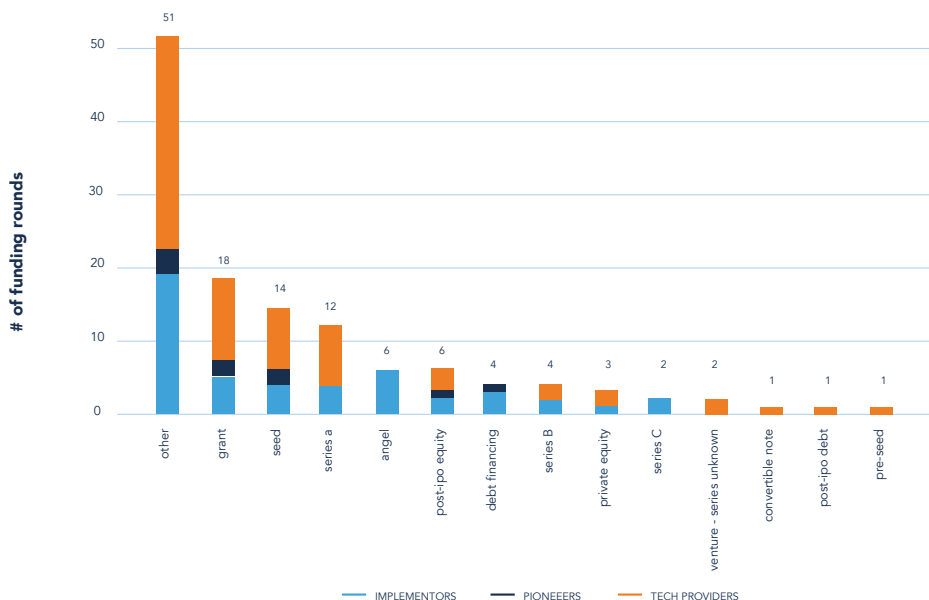


Total funding raised by Cleantech actors in Flanders, per funding type, split by membership

The domains raising the bulk of investments are related to energy. Vestas (a Danish provider of wind turbines with 2 facilities established in Flanders) alone raised over 700 million €, dominating the overall investment landscape within cleantech. But other successful investment rounds are primarily populated by different organizations offering services or products related to sustainable energy.

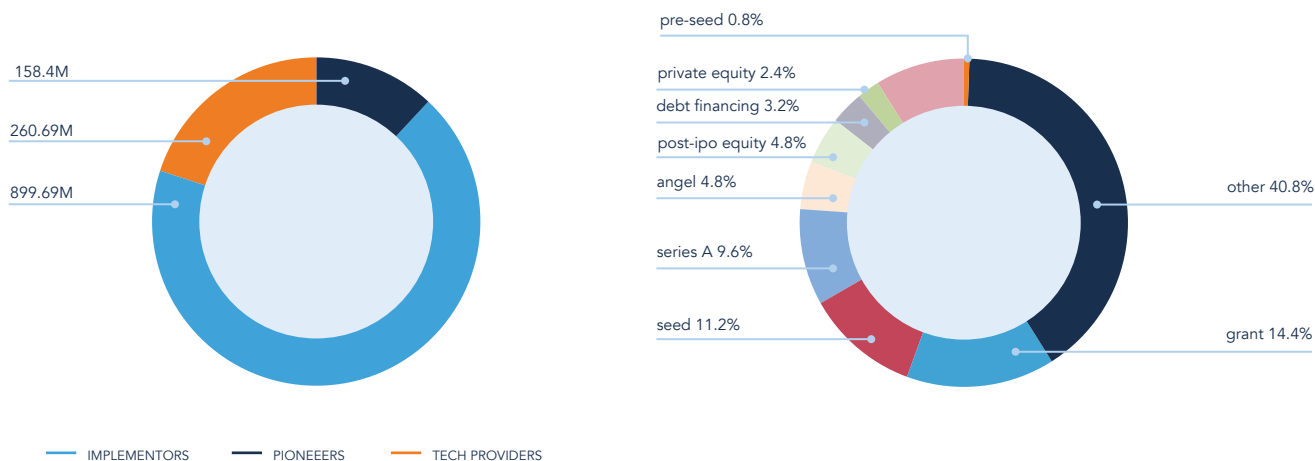


Funding rounds per type by Membership



Number of funding rounds completed per funding type, split by membership

The distribution of funding vehicles displays that cleantech companies in Flanders employ a wide variety of options to raise funds. It is worthwhile mentioning that grants remain a crucial and popular (18 out of 125 reported funding rounds were grants, or 14.4%) source of investment, it only accounts for a total of 20,90 M€ (or <2% of total investments). The main form of funding type accessed by the cleantech actors is categorized as "Other", comprising various funding forms typically provided by incubators, accelerators, and venture capitalists.



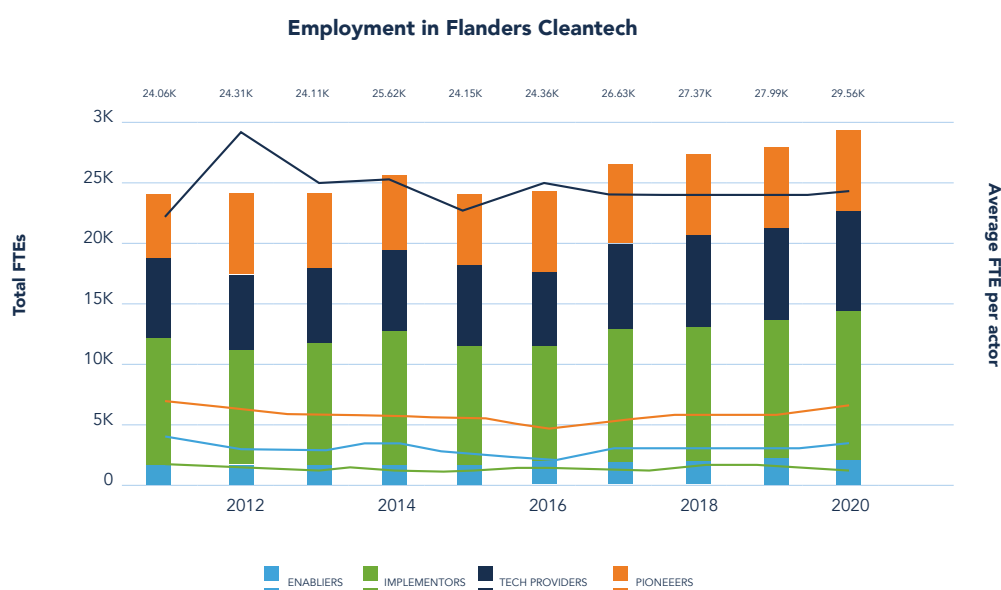
Total funding raised by cleantech actors in Flanders, split by membership.

Quantity of funding rounds per type of funding.

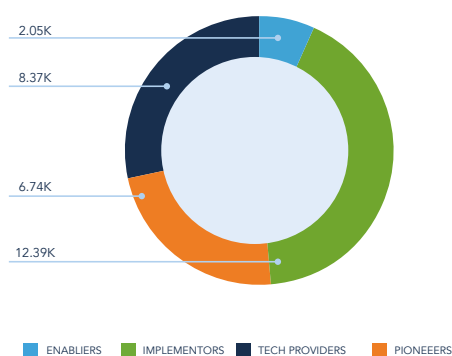


EMPLOYMENT

Cleantech in Flanders employed 29.564 people (full time equivalents) in 2020. Total employment has been steadily growing. The continued growth in the midst of a global health crisis further lends credence to the resilience of the sector. This is in contrast with the acute loss of jobs in many other sectors.



Relevant FTE employed by cleantech sector in Flanders. Total relevant FTE per membership as bar graph, average relevant FTE per actor as line graphs.



Tech Providers and Enablers are the main employers, accounting for approximately 70% of the total FTE's employed in cleantech. These memberships are typified by being SMEs. Given that both implementors and tech providers are a sector where acquisitions and mergers are a common strategy to strengthen market positions, it is anticipated that in the future the average number of FTEs per actor will continue to rise as the market grows and consolidates.

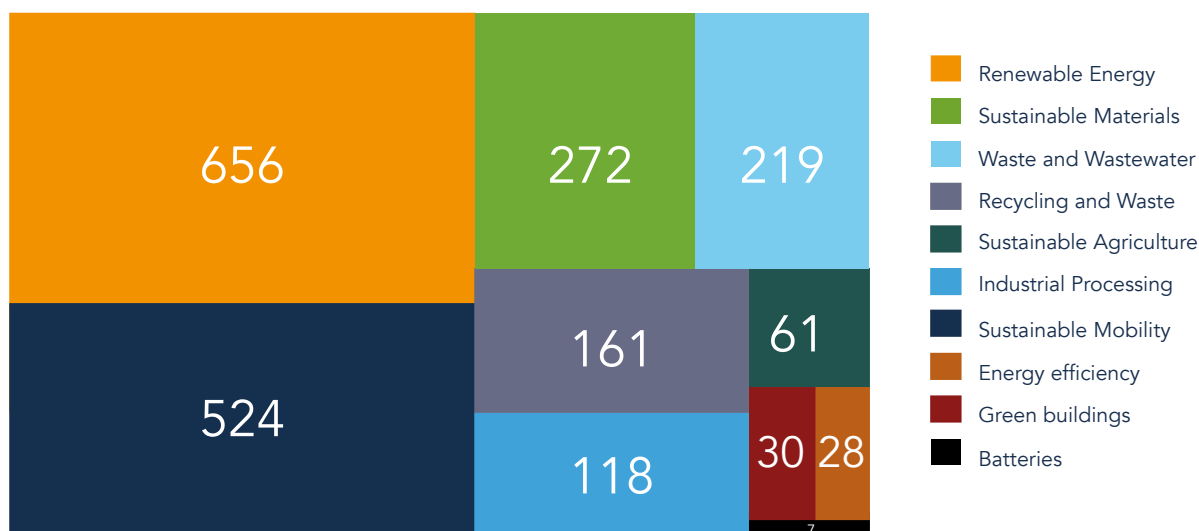
Employment of relevant FTEs across membership



INNOVATION

Innovation is the driver for any sustainable, competitive economy. And, with the COP26 delegates relying on innovative technologies to meet their goals, innovation is a pivotal element within the cleantech sector. To assess the degree and trend of innovation the simplified metric of unique patent families is investigated. It should be noted that for the patents, only data up until 2018 is considered. This is due to the lengthy nature of the patenting process. Many of the patents filed in 2019 are still under review and including approved patents of 2019 and later would show a very erroneous and negative picture of innovation over the past few years. The analysis is thus largely restricted to trends in the innovation landscape.

Looking at the data, it is evident that the domain of Renewable Energy has been the one where Flanders has made the most prolific contributions. The other domains with high levels of innovation are all directly related to greenhouse gas emission reduction through either energy optimization (energy efficiency & green buildings), or electrification (batteries & sustainable mobility). Other domains have seen more tempered and consistent patent filings.

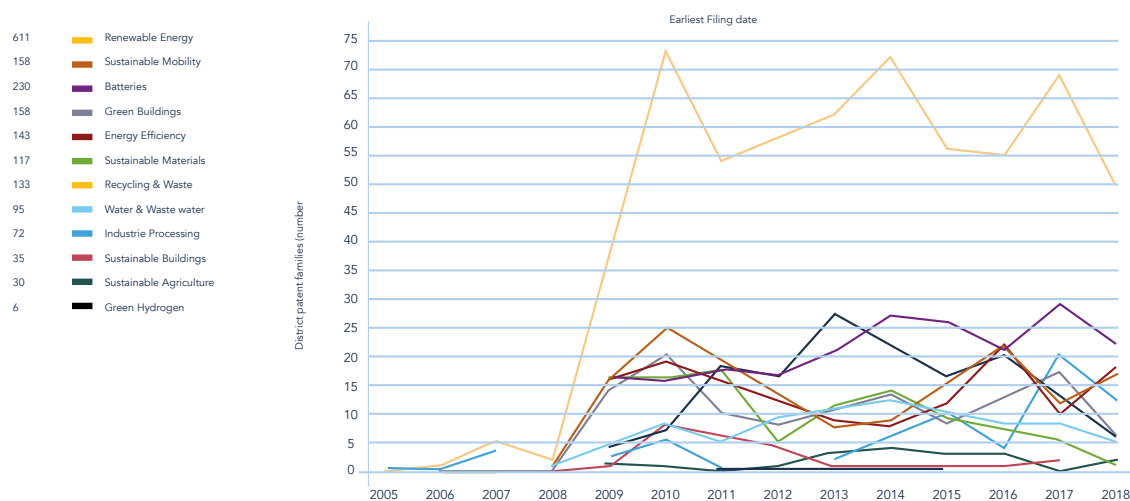


Top domains by number of unique patent families registered in Flanders



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	grand total
Renewable Energy		2	1	1	1	5	11	12	76	144	120	145	121	130	110	110	115	118	1219
Sustainable Mobility				1		3	5	4	28	31	55	56	54	63	98	80	89	76	642
Batteries		1			1	1	6		30	24	31	38	44	54	49	55	52	53	438
Green Buildings					2		2	6	42	54	49	57	28	28	33	36	36	48	421
Energy Efficiency					2	1	2	2	31	44	38	51	24	25	25	36	22	39	342
Sustainable Materials	1	2	1	3	3	7	6	13	35	38	49	17	33	24	22	16	18	19	307
Recycling & Waste				1		2	4	6	25	40	25	24	32	27	16	28	31	22	283
Water & Waste water				1		4	1	2	12	25	22	28	23	19	25	22	26	32	242
Industrie Processing			1		1		1	4	8	12	10	3	9	11	15	12	28	18	133
Sustainable Buildings								4	12	14	14	14	7	7	7	6	10	13	107
Sustainable Agriculture			1	1					6	3	3	6	7	10	5	7	9	9	67
Green Hydrogen											1	2	1	1	1		2	1	9
Grand total	1	4	4	7	7	19	27	40	204	300	305	305	279	289	303	284	323	320	3020

Year of Patent Family Filing Date vs Number of Unique Patent Families sorted by Domains.
Source: DataScouts



Evolution of number of patent family filings per Domain. Source: DataScouts



WE KNOW

A major activity of Cleantech Flanders is to inform on developments in the cleantech ecosystem for a multitude of domains: renewable energy, energy efficiency, bio-based and circular economy, mobility and transport, food and agro, sustainable materials, air, soil and water. Backed by a number of experts, Cleantech Flanders keeps you up to date with latest trends and evolutions in cleantech that we publish annually.

