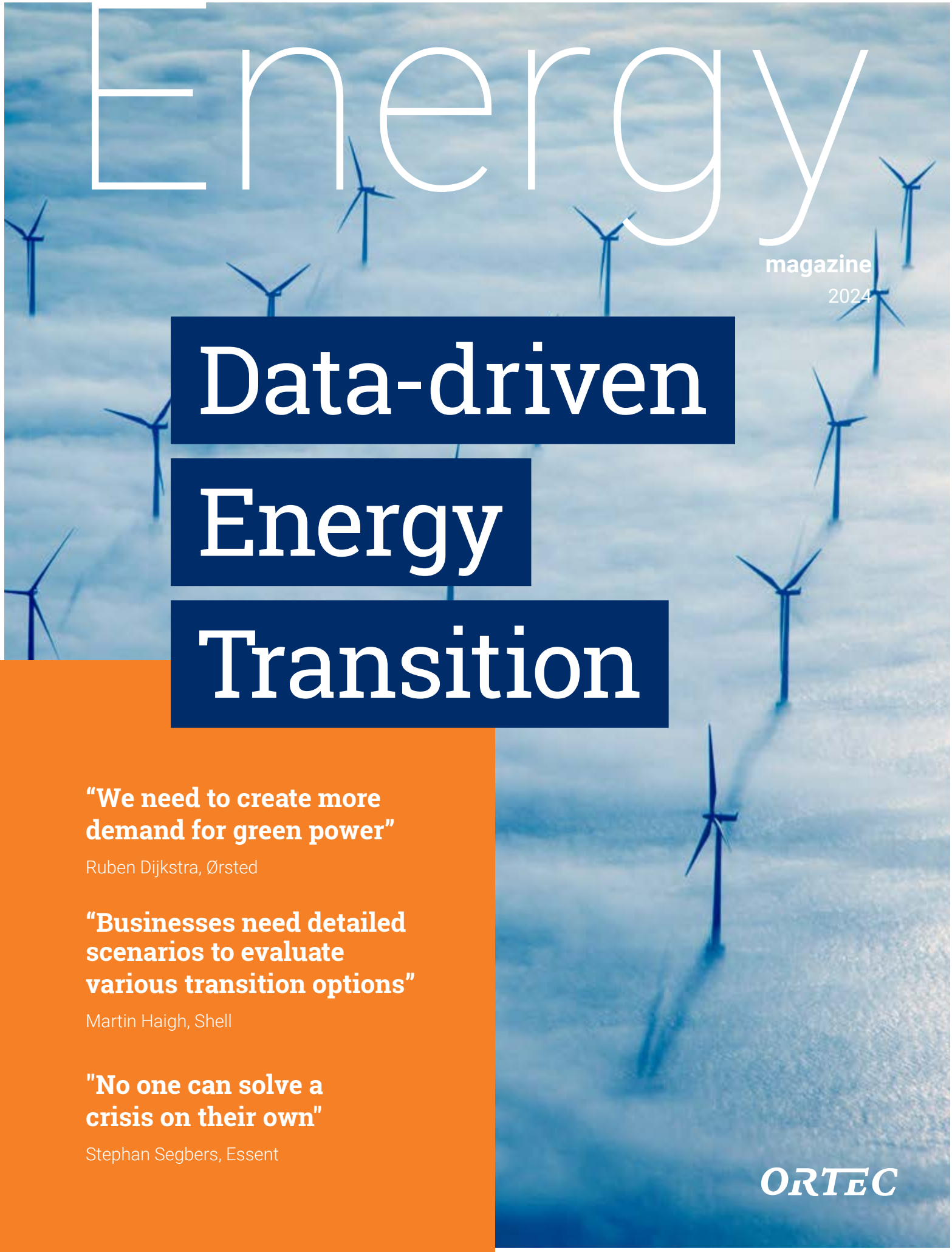


Energy

magazine

2024

Data-driven Energy Transition

“We need to create more demand for green power”

Ruben Dijkstra, Ørsted

“Businesses need detailed scenarios to evaluate various transition options”

Martin Haigh, Shell

"No one can solve a crisis on their own"

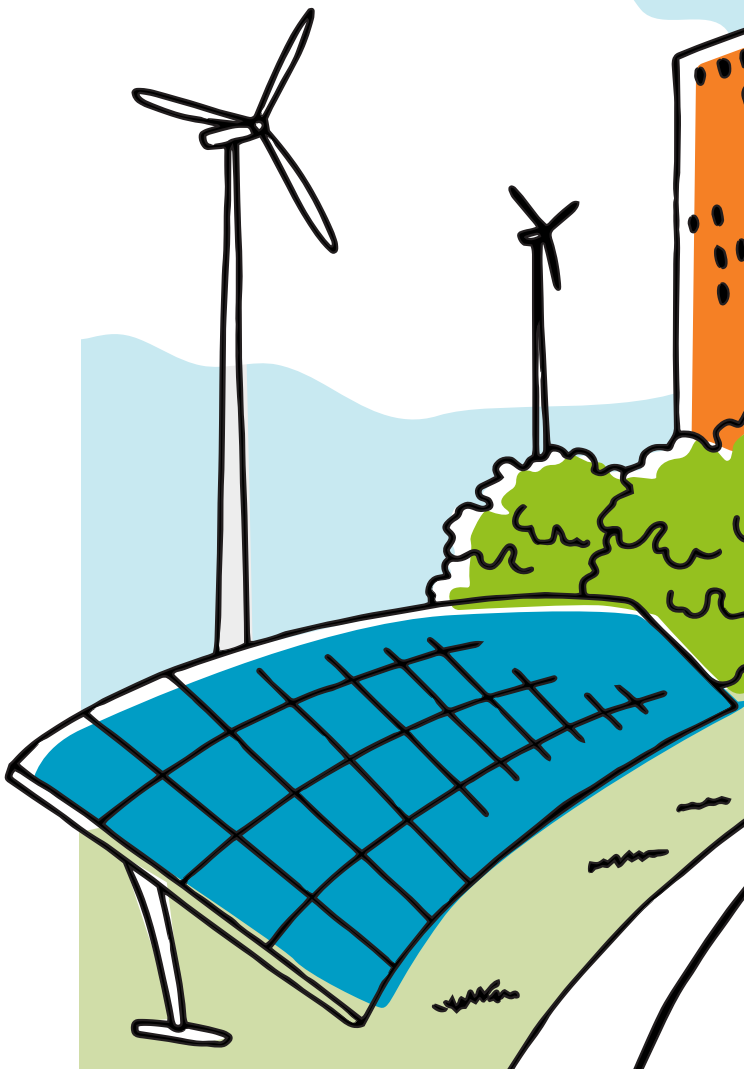
Stephan Segbers, Essent

ORTEC

MANAGAMENT SUMMARY

THE ENERGY TRANSITION: A JOINT CHALLENGE IN A COMPLEX PLAYING FIELD

In this special issue, we're taking a deep dive into the dynamics of the energy transition. It's a multi-faceted challenge, encompassing everything from international policy to finding the optimal location for offshore wind turbines and anticipating how the emergence of hydrogen will shake things up. Each facet is its own microcosm, and while not all interests overlap, there is one common goal: a green future. Math serves as our compass, our guide to navigate uncertainties. As Karin Griffioen, Global Industry Director Energy at ORTEC, puts it: "The energy transition is incredibly complex and requires us to rely on thorough analyses and models - because intuition does not always hold the answers. You can only make the right decisions with a calculated approach."



"Our energy infrastructure should serve the climate."

Ulco Vermeulen, Gasunie

Europe leading the pack

Mohammed Chahim, member of the European Parliament, believes that the EU can play a leading role in the future. He casts himself as a "pragmatic idealist", eager to find the most effective way to reach his goal. And Chahim has a clear goal in mind: the EU should be at the forefront of technological innovation while staunchly respecting human and social rights and fostering excellent environmental conditions. "Our turbines should be the gold standard. Not only should they be big and clean, but they should be just as durable and reusable, too. We should compete on innovation, not on costs alone." He stresses how important it is that governments invest in these technologies: "We have to be proactive and set up appropriate investment programs and funds."

> "We should compete on innovation, not on costs alone."
>
> **Mohammed Chahim, Member of European Parliament**

> "Strategic visions, underpinned by future scenarios, are essential for both companies and countries"
>
> **Lucia van Geuns, HCSS**

Working in unity to ensure security of supply

Lucia van Geuns, Strategic Advisor Energy at The Hague Center for Strategic Studies, emphasizes the importance of close cooperation between government and industry. She is an expert on the geopolitical aspects of energy security and is in favor of energy independence in Europe.

The underlying ambition of the Green Deal is to increase Europe's energy self-sufficiency. And yet, Van Geuns warns, fossil fuels will retain their dominant presence in our energy

> "The energy world is rapidly digitizing, and any future-oriented energy company should be strongly data-driven"
>
> **Stephan Segbers, Essent**

system in the near future. The speed of the transition to renewable sources will be largely determined by local factors. "Will solar and wind account for the lion's share of the world's energy mix in 2050? And to what extent will the share of fossil fuels have shrunk?"

Van Geuns argues that strategic visions, underpinned by future scenarios, are essential for both companies and countries. She emphasizes that the multi-faceted challenges accompanying the energy transition can only be overcome by taking a holistic approach.

Scalable and affordable

Ulco Vermeulen, former board member of Gasunie, a key player in the Dutch energy transition, welcomes the increasingly comprehensive spotlight put on the energy supply in the Netherlands. "The dialogue on energy sources and raw materials has become less superficial, and a more holistic approach is gradually emerging, focused on topics such as hydrogen and carbon storage." Vermeulen predicts that the climate will take center stage: "Our energy infrastructure should serve the climate."

Gasunie has set its sights on heat, green gas, hydrogen, and carbon capture and storage. Vermeulen believes that in the short term the latter holds the most promise. "Hydrogen is the future, but its impact will remain limited in the years to come, because it is yet to be made cost-efficient and scalable." Vermeulen also forecasts that data technology will be embraced at ever greater scales: "I expect considerable advances in data-driven coordination between hydrogen and electricity, laying the foundation for a new domain in which data becomes a crucial part of the decision-making process."

Increased demand for green electricity

Where hydrogen is likely to become a meaningful energy source for industry, wind power will undeniably continue to play a central role in our energy supply. Ruben Dijkstra, Director Benelux at Danish offshore wind pioneer Ørsted, believes that the pursuit of energy independence and climate preservation give ample reason to invest heavily in offshore wind. "Our goal is to get to 30 gigawatts of offshore wind capacity by 2030, up from the 22 gigawatts we currently have operational and in the pipeline." Dijkstra confirms that models and data are indispensable in his industry. "Before you decide to invest, you need accurate insight into the potential yield of a wind farm. This is a science in and of itself. We also have an arsenal of sensors and data to track how components behave, to analyze outages and to schedule preventive maintenance."

Wind energy supply is growing so rapidly that it will soon outstrip demand for green power, but Dijkstra believes that electric transport, heat pumps, and especially the greening of industry, provide opportunities to boost demand. To stimulate this development, the conversion of wind energy to other energy carriers like hydrogen is high on the priority list.

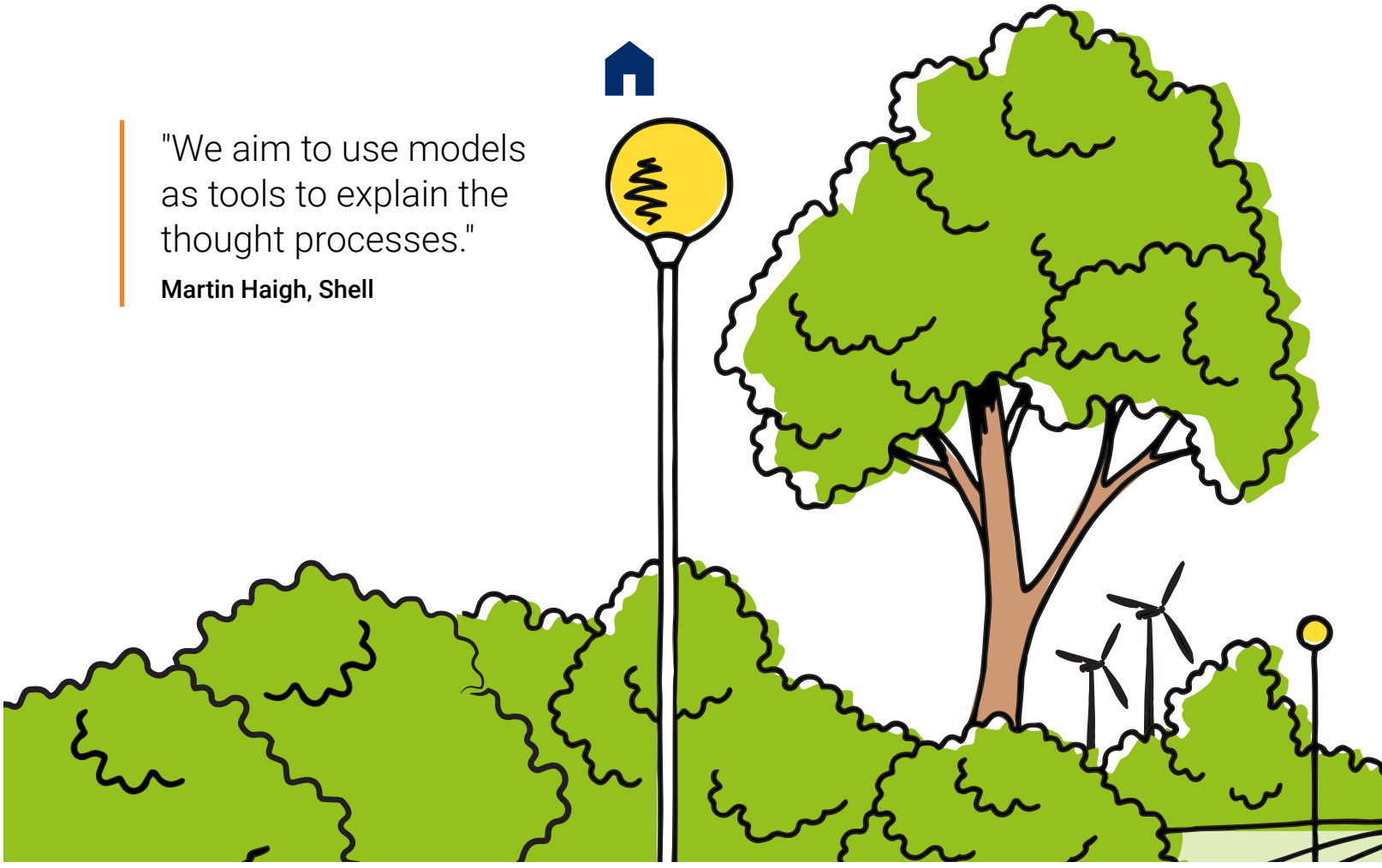
For Dijkstra, the speed with which infrastructure adapts to changing needs will be an important factor in setting the pace of the energy transition in general.

