Vestas

Paving the road to a sustainable future

CBS Case Competition Invitational 2023

CBS CASE COMPETITION

Wind. It means the world to us.™

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Setting the Stage

Letter from Henrik Andersen President and Chief Executive Officer

Dear case participant,

I am happy to reveal that Vestas is the case company for the CBS Case Competition in 2023.

Vestas is determined to transform the global energy system. To achieve our vision, we need to pave the way for wind energy to play a central role in energy systems across the world. Therefore, we are working to accelerate the expansion of renewables by collaborating closely with key stakeholders across the energy landscape. We do this because we believe in building a more sustainable planet for future generations.

The urgency to act has never been clearer. Increased evidence of the climate crisis, improvements in sustainable energy solutions, and political momentum have all grown significantly. In dominant economies such as the USA, China, the EU, and Japan, climate targets are becoming more ambitious. As a result, plans to accelerate the energy transition to achieve net zero are now more concrete. With further technology innovations and improvements to come, Vestas remains firmly at the heart of the energy transition and a major driving force in the journey to net zero.

Wind energy is Vestas' heritage and continues to be the core of our business. However, transforming to a truly sustainable energy system requires capabilities beyond power generation from wind.

As renewables replace fossil fuel power plants and electrification accelerates and expands, innovative solutions are needed to ensure stability and enable indirect electrification. Key to these efforts is the commercialisation and scaling of Power-to-X solutions. One of the main challenges of the future will be to decarbonise the hard-to-electrify sectors, such as heavy industry, transport, and agriculture.

To ensure our core business becomes fully sustainable and continues to grow, Power-to-X is a long-term strategic enabler to reach our vision of becoming a global leader in sustainable energy solutions. However, Vestas has not invested in this industry yet.

While Power-to-X is still not commercialised at scale, Vestas aims to investigate how our existing capabilities, as the world's leading wind power OEM, can be leveraged to develop new solutions and offerings within the Power-to-X space.

Therefore, we pose the question to you:

> "How can Vestas leverage its position as a global leader in wind power plant solutions to create new business from Power-to-X? What should Vestas' strategy be towards 2030?

To guide your answer, please consider the following questions:

- In what part(s) of the Power-to-X value chain should Vestas play a primary role, and why?
- What financial or commercial goal(s) should Vestas set for 2030?
- How can Vestas leverage its internal capabilities and partnerships to win in Power-to-X?

We, at Vestas, hope that this case will challenge you and we are eager to hear your perspectives, which will hopefully aid us in paving the road to a sustainable future. Thank you all in advance for your time and engagement.

Section 1
Vestas at a glance

Vestas' history dates back to 1898, when the 22-year-old Hans Søren Hansen bought a local blacksmith workshop in the small farming town of Lem, in the western part of Jutland, Denmark. After the war in 1945, Hans and his son Peder Hansen, established Vestas - a multipurpose manufacturing firm using know-how and expertise to produce equipment that they knew their customers wanted. Their opportunistic approach to business development meant that the company, over time, produced everything from household appliances to agricultural equipment, milk urn coolers, and hydraulic cranes for light trucks. The breakthrough in the production of wind turbines was made in 1971, when the first engineer was hired by the company. With the oil crisis looming in the 1970s, Vestas carried out initial wind turbine experiments with the ambition to innovate an alternative form of energy production. In 1979, the first turbine was sold and installed. Growing interest in alternative energy and the consistent growth of Vestas' renewable energy solutions have formed an entirely new industry during the past 50 years.

Vestas today

Today, Vestas is still the world's largest wind turbine OEM and employs around 29,000 employees worldwide to help create a better world. Vestas has expanded its business from purely designing, manufacturing, and installing wind turbines to also developing and servicing wind energy and hybrid projects all over the world. With more than 160 GW of wind turbines installed in 88 countries and more than 140 GW under service contracts, Vestas is the global market leader in onshore wind solutions and services, as well as a leading global player in offshore solutions.

The increasing customer demand and competition have pushed technology development to new heights: Vestas now produces offshore turbines with a rotor diameter of 236 metres and a power rating of 15 MW – enough to power around 20,000 European households and save more than 38,000 tonnes of CO_2 every year. Vestas' sustainable energy solutions have prevented 1.7 billion tonnes of CO_2 from being emitted into the atmosphere and have contributed to a more sustainable energy system, officially making Vestas the most sustainable company in the energy industry 2023.

For Vestas, wind energy is its heritage and core competence. It is the company's belief that wind will form the backbone of the sustainable energy systems of the future, and they remain focused on developing solutions that accelerate the energy transition and strengthen Vestas' continued leadership in wind power generation.

Timeline

1898

Hans Søren Hansen buys a blacksmith workshop in Lem, in the western part of Jutland, and starts producing steel window frames for industrial buildings and household appliances.

1945

After the war, Hans Søren Hansen and his son Peder Hansen establish Vestas, which is short for Vestjysk Staalteknik A/S (Western Jutlandic Steel Technology).

1971

Vestas hires its first engineer to experiment with alternatives to energy production in the era of the oil crisis. During the mid-70s, the first wind turbine experiments are carried out in secret.

1979

Vestas sells and installs the first wind turbine – a 10-metre rotor with a rated capacity of 30 KW.

1987

Wind turbines become a key strategic focus area – Vestas Wind Systems A/S is born.

1995

Vestas continues pioneering the wind industry by building one of the first-ever offshore wind farms, Tunoe Knob.

1998

Vestas gets listed on the Copenhagen Stock Exchange. At this time, Vestas' turbines generate ~22% of the world's wind power.

2003

Vestas is merged with the Danish wind turbine manufacturer NEG Micon to create the largest wind turbine manufacturer in the world.

2014

Mitsubishi Heavy Industries and Vestas form a joint venture to handle marketing, sales, and service of offshore wind turbines.

Vestas formalises service operations for wind turbines in a separate business unit.

2020

Vestas acquires full control of the offshore turbine business, MHI Vestas, the joint venture established in 2014 with Mitsubishi Heavy Industries.

Vestas acquires 25% of Copenhagen Infrastructure Partners to further expand its presence across a wider range of the renewable value chain.

2021

Vestas formalises its development activities in a Development business unit that secures land rights, obtains appropriate permits, designs sites, ensures grid connection, negotiates project offtake agreements and financing.

To explore and develop Power-to-X as a new potential business area, Vestas forms a small, dedicated technology and commercial team.

2022

Vestas named most sustainable company in the world in Corporate Knights' Global 100 ranking.

Organisation

Vestas' organisation is structured in a two-dimensional matrix with seven global functions, each headed by an Executive Vice President. Together with the Group President & CEO, Henrik Andersen, the Executive Vice Presidents form the Executive Management team.

Seven Global Functions
Each global functional area represents the key disciplines of the company:

- Sales
- Technology
- Manufacturing & Global Procurement
- Service
- Finance
- People & Culture
- Digital Solutions & Development

Five Regions
Each region, headed by a regional CEO together with a management team reflecting all seven global functions, is responsible for full profit and loss and all frontline customer engagement, including end-to-end sales, construction, and service. Combined, the five regions form Vestas' total operating area.