- [A flourishing market for stationary battery storage](#) >
- [Flanders, an innovation hub for electric mobility](#) >
- [Towards a circular battery industry in Flanders](#) >
- [Sustainable extraction of battery raw materials in the deep sea](#) >
- [Blue Deal to make Flanders 'waterproof'](#) >
- [The dream of the hydrogen economy is still very much alive](#) >
- [How 'fintech' can help fight global warming](#) >
- [European and Flemish recovery resources for sustainable growth](#) >





WE
KNOW

A FLOURISHING MARKET FOR STATIONARY BATTERY STORAGE

While home batteries have become almost commonplace, and therefore largely standardised, there is still plenty of room for innovation in the market segment for battery systems with a larger storage capacity. Flemish companies know this and are coming up with new products and services in rapid succession.

The electricity network is seeing a thorough change through the proportion of intermittent sources such as wind and solar energy, which is only rising. Decentralised production, such as solar panels on the roofs of homes, offices and factory buildings and large solar and wind farms, as well as consumers who produce at the same time ('prosumers'), demand a whole new way of keeping supply and demand in balance and ensuring security of supply. Flexibility is the key concept here. Energy storage can be an important source of that flexibility. This can shift energy consumption through time and provide extra stability for the network (the 'grid').

HOME BATTERIES: MORE AND MORE COMMON

Innovations in terms of battery technology have already made sweeping changes to our economy and society in recent decades. In the 90s, improvements to rechargeable batteries saw the market in portable electronics flourish. After the turn of the millennium, innovative technologies led to the (re)birth of electric vehicles. The latter application in particular matured battery technology further and provided for a sharp reduction in costs. Today, practically all installed systems for stationary energy storage are based on batteries. The lion's share of these are taken up by the most popular type: the lithium ion battery. This is highly versatile, meaning it can be used for many applications while being eminently scalable.

Residential, otherwise known as home batteries, are becoming more and more common in Flanders. Tens of thousands of them have now been installed, which makes it unsurprising that every Flemish installer of solar panels also offers home batteries these days. It is anticipated that between 15 and 25 percent of new PV installations will be equipped with one this year.

However, most home batteries are manufactured outside Europe, predominantly in Asia. But our industry can still make a difference by making the batteries 'smart', so that prosumers can get the most from their energy storage systems, while keeping their electricity bills low and – at the same time – helping to stabilise the grid.

Companies such as LifePower and iinno-benelux offer applications and platforms for optimising the operation of a home battery, such as in line with the behaviour of the residents or users, weather forecasts, varying energy prices, the capacity tariff and other signs from the energy market – as well as the grid's stability requirement, of course. That makes the home battery the core of future energy provision, not just locally within a home or building but also at a wider scale – and even when the sun isn't shining. In addition, it always guarantees a maximum yield from the investment for the home battery's owner or user. Flanders is well on its way down this route and it will be able to welcome countless new players, products and services in this flourishing market of optimisations for home batteries.

LARGE BATTERY SYSTEMS: THE MARKET IS STILL WIDE OPEN

Home batteries are therefore becoming commonplace at a rapid pace which sadly also means that there are few remaining opportunities for competition with the large Asian manufacturers in terms of production. But the larger batteries that are being installed at industrial sites or as a 'district battery' for an entire residential neighbourhood are a very different story. No standard solutions exist for this, or those that do cannot be scaled as desired. It is in this market segment that Flemish companies such as Battery Supplies, D-Centralized, Posetron and C-energy are designing and manufacturing full battery systems, from the level of individual battery cells or modules to custom-developed solutions. These kinds of systems generally come with a smart platform for managing the energy housekeeping 'behind the meter' and for enabling trade and services in energy (e.g. offering stability for the grid).

At an even larger scale, some battery systems are already flirting with storage capacities of some tens of thousands of megawatts and hundreds of megawatt hours. Those systems are seeing some excellent market opportunities in this country. Last September, for example, a special auction was organised (the Capacity Remuneration Mechanism). This selected a system with a capacity of no less than 25 megawatts and 100 megawatt hours to provide flexibility to an energy mix with a higher proportion of renewables.

Yuso is an example of a company that, among other things, offers batteries that continually maximise income streams through the use of forecast models, artificial intelligence and big data. In doing so, Yuso is focusing on local energy services such as maximising the use of renewable sources, linked to the developments in the energy markets and to balancing services for the grid. Another example of creating (even further) value is provided by Centrica Business Solutions, a company that is pioneering the integration of the battery fleet for the Terhills business park in Limburg (accounting for a capacity of 18 megawatts) in primary and secondary control and reserve markets. This combines flexible industrial processes with storage in a virtual electricity power station to support the grid. Finally, large collections of smaller batteries (such as home batteries) can also create added value in a several markets. One example of this is the Flexcity platform, which manages the backup batteries for telecoms provider Orange. The platform does this not only to guarantee security of supply at Orange's site, but also to utilise the storage capacity by offering this through demand response services.

Up to now, this has only been about batteries and battery systems constructed from new battery cells. But for several years now, there has been ever greater consideration for the reuse of end-of-life batteries, as they are known (originating from electric vehicles, for example), in energy storage applications. Companies such as Watt4Ever, Bebat and Octave are studying a sustainable approach to the entire value chain, from collecting end-of-life batteries through transport, dismantling, inspection, conversion, certification and market introduction to, ultimately, 'second-life batteries'.



JEROEN BÜSCHER

Product Manager Electrical Storage VITO/EnergyVille

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FLANDERS, AN INNOVATION HUB FOR ELECTRIC MOBILITY

In the EU's ambition to become climate-neutral by 2050, the electrification of transport and mobility plays a crucial role. In this transition, internal combustion engines need to make way for electric vehicles powered by batteries. With so many actors active throughout the entire battery value chain, Flanders is a veritable hub for e-mobility.

The automotive industry, which encompasses so much more than just car manufacturing, has traditionally been a very important branch of industry in Flanders and Belgium. For decades, cars, trucks, buses and other vehicles have rolled off assembly lines here. Including suppliers and related companies, the sector accounts for more than 300 companies, a turnover of EUR 16 billion and no fewer than 45,000 direct jobs. However, in the near future, the sector will undergo a major transformation. Anything that can be electrified will be electrified. And this means that internal combustion engines will no longer be at the heart of vehicles, they will be replaced by electric motors, whether for freight or passenger transport.

NEW BATTERY TECHNOLOGIES

Innovation will be needed to make this transition a success, here in Flanders and across the widest possible value chain of batteries. And innovation means highly-trained workers and highly skilled researchers. Our region has always excelled in these areas. It is therefore crucial to keep the bar high enough. The large-scale embedding of knowledge and research institutions in Flanders, such as universities but also strongly market-oriented research centres, is an asset in this respect. The research institutions and universities that collaborate under the flag of EnergyVille*, as well as VUB are playing a leading role in the research and development of new battery technologies, both on a national and international level. VITO/EnergyVille is also an active partner within EIT InnoEnergy, which organises training courses on battery research through the European Battery Alliance and helps in bringing battery innovations to the market faster.

The value chain for e-transport and e-mobility is therefore inextricably linked to the value chain for batteries. It is therefore crucial for Flanders to reinforce its role in this regard, in the widest possible sense. The presence of so many companies active (directly or indirectly) in the automotive industry can only help. For example, the two major car factories in our country: Volvo Cars in Ghent and Audi in Brussels. Both factories already have their own facilities for the production of batteries. Volvo's facility was set up in March 2020. The batteries are used in two models: the Volvo XC40 Recharge (the car maker's first all-electric model) and the C40 Recharge. This year, Volvo intends to achieve a share of no less than 60% electric in its total production at Ghent.

The Audi factory in Brussels is one of the German carmaker's most important "e-sites". The Audi e-tron, an all-electric SUV, has been produced here since 2018. The Audi e-tron Sportback is a recent addition to the range. And the Audi Q8 e-tron will also soon roll off the assembly line. Moreover, Audi's Brussels plant is also certified CO₂-neutral, a world first.

*VITO, imec, KULeuven and UHasselt



ALSO HEAVY DUTY TRANSPORT

Besides car factories, Flanders also has several large-scale construction sites for buses. The VDL Bus & Coach factory in Roeselare builds fully electric city buses. The company is a frontrunner in e-mobility, something it owes to its long-standing focus on electric transportation. VDL Citeas city buses are currently in use in more than 50 European cities. Together, the more than 800 buses have already covered more than 100 million electric kilometres. Meanwhile, the company is continuing down the electric path. This year, it will commission a new CO₂-neutral production site in Roeselare.

Another well-known bus manufacturer in Flanders is of course Van Hool, based in Lier. Although the company was originally more active in the development of hydrogen-powered buses, it is now also active in the electric bus segment. In 2020, Van Hool launched the CX45E, an all-electric coach intended for the North American market.

Although electric power from batteries seems less suitable for long-distance heavy duty vehicles, Volvo is already convinced that trucks can also be fully electric, i.e. powered only by batteries. And once again, Volvo Trucks' Ghent site is a crucial player in this ambition. The plant supplies batteries to all Volvo Trucks sites in Europe. The company started selling its very first electric trucks in 2019: the Volvo FL Electric and the Volvo FE Electric. Volvo Trucks' electric portfolio has since grown to six models.

In January 2021, the creation of a new business area was announced, Volvo Energy, with the purpose of strengthening business flow of batteries over the life cycle. The new business area Volvo Energy will strengthen the Volvo Group's business flow of batteries over the life cycle as well as the customer offer for charging infrastructure. At the same time, the environmental impact from electric and hybrid electric commercial vehicles and machines will be reduced by giving used batteries a second life in different applications.

Meanwhile, niche players in transport and mobility are also exploring the electric option. For example, Mol Cy, a Staden-based manufacturer of heavy equipment such as railway rolling stock and terminal trucks, is looking into how this form of specialised transport can also be electrified.

And then of course there are the many different suppliers. Flanders traditionally had a very strong line-up in this area. Umicore, Siemens, ABB, Melexis, PEC, Leclanché, DAF, Borit, Punch Metals, Solvay, 3M, JSR Micro, Punch Powertrain ... all companies with branches in Flanders that are active in e-transport or e-mobility. In the area of R&D in battery innovation, a company like Umicore stands out. Not only does the company research better batteries (e.g. more powerful variants with longer lifespans) but also ways to recover and recycle battery materials - and raw materials - as much as possible, for subsequent use in new batteries or other electronic products.

TOWARDS SUSTAINABLE EUROPEAN BATTERY PRODUCTION

Our country is also actively involved in two major European projects to stimulate research and innovation in the battery value chain - so-called IPCEI projects. In the first project, started last year, hundreds of companies and organisations from 12 European countries are working together. In the other initiative, which has been running since late 2019, seven Member States are working together. Five Belgian companies are involved in both multi-year projects, which represent an investment of several billion euros: Umicore, Solvay, Nanocyl, Hydrometal and Prayon.

The projects are aiming to revolutionise the European battery market by focusing R&D on both state-of-the-art versions of current lithium-ion batteries and next-generation battery technologies. In this way, the EU has resolutely opted for sustainable battery production, based on energy-efficient production processes and low greenhouse gas emissions throughout the entire value chain. Future European battery production will



therefore look substantially different from how it does today. And cleantech will play a leading role in this regard.

Flanders also has extensive knowledge and expertise at its disposal for the reuse and recycling of batteries. Companies such as Febelauto, Bebat, Out of Use, Watt4Ever and ReVolta have experience in setting up process lines for reuse and recycling. And with Umicore, Flanders has a pioneer in the field of end-of-life recycling and the extraction of valuable materials and raw materials from waste batteries.

In 2019, the Flemish technology federation Agoria produced an overview of the business opportunities and challenges regarding the entire value chain for lithium-ion batteries. This study formed the basis for the Re2LiVe project, which examined the collection, logistics, dismantling, remanufacturing, re-use and recycling of end-of-life batteries from electric vehicles. Both companies and knowledge and research institutes are currently busy using the results of the project to devise strategies to take advantage of all these aspects.

Finally, Flanders is also a logistics hub, thanks to its central location in North-West Europe, but also its seaports. It is therefore an important logistics hub for the transport of electric vehicles. The port of Zeebrugge is already fully focused on this, among other things via extensive charging infrastructure for charging unloaded vehicles. The vehicles are charged with power from local windmills and solar panels in the port.



CARLO MOL
Project Manager at VITO/EnergyVille

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TOWARDS A CIRCULAR BATTERY INDUSTRY IN FLANDERS

With its strong collection and processing industry, Flanders is leading the world as regards 'end-of-life batteries'. In order to consolidate and extend our region's role in this, we need to look closely at the developments in both the supply of these batteries and their applications. Governments, research institutions and companies are joining forces for this.