> "Before you decide to invest, you need accurate insight into the potential yield of a wind farm. This is a science in and of itself."
>
> **Ruben Dijkstra, Ørsted**

A pragmatic approach

Stephan Segbers, director of operations at energy company Essent, emphasizes the crucial role of reliability and security

> "We aim to use models as tools to explain the thought processes."
>
> **Martin Haigh, Shell**



of supply in his industry, and argues that sustainability fits that list perfectly. "Large energy companies have made the shift to sustainable business models, and the entire industry now understands that you need a sustainable business model for medium- and long-term success. How our B2C and B2B customers think about energy has been flipped on its head. A product that was once taken for granted has now captured everyone's attention, which will only expedite the energy transition."

If Segbers had his way, companies would devise robust future plans for the transition. "We have to be more adaptive and more flexible, we have to be quicker on our feet. The energy world is rapidly digitizing, and any future-oriented energy company should be strongly data-driven. A fundamental understanding of energy markets and systems will remain key but must be complemented by cutting-edge knowledge of IT and data, as well as a holistic view of how to combine products and solutions, and the interaction between the two."

Transparent models

Martin Haigh, Energy Fundamentals Manager at Shell, is an expert on energy scenarios. He employs sophisticated models that factor in uncertainties and are aimed at sparking discussions and exploring diverse future perspectives.
One of Haigh's core challenges is to capture the transitioning of the energy system. "How do you model the energy system through a transition? That raises a debate about what lessons from the past we can rely on. In statistical terms: what relationships would persist, what parameters could you even rely on, and what is up for change?"
Haigh has helped develop an extensible model that is capable of simulating various processes. In an era marked by the increasing availability of data, he stresses the importance of transparency. "There's a danger that modelling becomes a black box, with people blindly accepting – or rejecting – the outcomes without questioning the assumptions behind them. We aim to use models as tools to explain the thought processes."

Haigh is a firm believer in the key role that governments and companies have to play in the energy transition. "The market leaders of the future are the companies that take the initiative and demonstrate innovation, both in business models and technology. The major challenge, for organizations like Shell and the system at large, is scaling solutions quickly."

> “Models are an essential tool for testing our intuitions and assumptions, providing a calculated basis for decision-making.”
>
> **Karin Griffioen, ORTEC**

Sound analyses provide guidance

Karin Griffioen, Global Industry Director Energy at ORTEC, discusses the use of solid analyses in the energy transition: “Models are an essential tool for testing our intuitions and assumptions, providing a calculated basis for decision-making.” She argues that while we build our new energy system, we should ensure that fossil fuels are used efficiently. “Mathematics can be a valuable tool to achieve this, for example by designing and operating an efficient fuel network.”

Griffioen points out how mathematics can help people reckon with complexity and manage uncertainties, e.g. when expanding energy grids and storage facilities. She also stresses the importance of math for planning investments, given the long lifespan of the assets involved and the myriad forms of uncertainty that must be taken into account.

Different perspectives, one route

Clearly, the energy transition is a comprehensive issue that touches on a wide array of different parties, each of whom must protect their own interests. Nevertheless, there is common ground to be found in a shared goal: a sustainable future. And the support of sound data analysis and smart mathematical applications makes pursuing this shared goal easier.

We hope you enjoy reading this special edition on the role of data and mathematics in the energy transition.

The ORTEC Energy team

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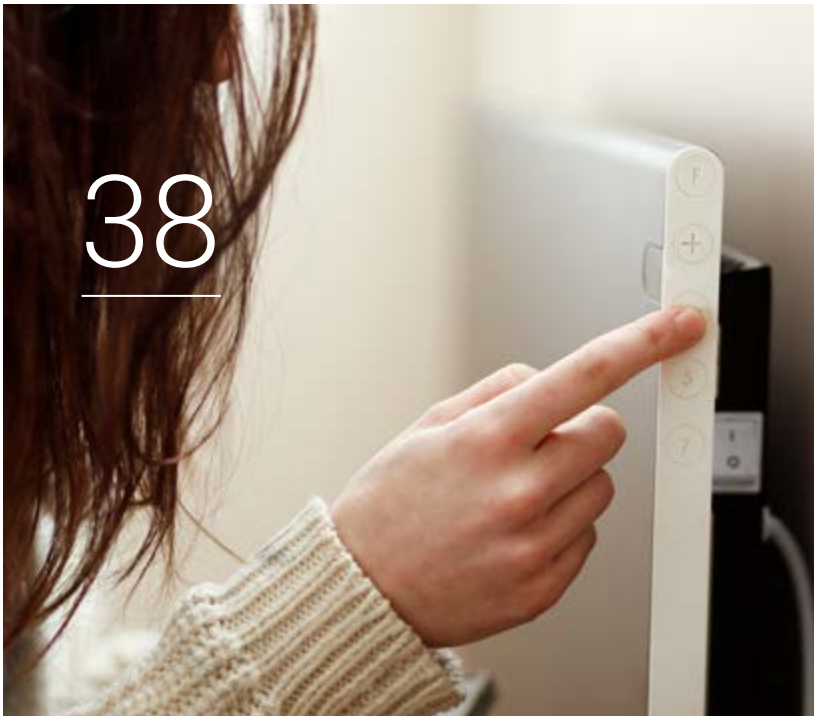

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The exit of the opera

When asked what scenarios mean in Shell's world, Haigh responds: "The official answer is that scenarios are alternative futures. There are different ways of representing uncertainties concerning the future."

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POINT OF VIEW

MATHEMATICS IN THE ENERGY TRANSITION

Karin Griffioen, Global Industry Director Energy at ORTEC, is a staunch believer in the added value of mathematics in the energy transition: “Putting mathematics to smart use can make all the difference in solving all sorts of problems. The energy transition is a complex challenge because of the myriad actors involved, the inherent uncertainty, the long-term scope and the sensitivity of the topic. Solutions should be backed up by models, because gut feelings on this topic may not always be correct. It’s paramount that we provide decision-making tools based on sound analysis. I’m not saying that models will automatically churn out the right choice, but they can hand options to the people in control. Hopefully, they will come to see more and more how important models can be.”

"WE'RE WELL EQUIPPED TO RECKON WITH COMPLEXITY"

Much remains to be done if we are to be ready for the transition, and Griffioen advocates a realistic approach in the interim: "We have to buy the time needed to get the system in order. The industry is rife with different perspectives, and many different actors all of whom have their own part to play. ORTEC's vision is to support the energy system of the future with the help of mathematics, while also explicitly supporting the current energy system for as long as it is still needed. This is a deliberate choice. At the same time, we are also committed to stimulating the transition between the two systems. The new system is yet to materialize and it will take some time to build. For now, we cannot do without fossil fuels yet, but while we're forced to depend on them, we had best use them as efficiently as possible to buy the time we need to build and integrate a new energy system. Mathematics can be a valuable tool to achieve this, for example by designing and operating an efficient fuel network."

The problems we face are multifaceted and multi-tiered, Griffioen argues. On the one hand, the design of the new system poses major strategic issues , such as when building wind farms and when integrating hydrogen in the energy chain. On the other hand there are a large number of more specific issues such as optimized utilization of your fleet during the transition to zero-emission mobility.

> "Complexity should be addressed with a well-grounded method, with data and analyses, not with a gut feeling."

> "A fleet of less than ten cars gives you more than ten trillion choices per day, considerably more than any human being could contemplate."

Complexity in the transition

For Griffioen, it is a general rule of thumb that as things grow more complex, it becomes more important to approach them with systems that can handle this complexity. "You need a well-grounded method, data and analyses, not a gut feeling. These analyses are especially complicated in the energy industry, which is characterized by significant uncertainty and long-term horizons. Investment decisions span dozens of years. Assets in the energy industry, from power plants to wind farms, have a lifespan of several decades, and we will have to make decisions about these assets during the transition phase." Regardless of what form the new energy system will end up taking, overall electricity use will go up and Griffioen warns that "it is essential that energy grids be able to cope, even in areas that are currently underdeveloped. Seeing as renewable energy sources are typically more intermittent, we will need to be able to store energy. Grid operators are already working on reinforcing grids and enhancing their storage capacity and they would do even more if they could. The question remains: how much should you invest, when should you make your move, and what locations are best? Mathematical models are excellently suited to this type of asset investment planning. Incidentally, the same questions apply to heat and gas grids. Moreover, since these types of energy are all mutually convertible, the accompanying investment challenges can best be tackled holistically, which we are currently researching."

Mathematical models can capture uncertainty

The long-term horizons and the inherent uncertainty of the energy transition make it a particularly complex affair. "No matter how you spin it, the energy transition will take decades. In addition, the transition is rife with uncertainties, ranging from the classic uncertainty about supply and demand to uncertainty about behavior, technological developments and prices and political developments, all of which affect the choices you can and must make. The effects of all these uncertainties can be hard to fathom for humans, but mathematical models can provide valuable support."

"Policymakers face various complex challenges as part of the energy transition. Gas, for example, is a significant energy carrier in our current energy system, while renewable energy sources often generate electricity. What's more, sustainable energy sources tend to have more highly variable yield than their traditional counterparts because they depend on the wind and sun. On top of that, socioeconomic, technological and other developments make it very difficult to predict how the transition will play out. By looking at all energy carriers from a systems perspective, we can enable policymakers to make better long-term investment plans."

Iris van Beuzekom, PhD - Optimizing Investment Planning of Integrated Multi-Energy Systems

Download the Phd thesis here

The transition is made even more complex by the fact that many issues have numerous different stakeholders, "some of whom might not be on the same page or have different roles to play. And still, we need individual parties to make choices that bring us closer to our collective goal. The question is, how do you make that happen? There are plenty of opportunities to gain more insight into the system side of things, such as how authorities use political instruments to incentivize certain behavior among consumers and companies. Take tax credit schemes, for instance, which encourages the purchase of solar panels or electric vehicles. If you ask me, there is still a lot of potential to apply more analytical methods, which can help us map out and understand the dynamics between different roles - now and in the future."

"Feeding mathematical models with data that represent what we expect the future to hold is a big pitfall, as the underlying models will only produce optimal outcomes if the future turns out exactly as you predicted. Unfortunately, there is simply no telling what will happen in the future, and even relatively short-term predictions of demand are often slightly off the mark. With a bit of luck, though, real demand will still be within a certain expected bandwidth, or you could sketch multiple different future scenarios, allowing you to consider multiple long-term outcomes. Inputting these ranges or scenarios into a mathematical model will produce actionable results even if the future ends up defying expectations. With that insight, you can make sure you satisfy demand even if it outgrows your expectations while balancing costs with the expected uncertainty."

Ronald Buitenhek, Principal Consultant Analytics, ORTEC

Improvements as a result of a more proactive customer inventory management

Start with what you have

For Griffioen, the energy transition hinges on several key themes: "We need to build a new energy system, and math can help us. This new system will not be created overnight. We will necessarily end up in a transition phase in which the old system has to stay up and running, while we are still building the new one without knowing exactly what it will look like. To make this happen, we need time, which we can 'buy' by maximizing the efficiency of the current system for as long as we depend on it."

There is plenty we can accomplish in the short term: "Even seemingly small routing schedules can get mind-bogglingly complex, with fleets of no more than ten cars resulting in more than ten trillion choices per day. This alone is considerably more than any human being could grasp, and that's without taking inventory, allocations and prices into account. You need advanced planning tools to achieve optimal results. ORTEC provides exactly these solutions to countless companies."

Challenges in the transition phase

In the meantime, we will have to get to work on the new energy system, Griffioen confirms. "We have to start building the new system while still relying on the old one. This transition comes with challenges of its own, such as with regard to mobility. Many companies are looking to green their fleets, and while their commitment to sustainability is clear, deciding on the best approach is more complicated. Should you invest in electric trucks or opt for hydrogen? And what would be the right time to invest? What kind of charging infrastructure will you need, and will you have to upgrade your distribution center's power grid? ▶

"If you factor in the effects of the prevailing wind direction, the wake effect that a turbine can have on a turbine behind it, and the characteristics of the seabed, you can position wind turbines to have them generate energy as cost-effectively as possible."

"Maintenance is one of the factors that makes offshore wind more expensive than its onshore counterpart. At the same time, it's highly optimizable."

Scenario modeling enables us to analyze all of these questions, factoring in all complexities, options and uncertainties. This effectively reduces the risk of making suboptimal multimillion-dollar investments."

There are also operational challenges to consider. Griffioen: In the transition phase, you may have a partly electrified fleet and will have to choose which delivery runs to make with your electric trucks. On top of that, trucks with a limited range may introduce a new constraint to your routing, with charging intervals and durations becoming other factors of concern. We are working on upgrading our planning solutions to allow them to factor in these variables too."

Towards full sustainability

ORTEC also plays a part in expediting the transition to a fully sustainable energy system, as Griffioen stresses by citing examples from the offshore wind sector: "Looking at offshore wind farms from the beach, you might think that all turbines are neatly arranged in a grid. However, that would be a significantly suboptimal approach. If you factor in the effects of the prevailing wind direction, the wake effect that a turbine can have on a turbine behind it, and the characteristics of the seabed, you can position wind turbines to have them generate energy as cost-effectively as possible. This is just one of the challenges we have been able to solve for companies." Griffioen continues with a more practical example: "Maintenance is one of the factors that makes offshore wind more expensive than its onshore counterpart. To get to offshore turbines, you need to take a boat or helicopter, which means sea and wind conditions become a factor. Finding a way to cut those costs through optimization will make offshore wind more competitive, and predictive maintenance and smart planning allow you to do just that."