The five regions are:
- Northern America (Canada & US)
- Latin America (from Chile to Mexico)
- Northern & Central Europe (from Finland to Austria)
- Mediterranean (from Portugal to the Middle East)
- Asia Pacific (from Thailand to India and Japan all the way to New Zealand)

Executive Management

Henrik Andersen
Group President & CEO

Hans Martin Smith
CFO

Christian Venderby
EVP & CSO (service)

Kerstin Knapp
EVP & CPCO

Tommy Rahbek Nielsen
EVP & COO

Javier Rodriguez Diez
EVP & CSO (Sales)

Anders Nielsen
EVP & CTO

Thomas Alsbjerg
EVP Digital Solutions and Development

Regions

Northern America	Latin America	Northern & Central Europe	Mediterranean	Asia Pacific
Laura Beane Regional President	Eduardo Ricotta Regional President	Nils de Baar Regional President	Jose Luis Jimeno Regional President	Purvin Patel Regional President

Vision

With a vision to become the global leader in sustainable energy solutions, all of Vestas' activities revolve around the development and deployment of solutions supporting that goal.

Wind energy is Vestas' core focus, and the company designs, manufactures, installs, develops, and services wind energy solutions that accelerate the transition towards sustainable energy solutions.

Purpose
Vestas' purpose is shaped by a passion to make the world a better place and to contribute to a sustainable future. The company's more than 29,000 passionate employees are its most important asset, and it is therefore essential to Vestas to constantly develop and sustain a culture that develops talent and allows employees to reach their full potential.

Vestas Values
Vestas' values describe the set of principles and standards of behaviour that shape how Vestas employees do their jobs, how they interact with each other, how decisions are made and guide the day-to-day work.

Vestas aims to have its values reflect a deeper level of relevance and impact throughout the organisation. Vestas wants to take its values past mere words and turn them into real and actionable ideals that engage employees on the professional, emotional, and intellectual levels.

Accountability
We have the courage to speak up and deliver on our commitments.

Collaboration
We win and lose together, and pick the best team for the job.

Simplicity
We strive to simplify our work and our solutions to the benefit of our customers.

Passion
We are dedicated to our Planet, People and Vestas.

We think.
We feel.
We act.
We care.
We lead.
We challenge.
We inspire.
We include.
We develop.
We learn.
We transform.
We persevere.
We win.

We make the world a better place.

Vestas' business model

The core of Vestas' business model is aligned with the industry's value chain and consists of Onshore- and Offshore Wind (Power Plant Solutions), Service and Development. Through these business areas, Vestas accelerates the deployment of wind energy through project development, wind turbine R&D, manufacturing, installation, and servicing of the wind turbine fleet. Vestas operates in the B2B space with project and service sales to its key customers, primarily consisting of:

Power Utilities
EDP Renewables
EDF renewables
enel
NEXTera Energy

Global Project Developers
Copenhagen Infrastructure Partners
O2 POWER
Eurowind Energy

Commercial & Industrial Customers
IKEA

Oil & Gas Majors
TotalEnergies
Equinor
BP
Shell

Core

Power Plant Solutions

Onshore - Undisputed market leader within the onshore wind market
Offshore - New technology platform In place to become a market leader

Service

Undisputed market leader with expanding scale and capabilities servicing onshore and offshore

Development

Unique presence and knowledge drives growing pipeline of attractive, undiscovered wind projects

Through the three core business areas, Vestas is well-positioned to address the growth potential within the industry.

Power Plant Solutions (Onshore & Offshore Wind)

Increasing renewable penetration in the energy system.

What is it?

For Vestas, this business area involves designing, testing, sourcing, producing, assembling, and constructing complete wind turbine projects in accordance with applicable standards, requirements, and warranties.

Service

Providing resilience and stability in a fluctuating environment.

What is it?

The service segment includes all scheduled and unscheduled maintenance of installed projects throughout their lifetime. Typically, these agreements run for 20-35 years, as it is imperative for Vestas to guarantee the performance of equipment throughout its economic life.

With the projected exponential growth of the industry towards 2030 and beyond, Vestas is in a unique position to capture value and expand its current three business areas.

Development

Accelerating the energy transition by expanding our project pipeline.

What is it?

Development includes securing land rights for new wind or solar projects, applying for construction and environmental permits, measuring renewable conditions, applying for grid connection, designing the full power plant, and ensuring project offtake agreements and financing of the project. The development area was recently added to Vestas' core business areas. Despite its proximity to Vestas' original areas of manufacturing onshore and offshore, the capital requirements and general scale of development projects make it a gradual endeavour to enter.

Growth potential towards 2030

Power Plant Solutions

2x

Increase in MW across Onshore and Offshore

Service

3x

Increase in MW under service

Development

4x

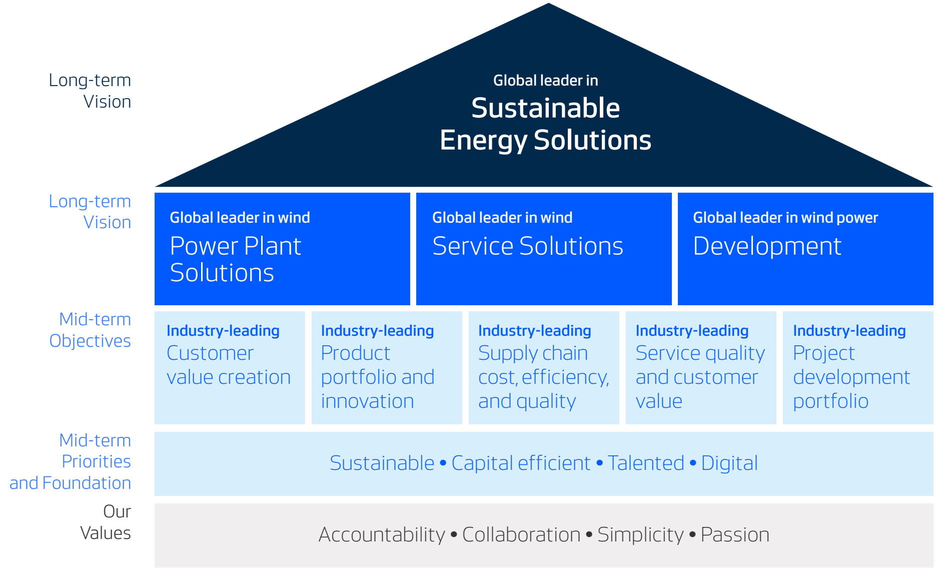
Increase in MW order intake coming from Vestas' own development or co-development

Vestas' Corporate Strategy

Vestas is on a journey to become the global leader in sustainable energy solutions, thereby playing an instrumental role in helping the world eliminate CO_2 emissions. To reach this ambition, Vestas' mid-term objective is to maintain or achieve global leadership in wind power development, wind power plant solutions (onshore and offshore), and service solutions.