Rechargeable batteries are an indispensable link in the transition towards a sustainable energy system. They enable the electrification of the mobility system and ensure that the demand for electricity can be aligned with the supply from intermittent sources like solar and wind. Indeed, the demand for lithium ion batteries (LIBs), which have always been the most popular type of rechargeable battery by some margin, has been rising enormously in recent years. It is anticipated that the demand for these in electric vehicles in Europe alone will increase by a factor of seven in the coming ten years. In Belgium, too, we are finding that, partly due to the policy of greening company cars, the electric car is on the rise. According to recent figures, almost one in five cars sold (full-electric as well as hybrids) contains an LIB.

Due to this growing demand, the need for critical raw materials, as they are known, such as lithium as well as nickel, cobalt and graphite, is of course rising too. As a region where raw materials are scarce, however, Flanders plays no meaningful role in the production value chain for LIBs, although with three major exceptions: the production of cobalt for battery applications, industrial know-how for production of cathode materials, and battery assembly in car factories in our region.

A GEOSTRATEGIC OPPORTUNITY

But at the other end of the battery value chain, the picture looks completely different. Due to the anticipated growth of the electric car fleet in Flanders, the urban mine for raw materials for LIBs will also scale up significantly. This presents Flanders with an almost geostrategic opportunity that should not be underestimated: to become or remain a global player in the collection, dismantling, conversion and recycling of rechargeable batteries.

Flanders has seen a long and strong tradition in the industrial collection and processing of batteries that have reached the end of their life. As regards these 'end-of-life batteries', we are in a world-leading position. It is from this position of strength that we are presently working hard to convert LIBs from electric vehicles, which often still perform well, into e.g. home batteries for energy storage. This way, the conversion of LIBs creates local added value: the intrinsic value of the batteries and their materials largely remain in Flanders and the production of new LIBs for use in home batteries is avoided, thereby ensuring a low environmental impact worldwide.

In order to grasp this opportunity and realise the potential benefits of a Flemish conversion industry for LIBs, in both economic and environmental terms, there are still a number of major challenges that need to be



tackled. In technical and economic terms, for example, the ability to dismantle and convert the wide variety of LIB types at an acceptable cost is a tricky task. For example, it is not easy to find out the 'health' of batteries today. The transport and dismantling of LIBs also comes at considerable expense. Various parties and consortia in our region are working on solutions to these kinds of problems.

FOCUS ON SUSTAINABLE BATTERY PRODUCTION

With the Umicore plant in Hoboken, Flanders already has a recycling facility for end-of-life LIBs, albeit mainly for batteries originating from old electronics, such as smartphones and computers. Today, this Flemish LIB recycling capacity accounts for 21 percent of the total European capacity. This total capacity will need to rise substantially in the coming decades, however, especially because the European Union intends for a strong focus on sustainable battery production with a more local supply of raw and intermediate materials. The EU is doing so by encouraging battery recycling with recycling quotas that have a heavy focus on the recycling of critical raw materials, among other things.

We still face a great many technological challenges in the optimum processing of the large quantities and diversities of LIB waste into new resources, materials and/or batteries in the future. Battery packs for electric vehicles are in fact products that consist of a complex assembly of different components and materials. Efficient disassembly of such packs is needed to separate the cabling, electronics, cooling system, casing and battery modules and then to process or reuse these in the optimum way. Flemish research groups are currently studying how to fully or partly automate disassembly in order to limit safety risks and speed up the whole process.

Another challenge in the recycling process is the optimum separation of battery modules and cells in line with their material composition. After all, LIB cells often contain various types of electrolyte and anode and cathode materials. For optimum recycling, this composition must be known and it must be possible to sort the materials in question. The large diversity of battery shapes and compositions hinders efficient sorting here as well. But Flemish researchers and industry experts are working on solutions to this problem too. One way they are doing so is through the development of automatic battery sorting systems based on smart sensors, image recognition and artificial intelligence.

INNOVATIVE RESEARCH

When recycling LIBs, especially during the pre-treatment, the cells need to be shredded and the material fractions need to be separated. New and improved methods are being developed for this too. The final step is then a metallurgical process, providing for optimum recovery of the valuable metals. The current processes are based on a highly efficient process that recovers valuable metals, such as cobalt, nickel and copper, but other materials, such as aluminium, lithium and graphite are lost. New processes should eliminate this shortcoming.

In addition, there is some innovative research into direct recycling routes. This is where functional materials, such as the electrolyte and the anode and cathode materials, are recovered from waste batteries, conditioned and immediately re-employed as materials for new batteries. Such processes, however, are technologically complex and come at a high cost, but they can recover the more valuable materials from waste batteries, thereby reducing the quantity of real waste. The Flemish metallurgical and recycling industry will play a major role in this with their expertise.

In order for circular industries for LIBs in Flanders to grow, it will be necessary to monitor developments in both the supply of end-of-life LIBs and the demand for applications very closely. This will enable Flemish industry and government actors to make informed decisions on investments and policy measures. In this context, we would like to mention the Re2Live project, which is being supported by VLAIO, through the



cluster organisations VIL, Flux50, SIM and Agoria and by the VITO, SIRRIIS and VUB research institutions. It is bringing together knowledge for mapping out the potential of LIBs from end-of-life vehicles for Flemish industry.

In addition, Flemish industry is given insight into Re2Live's results and is being encouraged to provide feedback. There is great interest from companies and the project's steering group already has more than twenty members, from car manufacturers through companies active in the recycling and reuse of batteries to the metallurgical industry, engineering firms and, of course, battery manufacturers.



JEROEN GILLABEL
expert circular economy at VITO



JEROEN SPOOREN
expert recycling technologies at VITO

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SUSTAINABLE EXTRACTION OF BATTERY RAW MATERIALS IN THE DEEP SEA

The transition to a sustainable energy system based on renewable sources is making the demand for rechargeable batteries explode. And therefore also the need for raw materials such as lithium, nickel and cobalt. Deep-sea mining of "metal nodules" may offer a solution in this regard. It would also be a welcome alternative to the often problematic extraction of critical battery raw materials on land.

The figures leave little to the imagination. According to the International Energy Agency (IEA), the demand for lithium, graphite, cobalt and nickel will rise exponentially in the coming years, by at least a factor of 20 for nickel and for lithium even by a factor of 42. The reason for this is the transition to an energy system based on renewable energy. This system is highly electrified and relies on a large storage capacity. In short, the transition is making the need for rechargeable batteries rise exponentially. And these raw materials are crucial for the production of electric vehicle batteries, for example. The message from the Executive Director of the IEA, Fatih Birol, when he published the above figures last year was therefore clear: 'We are heading for a mismatch between the world's climate ambitions and the availability of critical raw materials to meet them.'

RECYCLING

While everyone agrees that we need to move towards a circular economy as fast as possible, our present society does not have enough metals to recycle. According to the same IEA report, recycling will be able to meet only 10% of the need for primary metals by 2040.

UNCERTAIN SUPPLY

One problem with the current supply of critical battery raw materials, which is nowhere near adequate to meet the ever-growing demand, is that it is uncertain. Not only the extraction, but also the processing of the raw materials are highly concentrated geographically. For example, 70% of the cobalt used today comes from Congo, and 60% of it is processed in China. This is not what anyone would call a healthy security of supply, which would benefit from far greater diversity on the supply side.

There is also the problematic impact of mining and processing on the local environment. Currently accessible, rich ore reserves are depleted and mining companies need to look for new sources, the environmental and climate footprint of mining is growing. New mines are often located in areas of rich but fragile biodiversity, such as the nickel mines in Indonesia. These activities also create a residue stream, which is often toxic and must be disposed of. Finally, there is also the social impact of mining. The inhumane methods used to mine cobalt in Congo don't exactly give the resulting batteries a positive image.

METAL NODULES FOR THE TAKING

The world therefore urgently needs a sustainable, socially responsible source of critical battery raw materials. The good news is that this exists and is even well known. Billions of so-called metal nodules are



scattered on the ocean floor around the world, waiting to be harvested. The fist-sized, spherical mineral deposits are formed over millions of years as various minerals in the sediment and the water column are deposited around a nucleus, often a tooth or a piece of bone. The nodules contain a range of metals, such as manganese, nickel, copper and cobalt. To date, the richest known 'deep-sea mine' lies in the Pacific Ocean at a depth of five kilometres below the surface. This so-called Clarion-Clipperton Zone (CCZ) contains twice as much nickel and three times as much cobalt as all known ore reserves on land. Moreover, because four metals occur together in the nodules, the CCZ is in fact a combination of several land mines, as you won't find these four metals together in any one mine on land.

As the metals can be harvested without too much difficulty, the energy consumption of the mining, waste production and the disturbance of the environment are minimal. Moreover, deep-sea mining, although it does not yet exist today, is already very strictly regulated. The CCZ falls under the powers of the International Seabed Authority (ISA), which regulates international waters under the flag of the United Nations. The ISA will soon impose very strict standards on any operators looking to begin mining the deep sea bed for minerals. These are intended to guarantee that the deep-sea marine environment and biodiversity are protected by designating protect areas where no mining will be permitted. In addition, the royalties from deep-sea mining must be fairly distributed among humanity, with an emphasis on developing countries.

The emergence of deep-sea mining is part of a global, even planetary, approach to use the earth's natural resources in the most responsible way for the transition to a sustainable energy system. In this regard, land-based mining and deep-sea mining cannot be seen in isolation from each other.



KRIS VAN NIJEN
Managing Director at Global Sea Mineral Resources

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WE KNOW

BLUE DEAL TO MAKE FLANDERS 'WATERPROOF'

Extreme drought and flooding are different sides of the same coin, namely an unbalance between supply and demand of water, intensified by global warming. With the Blue Deal, Flanders is aiming to thoroughly revamp its water system and transform itself from a water-scarce region into a model region for efficient water usage.

De perceptie van de waterhuishouding in onze regio is de laatste jaren ingrijpend veranderd. Of beter: The perception of water housekeeping in our region has changed substantially in recent years. Or, to put it better: the seriousness of water stress due to either shortage or excess of water, has only now cut through to the wider population due to various heatwaves, long-lasting periods of drought and – not forgetting – the devastating floods of the summer 2021. Climate models indicate that, although the annual precipitation volume is remaining more or less constant, episodes of extreme precipitation, or the lack of it, are becoming more frequent. In response to this new reality, the Flemish government launched the Blue Deal in 2020. This comprehensive package of measures is intended to transform Flanders from a water-scarce region into a model region for efficient water usage.

SUPPLY, DEMAND AND RESERVES

Water management in the Blue Deal rests upon three pillars: the supply, the demand and the reserves. The demand side is in theory the easiest to manage, as this is fully determined by our collective behaviour. The Blue Deal aspires to make all sections of society responsible for rational water usage. For industry and agriculture, for example, this means that they need to go out in search of opportunities to reduce consumption or to start reusing wastewater using 'scans'. In doing so, the authorities set a good example by implementing a policy that facilitates the development of the entire package of measures in the Blue Deal. On the supply side, the Blue Deal strives for greater water infiltration into Flemish soil for making the water stocks more robust, and for a shift in the general mindset towards circular water. Concerning our water supply, nowadays all the water that we use in a private setting (as drinking water, but also for cooking, washing and cleaning) comes from groundwater reserves and from lakes, canals and rivers. The surface reserves are not very large in our region, however, which means Flanders is at risk of water stress from extreme weather events or from international troubles regarding water management. That is why it is important to focus on the use of alternative water sources: wastewater, rainwater, brackish water and even seawater. Since technologies are available, the challenge lies mainly in the smart coupling of the new concepts with energy and land use.

RETENTION OF WATER

The high degree of surface hardening in Flanders (16% of our surface) makes that a lot of rainwater is discharged more quickly towards the sea via the sewers. This increases the risk of flooding and at the same time hinders the replenishment of our groundwater supplies. Rendering the surface permeable and the creation of infiltration zones and green belts are therefore important to maintain our groundwater reserves.



These zones also have an additional beneficial effect, because they provide cooling. And with more natural cooling, less air conditioning is needed on hot days, reducing power consumption and therefore also water consumption by power plants.

WATERPROOF FLANDERS

The Blue Deal aims at making Flanders a waterproof region. Let this also be the name of an ambitious project led by VITO that through three large-scale demos, investigates how a more resilient water supply can be achieved through a combination of smart spatial planning, intelligent management of buffers and circular water networks. In concrete terms, we are going to work at a business park in Tielt, at the fruit growers in Haspengouw and we are investigating extra buffering capacity in natural water basins in the Kempen. The Flanders WaterProof project follows a systems approach in which the main cause-effect relationships within the Flemish water system are mapped, including the interactions with other systems such as energy, nutrition, mobility and health.

The importance of the Blue Deal cannot be overstated. With the Blue Deal, Flanders ensures support and the necessary dynamics. This is essential to make our water system climate-robust.



INGE GENNÉ
Programme Manager 'Water' at VITO

BACK TO WE KNOW >

THE DREAM OF THE HYDROGEN ECONOMY IS STILL VERY MUCH ALIVE

Hydrogen is like a Swiss army knife: it can be used for a hundred and one applications. But there is a catch, because emission-free 'green' hydrogen will become a scarce commodity in the coming decades. Therefore, the transition to a sustainable, climate-friendly global economy will only be possible if we use hydrogen wisely.