All in all, there is plenty of work to do, Griffioen concludes: "In the public debate, people tend to oversimplify the energy transition. While I understand the need to simplify complex matters, it is crucial to acknowledge the inherent complexity, which requires smart solutions. If the industry manages to convey this message, I see a lot of potential."

Karin Griffioen, ORTEC Industry Director Energy

When she realized the significance of the Energy industry and the positive impact she and her team could make in driving sustainable solutions, Karin Griffioen got very enthusiastic about working for ORTEC's Energy team. As the Global Industry Director for Energy, it gives her joy and purpose to be supporting the industry's transition to a more sustainable future and being a trusted partner for clients. During her career, she grabbed the opportunity to become one of ORTEC's appointed MBA students and graduated as the valedictorian of her class in the program 'Big Data & Business Analytics' at the Amsterdam Business School. She also holds a BSc and MSc degree in Mechanical Engineering from Delft University of Technology (TU Delft), with a specialization in robotics.

To get in touch with Karin, you can send her an e-mail at karin.griffioen@ortec.com or connect with her on ***LinkedIn.***

"The only way is to lead the way. Our windturbines have to be the biggest, but also the cleanest"

Mohammed Chahim has been a member of the European Parliament since 2019. He also happens to be one of the most influential politicians in Brussels when it comes to the energy transition. He describes himself as an idealistic pragmatist on an indefatigable search for things we can do today to optimize our long-term prospects. We have a long road ahead of us in the energy transition, and if it were up to Chahim, the government would invest heavily. “We have to keep moving forward: these investments will benefit all of Europe.”

Interview with Mohammed Chahim, member of the European Parliament

> "The great thing about studying econometrics is that you learn to reduce problems to factors that you can control. Essentially, it's structured problem solving."

"When you start off somewhere new, like a recent graduate starting their first job at ORTEC, for example, you get to be awestruck for one day, maybe two. After that, it's time to crack on and get to work. And the same goes for the European Parliament." Chahim did just that and his career took off. After only 18 months, he was appointed vice chair of the Progressive Alliance of Socialists and Democrats, the second-largest group in the European Parliament with 143 members. "It's almost as big as the Dutch House of Representatives, and I bear ultimate responsibility for 5 of the 20 standing committees. On top of that, I was also made rapporteur for the Carbon Border Adjustment Mechanism (CBAM)." According to Chahim, this new, historic regulation is intended to get goods imported into the EU to meet the high climate standards of the 27 member states. "It will mark the first time that Europe imposes a carbon price on non-EU producers. I expect other countries to follow."

Recipe for success

Chahim has forged a reputation for getting things through parliament. News site Politico ranked him among the top 28 most influential figures on European energy policy last year, along with three other Dutch nationals including Frans Timmermans and Femke Halsema. His recipe for success: be prepared, work hard, know what you want and truly believe it's the best course of action. "However, what you want can change over time. You can meet inspiring people every day - researchers, scientists, consultants - who can explain exactly why certain moves make sense or why an alternative would be better. The trick is to listen carefully and try to understand what people are saying. You can't get a message across until you understand what's behind it, which is something my team and I devote a lot of time to. Having a good team is absolutely critical." ▶

> "We need to lead the way when it comes to innovation and technological solutions, while optimizing human rights, social rights and environmental conditions."

European Green Deal

With the European Green Deal, the European Union aims to become climate neutral by 2050. This goal is to be achieved by cutting greenhouse gas emissions, investing in green energy solutions, protecting nature and restoring biodiversity. In 2021, these goals were signed into law with the European Climate Law, which also ensures regular monitoring of the progress being made.
Some of the highlighted goals from the European Green Deal:

- ***EU climate neutral by 2050***
- ***Reduce GHG emissions by 55% by 2030, compared to 1990***
- ***40% renewables in the energy mix by 2030***
- ***Zero emissions from new cars by 2035***
- ***Absorb 310 Mt of carbon emissions by restoring nature and biodiversity***

Source: European Commission

Target function

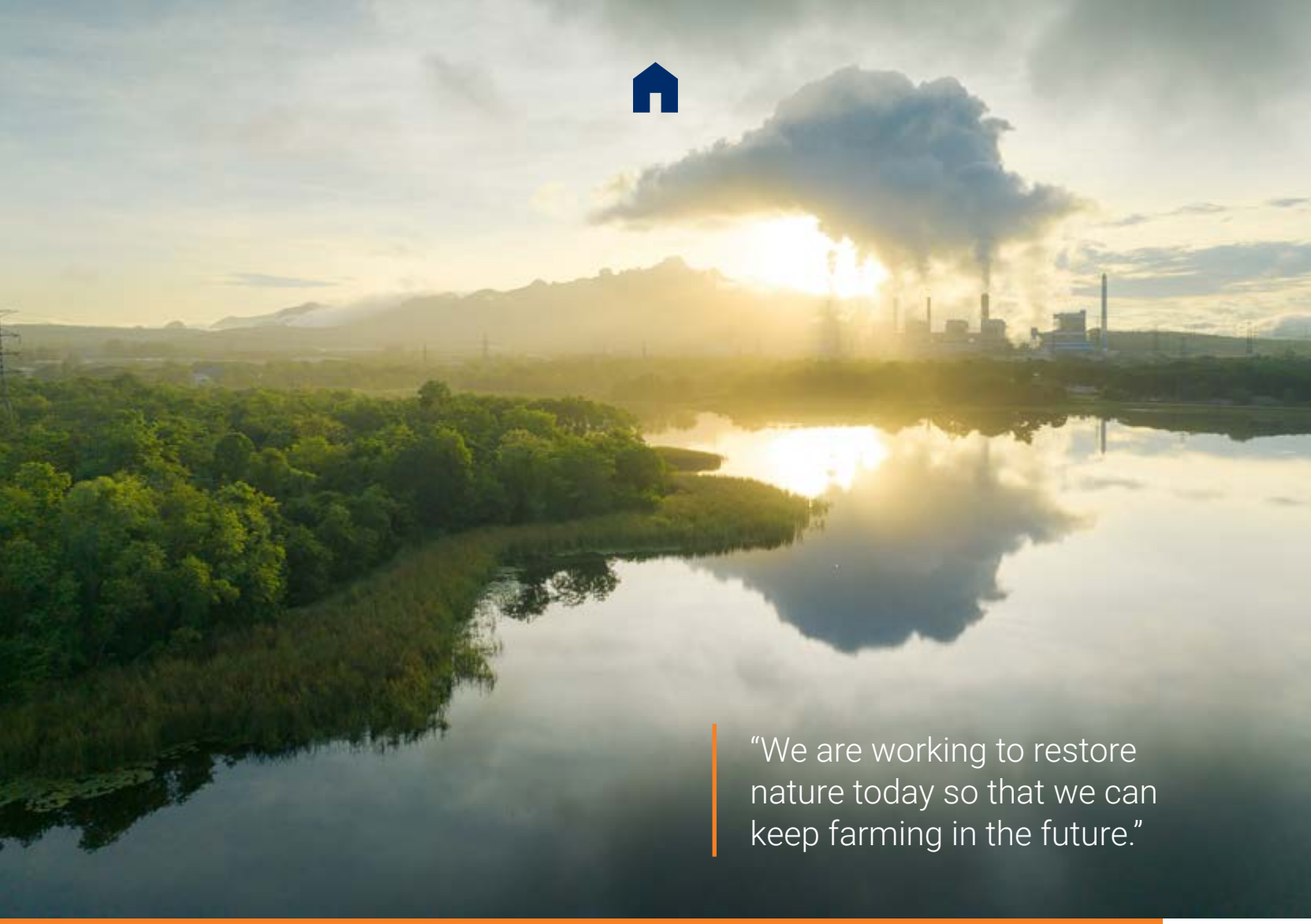
Chahim's background is a valuable tool in his day-to-day work: "The great thing about studying econometrics is that you learn to reduce problems to factors that you can control. Essentially, it's structured problem solving. As a rule, there's no problem that you can't approach from an Operations Research perspective and optimize based on certain constraints. Often, the first thing I do is come up with a target function in my head. It all starts with a vision, the situation you'd create if you had unrestricted development opportunities. What would the ideal world look like 20 years into the future? Next, you take a step back, impose certain constraints and ask yourself: what can I do today that will bring me closer to the goal I have in mind? It's a combination of idealism and pragmatism: an idealistic pragmatist explores what it will take to accomplish a goal as efficiently and optimally as possible. They're fundamentally different from pure pragmatists, who look at what they should do tomorrow to improve their situation compared to today. The outcome may be the same, but the underlying stories are worlds apart."

Leading the way

So what should the European economy look like in 20 years, what sectors should we excel in? And how can we make it happen? Chahim is adamant: "The only way is to lead the way when it comes to innovation and technological solutions. Cars produced in China are just as good as those produced here, but the prices are substantially lower, even if you disregard subsidies. How long will Dutch consumers keep buying Volkswagens, Renaults, or Mercedes if they can get the same car for a lower price, just with a different logo?" We need to innovate in battery technology, Chahim suggests, develop a new version, start exporting and guarantee the continued competitiveness of the European automotive industry. "Only with the best human and social rights and the best environmental conditions will we be able to lead the way. The same is true for other industries. Our wind turbines have to be the biggest and the cleanest, they have to be the easiest to dismantle and reuse. We will never be able to compete on cost or the availability of critical raw materials. Instead, we will have to use materials as smartly and efficiently as possible to stay ahead."

Equilibrium

In a nutshell, there is every reason to invest more in future-proof technology, and if Chahim had a say in the matter, public money should also be invested. "We have to keep moving forward, rather than sticking to what is 'feasible and affordable'. These investments will benefit all of Europe, as well as the result of the world. Someone has to pick up the bill, and I would argue that it's the joint responsibility of public bodies



and businesses. The government has to co-invest in technology and should not leave it to the whims of the market alone. We need serious investment programs and funds.” There will be plenty of failures on the way, the MEP stresses: “Some of the most promising technologies today will end up being entirely useless tomorrow due to the emergence of disruptive alternatives. Solar panels and wind farms are now the name of the game, but if we figure out nuclear fusion, our reality will change from one day to the next. That’s the beauty of transitions: you move from one equilibrium to another, without ever really knowing where you are. However, once you manage to strike a balance, you have a big advantage over other regions.”

Ancient churches

To get people on board with the transition, politicians need to be less technocratic, Chahim believes. “We need to paint a picture of a world that keeps getting clearer and more well-defined every day. We are working to restore nature today so that we can keep farming in the future. We are investing in green hydrogen to keep companies in the Botlek in the Netherlands. Just the other day, Frans Timmermans gave a lecture in which he argued that mankind has lost something that we used to be very good at: passionately building new things while being almost certain that you will not live to see the end result. Just take the beautiful ancient churches all over Europe that usually took generations to build. We have to regain that old mentality and make decisions that will impact an economy we will probably never experience ourselves. It is very complicated, but we cannot afford to sit idly by. We have to think about tomorrow’s jobs today and we should avoid becoming even more dependent on foreign countries for fossil fuels than we are today.” ▶

US Inflation Reduction Act

As Chahim indicates, the energy transition is a global challenge and therefore requires a global effort. Other countries around the world are working on similar legislation. For example, The United States signed the Inflation Reduction Act into law in 2022. This Act, in addition to other policy reform, sets similar targets for emission reduction and green energy developments. It offers several tax credits, incentives and loans to both consumers and corporations to invest in clean energy, home improvement, and electric vehicles. Some highlights from the Inflation Reduction Act:

- ***Setting out a path to achieve net-zero emissions by 2050***
- ***Reduce GHG emissions by 40% by 2023***
- ***$391 billion investment in Energy and Climate policies, including:***
- ***$37 billion tax incentives for consumers***
- ***$35 billion in nature conservation and development***

Sources: The White House, Congressional Budget Office

How can ORTEC help expedite the transition?

If change starts with industry, as Chahim argues, how can companies like ORTEC contribute? Chahim is particularly interested in data analysis as a tool to make the energy transition more targeted and fair. "At a high level, you could try to come up with a target function for the entire economy with a sound definition of economic growth, carbon emissions and circularity, and with meaningful constraints. Specifically for the transition, you could look at what critical raw materials we will need, and which renewable electrons and molecules (biogas, bioethanol, hydrogen) you can expect in the coming years. Using such a model, you could then distill a merit order that dictates who gets to use the limited amount of renewable electrons and molecules at what time, minimizing costs and carbon emissions to help achieve climate neutrality by 2050. It will never be an easy analysis to make, but I'd love it if we made it happen. That knowledge will force the government to make choices. If the government invests heavily in the transition, why would they not also be able to have a say in who gets to benefit first to create an optimum situation for society as a whole.

At a lower level, many companies have no idea of their carbon emissions, let alone how to reduce them most efficiently. Just being able to chart the biggest sources of emissions is very valuable. At TNO, I noticed that companies that are forced to cut costs usually do so in an area that they are very familiar with in order to maximize their gains. Helping companies do so by developing models and quick scans to analyze quick wins can make a big difference. On aggregate, the cost, energy and carbon savings that can be achieved by all SMEs together are truly enormous. I imagine that companies like ORTEC could come up with a fully automatic tool to quickly identify a top three measures that a company could take as early as this year."

> “The nitrogen crisis requires a structural change in industry.”

Strength

The Dutch tend to see themselves as pioneers of climate policy, the MEP claims. “And while that might very well be the case, we are miles behind when it comes to implementation. I do believe we will catch up, but Europe is the smallest level of scale at which to pursue effective climate policy. It’s only barely big enough. If you go any smaller, you’ll have no global impact whatsoever, but Europe as a whole does have that impact. The European Union is the second largest consumer market in the world, and we should leverage that strength. Not only can we be ambitious ourselves and impose our ambitions on our producers, but we can also ensure that everyone who wants to sell products in Europe has to meet the same standards. It’s a strength we tend to underestimate, but it bears repeating: the global market is not infinite and China will think twice before losing 25% of all sales.”