The strategy is guided by four financial targets

- Becoming the market leader measured by revenue
- Reaching an EBIT margin of at least 10% by 2025
- Achieving a ROCE of at least 20% over the cycle
- Generating positive FCF every year



1. Becoming the global leader in wind Power Plant Solutions

Vestas remains the global leader in onshore wind with 149 GW of installed capacity. They aim to continue their leadership by maturing the industry through timely and customer-centric technology introductions, strengthening commercial discipline, and capturing additional value from their onshore wind energy solutions.

In the past five years, offshore wind has experienced a meteoric rise. From a distant opportunity, it is now part of our energy systems from 2025 and beyond. Vestas re-entered the segment in 2020 with the acquisition of the remaining 50% ownership in the JV with MHI Vestas.

To continue growing Vestas' presence in offshore wind and position itself as strongly as possible for the future, Vestas remains focused on partnering with its offshore customers to secure orders for its new offshore turbine V236-15MW.

2. Becoming the global leader in wind Service Solutions

Vestas is the global leader in wind energy service solutions. Growing and developing the service business will strengthen the stability and integration of renewables within the energy system. Here, size and scale remain key differentiators in providing customer-centric solutions and improving efficiency and profitability.

3. Becoming the global leader in wind power Development

In the last five years, Vestas has built a +25 GW project pipeline in its Development business to help accelerate the energy transition. With the strong pipeline and the political momentum around renewable energy, the outlook for the Development business continues to improve. The demand for high-quality projects is growing along with the range of potential investors. To continue growing its Development pipeline and business profitably, Vestas' strategy focuses on the origination of new pipelines, the improvement of project quality, scalability and efficiency, and levers to maximise value.

The need for renewables

The wind industry as we know it arose as a result of the 1970s oil shock when the need for alternative and commercially viable energy became too pressing to ignore. Fifty years on, the fragility of the fossil-based energy system has been re-exposed by global events.

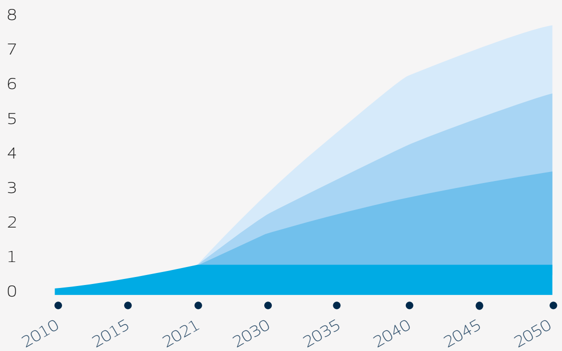
As a global leader in sustainable energy, Vestas is fully focused on creating sustainable and resilient energy systems that can help build prosperous societies. Vestas does this by building sustainability into everything they do and expanding renewable energy through the following three areas:

- Accelerating the deployment of renewables to increase the share of renewable energy in the electricity system.
- Driving direct electrification, meaning green electricity directly coupled with electricity consumption, e.g., electric vehicles and heat pumps.
- Developing and implementing solutions for indirect electrification, that is, powering non-electric sectors with green electricity by converting it to green hydrogen via electrolysis to supply trucks, ships, airplanes, and industrial processes with green fuel.

Regulatory growth drivers
The global and regional events of the early 2020s, with COVID-19, a war in Europe, and extensive global supply chains disrupted, have demonstrated that the true value of renewables is not only their ability to reduce costs and emissions. It is their potential to build resilient, sustainable, and prosperous societies. To reach net zero, it is estimated that annual wind power installations will need to increase to more than 240 GW. Even as stated policies and announced pledges indicate significant increases compared to current levels, the discrepancy is still striking.

Demographic growth drivers
According to the International Energy Agency (IEA), 240 GW is very conservative to reach net zero. In addition, energy demand is expected to grow as billions of people in developing economies gain access to services such as air conditioning and refrigeration, requiring massive amounts of electricity. In total, global energy demand is anticipated to increase by almost 50 percent by 2050 compared to today. Combined with the need to reduce global warming, there is an ever-pressing urgency to make renewable energy affordable and widely accessible.

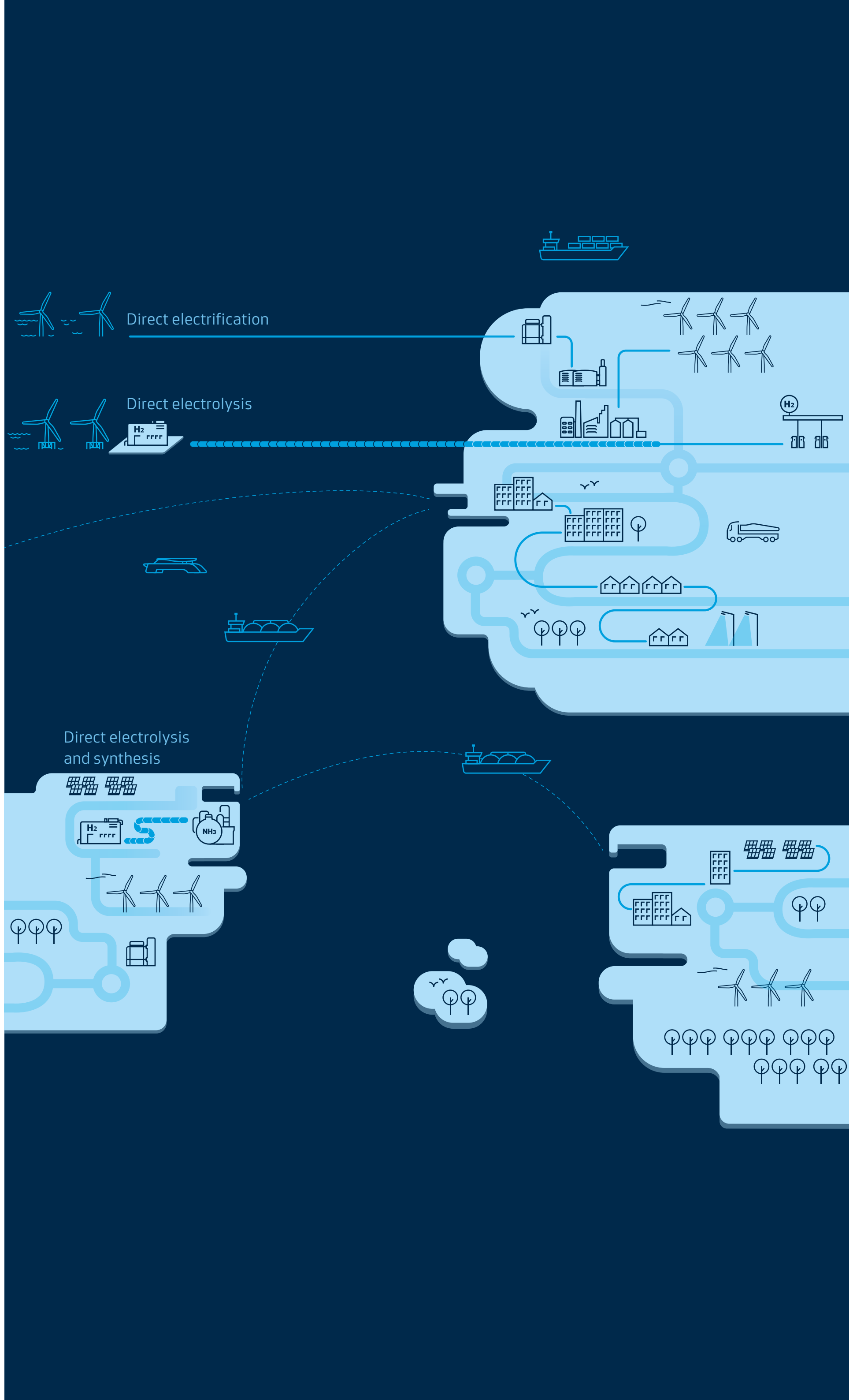
Global wind energy capacity scenarios Terawatt (TW)