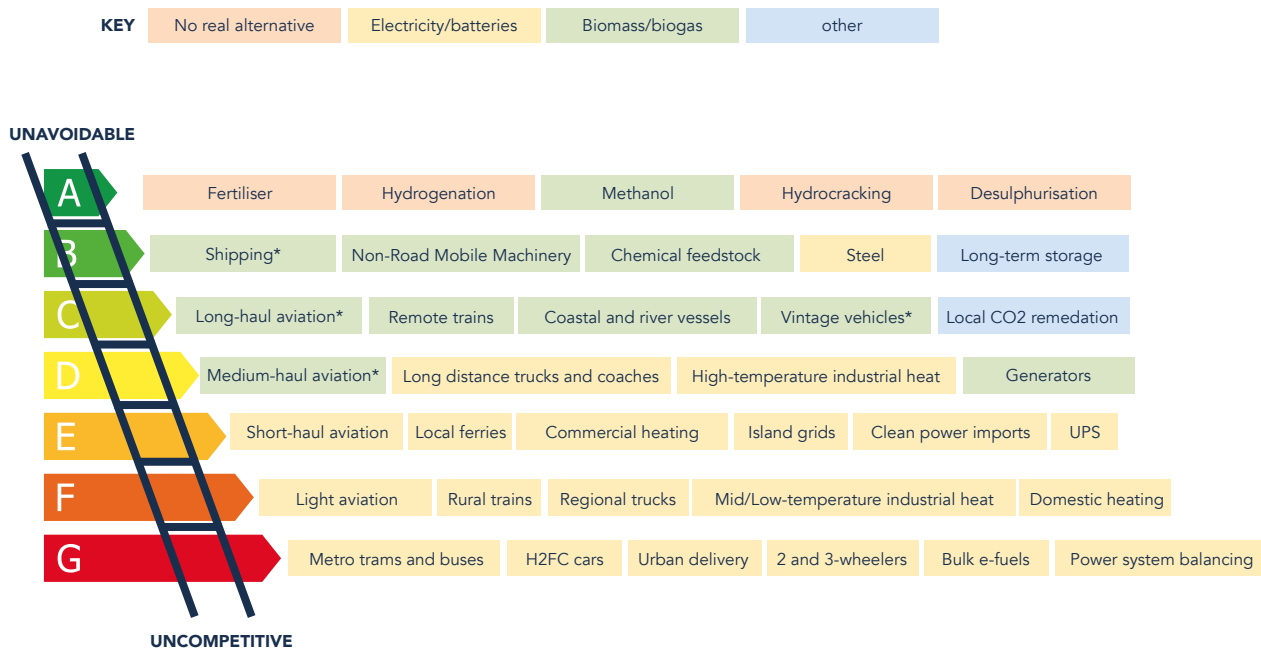
Hydrogen is the prima donna of the periodic table of the elements. It is the lightest element, but at the same time - especially in terms of application - it is one of the most unique. Indeed, in pure molecular form (H₂) it can be used for anything and everything. From the generation of electricity and powering cars, ships and aircraft, to the heating of buildings and the production of steel, to the manufacture of fertilisers, ammonia and other chemicals.

Unfortunately, pure hydrogen is very rare on earth. That means it needs to be extracted with energy from fossil raw materials such as natural gas, through a process called steam reforming, or from water through electrolysis. Almost all hydrogen is currently produced using the first method, releasing as much as 9 kilograms of CO₂ per kilogram of hydrogen. Needless to say, producing this so-called grey hydrogen is anything but climate-friendly.

INDISPENSABLE FOR POLICYMAKERS: THE HYDROGEN LADDER

That means the second method, electrolysis, has much more potential, also because this method of producing hydrogen offers comparable efficiency to steam reforming. But then the electricity used to split water into hydrogen and oxygen has to be as low-carbon as possible. Only then can we truly talk of 'green' hydrogen. Meeting this condition is much more difficult than it may seem. To green all hydrogen production in the world today, an electricity generation equivalent to 25% of total world electricity generation would be necessary. And all of this must be carbon-neutral energy, for example from renewable sources such as solar and wind or from hydropower. It is clear that this green energy does not exist today and will not exist in the near future - on the contrary, new 'green' capacity will be used as much as possible to electrify the economy.

This means that choices will have to be made. Choices between applications that simply cannot be decarbonised without green hydrogen, and applications for which sustainable alternatives do exist. An example from the first category is the steel sector, which currently uses coal as a feedstock to reduce iron ore. Hydrogen could do the same job, without CO₂-emissions, . An example from the second category is the (light) transport sector and the heating of buildings. Batteries and heat pumps, both powered by electricity, are much more efficient from an energy point of view for powering light vehicles and heating buildings, respectively. As such, it is not that hydrogen can be used for just about anything that that will actually be the case. On the contrary, while some applications of green hydrogen are unavoidable, others should be avoided. The British energy specialist Michael Liebreich has summarised this in an easy-to-understand format in a "hydrogen ladder". The ladder shows the most desirable applications of hydrogen at the top and the less desirable ones at the bottom. The diagram should be on the desk of every policymaker working with energy (and therefore hydrogen).



* Most likely via ammonia or e-fuel rather than H₂ gas or liquid

Source: Michael Liebreich/Liebreich Associates, Clean Hydrogen Ladder version 4.1.2021
Concept credit: Adrian Hiel, Energy Cities CC-BY 3.0

IMPORTS FROM 'HYDROGEN COUNTRIES'

In recent years, the idea of a hydrogen economy has made a comeback (even though it never went away). Hydrogen was first mooted in the 1970s and 1980s in response to the oil crisis, then faded into the background, only to return to the fore at the turn of the millennium. Today, the idea - often accompanied by the catchphrase "when you burn hydrogen you only emit water" - is being mooted again. And today, this 'hydrogen economy of the future' is a worldwide phenomenon. Since sun and wind are scarce, especially in a small and often cloudy country like Belgium, ambitious plans are being rolled out to import green hydrogen from areas where renewable sources are abundant and there is also enough space to exploit them. These are countries such as Australia, Morocco, Chile, Namibia and, of course, the Gulf States. The green hydrogen would be produced in these countries in electrolyzers and then distributed around the world in large tankers. As is the case today with oil and gas.

That all sounds very nice, but then the electricity mix in these 'hydrogen countries' has to be sufficiently green. And that is easier said than done, because it involves more than just connecting an electrolyser to a large solar or wind farm. Indeed, this approach does not green the power mix in the hydrogen-producing countries, and greenhouse gas emissions remain too high. So, first and foremost, this mix needs to be further decarbonised. Only when the emissions are low enough can it be used to produce low-carbon or green hydrogen. For this, energy experts use the limit value of 140 grams of CO₂ per kilowatt-hour of electricity. This is more or less how carbon-intensive the current production of grey hydrogen is. In order to produce green hydrogen, the value for the power mix must therefore remain well below this level. This is quite a challenge, because in Europe it currently stands at 216 g/kWh. And even in the above-mentioned future hydrogen countries, it is still well above 140 h/kWh. Therefore, the best way to green the global economy is first to reduce greenhouse gas emissions from the power mix.



FLEMISH INNOVATION IN HYDROGEN TECHNOLOGY

Meanwhile, the efficiency of the electrolysis process can be increased. Innovation in hydrogen technology is therefore certainly still desirable and even absolutely necessary. In this domain, our country is a hive of activity. For example, VITO/imec/EnergyVille has joined forces with several major Belgian companies to make the production of hydrogen via electrolysis more efficient. The aim is to increase efficiency from 70 to 80%. This is taking place within the HYVE project, in which a cost-efficient and sustainable technology platform is being developed for gigawatt-scale hydrogen production. Further, WaterstofNet aspires to increase knowledge sharing among its members and unites many parties that are active in relation to hydrogen.

Belgium, and Flanders in particular, are also ideally situated to play an important logistical role in the burgeoning global hydrogen economy. A study by the Hydrogen Import Coalition, in which not only the Flemish seaports but also governments and several major Belgian companies are working together, showed early last year that our region can be fairly ambitious in the international hydrogen market. As such, cooperation agreements have already been concluded with countries such as Oman, Namibia and Chile for the future import of green hydrogen from those countries to Flemish ports. In Oman, the Flemish company DEME is even involved in the development of a green hydrogen plant with a capacity of up to 500 megawatts. The plant should be operational by 2026. The Belgian company CMB, together with other companies from our country, is building a solar park in Namibia that will also be able to produce one million tonnes of green hydrogen locally from 2026 onwards.

For Flanders, green hydrogen offers superb economic opportunities and the actions taken in 2021 must therefore be built on in the coming years - preferably on a larger scale and faster. Indeed, without green hydrogen it will not be possible to achieve a sustainable global economy. In fact, there are no real alternatives to the decarbonisation of, for example, the steel and various chemical sectors - sectors that are, moreover, crucial to the Flemish economy.

The dream of the hydrogen economy is therefore still very much alive. But the versatility of green hydrogen also has a downside. Because it can be used for so many applications, it will become a scarce commodity in the coming decades - no matter how much we produce. In other words, we need to handle it very wisely. This is the only way the dream will be realised.



GERRIT JAN SCHAEFFER
General Manager EnergyVille

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WE KNOW

HOW 'FINTECH' CAN HELP FIGHT GLOBAL WARMING

To put a stop to global warming, drastic efforts are needed. And all sections of the economy and society must be on board. That includes the financial world, because it can ensure that the financing of cleantech investments and the creation of sustainable business models are given priority. In this report, at the request of Cleantech Flanders, Peter Adriaens, Professor of Engineering, Finance & Entrepreneurship at the University of Michigan, sheds light on this issue.

At my university in Ann Arbor, in the state of Michigan, I teach a course that focuses on the financing of infrastructure projects. It is part of the course for MBAs, engineers and policy economists and aims not only to impart knowledge but also to challenge students in a wide range of areas. From deal sourcing and due diligence on emerging technologies and markets and the impact of Internet of Things (IoT) on the venture and growth capital landscape to the role of 'fintech' in new asset financing models.

Recently, both a CEO of a blockchain technology company (Blockchain Triangle), a Managing Director of the digital group for a large engineering consultancy company (WSP) focused on resilient infrastructure, and an investment banker working for the US Treasury spoke in the course. We addressed this question: How are data and fintech likely to disrupt the financing, operations, and risk/return profiles of smart (cyber-physical) cities projects?

HYPE AND REALITY

Shortly before, I had participated in the Glasgow Climate Summit (COP-26), where I had joined Blockchain Triangle as a member of its advisory board to make investor and corporate connections. The company's value proposition as a blockchain-based ESG disclosure platform connecting infrastructure assets and investors is related to the EU and UK pronouncements to force banks to disclose their loan book portfolio exposure to climate change risks in their financing decisions. The US Financial Markets Authority (SEC) is also expected to take a position in the coming months on climate risk in investments.

During my course, this led to a discussion on the hype and reality around data-driven financing and business models for (climate)resilient infrastructure assets.

Indeed, experience with novel data-driven financing and business models is still largely relegated to operational efficiency and OPEX financing (for operating costs), with examples of pilot applications in CAPEX structuring (for capital expenditures) and data monetization for different infrastructure assets. Not surprisingly, revenue-generating assets such as water, energy, mining, and concessionary contract agreements such as toll roads tend to lend themselves to new efficiencies and real time valuation.



This becomes clearer if we look at some relevant use cases in the table below.

SMART HIGHWAYS

Governments can use digital technologies to collect data on traffic patterns. They can use these data themselves, but they can also sell them to insurance companies who use this data for insights on risk underwriting and cash flow reserve position management. In the United States, experiments are underway to measure the impact of logistics on the life cycle of roads and to provide financial compensation (e.g. to transport companies). These so-called 'smart slabs' (an Integrated Roadways product) can be integrated in roadways and bridges and outfitted with sensor hubs to inform the KPIs (key performance indicators) of P3 (public private partnerships) contractual agreements on structural health, traffic type and driver demographics. While the business model and cash flows models are still under development and being tested, provisional P3 agreements are being negotiated between technology companies and state agencies.

SMART WATER PLANTS

Public water agencies in many municipalities are facing budget pressures and are turning to digital solutions by integrating data from various sources to gain operational efficiencies (e.g. so-called non-revenue water from pipeline breaks) and invaluable insights to help them avoid major outages and reduce risk. The data solutions also include the conversion of capital expenditures to long term operational cash flows to pay for the delivery of water services (i.e. water-as-a-service). Municipalities are forming public private partnerships to develop long term solutions to this problem. The municipalities mandate contracts that include rights to the data collected from sensors and in some cases stipulate on-premise solutions with high security measures.

VARIABLE INTEREST STORMWATER BONDS (OR EIBS, ENVIRONMENTAL IMPACT BONDS)

Also in the US, water agencies are working with investment banks to structure variable interest rate revenue bonds where the payout to the investor is dependent on the data-driven performance of the stormwater asset. The focus of this model is on green infrastructure to replace grey infrastructure at lower capital cost. In addition, flow sensors, water quality sensors and weather data inform the risk and performance of the asset, resulting in a low yield spread on the revenue bond, which can range over a few 100 bps. This model has been deemed attractive by investors due to it being uncorrelated to other financial assets.

REVENUE-BACKED DEBT SECURITIES FOR WATER INFRASTRUCTURE

In Italy, local governments looking to upgrade and expand their water distribution and treatment systems have bundled unrated (and expensive) minibonds in a special purpose vehicle (SPV) and converted to rated debt securities which are sold to pension funds and development banks (EIB). The credit rating and liquidity of the Viveracqua Hydrobond securities were a financially attractive alternative relative to unrated bonds too small and lacking of sufficient data to justify the administrative cost while also spreading the credit risk. The SPV received a cash buffer, which can be backed by the utilities, performance options contracts or a liquidity facility and receive a favorable rating. Integration of performance data on - for example - changes in ratepayers, pipe leakage, or cost of water quality impairments can be structured in forward contracts. So-called asset-backed securitization of public private partnerships (ABS-PPP) is a new financing model that is being heavily studied as a form of structured finance for infrastructure projects, though it is not clear how many projects have been executed.