Collectivity

Chahim is a firm believer that collective problems require collective solutions. “You can’t just point the finger at individuals and blame lifestyle choices like eating meat for the nitrogen crisis. Right-wing politicians will tell you that those individual choices are too small to matter; but I’d rather make sure that they do. And the only way to make that happen is by a structural change in industry. If you transition to a circular plastics industry, in which plastics are manufactured in a closed loop, consumption is no longer a problem. If we manage to make air travel more sustainable, flight shame won’t be relevant. If we develop affordable, plant-based protein options, people will automatically choose them because they are best, either from a financial, climate or health-related point of view. When all is said and done, I think that change has to start with industry.”

About Mohammed Chahim

Dr. Mohammed Chahim is an influential politician in Brussels when it comes to energy. Chahim became a city councilor in Helmond in 2006, before becoming a member of the European Parliament for the Labour Party in 2019. As vice chair of the Progressive Alliance of Socialists and Democrats, the Green Deal is part of his remit.
Chahim received his doctorate in econometrics from Tilburg University in 2013, specializing in a theory that analyzes systems and tries to optimize them mathematically. After receiving his doctorate, Chahim spent six years as an energy transition researcher at TNO before making the move to Brussels.

The energy trilemma:

Balancing security, affordability and sustainability

Lucia van Geuns, Strategic Advisor Energy, focuses on energy security and the geopolitics of energy at independent knowledge institute The Hague Center for Strategic Studies (HCSS). In her expert opinion, the energy market will be facing a volatile and uncertain 10 to 15 years: “Developing future scenarios and storylines is crucial in strategic thinking, both for companies and countries. However, it is important to realize that there is no predicting the future. The path toward a new energy system will be a messy one, requiring a joint program allowing for a more strategic, coherent, and coordinated approach from governments and the industry."

Interview with Lucia van Geuns, Strategic Advisor Energy at the Hague Centre for Strategic Studies

> “We are consuming vast amounts of energy, the scale will determine the speed of the energy transition."

The Critical Raw Materials Act

The Critical Raw Materials Act (CRM Act) will ensure EU access to a secure and sustainable supply of critical raw materials, enabling Europe to meet its 2030 climate and digital objectives.

- ***Creating secure and resilient supply chains***
- ***Supply risk preparedness and mitigation***
- ***Improving sustainability and circularity of critical raw materials***
- ***Diversifying the imports of raw materials***

Benchmarks by 2030 for domestic capacities

- ***at least 10% of the EU's annual consumption for extraction***
- ***at least 40% of the EU's annual consumption for processing***
- ***at least 15% of the EU's annual consumption for recycling***
- ***no more than 65% of the EU's annual consumption from a single third country***

Source: European Commission

Want to read more about the Green Deal?

Read the interview with Mohammed Chahim -member of the European Parliament- on page 16.

Geologist Lucia van Geuns is somewhat of an 'odd one out' at HCSS. "Combining my STEM (Science, Technology, Engineering and Mathematics, *ed.*) background with politicology, defense and macro-economics gives me a great opportunity to spar with colleagues about oil and gas, tank storage and critical minerals." Doubling down, she stresses the importance of the latter: "Just like we blindly walked into Putin's gas dependence trap, we're doing exactly the same thing when it comes to strategic raw materials and Xi Jinping. We have been rerouting value chains through China for years, but we will need minerals like cobalt, copper, lithium and rare-earth metals to fuel the development of sustainable technology. Without those resources, transitioning to a low-carbon economy will be a huge task indeed."

Global energy mix

In her lectures at Delft University of Technology, Van Geuns primarily introduces students to the energy transitions of the past, such as the move from biomass to coal and the subsequent industrial revolution that heralded unmatched prosperity and economic growth. "We have gone through countless transitions already, most of which have revolved around technology. The world's mix of primary energy forms has evolved into a highly diverse mix, 80% of which still consists of fossil fuels. The same was true in 1990. Coal did not make way for oil, oil was simply added to the mix." Economic growth and demographic developments have determined the scale of our current energy consumption levels, Van Geuns explains: "Consumption levels have increased tenfold since the beginning of the last century. We are consuming vast amounts of energy, the scale - depending on where you live - will determine the speed of the energy transition. China's energy mix is dominated by coal, while sub-Saharan Africa depends mainly on traditional biomass. We will all have to go through the low-carbon transition, which will be dictated largely by policy and climate change concerns. Solar and wind will undoubtedly be a big part of the global energy mix in 2050, but how big? Will the share of fossil fuels be cut to 20% by 2050, or will it stay at 60%? In order to reach a net-zero economy in 2050 and cap global warming at 1.5° by 2100, you have to look at back-casting scenarios, working backwards from 2050 to find an approach that will get us where we need to be. *The Net-Zero by 2050* scenario published by the International Energy Agency in May '21 shows clearly that we are way off target. Even the IPCC has admitted that we stand no chance of curbing global warming at 1.5°C. It's a painful realization." And yet there is hope, Van Geuns argues. "The growing awareness of the need of a speedy, policy-driven transition in the past

decade has been essential. Transitions have always taken a very long time. The US is on track for 2050 and Europe has followed suit with the Green Deal. It will take China and India a little longer to reach net zero, but they will get there in the end."

Ukraine not a game changer

The so-called "energy trilemma", the balance between security, affordability and sustainability, plays an important role in climate policy. Van Geuns: "In the US, energy security has always been paramount. It is a very self-sufficient country and because the US is one of the world's main exporters of gas, it has more control over a sufficient supply of affordable energy. The Biden administration delivered a big infrastructure boost and a billion-dollar fund to encourage the US industry to produce as much renewable energy as possible. In doing so, the US has firmly committed itself to a clear course of action, and while Europe wants to do the same with the Green Deal and industrial policies, Europe is anything but self-sufficient. China, on the other hand, is largely self-sufficient, having invested heavily in nuclear energy and hydropower in addition to coal and leading the pack in solar and wind energy. At the same time, it has entered into bilateral relations with its Belt and Road Initiative. China has made great strides on critical minerals in the past 15 years, while Europe's recent EU Critical Raw Materials Act marked one of its first tentative steps to safeguard the future supply of these essential resources. The plan is to open more mines in the EU itself and ratchet up EU production, as well as establishing strategic bilateral relations with "friendly" countries if the first two options prove impossible, such as for gas. Admittedly, however, Europe is late to the party." Things have changed since the war in Ukraine, Van Geuns notes: "It has become abundantly clear that security of supply is an important component of sustainability policies. On top of that, we have had a major wake-up call with regard to the affordability of energy, with everyone suddenly worrying about their gas bills. From a global energy standpoint, however, I do not think that Ukraine will be a game changer. Global gas consumption will continue to grow until at least the early 2030s."

From molecules to data

Van Geuns is a proponent of the Green Deal, but doubts that there is room for much improvement in Europe. "Pushing more aggressively won't work: the biggest strides can be made by reducing demand, which will ultimately drive supply. The situation is complicated by the absence of a large-scale substitute for oil. In the end, the new sustainable economy will be IT-driven, she concludes. "You need IT to manage all those wind farms. All the infrastructure has been computerized and is controlled with the help of data and mathematics. At HCSS, we are researching the cyber security aspects of sustainable energy and have concluded that security by design is a must for wind farms, especially because China is such a big supplier of offshore software and hardware. We are moving from a molecular world of oil, gas and coal to an electrified/IT-driven energy system. It is not that one will replace the other. Instead, we are transitioning from an entirely fossil-dominated system to a new system that we have only just started building. The latter requires heavy investments, but we need to keep our old system running as well. We might be remodeling our home, but we have to keep the store open as well. The latter tends to fall by the wayside, but it's just as important."

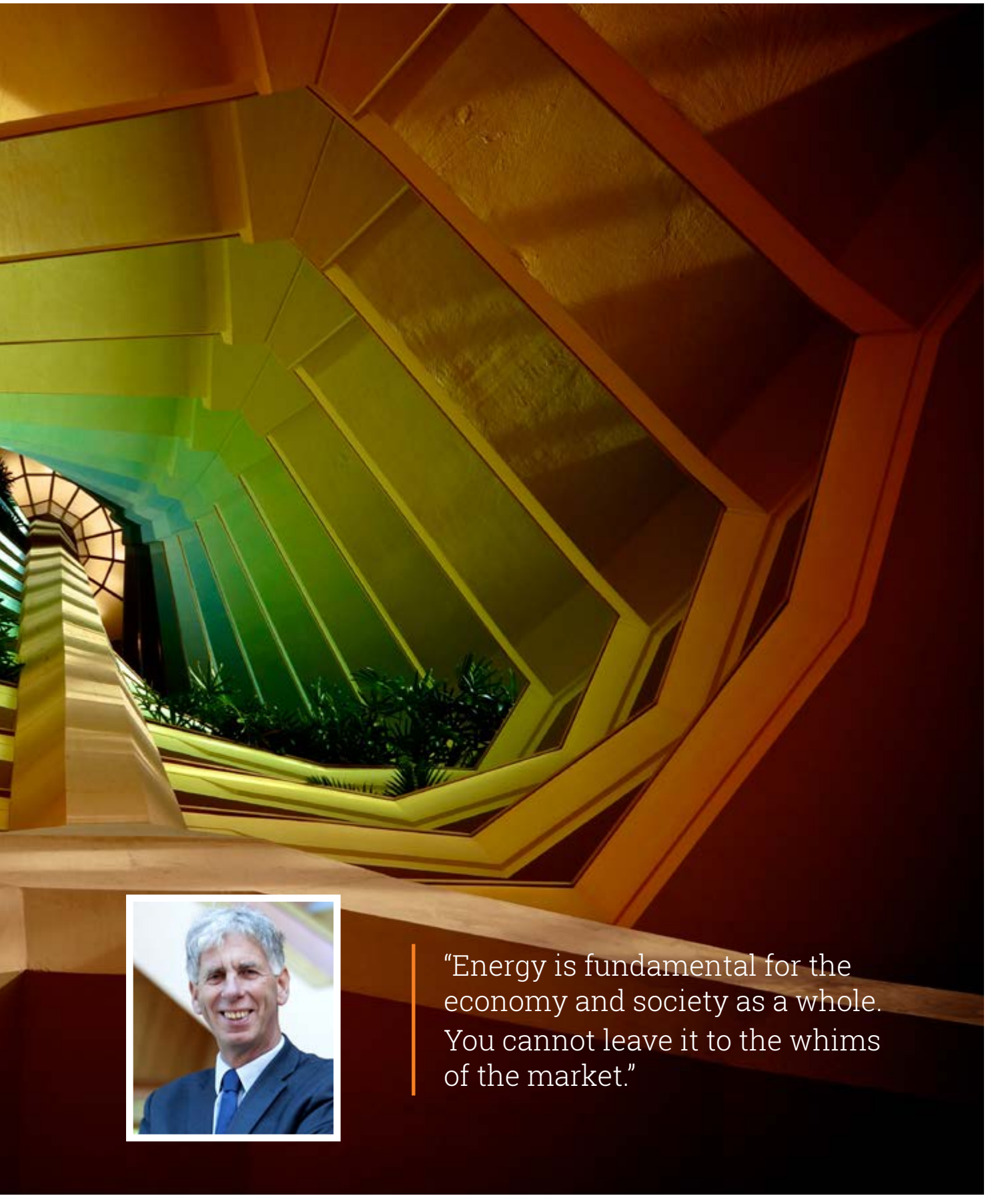
About Lucia van Geuns

Lucia van Geuns holds a degree in geology and worked at Shell from 1980 to 2002. She then served as a senior fellow at Clingendael, senior researcher at TNO, and president of the Royal Dutch Geological and Mining Society. In 2018, she joined the Hague Center for Strategic Studies (HCSS) as *strategic advisor energy*.

"The Netherlands can play an important role in Europe's new energy system."

Looking ahead, the Dutch energy system will be dominated by wind and solar energy, hydrogen, carbon storage, green gas and heat pumps. If you ask Ulco Vermeulen, former member of the Board of Directors at Gasunie, the Netherlands is slowly but surely maturing in the energy transition: "I'm glad that the debate has broadened from electricity alone to the country's entire energy supply. Gasunie has bent over backwards to make that happen."

Interview with Ulco Vermeulen, Director Business Development at Gasunie



"Energy is fundamental for the economy and society as a whole. You cannot leave it to the whims of the market."

Secondary to the climate

Nederlandse Gasunie is a 100% state-owned energy network company. Vermeulen: "Energy is a product, but it's wholly different from sausages and BMWs. It's fundamental for the economy and society as a whole: you can't just leave it to the whims of the market. Energy has to be affordable, clean and reliable. In the past 15 years, one of those three elements would always be out of balance: energy would either be too expensive, too polluting, or unavailable. If you look carefully, you can see the balance shifting. At the start of the century, price was everything, prompting liberalization, globalization, and the split of Gasunie, for example. Ten years ago, the climate change debate took off, and climate concerns started outweighing the desire for cheap energy approximately five years ago. In the summer of 2021, even before the war in Ukraine, energy prices began to rise, so the past year was mostly about helping to get things back on track." In the long run, Vermeulen believes that the climate component of energy will come to dominate, although he doesn't make any promises, given the Dutch nitrogen crisis: "We've seen first-hand how periods of rapid growth can be followed by stagnation, but, with a view to CO_2 emissions and rising temperatures, future generations will simply demand that we follow through. There is no other way. For Gasunie, serving society also means committing yourself to broad social welfare and focusing on the long term. The energy infrastructure must serve the climate."