Section 2
Power-to-X

What is Power-to-X?

Power-to-X (PtX) is the process of converting power (electricity) into something else (X). X covers a range of fuels or chemicals such as ammonia, hydrogen, methane, synthetic air fuels, and other fuel sources. The power utilised in the process is derived from either conventional fossil fuels or renewable energy sources such as wind turbines or solar panels, making these essential enablers for the PtX industry. The core technology in PtX is called electrolysis, which uses electricity to split water molecules (H_2O) into oxygen (O_2) and hydrogen (H_2). As such, the primary outcome of a PtX process is hydrogen. The hydrogen can either be directly utilised in industrial processing or it can be converted into other fuel sources such as ammonia or methane via a second process step called synthesis. Today, most hydrogen is converted into ammonia and used as a fertiliser for agriculture. Thus, the processes of electrolysis, and potentially synthesis, allow for decarbonisation of hard-to-abate sectors. Hydrogen produced from renewable energy is called "green hydrogen," whereas conventional hydrogen produced from fossil sources such as natural gas is referred to as "grey hydrogen".



Power-to-X, therefore, presents a vital technology, as it offers a solution to decarbonising areas of society which electricity cannot power directly. Furthermore, direct electrification requires massive investments in grid infrastructure to transport the immense amounts of energy across regions, countries, and cities. The build-out of grids has traditionally been very slow which is a global obstacle to widespread electrification. PtX presents an opportunity to decarbonise other sectors without the build-out of electric grids. These sectors include various industries such as the production of cement or steel, or heavy transportation such as container ships where a lot of energy is required and batteries cannot satisfy the needs.

However, while the potential of PtX is great, there are also several challenges and key uncertainties. With today's technologies, namely electrolysis, PtX is not a very efficient process. A lot of energy is wasted in the process of converting electricity from a sustainable source, e.g., wind, into hydrogen. Calculations show that around 70% of wind energy is converted into the propulsion of an electric battery-powered vehicle, while only around 30% of wind energy is converted into the propulsion in a hydrogen-powered car. However, vast uncertainties still pertain as technologies, regulation and end-use markets are developing. Whether passenger cars will be powered by electric batteries, hydrogen or a mix, remains uncertain.

Power-to-X (PtX) is the process of converting power (electricity) into something else (X)

The Power-to-X Value Chain

Vestas is currently assessing a potential position within PtX, but there is still ample uncertainty and flexibility concerning how Vestas should be positioned in the emerging market

Should Vestas be active across the entire value chain, from design and development to construction and operation, or should Vestas limit itself to specific parts of the value chain? Further, what should the value proposition of Vestas be under the various possible configurations?

To aid you in answering this question, the value chain of PtX can be broken down into six stages, as illustrated below.

1. First step	2. Second step	3. Third step	4. Fourth step	5. Fifth step	6. Sixth step
Development ▸	Design ▸	Supply ▸	Construction ▸	Operations ▸	Service

The first step is the development of PtX projects, which includes finding optimal land, making geographical assessments, obtaining various permits, and securing financing for the project. In recent years, Vestas has increased its focus on the development of wind energy projects rather than manufacturing.

The second step is the design of a PtX project. This includes the technical design and system layout such as determining the number of turbines and the size and type of the electrolysers, as well as modelling and designing all other components of the plant based on how much green hydrogen the customer desires. This is in many ways much like designing a wind park except the output is hydrogen and not electricity.

The third step is the supply of system components. This includes the supply of wind turbines, solar panels, batteries, electrolysers, energy management software, and other hardware and software components needed to complete a PtX plant. Vestas is historically a manufacturing company and has played an important role in advancing the supply of commercial wind turbines used today. However, Vestas has in recent years outsourced part of its manufacturing and instead increased its attention to project development, turbine R&D, and service.

The fourth step is the construction and commissioning of all assets and the construction of the PtX plant. This includes hiring subcontractors to build roads, installing cables in the ground or ocean, and other integrating activities required to run a PtX plant. Vestas will sometimes maintain this role for wind projects, but oftentimes the end-customer will take care of this themselves.

The fifth step concerns the operations of the PtX plant. This includes daily operations, trading of hydrogen, performance monitoring, maintaining service schedules and contracts, and continuous business case- and plant optimisation. This is an area where Vestas has limited expertise as it mainly supplies and installs turbines and does not own or operate them.

The sixth step is service which includes monitoring the site performance and the condition of systems, performing scheduled and unscheduled maintenance, including replacement of spare parts, and various repair services. Service is a key business area for Vestas today, with high profit margins and significant year-on-year growth.

A market in motion

The momentum for the green hydrogen industry is increasing, as it has been recognised as a key factor to reach the net-zero greenhouse gas emission commitments, as well as an opportunity to increase energy security.

On a global scale, the demand for hydrogen reached 94 million tonnes in 2021, equal to 2.5% of the global energy consumption, and a 5% increase from the previous year. Practically all of the hydrogen was grey, i.e., produced from fossil fuels.

The market for green hydrogen has low maturity, resulting in higher costs for green hydrogen compared to grey hydrogen. In 2021, hydrogen production from renewable energy (green hydrogen) accounted for only 0.1% of global hydrogen production. However, the market is expanding rapidly, with a 70% increase from 210 MW in 2020 to 510 MW in 2021, and current projections indicate that the market will grow with a CAGR of 9.8% towards 2030. Currently, the price for 1 kilogram of green hydrogen is trending around $5-8 in the USA, whereas the price for 1 kilogram of grey hydrogen sits around $2-3. With the continued cost decline of renewable energy coupled with the requirement for many countries and industries to decarbonise, often supported by government subsidies, green hydrogen is expected to become commercially viable by 2030.