CREDIT ENHANCEMENT FOR INFRASTRUCTURE PROJECTS

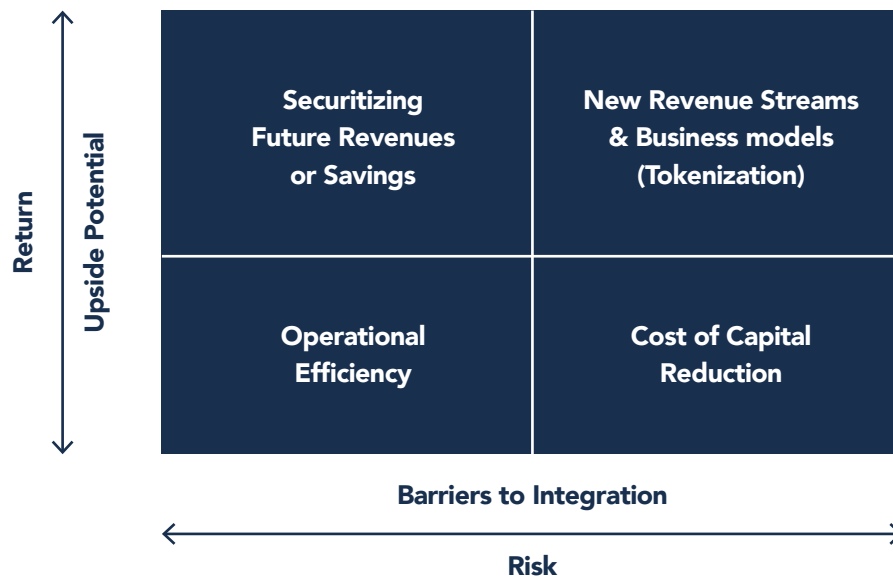
Proxy revenue swaps (PRS) are becoming a new data-driven options model to fix floating revenue of projects such as wind power and water provision for asset owners. The PRS serves to reduce uncertainties for debt or bond investors in the projects resulting in a higher credit rating and less conservative credit covenant requirements, thus rendering the project more bankable. PRS's are offered globally by insurance companies such as Nephila Climate short-term options, are structured against a long-term cash flow trend and are triggered by independent indexes for wind, rainfall or other metrics.

SMART MINING

Mining companies are increasingly moving towards digital twin technology to gain valuable insights into financial and environmental aspects. They have installed systems to gather multiple data points from their mobile assets such as trucks, shovels, etc. This helps them gain transparency into operating costs and emissions. In some cases, these companies worked with engineering firms to develop bespoke solutions to meet data acquisition needs.

NEW BLOCKCHAIN-BASED ENERGY AND MOBILITY INFRASTRUCTURE BUSINESS MODELS

In the US, Belgium, Germany and the Netherlands, technology companies are piloting blockchain applications to aggregate, distribute and manage decentralized energy supply and demand. The application allows for the residential owners to buy and sell energy within an energy marketplace of consumers using so-called smart (automated) contracts, and helps utilities to manage base and peak load demands. The applications of blockchain in mobility include pilots to have cars as unique identifiers (digital wallets) pay for infrastructure needs. As more data becomes available from infrastructure assets, more data-driven rules-based contracts can be coded and executed automatically, reducing costly middlemen and allowing for the design and payment systems for connected digital infrastructures (e.g. roads and stormwater assets) rather than siloed assets.



The above examples make it possible to display data-driven (digital) financing opportunities in a risk-return diagram. This maps barriers for integration against upside potential. For example, implementation may be hindered by technical (e.g. integration of cost and revenues with assets) and non-technical (e.g. stakeholder alignment) causes. The upside potential reflects the total possible return.

WHERE FINTECH, CLEANTECH AND CLIMATE-TECH MEET: SOME DEFINITIONS

Tokenisation is a technological process to replace confidential data with a unique combination of numbers and characters that contains necessary information without revealing the original related data (e.g. bank account numbers, credit card numbers, transaction details).

Securitisation is a financial technique that combines assets that are not tradable or difficult to trade into tradable securities.

Hedging is the covering of the financial risk of an investment by another investment.

Initial coin offering (ICO) or initial currency offering, is a form of financing using crypto coins. It is often a form of crowdfunding, although a private ICO that does not seek public investment is also possible.



For example, tokenization of infrastructure should be able to draw the maximum returns, because of new monetization mechanisms based on smart contracts, and unlocking of efficient capital (hundreds of billions of dollars). However, the technology is still immature, market demand very volatile, smart contracts not (yet) enforceable, and financial institutions not yet aligned with private contractors and government partners. Operational efficiencies could net benefits in the billions of dollars, and indeed projects have demonstrated how this can be done. Cost of capital reduction requires monitoring (digital infrastructure) to assure investors, underwriters and ratings agencies.

Securitization-based infrastructure financing is more mature and well understood (lower risk, but still a challenge for ratings agencies), has a significant capacity for forward selling of revenues and savings (note the increasing interest in asset backed security-public private partnerships (ABS-PPP) or aggregating sub-scale assets (too small for project finance) in novel SPVs.

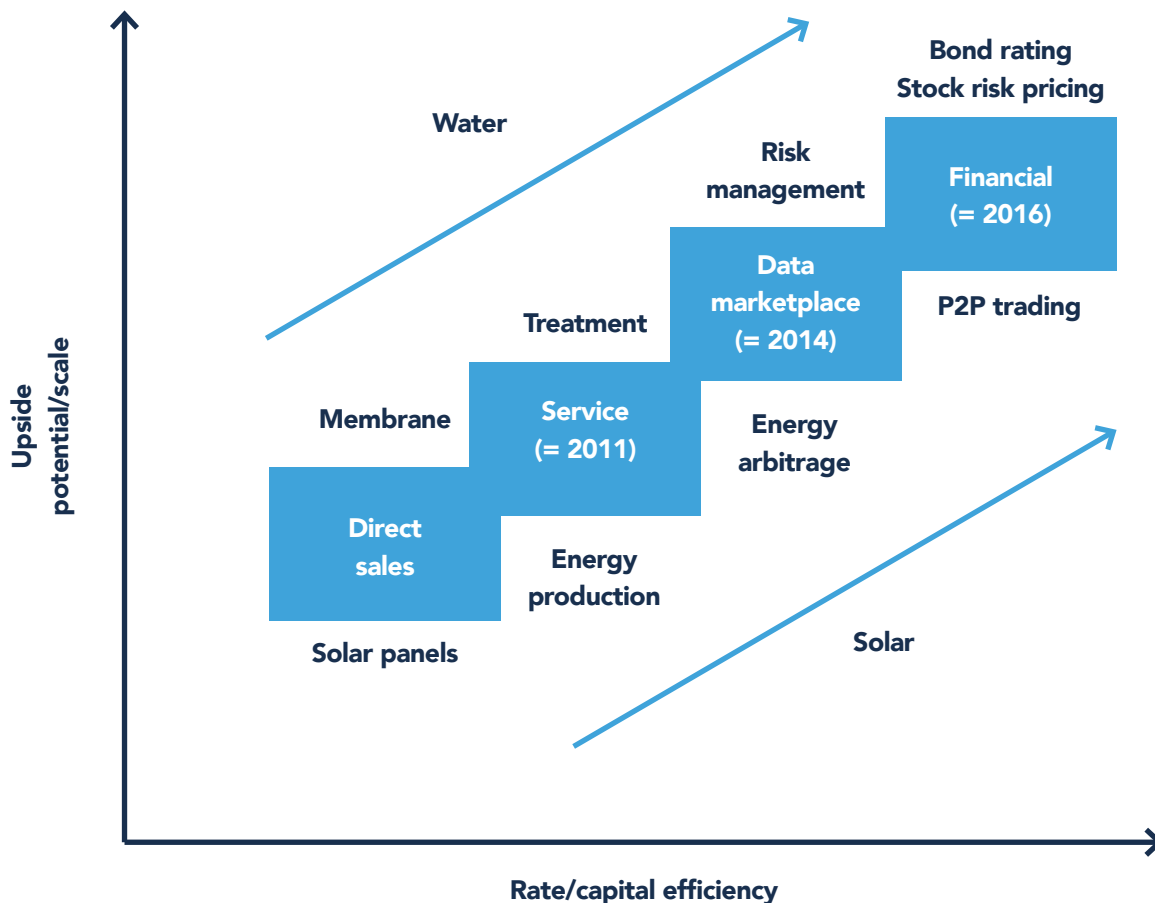
A BUSINESS MODEL SHIFT TO HEDGING

What do these financial innovations in the financing infrastructure tell us about business model shifts? I have been teaching and researching the cleantech industry for 30 years. First as a technology developer focused on microbial and chemical sensors, then as a deal flow analyst and early-stage equity investor at the Wolverine Venture Fund, and in recent years as an innovator in digital financing mechanisms with applications in the ESG and infrastructure space. The Center on Smart Infrastructure Finance that I lead at the University of Michigan is funded in part by Ripple, a blockchain company in the cross-border currency settlements space.

In addition, we have industry partners in financial services, technology and construction sectors who work with us to design and test value-added digital solutions. Working with these commercial partners has provided insight into the business model shift in cleantech since 2003, when the term ushered in a new technology investment industry . It also has provided a broader perspective in how new startups are figuring out new value capture and scalability opportunities in the digital landscape, and how corporations are transforming their own lines of business through partnerships, joint ventures and acquisitions. Ranging from startups such as Blockchain Triangle, InfraClear, Integrated Roadways and Equarius Risk Analytics, to corporate strategic and venture investors like Ford, WSP, Macquarie, and Kurita, and to financial services including the US Treasury, Nuveen, Ripple, MSCI and CitiGroup, new value propositions are emerging.

FROM 'A THING' TO 'THE WAY WE DO THINGS': THAT TOO IS CLEANTECH

The digitization of the economy, and the integration of IoT in industrial and financial systems and processes, shifted cleantech from 'a thing' to 'the way we do things' about half a decade ago. A lot has been written about that transition and how it has influenced investment in new cleantech companies. These investments are driving resource efficiencies with software-as-a-service and anything-as-a-service. The evolution of business models in the 'Rate of growth vs. capital efficiency vs. upside potential/scalability' space in water and solar is shown in the chart below. Direct sales models shifted to service models about a decade ago, and into a data marketplace driven by arbitrage and risk management values five years later, after full integration of cloud computing. .

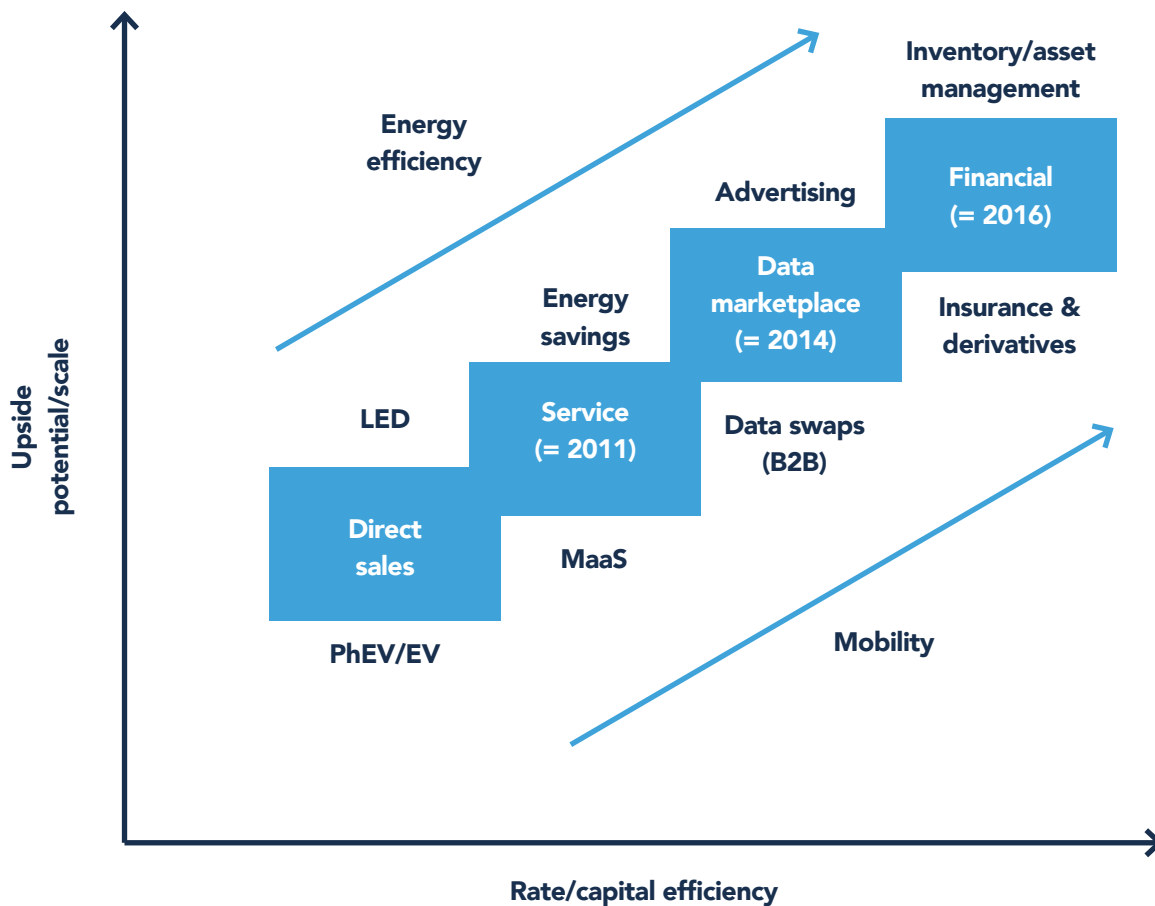


Financial technology now is further shifting how cleantech companies capture value from the next generation of business models. I am not referring to the initial coin offerings (ICOs) where companies issue tokens (classified in the U.S. as shares) for sale to retail investors to finance a startup. Rather, I refer to the integration of fintech in the value proposition of technology solutions as an operational efficiency gain driving increased valuations. Consider how real-time data insights are impacting the valuation of assets and enabling a financial model structured to deliver returns using peer-to-peer (P2P) trading for microgrids with companies. Or as companies use water and weather data in an artificial intelligence supported model to reprice company shares and bond ratings and inform insurance capital reserves, while participating in portfolio performance returns.