Mature energy system

Vermeulen sees Gasunie as a knowledge hub, with decades of experience with 80% of the country's energy supply. "We started contemplating system integration a while ago, carefully plotting what we envisioned the system should look like in the coming decades. The first step is building a network of on-shore hydrogen pipelines, and the Dutch government has now also asked us to commit to hydrogen infrastructure in the North Sea and the link between hydrogen and electricity." You would need a crystal ball to predict the actual energy mix of

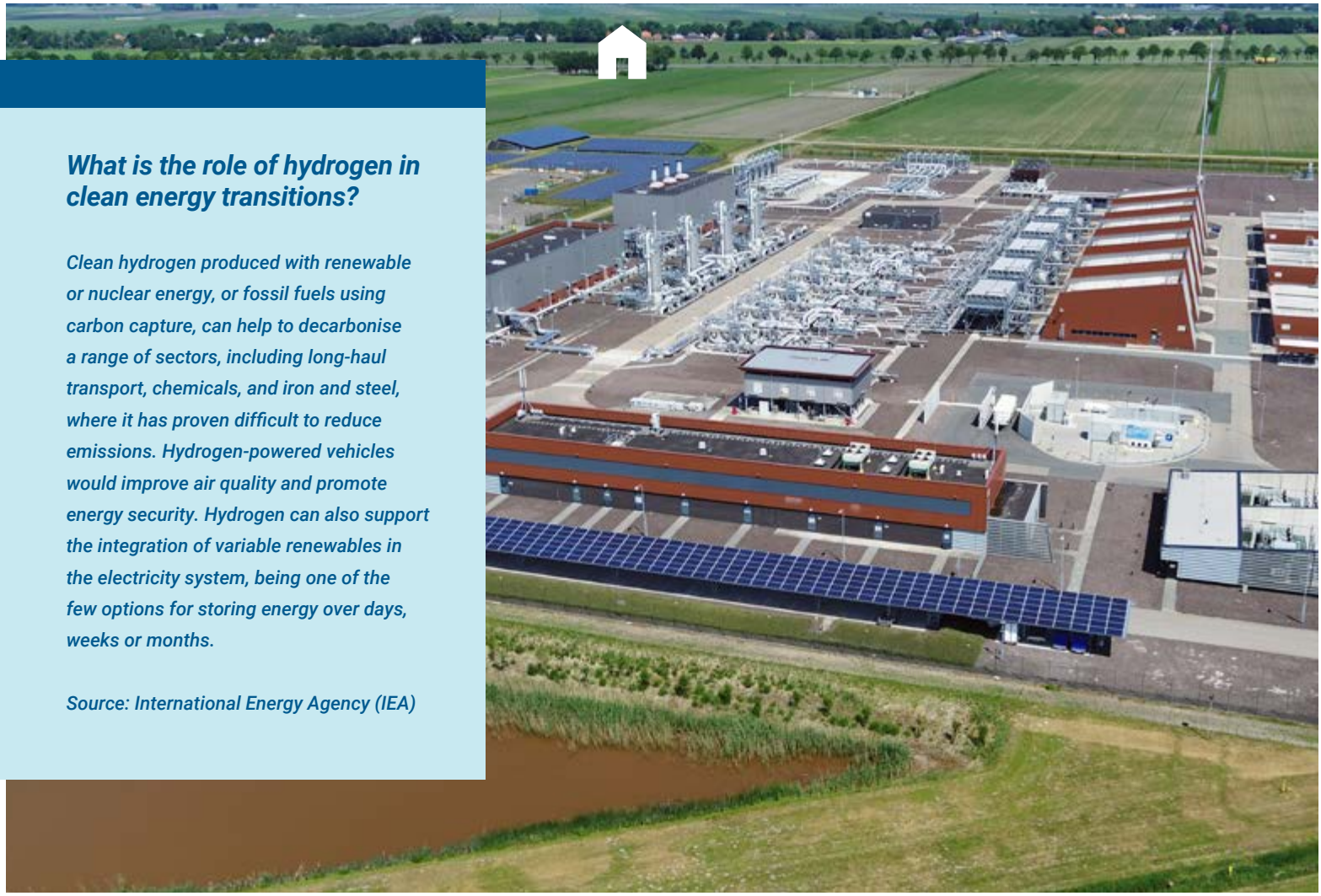
"I expect our region to harvest the most energy from wind."

the future, he stresses: "But the role of hydroelectric power will be limited, given our onshore water resources. Solar energy, although an infinitely renewable resource, is not very efficient on the piece of earth we call home. We get 1,000 hours of sunshine a year, so a single solar panel generates 1,000 hours of energy per year. In other words, PV panels sit idle for about 8,000 hours a year, hardly a solid foundation for an entire country's energy system. Wind energy is a lot more promising, especially if you set up shop in the middle of the North Sea. Worldwide, I expect that solar energy will become the most common energy source, while our region will harvest the most energy from the wind. That scenario is now gradually unfolding, with the government announcing plans to generate 50 gigawatts of wind power annually by 2040."
Vermeulen endorses the government's plans: "It's the one and only way forward for the Netherlands." Setting up an integrated energy system is more complex than rolling out a gas grid, he explains: "While it's still a massive project, it's one-dimensional. The new energy system will become weather-dependent, so you will have to mold solar energy, wind energy and electricity into a mature, comprehensive system that can power society, with all the necessary conversion infrastructure and storage systems."

"Time and time again, I'm overwhelmed by the speed of change.Things move at lightning pace."

Four-track policy

Gasunie has adopted a four-track approach to the energy transition: heat, green gas, hydrogen, and carbon capture and storage, Vermeulen explains. "Hydrogen and CCS (carbon capture and storage, ed.) are the two workhorses, while heat and green gas should be seen as auxiliary engines.



What is the role of hydrogen in clean energy transitions?

Clean hydrogen produced with renewable or nuclear energy, or fossil fuels using carbon capture, can help to decarbonise a range of sectors, including long-haul transport, chemicals, and iron and steel, where it has proven difficult to reduce emissions. Hydrogen-powered vehicles would improve air quality and promote energy security. Hydrogen can also support the integration of variable renewables in the electricity system, being one of the few options for storing energy over days, weeks or months.

Source: International Energy Agency (IEA)

We think we'll be able to produce 2 billion m^3 of green gas in the Netherlands, which would only account for a few percent of our total energy needs. It'll never be enough to significantly cut CO_2 emissions, but it may just help the few million homes that can't go fully electrical to be climate neutral nonetheless. The same goes for heat. Hydrogen will become incredibly important five, ten or fifteen years from now, but the quantities will be very limited for the next three to five years. With a view to achieving the 2032 goals, CCS is the workhorse that you can get up and running first. It's not the most elegant solution, and you'd prefer a fully circular system, but if Northwest Europe wants to reduce its CO_2 emissions quickly, CCS will have to be part of the solution. For now, we're fully committed to CCS and hydrogen." All self-respecting companies worldwide are now working on hydrogen, Vermeulen argues. "There is a lot of energy and money involved and companies have embarked on a rat race for control over new energy sources. That being said, the electrolyzer is yet to be developed and costs will have to be halved before hydrogen becomes feasible, affordable and scalable." Exactly how long that will take is the big question that everyone's trying to answer. "Time and time again, I'm overwhelmed by the speed of change. Things move at lightning pace."

Reliable pioneering

Gasunie, in Vermeulen's words, specializes in reliability, security of supply and safety: "I'm not too proud to admit that these are three things we do well. In the new world, we need to pioneer more, and stick our necks out more often. We started doing just that about ten years ago, but we'll also have to keep playing to our strengths." Gasunie's pioneering activities are not run by startups outside the company, nor have they been fully internalized: "As a board of directors, we decided to strike a balance between the two: we opted against setting up entirely new, innovative companies because we wanted to stay in the loop, while also ensuring that new initiatives are given sufficient latitude. Our pioneering branches are still fully integrated into the company, but they have enough autonomy to chart their own course. We've had an Energy Transition group, a Hydrogen Backbone group, and now we have a North

> "In the new world, we need to pioneer more, and stick our necks out more often."

Sea group and a Hydrogen Import group." Vermeulen expects data technology to play a role of increasing importance in future processes. "We are on the eve of tremendous growth and development in the data-driven coordination between hydrogen and electricity. There are lots of questions to be answered: where should you locate switches, how much should you invest, and how will the market and the government interact and cooperate? An entirely new field will emerge, in which data will play a key role, because the supply side relies heavily on the weather, while demand rests on market needs. And there's countless other factors to consider, too, like price incentives."

> "We have built an outstanding logistics position for fossil energy. We can do the same for hydrogen."

International chains

To optimally advance the energy transition, Gasunie will have to make the right investments at the right time. "It's quite a puzzle. We can't tell when hydrogen will become abundant, but we will need to build infrastructure before that time. Fortunately, hydrogen can be transported through the same pipelines as gas, and building infrastructure for gas is 10 times cheaper than for electricity, which makes taking on a little risk a lot less scary. Besides, hydrogen will primarily be used by industry first, so we don't need nationwide coverage right away. We will need about five years to build a pipeline backbone. We've invested € 2 million, which puts it at the lower end of transition projects." The Netherlands will have to seek out more international partnerships to set up robust energy chains, Vermeulen points out. "Our country has built an outstanding logistics position for fossil energy. We can do the same for hydrogen. We have the North Sea, a great starting point. We have the Port of Rotterdam, we have Eemshaven, we have gas infrastructure that is compatible with hydrogen. The Netherlands can keep playing an important role in Europe's new energy system."

About Ulco Vermeulen

Ulco Vermeulen has held various strategic and commercial positions at Gasunie since 1990, where he was responsible for exporting gas to Germany and selling gas to Dutch energy companies. He led Gas Transport Services, serving successively as Director of Participations and Development, Director of the first LNG terminal in the Netherlands, and Director of Participations & Business Development. Since May 1, 2016, he had been a member of Gasunie's Executive Board, before being succeeded by Hans Coenen on April 1.

Ulco Vermeulen plays a crucial part in the social energy debate in the Netherlands and is the chairman of Groen Gas Nederland. He also chairs the Dutch Top Consortium for Knowledge & Innovation Gas, in which companies, knowledge institutions and government agencies work together to achieve sustainable growth and involve the entire gas sector in the energy transition and new innovations.

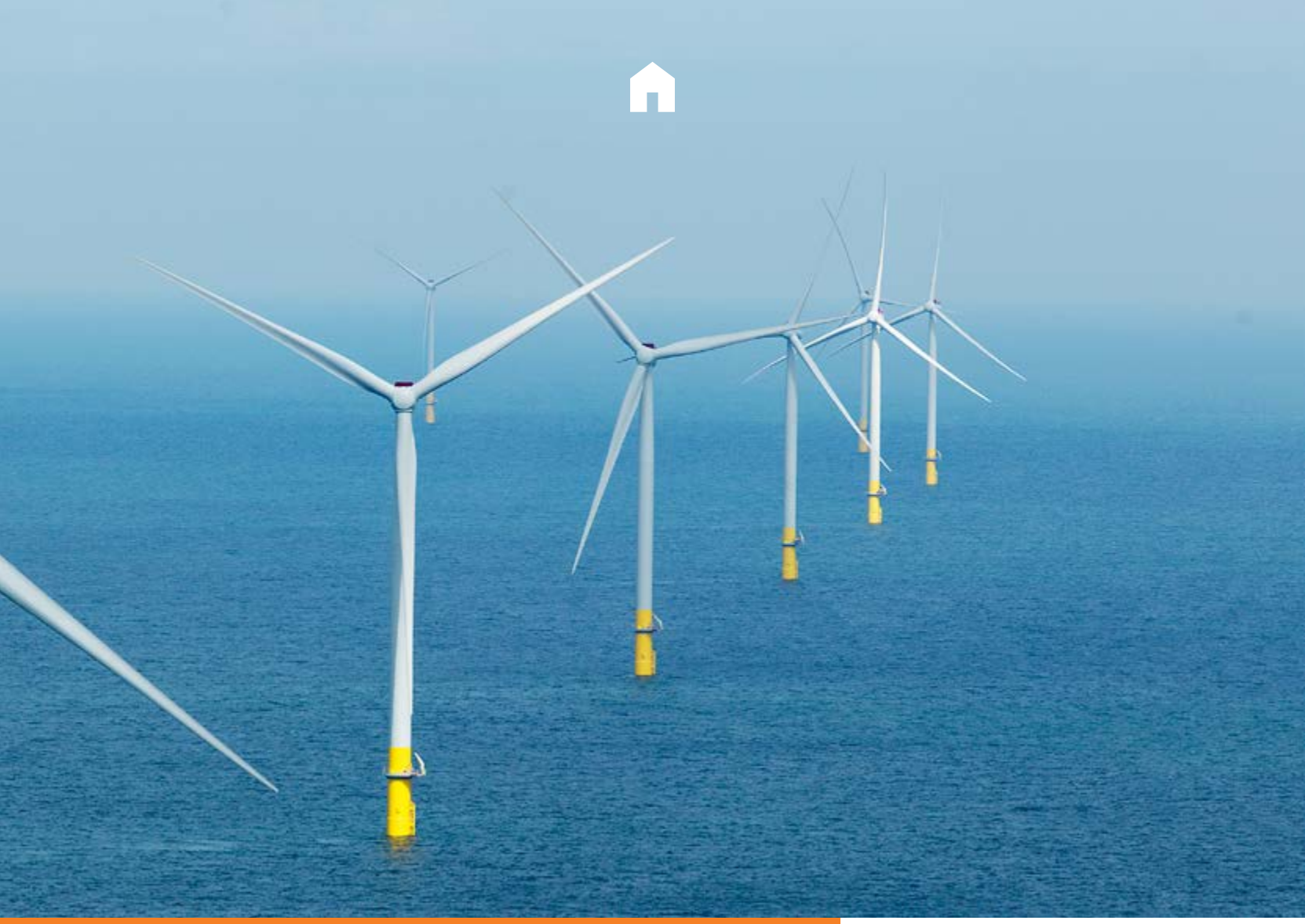
"We need to create more demand for green power"

The Netherlands and its North Sea neighbors want to go all out for offshore wind farms. The idea is to reach at least 260 gigawatts of offshore wind capacity across the North Sea by 2050, turning the wind farms into “Europe’s green power plant." One of the forerunners in offshore wind is the Danish company Ørsted (pronounced Uh-rsted), which has now also gained a foothold in the Netherlands. Ruben Dijkstra is Ørsted’s Managing Director Benelux: "The offshore wind industry has the wind in its sails."

Interview with Ruben Dijkstra, managing director Benelux at Ørsted

> "Today, energy independence is perhaps as big a driver as our climate ambitions.”