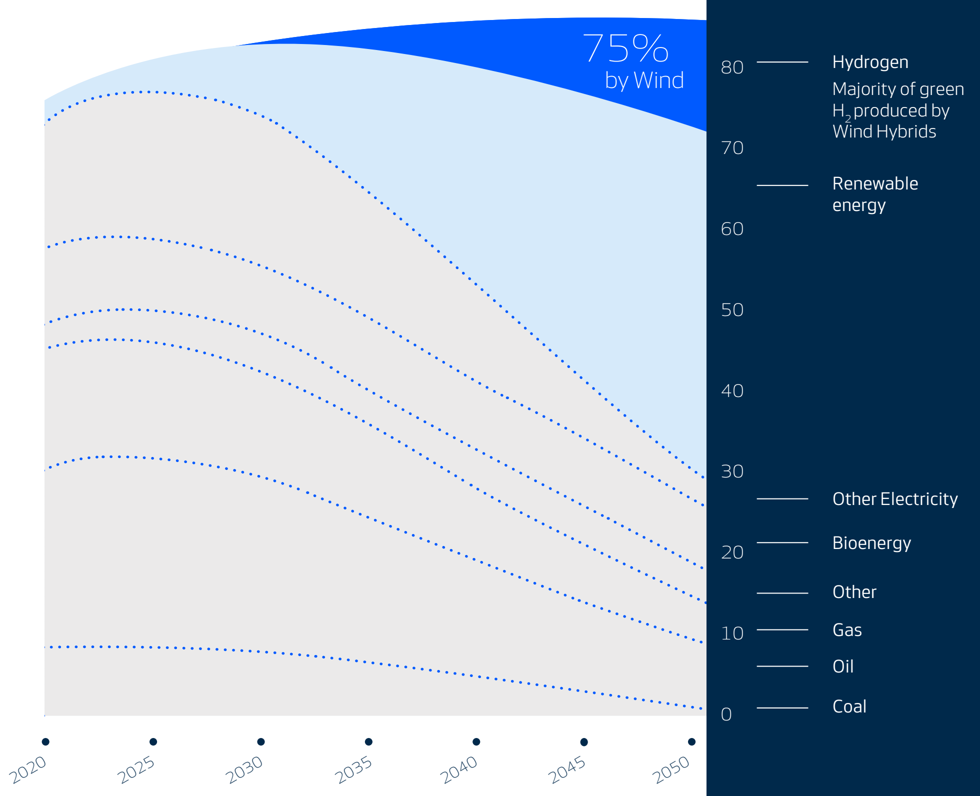
Globally, there are about 460 renewable hydrogen projects under development or construction, typically small-scale projects. Global electrolyser production capacity exceeded 1 GW at the end of 2022, with 40% of the capacity operational in China and a third in Europe. Based on the current green hydrogen project pipeline, global electrolyser capacity could reach 134 GW, equivalent to 24 million tonnes of green hydrogen, in 2030.

In the coming years, the market for green hydrogen is expected to emerge as a new driver for solar and wind power, with China being the leading region due to massive investments by the government. However, the supply and demand remain domestic in this region and are thus independent of the global market.

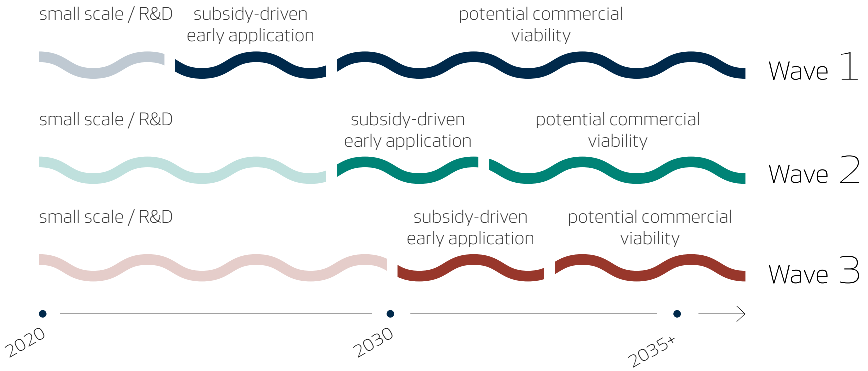
The accumulated demand for hydrogen is meanwhile expected to grow immensely, with the demand for power as the main driver.

Forecasted change in global final energy usage

TWh, 000



Forecast



Besides the projected growth from increased energy demands, it is also important to note the staged growth expectations of the market. While green hydrogen capacity is driven by the demand for decarbonisation, it is also highly dependent on technological maturity and the ability of industries to convert to new fuel sources.

The demand for green hydrogen is expected to increase in three waves over the next 15 years, each characterised by the time at which industries are expected to be able to utilise green hydrogen.

The first wave concerns replacing conventional hydrogen with green hydrogen in industries currently consuming hydrogen. Examples are the agricultural sector where the most important fertiliser is ammonia which can be produced via synthesis using hydrogen (Power-to-X), and the refining industry where hydrogen is used to remove sulphur from gasoline, diesel, or other fuels. In the first wave, green hydrogen and ammonia can directly replace their grey equivalents. Additionally, governmentally driven gas blending is also expected to be a potential market. Gas blending is a process where natural gas is mixed with some proportion of green hydrogen.

The second wave relates to the application of hydrogen in industries such as heavy transportation or supplementary heating. This wave is characterised by some degree of structural adaption in the industries, and commercial viability will thus take longer. For example, one of the structural adaptations that is of great importance is having a dedicated hydrogen grid from which industries can directly consume.

Wave 1

Refining

Ammonia

Other industrial

Natural gas blending

Wave 2

Heavy duty vehicles
Hydrogen fuel cells

Auxiliary power generation
Hydrogen power & storage units

Local maritime applications

Iron & Steel
Hydrogen for ore reduction

Wave 3

Aviation
Synthetic kerosene, liquefied hydrogen

Maritime
Ammonia, methanol, liquefied hydrogen

Cement
Hydrogen for heat

The third and last predicted wave of demand for green hydrogen requires major structural adaption in industries such as aviation, maritime, and cement production. While pilot projects in these industries are already underway, the structural transformation at scale requires major resources and supply chain investments. Substantial demand is thus not expected before 2030-2035. These industries are expected to create a significant demand for green hydrogen as they are all high emitters of CO_2 and have a massive incentive to decarbonise their operations. When the PtX technologies are mature enough to support the expected demand, the decarbonisation of these third-wave industries is expected to have a large impact on a global scale.
Although the three waves are set to happen within a timeframe of roughly 15 years, it will take time for the market to fully mature and for infrastructure to develop. Therefore, it is not realistic for Vestas to start any PtX-related operations prior to 2025, as tremendous development within the industry is still needed.

The question is

Which steps should Vestas take in order to develop capabilities within green hydrogen while being cognisant of the various stages the market will go through?
A strategy that is capable of capitalising on all relevant stages of development must be laid out.

Trends within Power-to-X

The market for PtX is characterised by immense ambition and expectations among politicians and business leaders.