The integration of IoT in products and systems builds data oceans, which can be parsed and processed to uncover trends that create value as monetizable data streams. I refer to my recent piece (<https://www.bloomberg.com/news/articles/2021-04-07/use-data-not-taxes-to-pay-for-infrastructure>) in Bloomberg CityLab on financial innovations. Whether in mobility, water, lighting, energy, waste or agricultural tech, business models of innovative CleanTech companies increasingly are adopting what I broadly term financial hedging models resulting from the increasing integration of IoT, monetization of data and (re)pricing of risk.

Based on the CleanTech Group's i3 Platform, similar trends as in water and solar are emerging in the LED/ lighting/energy efficiency and transportation mobility subdomains.

The transportation mobility industry comprises a mix of sales and service models addressing different customer segments, such as environmental, technology-savvy and autonomy, but the value capture shift towards derivative market and financial revenue streams is evident.



Analysis of the data supply chain in the mobility industry not only reveals their value for operational efficiency, but further drives data auctioning marketplaces resulting in ‘data swaps’ and ‘pooled derivatives’ between cross-industry partners, and insurance models. More recently, these contracts are being included in blockchain networks for transparent transactions. These models not only help to expand customer access and market scale, but inform asset allocation of operational investments in different geographies, for example.

WHAT CAN WE LEARN FROM THIS?

The trends, developments and examples described here are not limited to the mentioned investment domains, as recycling and waste management, grid-scale energy generation and storage, and biofuels/biomaterials are being similarly disrupted by data-driven startups with financial risk transfer business models. If ‘CleanTech IoT’ becomes a financial risk hedge or assess value proposition, its integration will permeate and be felt across all sectors. It is a systemic, cross-sector and silo-crossing value proposition. Real assets become data carriers for derivative value generation and income generation. If ‘CleanTech IoT’ becomes a financial risk hedging or rating value proposition, its integration will be felt across industries. It is a systemic, not an industry vertical value proposition. Real assets are becoming data vehicles for derivative value generation and monetization. Our conversations with the Asia Infrastructure Investment Bank (AIIB) and TESIAC, an infrastructure-as-a-service (IaaS) platform, indicate that data oceans, insights extraction and monetization are being integrated across energy, mobility, housing and other verticals.

My course panel discussion on the importance of data and fintech value propositions to integrate fintech and IoT in resiliency finance reflected caution in the applications of these financial hedging business



models. Data contracts are still too short term, volatile, and uncertain in their valuation to serve as collateral for loans or private equity financing in infrastructure. However, pension fund investors like Nuveen are betting on the repricing of bonds and municipal infrastructure finance using ESG data models, and banks like CitiGroup are exploring the opportunity of data assets to drive new revenue streams and reduce risk. If it is up to Blockchain Triangle and Equarius Risk Analytics, the nascent development of digital asset repositories to unlock new value through efficient capital and tokenization of financial instruments is key.



PETER ADRIAENS

Director, Center for Smart Infrastructure Finance;
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Professor, Environmental Engineering & Finance;
Professor of Entrepreneurship w/o tenure (2006-2016; Ross School of Business);
Professor w/o tenure, School for Environment and Sustainability, The University of Michigan at Ann Arbor

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WE KNOW

EUROPEAN AND FLEMISH RECOVERY RESOURCES FOR SUSTAINABLE GROWTH

The European Union loosened the purse-strings in 2020 to mitigate the economic and social consequences of the coronavirus crisis in the Member States. This recovery fund, known as NextGenerationEU, forms the basis for the Flemish Resilience recovery plan, along with our own resources.

The Flemish recovery plan accounts for a total investment of 4.3 billion euros. Around half of this comes from the European recovery fund, with the other half coming from the Flemish budget. The plan is structured around seven pillars, 35 clusters and no less than 180 projects.

One of those pillars involves making the economy and society more sustainable and accounts for an investment of 1.6 billion euros. The Flemish government has therefore chosen to make a substantial investment in the transition to greater sustainability. In practice, this involves investments in the following areas.

With **the Blue Deal**, the government aims to tackle the issues around drought and water scarcity in a vigorous manner. Half a billion euros will be spent on infiltration projects that aim to make Flanders a sponge once more – giving water space so it can see optimum use. A large-scale programme has been launched to accelerate the **sustainable renovation** of homes and other buildings. Heat grids will be rolled out at a large scale to distribute **green heat**.

Sustainable modes of mobility will be encouraged, including through greening the De Lijn fleet, through the accelerated roll-out of charging infrastructure for electric vehicles and through the installation of LED lighting along regional roads. The government is prioritising renewable energy with zest and is also investing in the capture and reuse of CO₂. There will be a further focus on the development of a **hydrogen economy**, in which Flanders could become a hydrogen hub.

The transition to a **maximally circular economy** is to be accelerated. Flanders must become even more of a recycling hub, which is why innovation in the construction sector is to be supported too, aiming towards circular construction. There will be **plenty of investment in R&D** through support for companies in Flanders and for research infrastructure at the Flemish knowledge institutions.

Through Flemish Resilience, our region is contributing to the achievement of the **Sustainable Development Goals (SDGs)**, the challenge of the 21st century.



JOHAN HANSSENS
Secretary-General dpt EWI

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WE SPREAD

Cleantech Flanders helps to upscale the cleantech business internationally of Flemish cleantech companies. It does so by representing the Flemish cleantech community abroad and by taking part in international events and trade missions, in many cases in collaboration with other actors like Flanders Investment&Trade.

- Flanders is helping developing countries achieve climate goals** >
- FIT's Science & Technology team: a global network** >
- Made in Belgium: our offshore wind energy is booming** >





WE
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FLANDERS IS HELPING DEVELOPING COUNTRIES ACHIEVE CLIMATE GOALS

With its Climate Action Programme, G-STIC, the Global Sustainable Technology & Innovation Community, and the department Environment are supporting developing countries in the battle against global warming. Cleantech Flanders, with its community of innovative SMEs, start-ups and scale-ups carefully built up over the years, is a partner of choice here for launching Flemish climate projects in developing countries.

Under the wing of G-STIC, a new initiative for international climate funding was launched in mid-2020. The aim of this Climate Action Programme is to help developing countries pursue low-carbon development paths (mitigation) on the one hand, and to make their society and economy more resilient against the consequences of global warming (adaptation) on the other.

This Flemish climate action programme is helping developing countries to achieve their mitigation objectives and carry out adaptation projects through the implementation and scale-up of initiatives from our region. These initiatives rely upon financial support from the Flemish government to do so. In 2021, a total subsidy amount of almost 5 million euros was available. With more than sixty project applications, there was great interest and the available subsidy amount was comfortably exceeded.

ENCOURAGING INTERNATIONALISATION

As a promoter of innovative Flemish cleantech and its implementation in society, Cleantech Flanders plays a major role in G-STIC's climate action programme. The Flemish community of cleantech companies that Cleantech Flanders has spent years carefully building up – with SMEs, start-ups and scale-ups in particular – mutually shares knowledge, networks extensively and encourages each other to internationalise – this being in collaboration with Flanders Investment & Trade. This is where our slogan comes from: 'We know, we connect, we spread'.

In combination with the international outreach from G-STIC, our community has proved to be a strong foundation for launching Flemish climate projects in developing countries. We see once more than cleantech SMEs with international ambitions, as long as they do business responsibly and align their business objectives with the UN's Sustainable Development Goals (the SDGs), have the wind at their back. We are certainly looking forward to this year's call. In anticipation of this, we will give a few examples of some of the initiatives that have already been supported.

With **the Climate adaptation and mitigation for Uganda's rice sector project**, a collaboration between the NGO Rikolto International (formerly Vredeseilanden), the research institute AfricaRice and a major Ugandan vendor of rice is aiming to encourage sustainable rice production in the Central-African country. The project also aims to contribute to the maintenance of marshland in Uganda in doing so.

Rikolto, David Leyssens: 'Rijst voedt de wereld. Voor meer dan 3,5 miljard mensen over de hele wereld vormt rijst het hoofdbestanddeel van hun dieet. Helaas brengt dit grote milieukosten met zich mee. Rijstteelt is een belangrijke oorzaak van habitatverlies in moerassen en bossen; een derde van al het zoete water in de wereld



wordt voor rijstproductie gebruikt en de rijstteelt is verantwoordelijk voor 10% van de wereldwijde door de mens veroorzaakte methaanuitstoot.

Rice feeds the world. For more than 3.5 billion people around the world, rice is the staple of their diet. Unfortunately, this has a large environmental cost. Rice cultivation is a major cause of habitat loss in wetlands and forests; one-third of all the world's fresh water is used for rice production; and rice cultivation accounts for 10% of global man-made methane emissions.

The cultivation and processing of rice, which is the most important source of nutrition for 3.5 billion people all across the world, has a heavy impact on the environment. The cultivation of rice is a major cause of habitat loss in marshes and forests, and a third of all the fresh water in the world is used for rice production. The project aims to make sustainable forms of rice production the norm in Uganda. In the short term, this will encourage more than ninety thousand farmers to apply the new cultivation and processing methods, thereby raising their productivity and reducing their climate impact.

With **Kericho**, Rietland, a Flemish developer of water purification systems, is aiming to expand an existing water purification facility in Kenya to include a wetland for aeration and a membrane infiltration unit. The aim? To demonstrate that it is possible to reuse the purified wastewater for the irrigation of fields or even as drinking water. It should increase the dependence on precipitation and thus the drought resilience of the area around the facility – the region of Kericho. Alongside local Kenyan partners, the University of Ghent is also working on this project.

The aim of the **Optimis** project is to standardise the monitoring of greenhouse gas emissions from rivers and to develop affordable ways of applying this and getting to grips with it in developing countries. The monitoring techniques are being locally taught and tested in various river basins in a wide range of climate systems, from Vietnam through Ecuador to Ethiopia. The University of Ghent is collaborating with the international advisory and engineering agency Antea Group to do so. The project results will also be used to develop strategies for reducing greenhouse gas emissions from rivers, along with local partners.

EmPOWERing high-IMPACT users by OPTIMISING clean energy grids is a project that aims to develop a mini-grid in Kenya. This will connect five hundred households, ten schools, ten companies and several hospitals. The network will be powered by electricity generated through hydropower. Not through large flood-control dams, but instead with hydropower turbines placed in small rivers. These turbines are small enough to have no impact on the rivers' ecosystems. The mini-grid should supply sustainable, reliable and affordable power to a rural community. This project is being led by Turbulent, a Flemish developer of small hydropower turbines.

Turbulent: "Decentralized hydropower, inspired by nature for nature"



DIETRICH VAN DER WEKEN
General Manager G-STIC



FRANS SNIJKERS
Director Cleantech Flanders



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**WE
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FIT'S SCIENCE & TECHNOLOGY TEAM: A GLOBAL NETWORK

Flanders Investment & Trade has ten Science & Technology Offices spread across the globe. As connectors, they put technology companies from Flanders in touch with the right partners in their geographical focus area. They also attract foreign players to invest in our region. This reinforces Flanders' position as a tech region on the world map.

There are ten Science & Technology Offices globally: in New York, Palo Alto, Paris, London, Copenhagen, Munich, Mumbai, Singapore, Guangzhou and Tokyo. Each S&T Office is responsible for a geographical focus area and lays an emphasis on one or more of three focus areas: digital tech, health tech and climate tech.

These FIT offices aim to reinforce Flanders' position as a tech region on the world map. This can be done by putting technology-driven companies from Flanders in the various geographical focus areas in touch with the right partners, thus giving them an edge in foreign markets. But also the reverse, by attracting foreign players and persuading them to invest in our region. In particular, this involves technology-driven players that can complement and enhance the innovative and economic fabric of Flanders. Lastly, the offices also connect Flemish companies, research centres, entrepreneurial organisations, incubators and accelerators with foreign players – the latter may be in the same sector, prospects, partners, distributors, potential investors, venture capitalists or just human talent.

A TALENTED TEAM

That human talent is, of course, crucial for the proper operation of the S&T Offices too. The Technology Attachés (TAs), along with the Science & Technology co-ordinator, play a crucial role in FIT's tech mission. They build up an extensive network of foreign tech companies, venture capitalists, knowledge and research centres, clusters, incubators, accelerators, etc. This way, they create new connections to the Flemish ecosystem.

Our S&T Offices welcomed three new climate tech attachés last year:



KIM DEMEYER
Technology Attaché
in Singapore



RALPH MOREAU
Technology Attaché
in Palo Alto



MAARTEN LAMBERT
Technology Attaché
in Copenhagen



From 1 March 2022, a climate tech deputy will start in Mumbai with a focus on India. For the full TA team, you can visit the FIT website.

<https://www.flandersinvestmentandtrade.com/nl/strategie/tech-makes-flanders-tick>



FILIP DE WEERDT
Science & Technology Coördinator in Brussel

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WE SPREAD

MADE IN BELGIUM: OUR OFFSHORE WIND ENERGY IS BOOMING

Although only a small piece of the North Sea is in our possession, this country is a front-runner in the production of offshore wind energy. This is down to strong and innovative companies, as well as a government that is fully behind the 'offshore' route.

As of last year, Belgium had racked up a total of nine wind farms in the North Sea, together accounting for a capacity of 2.26 gigawatts. 399 wind turbines generate electricity to meet the demand of 2.2 million households.

Since the connection of the first wind turbines in the Belgian North Sea in 2009, offshore wind energy has developed at an unbelievable pace. The Seastar, Mermaid en Northwester II parks that were completed in 2020, host turbines with a power of 8,4 to 9,5 MW. For comparison, the turbines on Belwind and the first phase of C-Power, installed in 2009, have a power of 3 to 5 MW. The technological progress has thus been keeping pace.