Ruben Dijkstra was only made responsible for Ørsted’s Belgian and Dutch markets relatively recently. After 14 years, he left Eneco in September 2022, a renowned Dutch energy company and developer of renewable energy assets, including offshore wind. Before that, Dijkstra spent about a decade in offshore oil and gas. "In 2008, I made my personal transition from fossil to renewable, on what I call the perfect wave," he says. "At the time, Al Gore was warning the world about how carbon emissions affected the atmosphere. It was a time of high oil prices and searching for alternatives. Putin had already started manipulating gas supplies to Eastern Europe, so energy independence was also a concern. The latter two arguments faded into the background for some time, but energy independence has since become as big a driver as our climate ambitions. High energy prices are also a factor. Now, 15 years later, all three issues that triggered my own transition are just as relevant as they were back then."



Greening a gray industry

Ørsted is the world's largest player in the offshore wind market in terms of installed capacity, as well as wind farms in the pipeline that are waiting to be built. Dijkstra points out: "Our own ambition is to get to 30 gigawatts of offshore wind by 2030. Our operational wind farms and overall portfolio are currently good for 22 gigawatts." The partially state-owned company, 50% of which is held by the Danish government, also has onshore wind and solar ambitions, in addition to its new, growing offshoot: 'power to x'. This business unit aims to convert generated green power into other products such as hydrogen or e-methanol. "Electrification is one way to make industrial companies more sustainable, but replacing fossil gas with hydrogen, or using the more sustainable e-methanol in the maritime transport sector, is another. A project to manufacture this e-methanol is currently underway in Sweden; while Ørsted is also developing more than 1 GW of electrolysis capacity in Zeeland. Ørsted's Dutch HQ is based in The Hague; while wind farms Borssele 1 & 2 are managed from Vlissingen. The company's next tender in the Netherlands is one for 4 gigawatts of offshore wind off the coast of IJmuiden (known as "IJmuiden Ver," *ed.*). "It's an enormous scale, especially in the context of the Dutch energy landscape. That is why it is so important that we create demand for all the new green power on the horizon. Especially given climate minister Rob Jetten's ambitions: 70 gigawatts of offshore wind by 2050 (equivalent to 140 times the capacity of the nuclear power plant in Borssele, *ed.*)."

"There are plenty of challenges in the Netherlands. But I am convinced that we will accomplish our objectives."

"Our own ambition is to get to 30 gigawatts of offshore wind by 2030.

Our operational wind farms and overall portfolio are currently good for 22 gigawatts."

Creating new demands

Peak demand in the Netherlands is currently about 21 gigawatt, so future supply is set to outstrip demand significantly. According to Dijkstra, the answer is to create more demand: This is partly in electric driving, partly in heat pumps, and to a very large extent in making Dutch industry more sustainable. However, demand will have to increase simultaneously with supply to avoid a situation in which too much green power goes unspoken for, causing market prices to plummet. "Negative energy prices - when supply significantly outstrips demand - are becoming increasingly common in the Netherlands." In the original energy system, supply was demand-driven, but Dijkstra is confident that it is set to pivot to a supply-driven market. "Users will move to charging their car in the afternoon, when solar power abounds, rather than charging it overnight. Not home charging stations, but office charging stations will become the norm, as will giving your energy company control over your washing machine. You can still load your washing machine in the morning, but the energy company will decide when it is switched on. It will require a behavioural shift, from consumers and industry. Fortunately, pricing can be used to influence behaviour."

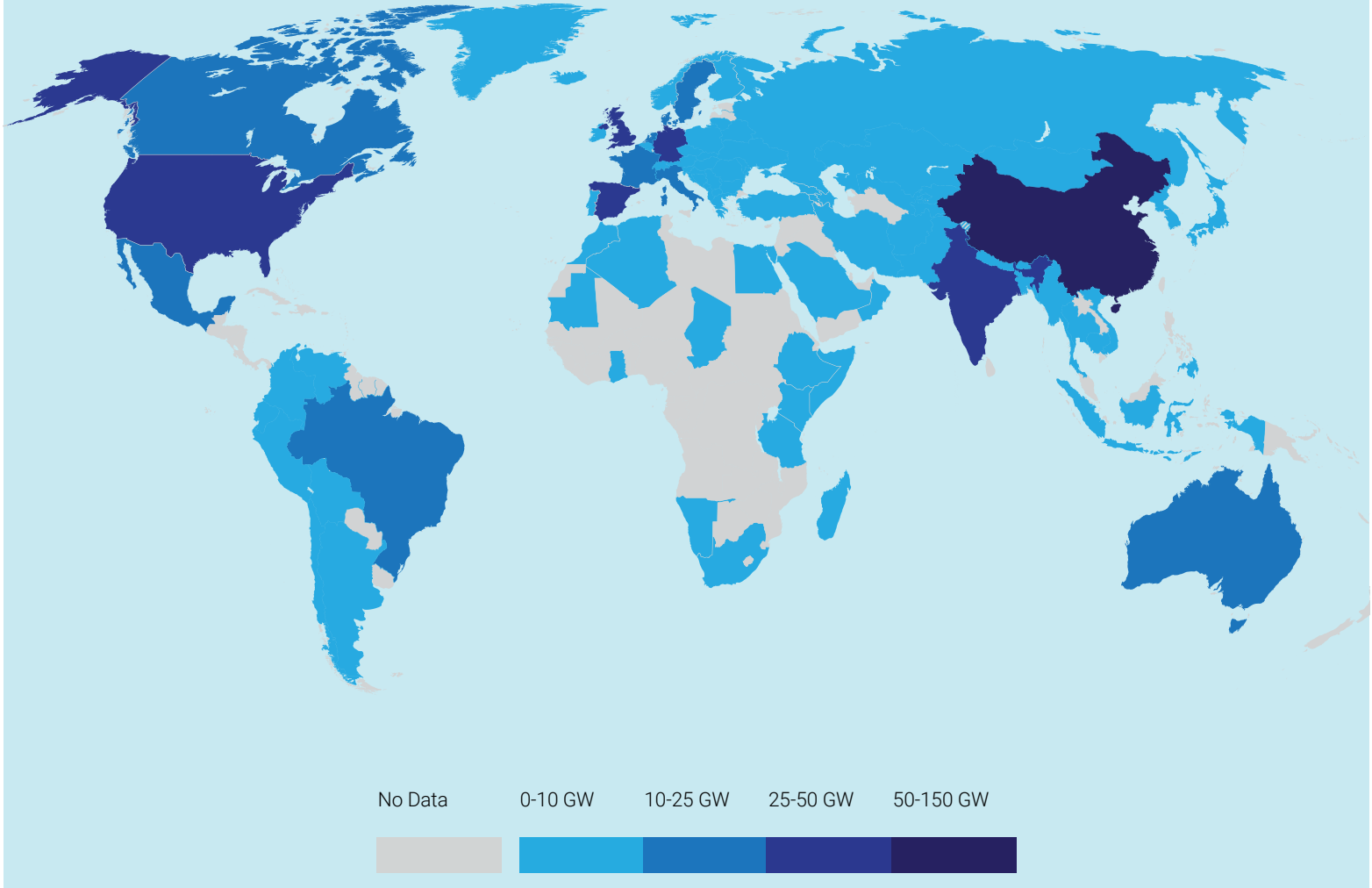
In a system dominated by a variable supply of renewable energy, this will be the norm: "There were hardly any incentives in the original system to drive demand. We have lower off-peak rates, admittedly, but making power cheaper overnight than during the day will not promote sustainability. We will need dynamic hourly rates for that. I expect that to be the case within the next 5 years. Price sensitivity is increasing, which makes anticipating it more commercially appealing. The revenue model of battery storage is based on ▶

Data, math and offshore wind

"Models and data are widely used in our industry. Before you decide to invest, you need accurate insight into the potential yield of a wind farm. This is easier said than done, because all the wind models we used to use are based on onshore wind turbines. As a result, we can't use them to predict how a wind farm in England will affect a Danish wind farm with a westerly wind. That's where the offshore industry is now looking to make major improvements. Once we get a farm up and running, we follow weather fronts as closely as we can. We also benefit from these insights on the trading floor. Furthermore, we have an arsenal of sensors and data to track how components behave, to analyze outages and to schedule preventive maintenance. We shuttle back and forth between Vlissingen and our offshore wind farm every day. Whether we can get off the boat and onto the wind farm depends on the wind and waves. And while it'll always be a judgement call for the captain, making the trip when you know that the chances are slim is a waste. Using data to predict the odds of accessing the turbines would be very interesting, as it would help cut the number of unnecessary trips."

CUMULATIVE INSTALLED WIND ENERGY CAPACITY

Including both onshore and offshore wind sources



SOURCE: OUR WORLD IN DATA, 2022

> "The big question is when the industry will be able to unlock the capacity it needs."

"Mastering the intricacies of wind turbine siting, where energy production and cabling costs often clash, is a formidable task. The remarkable achievement of our research lies in its ability to find the delicate balance between maximizing energy output and minimizing the often-prohibitive cabling expenses. It underscores the practical significance of optimizing wind turbine siting, ensuring that renewable energy projects not only harness the power of the wind but do so with cost-effectiveness at the forefront."

- Prof. dr. Joaquim Gromicho, Science and Education Officer
- Application of selection hyper-heuristics to the simultaneous optimization of turbines and cabling within an offshore windfarm

Click to read more

the inherent imbalance in the energy system. Huge battery projects are being proposed. They are the first step towards the flexibilization of demand, which will also find its way to consumers."

Capacity will set the pace

The transition in the industry, however, is of a completely different order of magnitude. "To meet industrial heat demands, the best solution would be to give up gas boilers in favor of electrical alternatives. Rather than making the current demand for electricity more sustainable, we will have to replace gas with electricity, requiring new connections to the grid. The big question is when the industry will be able to unlock the capacity it needs.

Dutch system operators like Stedin and Alliander have their work cut out for them: they will have to expand the grid to create capacity for the increase in demand." Capacity levels will set the pace of the transition in the Netherlands, Dijkstra stresses. "That is also why the government chose to include 'system integration' as award criteria for the most recent tender (Hollandse Kust West, *ed.*) and for the upcoming tender. Bidders will have to ensure that the power generated with offshore wind can be seamlessly integrated into the system by pairing it with additional demand. The previous round was won by RWE, which linked the generated power to electrolysis, which is yet to be developed, and partly to the heat grid. As a result, there is

> "Hydrogen infrastructure will not be built in a day, but we are progressing."

now a direct link between the capacity of the wind farm and flexible demands in the industry, potentially solving any future mismatches." Generally speaking, Dijkstra has a positive outlook: "From grid congestion to inflation and a lack of resources to the national nitrogen policy, there are plenty of challenges in the Netherlands. Still, I am confident that we will accomplish our objectives." One of the main reasons is that there is still plenty to be gained for Ørsted in countries like the US and Taiwan.

Critical infrastructure

The company is also looking to boost international cooperation within Europe. "The war in Ukraine has led to closer ties between European countries. There are discussions about building a hydrogen network, about the possibility of making Spanish hydrogen available to German and Dutch industrial companies via France. "Hydrogen infrastructure will not be built in a day, but the Netherlands has been progressing by appointing Gasunie as the transmission system operator (TSO) for hydrogen. They are working out how to repurpose pipes for hydrogen in the existing network, which requires international coordination on infrastructure and hydrogen quality." Dijkstra agrees that the attack on the Nord Stream pipelines has been a wake-up call, revealing the vulnerability of critical infrastructure. "The same goes for offshore wind. Large capacities are at stake: At IJmuiden Ver, 4 gigawatts pass through two cables to the coast. If malicious persons blow up a 2 gigawatt cable, the consequences will be greater than only a minor ripple that can be managed by opening up reserves. It will have a significant impact and might even trigger a blackout. As an industry, we have sat down with the government to explore ways to improve safety. It is uncharted territory: we do not even know which enemies we have to protect ourselves against. Whoever was responsible for destroying the Nord Stream pipeline proved that it was possible. The attack prompted us to critically review our processes and systems, looking at both physical barriers and cyber security."

"No one can solve a crisis on their own"

It comes as no surprise that we are currently experiencing turbulent times, characterized by a series of simultaneous crises that are putting our resilience to the test. The combination of a global pandemic, extreme weather events, inflation, war, and an energy crisis has led to far-reaching implications, including the emergence of unprecedented energy poverty and the potential erosion of European industrial competitiveness, as Stephan Segbers points out. "We have to realize that energy will never again be as cheap as it used to be."

Interview with Stephan Segbers. Chief Operations Officer at Essent Netherlands. Starting in October 2023, Segbers continued his career as Chief Sales Officer at RheinEnergie.

Co-creation in times of crisis

"The energy triangle consists of security of supply, affordability and sustainability. Before all these crises, the Dutch had always taken the first two factors for granted," Segbers explains. "In recent years, the carbon emissions and sustainability took center stage, but now that geopolitical tensions have led to scarcity, the energy triangle has been recalibrated, as it were, with security of supply and affordability coming to the fore. For now, sustainability has returned to the back seat." Though COO Segbers understands why, he also has a warning: "There is no planet B and the clock is ticking. Pushing through an energy transition is the only way to save the planet and free Europe from its dependence on Russian gas in order to secure sustainable long-term energy supplies." The industry saw the energy crisis coming even before the war in Ukraine broke out, Segbers recalls. "In the last quarter of 2021, prices skyrocketed and volatility hit unprecedented levels, ushering in a completely new market dynamic, in which extreme price fluctuations caused extreme reactions. It was almost like a self-reinforcing cycle." The energy crisis was caused not by one isolated event: it was sparked by myriad different factors: "The COVID pandemic that wreaked havoc in various sectors and left major supply problems in its wake, the availability of energy, slowly rising interest rates, followed by the terrible events in Ukraine that shook the world from a geopolitical point of view."
C-level executives have to push boundaries in times of crisis,

> "We are facing enormous challenges: how should we source our energy, how can we avoid de-industrialization, and how can we make sure we don't lose the momentum of the sustainability movement at the expense of security of supply?"