This is reflected in the commitments and pledges made just within the past year. The Inflation Reduction Act (IRA) recently adopted in the USA provides a tax credit incentive of up to $3.00 per kilo of green hydrogen produced given a set of criteria. This means that for every kilo of green hydrogen produced, the US government will reimburse $3.00 – a mechanism created with the intention of accelerating the development and production of green hydrogen.

In March of 2022, the EU announced the RePowerEU plan which included a target to produce 10 million tonnes of green hydrogen in Europe and import 10 million tonnes of green hydrogen by 2030 to satisfy European needs and make Europe increasingly independent of Russian gas.

The Prime Minister of India, Narendra Modi, has predicted green hydrogen will help India make a "quantum leap" to energy independence by 2047. And back in 2017, Japan announced its ambition to become the world's first hydrogen society by adopting the fuel across all sectors.

Despite the enormous expectations relating to green hydrogen, the market has low maturity with almost all hydrogen production coming from fossil fuels and that of green hydrogen coming from small pilot projects only. Green hydrogen is not competitive in any markets today. Many projects under development are first movers that face a combination of risks, including uncertain demand, uncertain regulatory frameworks, lack of infrastructure, and supply chain scale-up, which again poses a risk to the financing of these projects as lenders require higher premiums.

As a result, companies across the value chain are increasingly coming together in partnership constellations to minimise risks and uncertainty and improve the likelihood of success. The illustration below describes four typical partnership models observed within the green hydrogen industry.

Typical Transactional Model

The first model is a typical transactional model, wherein businesses own the entire PtX value chain and employ suppliers for each part of the chain, such as wind turbine producers, electrolysis producers, and transmission engineers.

Project Consortia

Players across the value chain team up to accomplish specific projects. For example, a consortium of 10 private and public sector partners are collaborating on the North-C-Methanol project in Belgium. This type of partnership draws on the expertise of partners across the value chain, while reducing the risk for each of them.

Joint Venture

Some companies have combined forces, in the creation of joint ventures dedicated to the production of commercial green hydrogen. For example, the wind turbine producer Siemens Energy and the industrial gas supplier Air Liquide have announced a joint venture. This type of partnership also reduces risk; however, they are not limited to a single project.

Value Chain Expansion

Value chain players, including renewable developers, engineering firms, and logistics companies, move into adjacent businesses. One of the world's leading solar technology companies, LONGi, announced the foundation of its subsidiary LONGi Hydrogen in March of 2021. The new subsidiary focuses on producing water electrolysis production equipment.

Section 3 Commercial challenges within Power-to-X

In 2022, Vestas pioneered the world's first hydrogen-powered offshore service vessel.

Demand uncertainty

Across many stakeholders, there are great ambitions for PtX to play a role in the transition of the global energy system to renewable energy rather than fossil fuels. But while the development of projects is accelerating, off-take arrangements are lagging behind. Only a few projects have a customer or potential hydrogen offtaker in place. Long-term, most PtX projects are expected to be primarily debt financed while initially, lenders may hold off due to the vast uncertainties, which will favour more traditional E&P financing models. Lenders will be looking to where the sale of hydrogen has been secured, e.g., over a 10- or 20-year agreement.

Today, there is a limited demand for green hydrogen as it is relatively costly to produce and trade. Additionally, companies consuming grey hydrogen need to rearrange their existing procurement agreements and integrate green hydrogen instead.

The disparity between production and off-take is even more pronounced for hydrogen exports. Green hydrogen projects for domestic use are commonly developed onsite or nearby a planned end-use consumer. Hydrogen export projects are often not designed for a particular end-user but will instead be traded on the global commodity market. For example, the EU and Japan both expect to receive up to half of their green hydrogen demand from other regions such as Australia, the Middle East, or Latin America. Due to very favourable wind and solar resources, these regions see a potential to become large exporters of green hydrogen.

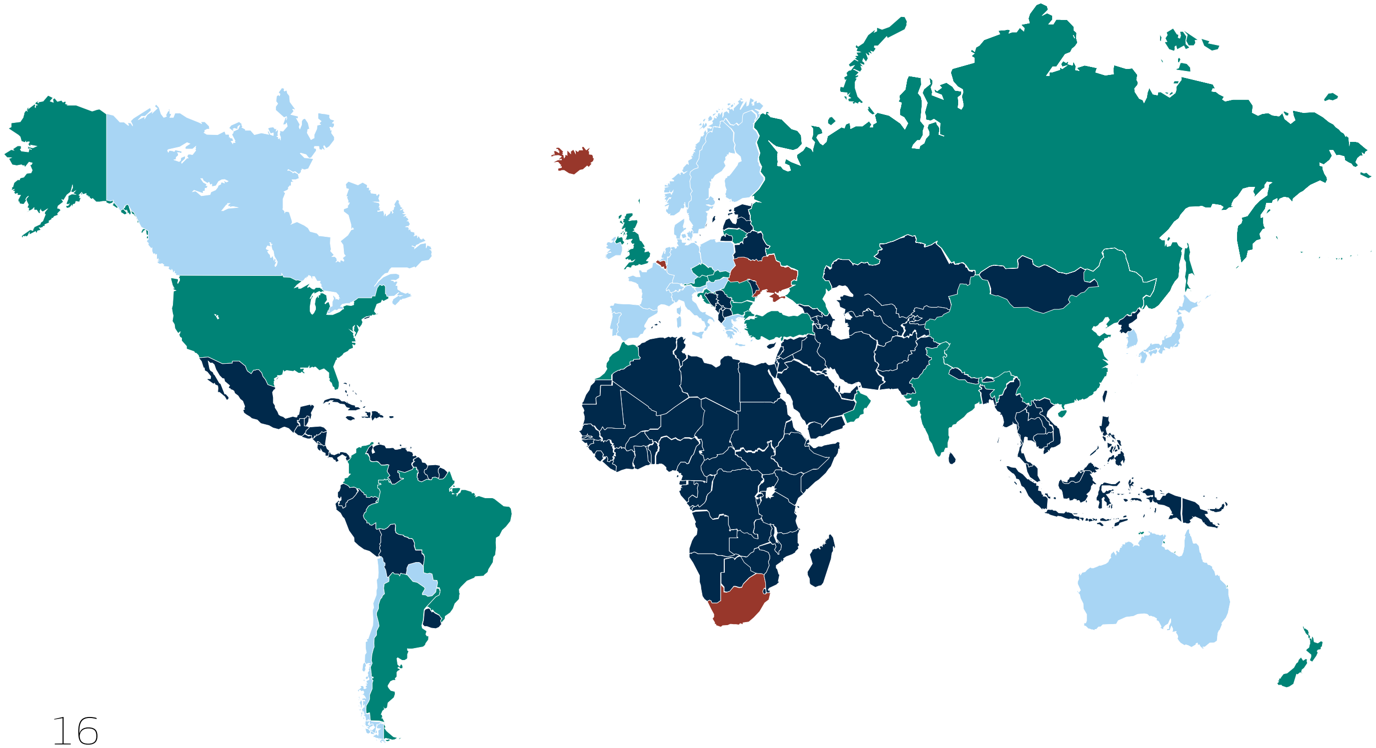
In the longer run, there will certainly be a sizeable demand for green hydrogen, but the order of magnitude is still uncertain. In the second and third waves of forecasted green hydrogen demand, the forecast is contingent upon the successful transition of industries such as shipping and aviation to hydrogen-based vessels and aircrafts. If this transition fails or is delayed, expected demand will be significantly lower than current projections indicate.