CRUCIAL LINK IN ENERGY TRANSITION

Thanks to economy of scale and the building up of experience, the manufacturing costs for turbines and the installation costs for wind farms have also dropped over that period. Indeed, according to the International Energy Agency, wind energy, both onshore and offshore, has been a competitive energy source in Europe since 2020. It can generate electricity at a price comparable price to gas or nuclear power stations. But the drop in costs has not yet ended. According to sectoral organisation WindEurope, the costs per megawatt hour supplied will fall again by almost half over this decade.

The federal government, that is authorised for offshore activities, recently confirmed the trust in off-shore wind energy and increased the ambitions for creating a second zone in the Belgian North Sea. This Princess Elisabeth Zone is intended to deliver 3.5 gigawatts of extra capacity by 2030. It will turn our North Sea into a climate-friendly energy station with a capacity of almost 6 gigawatts, making it a crucial link in the energy transition.

But before that second zone can become fully operational, policy-makers and developers of wind farms are facing a few more challenges. After all, the construction and operation of an offshore wind farm remains a complex and capital-intensive exercise, in which any uncertainty will push up funding costs. This is why a clear and stable policy framework is needed. Any delays in the enhancement of the infrastructure needed to bring the power generated at sea to the consumer on land also need to be avoided to the extent possible, as these pose a risk to investors.

Offshore wind energy has been given a major role in the European Union's ambition to be climate-



neutral by 2050. The European Commission recently proposed quintupling the total installed capacity to 60 gigawatts by 2030, and to 300 gigawatts by 2050. Other European countries that have traditionally performed well in wind energy, such as Denmark, Germany, the Netherlands and the United Kingdom, are also planning further developments in the North Sea. In addition, new markets are opening up in France, Poland, Lithuania and Greece, among others.

BELGIAN OFFSHORE EXPERTISE IS CONQUERING THE WORLD (SEAS)

Various large companies from this country have since gained a pioneering role in offshore wind energy. In addition, an ecosystem has arisen of innovative SMEs that are active in 'offshore', such as in terms of maintenance and cabling for wind farms or in equipment for turbines. Parkwind, which built four of the eight Belgian wind farms, is currently active in Germany and Ireland. DEME's offshore division is also working as a maritime service provider in several projects in Germany and France, among others, as well as in China and Taiwan. In the same sector, Jan De Nul is busy constructing a wind farm in Denmark. Also in Denmark, Deme is a member of a large consortium that is a candidate for constructing an energy island there. Belgian companies are active on the other side of the ocean too. Both DEME and Jan De Nul are involved in the construction of Vineyard Wind, the first commercial wind farm in American waters.

This means our companies are succeeding in converting the expertise built up in offshore wind energy into major global projects. At the same time, the federal government is ensuring that the potential in our own North Sea is seeing maximum utilisation.



ANNEMIE VERMEYLEN
Secretary-General Belgian Offshore Platform

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WE CONNECT

Cleantech Flanders continuously builds the Flemish cleantech community and offers a platform for promoting and stimulating innovation and accelerating implementation of clean technologies in society. Amongst others by overviewing the ecosystem, we can bring partners in touch with like-minded actors in our community.

A transition to 'circular' tailored to Flanders



10 jaar EIT InnoEnergy: katalysator voor de energietransitie



10 years of climate innovation in Flanders



The future is looking blue for Flanders too





A TRANSITION TO 'CIRCULAR' TAILORED TO FLANDERS

Flanders is among the leaders in Europe in the transition to a circular economy. This is already making itself felt in practice in a range of different sectors. Not least in waste processing.

Global warming is not just an energy problem. On the contrary, the extraction of raw materials and the transport, production and use of materials and goods account for 60% of global greenhouse gas emissions. The sustainable management of our planet's material resources is therefore crucial. And this management requires circular economic strategies and applications. It is no exaggeration to say that the transition to a circular economy is also a transition to a more liveable planet. This is in strong contrast to an economy based on business-as-usual, where the use of the earth's natural resources continues unabated.

STEPPING UP THE EFFORTS

Flanders has understood the stakes. 'Circular' here is no longer just an idea or a theoretical concept. It is already being put in practice in a wide range of different sectors. All thanks to the many stakeholders developing circular solutions, helping scaling them up, bringing them to the market or - on the other side of the economic spectrum - putting them into use. Some of these solutions are cleantech innovations: these are products and services driving forward the still fledgling circular economy in Flanders. When it comes to 'circularity', Flanders is in the European vanguard. It can only maintain its leading position by stepping up its efforts.

Flanders may be a relatively small region, but it is very strong in economic terms. It owes this strength in no small part to its geographical location and the major ports that make Flanders a logistical hub for primary raw materials, semi-finished and finished products. At the same time, there are various opportunities to make the economy circular.

Flemish companies are getting better and better at creating so-called 'added circular value'. They do this by designing products smarter, so that they can be easily repaired, upgraded, disassembled or transformed into other, new products. The materials used come from recycling or have bio-based origins. And of course, they are also recyclable or biodegradable when the products reach their end-of-life.

When is an economy circular? When is it circular enough? The second question is difficult to answer, because the more circular, the better. But 100% circularity simply goes against the laws of nature. Nevertheless, that is no excuse for lowering the ambitions. For example, Flanders intends to reduce its materials use by 30% by 2030 (compared to 2010). It is a challenging resolution, and it is also clear. The latter aspect is important, in order to get as many stakeholders as possible on board, and give them the opportunity to fully familiarise themselves with the circular world. Circular Flanders, the Flemish government's support centre for the circular economy, is facilitating and closely monitoring this transition.

THEMATIC AGENDAS

Circular Flanders was set up in 2017 as part of the Public Waste Agency of Flanders (OVAM). The public-private partnership is steered by around 20 organisations: governments, companies, research and financial institutions and civil society organisations. It simultaneously acts as a hub, matchmaker and source of inspiration for the



Flemish circular economy. In the early years, Circular Flanders primarily focused on raising awareness and forging early partnerships between relevant stakeholders. But it also supported pilot projects and initiatives for more knowledge creation.

Once the groundwork was done, the focus shifted to scaling up circular innovations and familiarising organisations with the 'circular' ethos. Since last year, the public and private partners within Circular Flanders have been working closely together within specific 'Thematic Agendas', which focus on concrete milestones and goals. These Agendas are tailored to Flanders: they focus on the aspects in which our region excels: circular construction, circular chemistry and plastics, water, bio-economy and the food and manufacturing industries. 'Acting in a circular way requires intensive cooperation' is the maxim that links the various agendas. Each Agenda has a public and a private leader, complemented by a community of relevant stakeholders. Working together in co-creation, they ensure that circular strategies and applications are incorporated as much as possible in the specific thematic fields.

Cooperation within the Thematic Agendas will be further enhanced in 2022. There will also be an even stronger focus on concrete action. Nevertheless, the door remains open for stakeholders who are interested but not yet involved. Circular Flanders will also work closely with various expert groups to remove the obstacles in the transition to a circular economy and make faster progress. The levers it uses in this regard a legal and fiscal framework, financing of circular strategies, circular procurement procedures, research and innovation, new business models and jobs and skills in the emerging circular economy.

The Circular Flanders team is predominantly a facilitator for cooperation in the 'circular' domain. At the same time, the Circular Economy Policy Research Centre, together with VITO, provides scientific underpinnings. This is complemented by a so-called barometer to monitor progress in the 'circular' domain. The Flemish CE Monitor was launched on 22 November 2021, with around a hundred indicators showing the impact of all the efforts towards the circular transition on the Flemish economy and society.



BRIGITTE MOULIGNEAU
Transition Manager at Circular Flanders



THE 'DEMOLITION GUIDE' (SLOOPWIJZER) TOOL PROVIDES AN OVERVIEW OF MATERIAL STOCK

Flanders wants to reduce its use of materials by 30% by 2030. Circular construction can contribute to this by reusing or recycling materials and raw materials from demolished buildings as much as possible. To facilitate this approach, VITO developed the 'Demolition guide' (Sloopwijzer) tool to smarten demolition. The tool estimates the material stock of a building, district or entire city or municipality. For example, the tool provides insight into which materials and raw materials (and in what quantities, weights and forms) go into and out of a given area. Such concrete information is precisely what is needed for sectors like waste processing and recycling, as well as construction and the transport sector, to encourage entrepreneurship with a more circular approach. That way, the companies in these sectors know what to expect, so that they can focus their activities accordingly. The 'Sloopwijzer' tool works on the basis of images of house and building façades taken from the street, for example by Google Street View®. Artificial intelligence is applied to these images to recognise specific construction elements such as windows and window profiles, as well as specific materials. The tool was rolled out in the city of Leuven last year and works semi-automatically. Some human intervention is necessary for selecting the images in the tool software, but after that everything runs automatically. The tool's ultimate output indicates how much of a given construction element or material is present in a building.

To obtain an aggregated result for a 'scanned' area and find out how the exact quantities of construction elements and materials are distributed across the local building stock, however, further development is needed. This information may be of interest not only to the above-mentioned businesses, but also to policymakers. Policymakers can then use it as a basis for market economy studies for renovations.

80% RELIABLE

In the coming months and years, the 'Sloopwijzer' tool will be further fine-tuned. There is still some room for improvement. There is a considerable technical challenge: façades of houses or buildings need to be clearly visible, for example, and this is often not the case due to parked cars or trees. In addition, the algorithm being trained on thousands of images of construction elements and materials through deep learning is not perfect. At present, the reliability of the tool is between 80 and 90%. This means an average of 10 to 20% of detections are still errors.

Using street images is therefore an asset for the 'Sloopwijzer' tool. Indeed, besides Google Street View®, cameras can be used on vehicles that frequently pass through streets in any case, such as bin lorries, Post Office bikes and cars, and public transport.



YOKO DAMS
Research team lead

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10 YEARS OF EIT INNOENERGY: A CATALYST FOR THE ENERGY TRANSITION

To become climate-neutral by 2050, Europe's energy supply needs to be decarbonised as effectively as possible. In the coming decade, the EIT will therefore continue to stimulate and accelerate much-needed cleantech innovations to achieve this.

Over the last 10 years, the energy community of the European Institute of Technology (EIT) has funded the development of a strong and extensive network of organisations (companies, research institutes but also educational institutions) that are helping to shape the energy transition in the EU. In this way, by bringing people and resources together, EIT InnoEnergy is stimulating and accelerating innovations that bring a climate-neutral economy and society within closer reach. New ideas, products and services that make a real difference are emerging from the community. And it is becoming fertile ground for (new) companies and people to successfully bring these innovations to the market.

AN IMPRESSIVE PORTFOLIO

As a catalyst for cleantech innovation, EIT InnoEnergy is not only contributing to the transition to carbon neutrality by 2050, but is also ensuring sustainable economic growth and employment, strengthening European competitiveness and ensuring a secure energy supply.

In the past ten years, fully 480 innovations have been realised and brought to the market. This was often accomplished by innovative cleantech start-ups - indeed, InnoEnergy's start-up portfolio is one of the largest in the world. Bringing innovations to market has been stimulated, inter alia, by de-risking business cases and shortening the time-to-market.

The European Battery Alliance (EBA) was set up by InnoEnergy in 2017 with the aim of bringing together all stakeholders involved in the battery value chain - from the extraction and processing of basic raw materials to recycling - and initiating joint projects. Indeed, control over the battery value chain, including through a dedicated battery industry, is vital for Europe. Not only for the transition to a sustainable energy supply, but also for the competitiveness of the industry. The collaboration has already borne fruit, as evidenced by the recent start-up of the Northvolt 'gigabattery' plant in Sweden.

The success of the EBA left InnoEnergy hungry for more. This led to another initiative being set up: the European Green Hydrogen Acceleration Center (EGHAC). This centre focuses on innovations that help green energy-intensive (and hard-to-sustain) sectors such as the steel and cement industries. In the flagship H₂ Green Steel project, the EGHAC is bringing together relevant partners to establish an economically viable value chain for carbon-neutral, 'green' steel. This is done by the partners through intense cooperation in which the benefits, but also the risks, are shared.

Another example of industrial cooperation that has emerged from EIT InnoEnergy is the European Solar Initiative (ESI). This aims to redevelop (or more accurately, resurrect) a strong solar cell industry in Europe, once again for the entire value chain. The industry needs to help the EU install around 20 gigawatts of new solar power capacity

every year in the coming years.

It is clear that decarbonising the energy supply will not be possible without innovation. In this regard, EIT InnoEnergy is focusing on strategic industrial value chains, among other things. And it will continue its efforts in this regard.

ALSO IN FLANDERS

EIT InnoEnergy has also been very active in Flanders over the past decade. One striking success was the Genk-based start-up Act&Sorb. This company developed a sustainable and high-quality process for recycling wood waste, such as MDF. It involves upgrading the waste to activated carbon, which can then be used in filters for air, water and soil cleaning technologies. What started out as a rough-hewn idea a few years ago has now developed into a large-scale production facility.

Another innovative Flemish start-up in EIT InnoEnergy's portfolio is The eCloud Company in Jabbeke. This company developed a now patented system for authenticating electric vehicles and power sources for charging them. EV users can plug their vehicle into any (standard) power outlet, and smart software will calculate the power consumption and handle the payment. This is giving a boost to the roll-out of electric mobility. In 2022, EIT InnoEnergy will continue to look for new start-ups to help them realise and, above all, market their innovations. And in the meantime, the community is also building for the future by training young people. Over the past 10 years, students from more than 100 countries have been updating their knowledge on energy innovation at the EIT InnoEnergy Master School. More than a thousand graduates are now working in key positions in the European energy sector.