Segbers argues: "You are forced to keep an eye on different indicators and cash becomes a lot more important. On top of that, you usually find yourself working with politicians more closely, because they know that crises are a time for action. As the market leader in the Netherlands, we have an obligation to our customers. We want to be a reliable partner, while also making sure that people can still afford our product. No one can solve a crisis by their lonesome, so we always try to co-create. This was understood by the industry and politicians alike: we need to foster a constant dialogue to explore the consequences of potential actions and identify the latest market developments. If we learn from each other, we can all make it out to the other side together. Industry, legislators, regulators and other stakeholders have to contemplate the future of the market, shape the market in a way they deem best, and accept its limits."

"It is a challenge that we will have to overcome."

Stephan Segbers has been in the energy industry for more than 15 years. He is committed to accelerating the energy transition and has held various positions with E.ON Group across virtually the entire (energy) value chain. During his career, he worked in both Germany and the Netherlands, carrying out assignments throughout Europe. Segbers holds a bachelor's and master's degree in International Business Administration and an MBA in Energy Management.

During his career in the energy sector, Stephan Segbers has seen his fair share of transitions. And yet, he believes the energy transition ahead of us is "the biggest challenge our generation will face." There are no two ways about it for Segbers, a father of four: "it is a challenge that we will have to overcome."

Sense of urgency

Awareness of climate change has increased significantly in recent years, Segbers observes, as has the realization that a more sustainable and environmentally friendly energy system is a must. "Younger generations in particular have a completely different mindset from the generations that preceded them, and the growing awareness in all layers of society has accelerated the energy transition. Major energy companies have embraced new business models, and the industry as a whole has come to the understanding that a sustainable business model is ▶

> "The energy world is becoming increasingly digital, so any energy company wishing to perpetuate its success will have to be a data-driven organization."

the only way to guarantee medium to long-term success. How our B2C and B2B customers think about energy has been flipped on its head. Nobody used to bat an eyelid at energy, and now it has become one of the most hotly debated issues overnight, which will only help expedite the energy transition. Demand for new energy solutions among consumers already far exceeds supply and our business customers have also cottoned on to the growing need: there is a different sense of urgency. Admittedly, the urgency we felt late last year is subsiding now that we have survived the winter and prices are falling below the price ceiling. But still, the war in Ukraine has marked a paradigm shift." It will take at least another 15 years for the Netherlands to become carbon neutral, but that is not Segbers' preferred perspective: "I'm a pragmatist at heart, so I care most about what I can do today to make sure we're still heading in the right direction. I can go around telling everyone what state-of-the-art fuels we'll be using in 2037, but I'd much rather explain how to make your house energy-neutral tomorrow. The energy world is becoming more complex and we need to shepherd our customers and help them find their own pathway through the transition. In the past, our customers were pure consumers. Now, they have become producers in their own right, generating electricity themselves. New energy solutions are being developed, leading to peaks and valleys in energy consumption and generation. Our goal is to help customers take the next step."

The energy world of tomorrow

Fossil fuels are being phased out, but we don't have a self-sufficient alternative without relying on coal and gas. That is why Segbers believes that nuclear power could be an interesting option for the Netherlands. "Other countries have also embraced it as a realistic future energy source. It is efficient and has low carbon emissions, although storage is still an issue. Regardless, I think that nuclear energy will become more important than many people currently anticipate. Furthermore, offshore wind and solar are growing tremendously fast, but we will need other energy sources in the near future to supplement renewable energy where needed. It is also important to realize that we will not be able to electrify industry and mobility across the board, which is why I am convinced that hydrogen will play a key role in tomorrow's energy world. Australia and North America in particular have made tremendous progress in hydrogen and you could almost argue that they are locked in a race for grant money. There is still work to be done, especially when it comes to transporting hydrogen, but recent developments and crises have pushed hydrogen technology forward by at least 5 years. On top of that, the world has realized that demand for hydrogen will be higher than we thought a few years ago. Amidst all these developments, it is key for the Dutch energy sector, and the Netherlands as a whole, to stay competitive. How can you protect prosperity and prevent deindustrialization? The Inflation Reduction Act is an unprecedented grant program that was launched with the aim of drawing investors to North America. Companies that are heavily affected by energy prices and availability will think carefully about the best destinations for their production facilities and investments. How can the EU keep prices at a level that will allow us to compete with Asia and the US in the future? The energy crisis is a European crisis, so national governments and the EU need to step in and realize the importance of staying competitive."

More digital and data-driven

"The energy world is changing at lightning speed, and our mindset will have to change with it. We need to become more flexible and agile and make decisions faster. Moreover, the energy world is becoming increasingly digital, so any energy company wishing to perpetuate its success will have to be a data-driven organization. A fundamental understanding of energy markets and systems will remain key but must be complemented by cutting-edge knowledge of IT and data, as well as a holistic view of how to combine products and solutions, and the interaction between the two. Essent has to keep up with these developments or face losing its relevance as a company."

THE ENERGY TRANSITION IN NUMBERS

73% of global greenhouse emissions come from the energy sector.

$4 TRILLION are needed to reach net-zero emissions by 2050 - meaning that annual clean energy investments worldwide have to more than triple by 2030.

30 MILLION jobs could be created by the energy transition.

70% Annual energy-related CO_2 emissions need to decline 70% below today's levels by 2050 to set the world on a pathway toward meeting the climate goals. Renewables, energy efficiency and substantial electrification can provide over 90% of the necessary reduction.

$423 BILLION are spent every year by government to subsidize fossil fuels. Repurposing these subsidies could pay three times over the annual amount required to 'eradicate' extreme poverty as measured with the PPP$1.90-a-day poverty line.

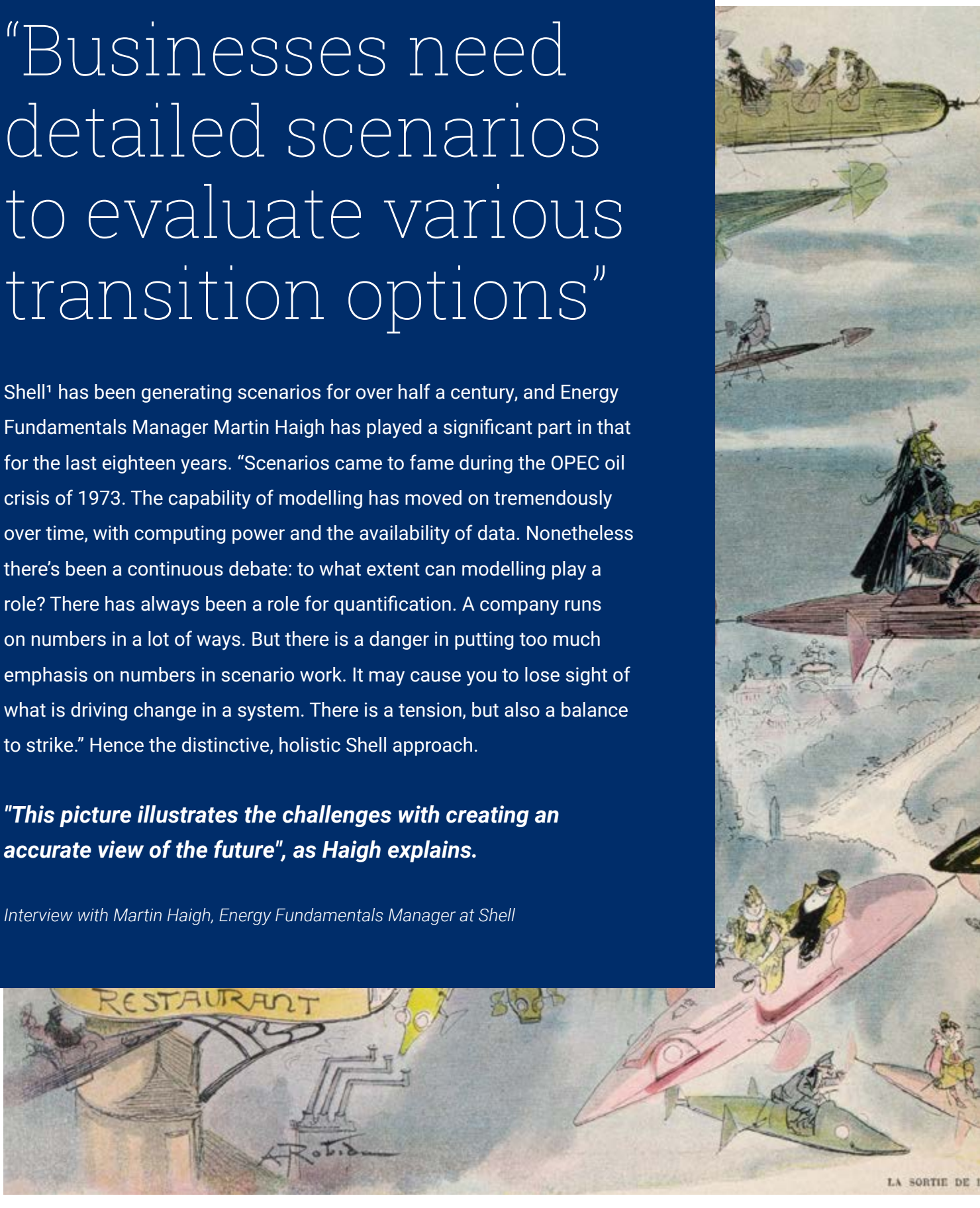
SOURCE: THE UNDP SUSTAINABLE ENERGY HUB

“Businesses need detailed scenarios to evaluate various transition options”

Shell[1] has been generating scenarios for over half a century, and Energy Fundamentals Manager Martin Haigh has played a significant part in that for the last eighteen years. “Scenarios came to fame during the OPEC oil crisis of 1973. The capability of modelling has moved on tremendously over time, with computing power and the availability of data. Nonetheless there’s been a continuous debate: to what extent can modelling play a role? There has always been a role for quantification. A company runs on numbers in a lot of ways. But there is a danger in putting too much emphasis on numbers in scenario work. It may cause you to lose sight of what is driving change in a system. There is a tension, but also a balance to strike.” Hence the distinctive, holistic Shell approach.

"This picture illustrates the challenges with creating an accurate view of the future", as Haigh explains.

Interview with Martin Haigh, Energy Fundamentals Manager at Shell

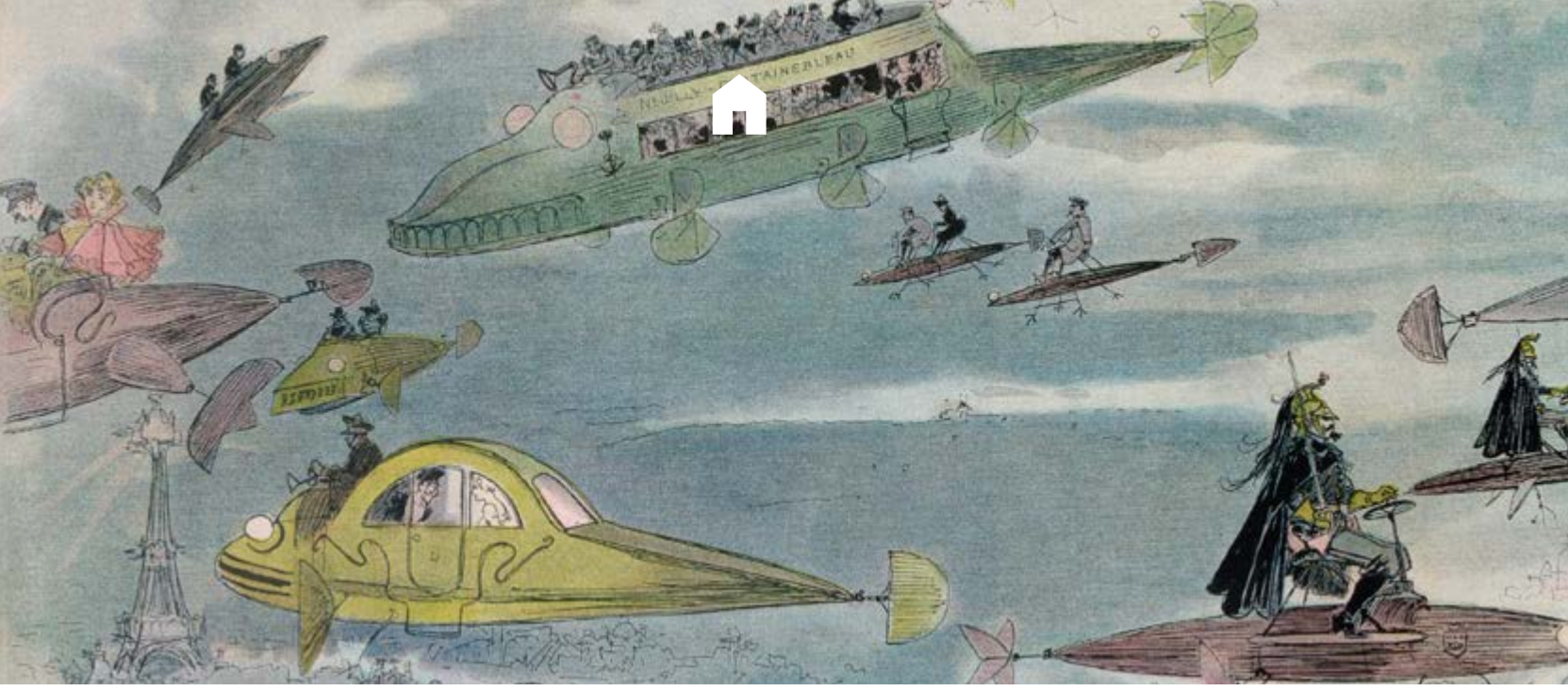


[1] *The companies in which Shell plc directly and indirectly owns investments are separate legal entities. In this content “Shell”, “Shell Group” and “Group” are sometimes used for convenience where references are made to Shell plc and its subsidiaries in general.*

The exit of the opera

There is a danger in over-emphasizing the impact of technology on our lives. To illustrate this, Martin Haigh often shows a picture made by the French artist Albert Robida: 'The exit of the opera in the year 2000': "Robida created this picture around 1890, and it's the earliest image I've seen that has flying cars in it. Flying cars have become our image of the future since then. And here we are, 140 years later, and we still don't have them. "

IMAGE: THE EXIT OF THE OPERA IN THE YEAR 2000, ALBERT ROBIDA



With a university background in mathematics and operational research and having worked in railways in Britain, followed by a stint in telecoms consultancy, Martin Haigh started his job at oil and gas multinational Shell some twenty years ago. For eighteen years now, he has been shaping and overseeing the modelling of the scenarios at Shell. "When I came in, the feeling was that the scenarios team needed to step up, because other teams were getting better and better at doing quantified energy outlooks. The goal was to develop a more comprehensive energy system modelling capability. The Scenarios team built two principal versions of the World Energy Model in-house. Since 2017, ORTEC have been working alongside the Scenarios Team in a steadily deeper collaboration to support the modelling work. The ORTEC team have played a core role in rebuilding our latest – third – World Energy Model in a Python framework."