Regulatory uncertainty

Currently, the ambitions are high within the renewable energy sector, not only from a company perspective, but also from a legislative perspective. However, there is a mismatch between government ambitions, actual policy support, industry maturity, and the speed at which PtX can scale .

Many countries have set ambitious goals and taken initiatives in order to reach their announced reductions in carbon emissions/clean energy transitions regarding decarbonisation. At the moment, 25 countries and the EU Commission have announced strategies that include low-carbon/green hydrogen as a key component in their energy transitions.
Specifically, the sectors of transportation, industry, and infrastructure are the focal points of decarbonisation. Many companies have announced net-zero carbon emission goals over the next 20-30 years, however, there are relatively few support schemes in place today that financially supports the deployment of early-stage PtX projects. This is important to provide lenders, suppliers, owners and customers with sufficient certainty to invest.

In terms of regulation on hydrogen created from renewable energy, it is very limited. Most companies and countries are right now following policy movements closely, as many policies are announced in parallel with the development of international standards.



16
available

27
in preparation

03
support for pilot and demonstration projects

106
not assessed

National hydrogen strategies as of July 16 - 2021

Neither the International Organisation for Standardisation (ISO) nor WTO have introduced any standards or regulations to determine the emission intensity of hydrogen, and many governments have yet to implement specific hydrogen trade policies, which are necessary for the successful development of projects.

As such, project developers and investors are facing risks and uncertainties of investing in this market and seek various approaches to mitigate those financial risks, such as the typical partnership models shown in Section 2.

The main concern is that political ambitions are moving at a much faster pace than what is able to be realised, as investments in green hydrogen technologies at scale need to catch up.

If we are to reach net zero commitments, the next decade must see a marked shift from political commitment to political action. And such action must involve new investment patterns, along with the removal of regulatory bottlenecks that currently obstruct renewable power installation.

Capital intensity and investment horizon

In addition to the demand uncertainties and regulatory shortcomings pertaining to the industry, PtX is not yet a proven, low-risk investment opportunity for investors compared to more traditional wind or solar power plants.

The technology used in PtX, that is electrolysis, gas handling and gas infrastructure, is not necessarily new, but it is now being utilised in an innovative way – directly coupled with intermittent, fluctuating renewable energy as opposed to consuming energy from the electric grid that is stable and predictable.

During the past few years, PtX has rapidly developed and is on the cusp of a large widespread expansion expected to accelerate during the second half of this decade and beyond 2030.

To reach large-scale deployment of PtX and green hydrogen, massive investments across the value chain are required to achieve scale, cost outs and industrialization. Through REPowerEU, EU has set an ambition to produce 10 million tonnes of hydrogen domestically by 2030, which would require around 100GW of electrolyzer capacity and some 125GW of renewable energy. Europe aims to import 10 million tonnes as well. Given there is currently high uncertainty pertaining to PtX and the bankability of projects, a mix of public and private funding is required to kickstart the industry and achieve sufficient scale. A production tax credit system helped pave the way for wind energy in the US. Several EU countries are currently investigating CfD mechanisms (contract for difference) to provide price certainty for the sale of hydrogen.

Additionally, due to the long timelines associated with PtX, it will take many years before investors see any sort of return on investment. Given that the entire project must be set up and developed, there are also high costs and long timelines involved, making investors hesitant to take on the risk of a largely unproven concept without a solid end-use market at present or a guarantee for the sale of green hydrogen.

Ecosystem

Although the market for green hydrogen and PtX is immature, many players are positioning themselves to capture the expected market potential. Due to the many different components within PtX, the competitive landscape consists of many diverse players.

Vestas' direct competitors include Siemens Gamesa - the second-largest wind turbine producer in the world after Vestas. Further, Nordex and General Electric (GE), producers of onshore and offshore turbines, are also priming for entry into the market.

Siemens Gamesa is currently developing a way to produce green hydrogen by integrating an electrolyser (developed by Siemens Energy, the majority owner of Siemens Gamesa) into an offshore wind turbine. Thereby, Siemens Gamesa leverages knowledge and experience within offshore wind to offer a superior solution with their in-house developed electrolyser. Their solution is expected to be ready for a full-scale demonstration by 2025 or 2026.

Another wind turbine manufacturer that has entered the market for green hydrogen, is Nordex. In addition to producing turbines, Nordex's majority owner, Acciona, has also entered into a partnership with US-based electrolyser manufacturer, Plug Power. Plug Power has laid out ambitious plans to expand its capabilities in producing electrolysers and fuel cells, as well as building multiple green hydrogen production plants.

LONGi, a Chinese world-leading manufacturer of solar panels, is also a world-leading manufacturer of electrolysers. Therefore, LONGi can optimise the two solutions together and offer a more complete, integrated photovoltaic-to-hydrogen system to customers.

However, it is not only producers of wind turbines and other already established players within the sustainable energy sector that are looking to gain a position in the green hydrogen space. An increasing number of large players in the oil and gas industry are looking to diversify and decarbonize their operations by investing in PtX projects involving green hydrogen. British Petroleum (BP) has made significant strides by investing in a large green hydrogen production facility and acquiring a large stake in the Australian Renewable Energy Hub, a prestigious super-project that will produce green hydrogen from wind and solar energy with the purpose of exporting the hydrogen to global demand centres such as Japan, the EU and the U.S.

Lastly, current end-users of hydrogen are also looking to enter the PtX market. These companies include LKAB, Rio Tinto, and Maersk, who all consume a lot of energy in their operations and are searching to replace current energy sources with sustainable ones. These companies increasingly offer sizeable offtake commitments of green hydrogen. They are able to do so due to their size and scale. These are key partnerships to realise the decarbonisation of their operations.
All in all, the competitive landscape is not dominated by any one player yet, and all parties possess different competencies and strengths that can be utilised throughout the value chain. Therefore, a high level of competition is expected in the market, and the industry is expected to be characterised by many specialised actors with a low market share.