JACOB RUITER
CEO voor de Benelux bij EIT InnoEnergy

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10 YEARS OF CLIMATE INNOVATION IN FLANDERS

The EIT's climate innovation community brings together hundreds of organisations to draw on innovation, often in the field of cleantech, to tackle global warming and safeguard Europe and the world from its consequences. In Belgium too, a highly diverse community is working on various initiatives aimed at systemic transformation.

The Climate-KIC (Knowledge and Innovation Community) of the European Institute of Technology (EIT) has supported over 4,500 companies in more than 50 countries in and outside the EU in their ambition to use innovation - whether in technology, policy, finance, civic engagement or social aspects - to make the economy and society climate-friendly while safeguarding it from global warming. This is without losing sight of important aspects such as social justice and inclusiveness.

Ultimately, the goal of EIT Climate-KIC is to contribute to the much-needed paradigm shift from a linear system of industrial production to a circular, regenerative model. This will be achieved by drawing on the knowledge and expertise of more than 400 organisations (large and small companies, governments, knowledge institutions, NGOs). For example, EIT Climate-KIC intends to help bring about much-needed innovation and disseminate it throughout the community and beyond.

The climate innovation community is also very active in our country. We can highlight four recent initiatives in this regard.

Climathon is a global programme that offers cities the opportunity to take highly concrete climate action. It was launched within EIT Climate-KIC from small groups of entrepreneurial and action-oriented citizens from different cities. They prepared a brainstorming exercise on local climate and sustainability challenges, with the aim of addressing them in highly concrete terms through innovative solutions.

In Leuven, citizens came together for 48 hours to look at five challenges on different themes, ranging from renewable energy supply in buildings to zero-emission urban transport to the fight against food waste.

ClimateLaunchPad is the world's largest competition for green business ideas. The aim is to tap into the potential of cleantech ideas in the fight against global warming. In recent years, 15 companies (primarily start-ups) from Belgium have also taken part in the competition, not without success.

CO₂ElectroRefinery is developing a production platform to use CO₂ as a basic building block for high-end organic chemicals. The start-up is aiming to create an industrially relevant bio- and electrochemical system that can convert CO₂ from flue gases into hydrocarbons and other organic components.

Health-e-Move is developing an app to assist users in their transition to more active outdoor mobility modes such as cycling and walking. The app works by presenting the benefits of these modes in a personalised,



science-based way. Users gain insight into the air quality but also into their health benefits through physical exercise.

Smart up my water is aiming to make 1/5 of the existing hot water boilers in Flanders 'smart' by 2026, without the owners or users having to pay for it. The advantage of a smart boiler is that it can automatically use the surplus from the generation of renewable energy - for example, from solar panels on the roof.

ClimAccelerator is a global initiative that supports start-ups in developing, accelerating and scaling up climate innovations. The 'accelerator programme' works both thematically and locally. In recent years, various Flemish start-ups have also taken part, often with success.

Faro 360 supplies small recycling plants for plastic waste in developing countries. The initiative provides local training in waste management, organises awareness campaigns and clean-up operations, and maintains a global network for cooperation and exchange of knowledge and expertise.

Staenis BVBA has developed an affordable building product that can be used for the construction of sustainable, circular floors.

Sumaqua provides customised advice and solutions for water management, for watercourses but also for cities, agriculture and industry. The provided service is based on a combination of big data, smart monitoring and state-of-the-art modelling.

Strategic water offers solutions for water and other cleaning technologies based on machine learning. This allows the technology to work more efficiently: more cheaply and with fewer emissions.

Deep Demonstrations are large-scale projects that in turn are thematically or locally inspired. Leuven is one of 15 European cities participating in the Healthy, Clean Cities theme. The city has drawn up an ambitious roadmap to become climate-neutral by 2050, with key interim milestones in 2025 and 2030. This is not something for the future, as participation in the EIT Climate-KIC project has already borne fruit. For example, the number of inhabitants using a bike instead of a car has increased by as much as 44% in the past year.

"By connecting local innovations to global demand and the other way around, EIT Climate-KIC offers opportunities to jointly scale, experiment and learn to accelerate the transformational change needed for climate. I am happy to see Belgium partners being actively involved therein"



SAVITRI GROAG
Head of Innovation Benelux - EIT Climate-KIC

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THE FUTURE IS LOOKING BLUE FOR FLANDERS TOO

The blue economy, as it is known, now accounts for over five percent of Flanders' gross domestic product. This makes it just as large as the chemistry or food sector. As a Flemish government spearhead cluster, Blue Cluster is encouraging 'blue' innovation and the valorisation of this, in Flanders and Belgium as well as internationally.

Since it was established in late 2017, Blue Cluster has been the preferred partner for companies wishing to develop innovative ideas in the sustainable blue economy, i.e. sustainable economic activities linked to the sea and the ocean. We are supporting these companies first and foremost in a strategic sense, by developing highly detailed roadmaps along with them and the other partners involved in our operation. This way, we are reducing the risks involved for them in innovation, and we are doing so by focusing on various domains. It is of course helpful that we can also support companies financially as one of the Flemish government's official spearhead clusters. Alongside Flemish resources (from Flanders Innovation & Entrepreneurship), we also help with funding requests aimed at federal, European or other subsidy providers.

NEARLY TWO HUNDRED MEMBERS

Central to our operation is the cluster in which companies – large and small, and often in competition with one another – come together. Consortia are formed in which innovations can flourish through match-making. At present, we have nearly two hundred members, and that number is steadily growing. No less than 118 of them are SMEs. Besides companies, all Flemish universities and major knowledge institutions are also members of Blue Cluster. Naturally, we are also a strong and reliable partner for the government, at any policy level. It is precisely the interaction with the government, citizens, companies and the world of academia & research that has enabled us to achieve our ambitions in the sustainable blue economy.

When referring to the blue economy in Flanders, we are of course looking to the North Sea in the first instance. The surface area of our territorial waters is limited. We therefore argue for making optimum use of the available space. This can be done by combining wind farms with floating solar panels, for example. Nonetheless, the possibilities for growth in our part of the North Sea are limited, which is why we expressly opt for internationalisation. To this end, we have at our disposal an intrinsic knowledge of the markets in which our companies are developing and where their future opportunities lie – in 'our' North Sea or beyond.

PIONEER IN OFFSHORE WIND ENERGY

Our activities range across six areas: coastal protection and use of mineral resources, sustainable seafood & marine biotechnology, maritime connection, renewable energy & freshwater production, ocean pollution & waste solutions, and sustainable blue tourism. The central threads running through all these areas are our ecosystem approach and a concept we call 'smart sea'.

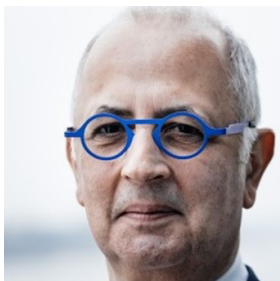
A sustainable blue economy implies that we resolutely opt for ecological, economical and social objectives for



blue growth. After all, without a healthy ecosystem, no sustainable economic activities will be possible. At the same time, we are in search of applications for digitalisation and other smart technologies, such as innovative measurement and regulation techniques, ingenious computer models or advanced drones. This way, we help achieve the UN's Sustainable Development Goals (the SDGs).

One of the areas in which we are definitely playing a pioneering role is that of offshore wind energy. At present, there are nine wind farms in our North Sea, the oldest dating from 2009. Together, they account for a capacity of 2.3 gigawatts, and with the new Princess Elisabeth Zone to come, this will even be 5.6 gigawatts by 2026. This puts Belgium in fifth place worldwide as regards installed capacity. It is also thanks to this pioneering role that one in three offshore wind turbines in the world has been installed by a Flemish company. Through our internationalisation strategy, we aim to retain that leading position, in part through innovation.

It should be clear: a large part of Flanders' future lies at, in or on the sea. The blue economy already accounts for 5.2 percent of Flemish GDP, and it provides work for 77,000 employees. This means it can contend with the chemistry and food sectors – two sectors that are traditionally viewed as stalwarts of the Flemish economy.



MARC NUYTEMANS,
CEO of Blue Cluster

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CLEANTECH HEROES: 3 LAUREATES 2021

To increase awareness about cleantech solutions, Cleantech Flanders introduced the first 'Cleantech Heroes' in 2021. Flemish companies within the network of Cleantech Flanders who develop and market innovative cleantech solutions can register to be selected as Cleantech Hero within their domain. The positive impact (in Flanders and beyond) of these cleantech companies must be clearly verifiable. The TRL level of their cleantech solution, the link to the SDGs and the company's potential to be an 'ambassador' of the Flemish cleantech in Belgium and abroad are a few of the selection criteria to obtain the prestigious Cleantech Hero label. Companies that win the award, gain momentum during a whole year. The Cleantech Heroes can wear the label for a full year and receive promotional support through Cleantech Flanders channels. Permanent jury members of this election are Dirk Fransaer (CEO VITO), Frans Snijkers (Director Cleantech Flanders) and Claire Tillekaerts (CEO Flanders Investment & Trade). For each category of the Cleantech Hero the permanent jury will be assisted by a number of guest jury members with expertise in the specific domain.



HEROES

	BOSAQ: Cleantech Hero Water technology	>
	THIOMATERIALS: Cleantech Hero Circular economy	>
	TURBULENT HYDRO : Cleantech Hero Energy	>



Cleantech Hero Water technology

In March 2021 BOSAQ, a company that develops innovative technology for decentralised drinking water purification solutions, was selected as the first Cleantech Hero Water technology. After an initial selection, three finalists were chosen: BOSAQ, Hydrovolta and InOpSys. In the end, the jury decided that BOSAQ was the perfect ambassador. In its report, the jury praised the company not only for its strong commitment to circular water use, but also for its attention to socially responsible entrepreneurship. BOSAQ donates at least 10 % of its profits to the non-profit organisation Water Heroes, which helps vulnerable local communities gain access to better sanitary facilities and clear drinking water. BOSAQ also takes care of technology transfer to the local population. It manages to combine sustainable objectives and corporate social responsibility (CSR). Its international approach and ambition and the fact that the company aligns its business goals with the SDGs strengthened its position.



BOSAQ develops innovative technology for decentralised drinking water treatment solutions. BOSAQ's systems transform any ambient water into drinking water in the most energy and operationally efficient manner. The projects are clearly linked to the SDGs of the United Nations. SDG 6 (clean water and sanitation) is central to this, but through the approach other SDGs such as quality education, health, innovation, sustainable energy, gender equality, etc. are also addressed. BOSAQ provides areas with decentralised drinking water with the highest quality guarantee with technology transfer to the local population and the establishment of a local economy to give the projects a long-term chance of success. A sustainable approach along the entire line of project/concept implementation.

www.bosaq.com



Cleantech Hero Circular economy

In this category 5 finalists were appointed: Circular Matters, Nuresys, Orineo, Resus and THIOMATERIALS. "We had to conclude that our five finalists scored very highly on many points", the jury stated. After deliberation, the jury elected THIOMATERIALS of De Bonte group as second Cleantech Hero laureate in June 2021. THIOMATERIALS specialises in the development of railway sleepers and sewage pipes from 100 % circular sulphur concrete.



THIOMATERIALS pioneered with railway sleepers and sewage pipes from 100 % circular sulphurous concrete. In sulphur concrete, cement and water as binding agents are replaced by sulphur that is completely circular. This eliminates the traditional heavy CO₂ emissions from cement and also avoids the use of precious water. The production is based on the physical process of melting and solidifying sulphur. Because this process can be repeated endlessly, the sulphur concrete can be reused endlessly as a primary raw material. This allows network operators to fully embrace circularity. When using sulphurous concrete, CO₂ emissions are reduced by approximately 40 % to 80 % compared to similar products made from traditional concrete, synthetic materials or ceramics. Thanks to the circular properties of sulphuric concrete, there are no secondary waste flows and both pipes and sleepers can be completely reworked into identical products without any loss of quality. Trial projects at Aquafin, Infrabel, De Lijn, SNCF and NS were successful and resulted in accreditations and quality marks. By using this sulphur concrete, Infrabel, for example, will reduce its CO₂ emissions by 6,000 tonnes through the already planned replacement of 200,000 railway sleepers with THIoTTRACK sleepers made from sulphur concrete.

www.thiomaterials.com



Cleantech Hero Energy

During this first year when Cleantech Heroes were selected, all the honour was given to Turbulent Hydro as the first Cleantech Hero Energy. The jury selected three finalists: Smappee, the Sniffers and Turbulent Hydro. Once again the jury was very impressed by the level of the candidates. However the choice of the jury experts went almost unanimously to Turbulent Hydro. "Turbulent has carefully chosen to develop a technology that is mainly suitable for countries in emerging economies and with a clear link to a number of SDGs. It highlights everything that a sustainable innovation project should be."



Turbulent Hydro changes the way new hydropower is developed. A Turbulent micro-hydropower plant requires no dams, no river impediments and no large infrastructure. The system needs only 1.5 metres of water height difference to generate energy. Therefore this technology results in a fish-friendly, low-maintenance hydropower plant that efficiently produces clean electricity 24h/7d/365d. Turbulent Hydro has large international potential and is already running projects in Chile, Taiwan, the Philippines, Indonesia, Congo, Thailand, Portugal, Estonia, Slovenia, France, the United Kingdom and, of course, Belgium. By installing distributed clusters of turbines, entire regions can be supplied with 100 % green, clean, stable and reliable electricity. Turbulent works together with nature, not against it. Turbulent Hydro also contributes to the SDG goal of affordable and clean energy (SDG 7), as well as to other SDGs, including those for water (SDG 6), resilient infrastructure (SDG 9) and climate change (SDG 13).

www.turbulent.be



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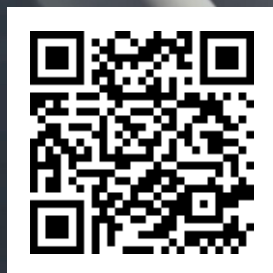
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