The exit of the opera

When asked what scenarios mean in Shell's world, Haigh responds: "Our answer is that scenarios are alternative futures. But there are different ways of representing uncertainties concerning the future. A typical one, specifically if you come from a mathematical background, is to produce a forecast and an uncertainty range around that. Simulation exercises can often produce this sort of outlook. But what if the uncertainty is more structural than that? The models include certain rules about the way the world works, and that can give you a narrow range of the uncertainty. Another popular approach is what we call the normative scenario, which works back from a target that you want to achieve, to see what plan is needed to deliver that particular outcome."

However, states Haigh, these models can be limited in capturing turning points that significantly change the trajectory of events. So, Shell uses scenarios to incorporate both qualitative and quantitative elements within a broader framework. The aim is to understand and project different outcomes based on varying unpredictable drivers, ensuring each scenario remains internally consistent. This approach is useful for stimulating discussions and understanding different perspectives on possible futures. The energy industry, due to its long-time horizons and numerous interactions with other systems, seems particularly suited for this approach. Energy scenarios touch upon politics, economics, technology, and human behavior. "We tend to overemphasize the impact of technology on our lives. To illustrate this, I often show a picture made by the French artist Albert Robida: 'The exit of the opera in the year 2000'. He created that around 1890, and it's the earliest image I've seen that has flying cars in it. Flying cars have become our image of the future since then. And here we are, 140 years later, and we still don't have them. This shows the danger of over-emphasizing technology. In the same painting, the people supposedly leaving the opera in 2000 are wearing 19th-century clothes. Men with ruffs

> "There are different ways of representing uncertainties concerning the future."

and women with elaborate hats. That's a symbol of social change that tells us what is completely overlooked. And sometimes it's these social changes that we might not be looking at but that could have more impact on energy. Plus, some things do not change. That is also reflected in the picture: the bridges over the river Seine are much the same today in Paris as they were in the 19th century. There will be prints of the present into the future as well."

More extensive consultations

So, how does Shell 'predict' the future? "Well, we wouldn't pretend to 'predict' the future. Rather, it's about finding what you can say usefully about the future. When I was brought into the team, one of the challenges was the fact that the energy system is transitioning. How do you model the energy system through a transition? That raises a debate about what lessons from the past we can rely on. In statistical terms, what relationships would persist, what parameters could you even rely on, and what is up for change? In my opinion, we needed to keep more input exogenous to the model." Haigh describes Shell's energy modelling system as something more than 'a giant adding machine'. "There's significant mathematical work within it. But it combines exogenous inputs and produces the cumulative result of our assumptions. Essentially, it's our way to mirror a scenario story that the team come up with, and then test its consistency and plausibility.

Last year, while we were developing the Energy Security Scenarios, we began with a series of monthly team workshops." The sessions aimed to provide clarity on the team's path, leading to the quantification of their understanding. "It became the most iterative process that we have achieved so far, where the preliminary numbers were scrutinized, refined, and then reshaped either to align better with the scenario narrative, or help the Scenarios Team fill out details of the narrative. Our new system has made the process far more efficient, allowing for more extensive consultations. This is crucial as stakeholders need time to digest the information, and we benefit greatly from multiple perspectives that help stress-test our models. One of the things I was a bit skeptical about to start with, was whether our new programming framework in Python would be any easier to enhance and extend to more processes than before. I wanted to extend the capability of the modelling, not just make the modelling faster. My initial fears proved unfounded. It's a more flexible platform and it is easier to upgrade. And the key case in point was that we were able to include direct air capture of CO2 and power-to-liquids. These technologies in the energy system are of great interest to the technological optimists, and we got them in ahead of other energy systems modelling teams."

Numbers in context

In the future the model's functionality can be expanded further, leading to more detailed analyses and answers to newer, more complex questions. However, over-complicating things must be avoided, says Haigh. Another avenue is the potential integration of various models, ensuring consistency in the outputs. Lastly, there's a significant push towards democratizing the data, making it more accessible both internally and externally. Previously, providing colleagues with detailed data required a labor-intensive process. "Now, thanks to our dashboard, we've been able to make all this data accessible to Shell staff. We're also keen on expanding this accessibility externally, but there are hurdles, such as licensing issues. I'd like to make more of this data available externally. I think most of us in the team see a great benefit for Shell in being a part of the conversation about the energy transition. We have to show how we think, where we've come to, the conclusions we've got to." Transparency in all aspects is essential, says Haigh: "There's a danger that modelling becomes a black box, with people blindly accepting – or rejecting – the outcomes without questioning the assumptions behind them. We aim to use models as tools to explain the thought processes. Sometimes a model might yield a surprising result, not necessarily due to an error but because of the way variables scale and interact. That's why it can be valuable to project even up to 2100. Such long-term views can highlight trends and factors we might not immediately see, but which can inform earlier decisions.

> "People often confuse scenarios and strategy, thinking the scenarios directly reflect the company's future actions. But our scenarios depict what the world is doing. They are merely one of many inputs into our strategy."

Helping to understand the story behind the numbers is also vital. While I can't dismiss the importance of the figures – given that my team produces them – it's crucial to see these numbers in the correct context."

Possible global directions

Speaking of context: by no means do scenarios represent Shell's strategy. "We've even added a slide in our presentations distinguishing between scenarios and strategy. People sometimes confuse the two, thinking the scenarios directly reflect the organization's future actions. But our scenarios depict what the world is doing. They provide context for the organization to understand possible global directions. While there may be big opportunities in the global context, Shell might also focus on niches where it has a distinct advantage, because given the sheer scale of the world's energy system, niches can still be very large business opportunities indeed. Scenarios are merely one of many inputs into our strategy." At the same time, scenarios are used in multiple ways, states Haigh: "And we're always striving to incorporate them more extensively. They serve as a unifying concept within the organization. If someone proposes a new business prospect to Shell's executive committee, tying it to our scenarios can give it context and significance. For instance, aligning a proposal with known scenarios like 'Archipelagos' or 'Sky 2050' helps the leadership understand its place in the broader scheme. Businesses need detailed scenarios to evaluate various transition options. We provide that broader backdrop and then allow businesses to delve deeper based on their needs." Another application has been the creation of integrated clean energy hubs in key operational areas worldwide. Over the years, members of the Scenarios team collaborated with in-country teams to explore various energy transition possibilities in these regions. "Shell's leadership also refers to our scenarios in their communications. Sometimes they'll juxtapose our findings with those from other reputable organizations like the International Energy Agency (IEA). This helps in understanding where we align or differ with external views and why. For instance, we noted a difference in what we see as the plausible range for world energy demand in 2030 compared to the IEA's 'Net Zero 2050' scenario. Understanding such differences of view aids decision-making."

Tight timeline for targets

Geographical diversity is another essential aspect. Scenario generation can be susceptible to group think, so we have to work hard to draw in different perspectives. "We prioritize global engagements, and technology has made this even more feasible nowadays. We've recently introduced the idea of archetypes in our scenarios. This stemmed from recognizing that the green-first philosophy of energy transition dominant in Western Europe isn't universally embraced. The goal is to trigger debate and consider multiple world views because a myriad of challenges exists, says Haigh, from climate concerns to developmental issues. While I'm proud to work for an organization that's a part of this transitional story, a sustainable business model is crucial. In the triumvirate of consumer, government, and business, each player tends to argue the other two should be more proactive. However, I'd argue that government policy is paramount. They have the tools to coordinate, support emerging technologies, and provide various types of support, from R&D to integration into the system. Companies, too, play a vital role. Those that take the initiative and demonstrate innovation, both in business models and technology, will emerge as leaders. The major challenge, for organizations like Shell and the system at large, is scaling solutions quickly. The timeline for targets, such as net-zero by 2050, is tight. Thus, solutions need to not just be effective but also rapidly scalable." In the end, Haigh stays optimistic: "Part of our work is to help guide discussions, drawing on sources like the IPCC. Rapid changes are indeed occurring, but we mustn't lose hope due to dystopian narratives. Humans have shown great resilience and adaptability in the past."

About Martin Haigh

Martin is Senior Energy Adviser at Shell and leads the Energy Fundamentals team, which explores how energy demand is evolving in different countries and sectors. Martin joined Shell in 2003 and has been a member of the Shell Scenarios team since 2004. He has led the development of Shell's World Energy Model, which has underpinned the last five Shell scenario rounds and built on Shell's 50-year history in scenario planning. Martin works with many institutions, including MIT's Climate Science team and the International Energy Agency, and has participated in the IPCC Sixth Assessment focusing on energy systems modelling. He is a Fellow of the Royal Geographic Society.

Martin has a background in mathematics. He has experience in mathematical and economic modelling in the transport, telecom and energy industries.

ABOUT ORTEC ENERGY

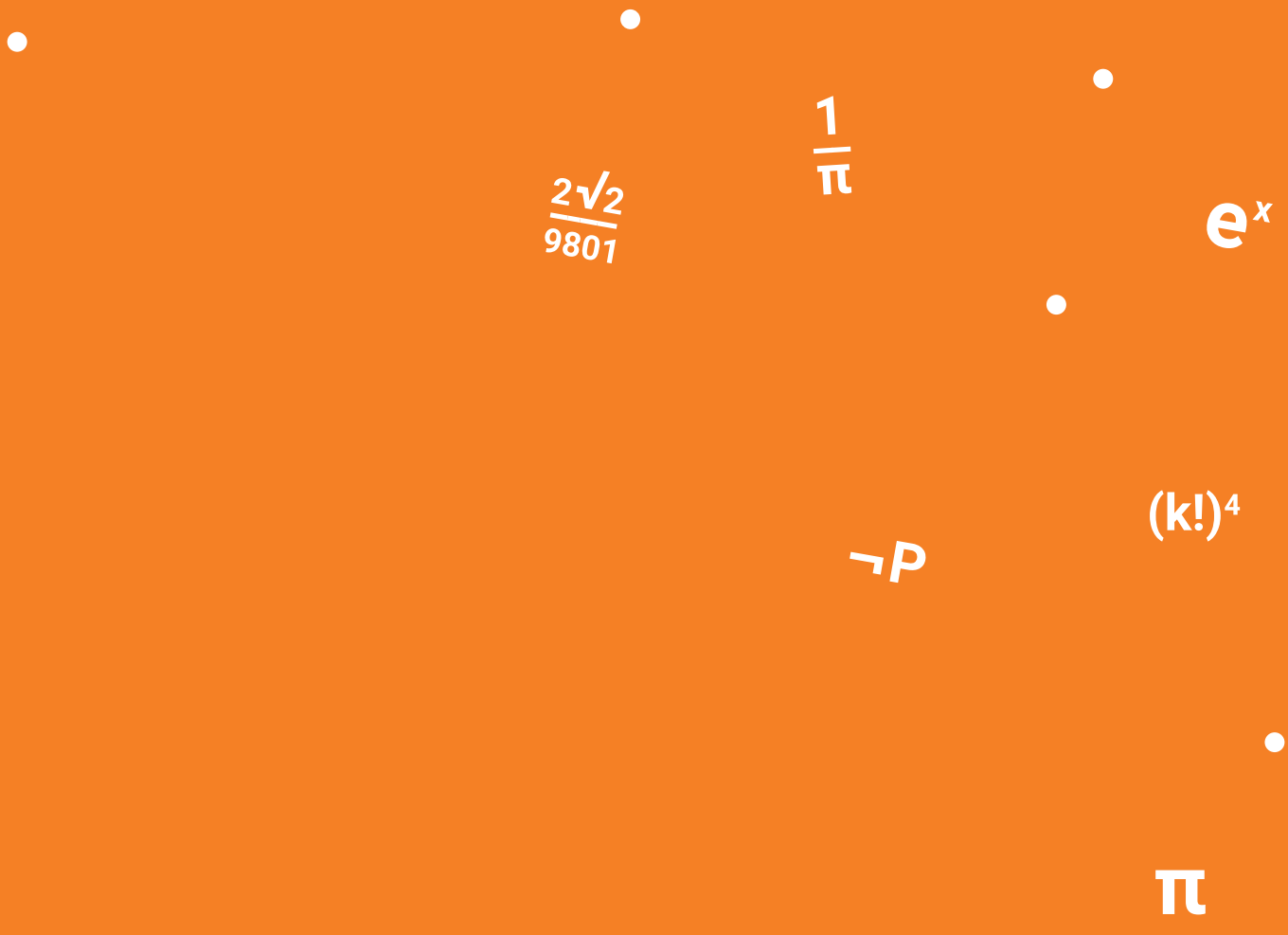
Improving the world, using our passion for mathematics

In today's data-driven and complex world, it is key to continuously adapt to a rapidly changing environment. But how to optimize business decisions under changing circumstances?

At ORTEC, we support organizations in making better decisions by leveraging data with applied mathematics. We are driven to improve the world using our passion for mathematics. Today, this purpose steers not only our decisions, but also those of our customers. It shapes our actions, at every level of our business.

On our journey to increase our impact on the world, we focus - amongst other industries - on the energy industry. We guide and support energy organizations in data-driven decision-making and use innovative mathematics tools to help them deliver the energy needs of today and tomorrow. The energy industry is a highly complex world, with shifting market dynamics, intertwined supply chains, long investment timelines and high levels of uncertainty. At ORTEC, we help our customers to navigate this complexity, and to use available data for daily operational challenges as well as long-term strategic decisions. Together we can tackle topics such as selecting optimal locations for worldwide assets, making efficient investment and maintenance plans, and reducing kilometers driven and emissions from existing supply chains.

Together with our customers, we increase economic and social value and reduce environmental impact, year after year.



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