Since the industry is still in rapid development, there are many actors that are interested in participating - including some of Vestas' current customers as listed below:

Global Project Developers
Copenhagen Infrastructure Partners
Ørsted

Renewable Energy Manunufacturers
Vestas
Siemens Gamesa
Nordex
LONGi

Electrolyser Producers
PLUG POWER
ITM POWER
Siemens Energy

EPCs & system integrators
Linde
Air Products
Worley

Conventional Fuel Producers
BP
Shell

Energy Utilities
EDP Renewables
enel

End-users
LKAB
Rio Tinto
Maersk

Section 4
Closing remarks

The first Vestas wind turbine was designed when the magnitude of climate change was generally unknown. Vestas' entrepreneurs and engineers acted on a vision to replace fossil fuels because they realised the need for alternatives to finite and polluting energy sources. Today, more than 40 years later, we have a better understanding of the impact of CO_2 emissions. We also know that this crisis, which is the greatest challenge humanity has ever faced, can only be solved through another major industrial revolution: the global energy transition.

Vestas has historically been a key player in spearheading this transformation and is currently in a leadership position in both the onshore, offshore, and service segments. Their 29,000 employees have installed more than 160GW of wind energy, which has prevented 1.7 billion tonnes of CO_2 being emitted into the atmosphere.

However, while wind power solutions will remain at the core of Vestas, technologies evolve, ambitions increase, and new opportunities arise for Vestas to capitalise on. One area which presents enormous potential is Power-to-X. While the expectations to Power-to-X are vast, the market has low maturity. Much regulation is yet to be introduced, and no large-scale commercial projects are yet present as it takes many years to develop. As such, to determine their level of engagement with Power-to-X, Vestas needs your help to prepare for long-term scale and address the following questions:

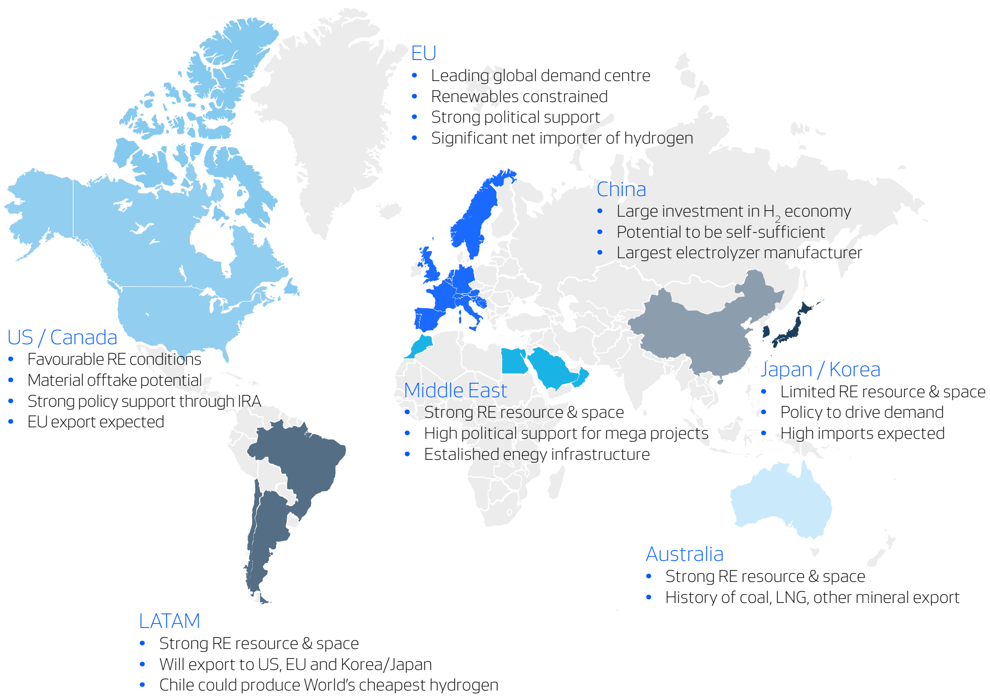
> How can Vestas leverage its position as a global leader in wind power plant solutions to create new business from Power-to-X? What should Vestas' strategy be towards 2030?

- → In what part(s) of the Power-to-X value chain should Vestas play a primary role, and why?
- → What financial or commercial goal(s) should Vestas set for 2030?
- → How can Vestas leverage its internal capabilities and partnerships to win in Power-to-X?

Appendix

Geography appendix

When considering where to build PtX aplants, there are many things to consider. Some of the most important criteria are (i) proximity to consumption of hydrogen to avoid long transportation, (ii) strong availability of renewable energy resources (wind speeds and solar irradiance), and (iii) specific funding schemes to support the bankability of the project.



Regional performance

NAFTA/LATAM

Order intake (MW)

2018	2019	2020	2021	2022
6,271	10,269	6,403	4,571	4,547

Deliveries (MW)

4,520 — YoY ↓21%

Top three markets:

USA	Brazil	Canada
2,275 MW	1,528 MW	325 MW

Total order backlog
Power Solutions and Service (bnEUR)

2021	2022
13.6	16.0

EMEA

Order intake (MW)

2018	2019	2020	2021	2022
5,599	6,001	7,417	7,637	4,568

Deliveries (MW)

7,467 — YoY ↓13%

Top three markets:

Finland	France	Poland
1,185 MW	1,002 MW	957 MW

Total order backlog
Power Solutions and Service (bnEUR)

2021	2022
26.2	25.2

APAC

Order intake (MW)

2018	2019	2020	2021	2022
2,344	1,607	3,429	1,688	2,074

Deliveries (MW)

1,341 — YoY ↓40%

Top three markets:

Japan	Australia	Vietnam
399 MW	376 MW	179 MW

Total order backlog
Power Solutions and Service (bnEUR)

2021	2022
6.2	8.2

Financial and operational key figures

Financial key figures

mEUR	2022	2021[1]	2020	2019	2018
Income statement					
Revenue	14,486	15,587	14,819	12,147	10,134
Gross profit	118	1,556	1,538	1.761	1,631
Operating profit before amortisation, depreciation and impairment losses (EBITDA) before special items	(63)	1,342	1,391	1,550	1,394
Operating profit (EBIT) before special items	(1,152)	428	750	1,004	959
Operating profit before amortisation, depreciation and impairment losses (EBITDA)	(437)	1,271	1,382	1,550	1,379
Operating profit (EBIT)	(1,596)	289	698	1,004	921
Net operating profit after tax (NOPAT)	(1,071)	275	619	773	719
Net financial items	(110)	(101)	(95)	(98)	(51)
Profit before tax	(1,696)	224	934	909	910
Profit for the year	(1,572)	143	771	700	683
Balance sheet					
Balance sheet total	20,090	19,648	18,160	14,331	11,899
Equity	3,060	4,697	4,703	3,345	3,104
Investments in property, plant and equipment	371	476	379	451	312
Net working capital	(1,349)	(1,049)	(1,127)	(1,583)	(2,040)
Capital employed	5,487	6,133	6,057	4,165	3,602
Interest-bearing position (net), at the end of the period	46	1.200	1,920	2,452	3.046
Interest-bearing debt, at the end of the period	2,427	1,436	1,354	820	498
Cash flow statement					
Cash flow from operating activities	(195)	956	743	823	1.021
Cash flow from investing activities before acquisitions of subsidiaries and financial investments	(758)	(773)	(687)2	(729)	(603)
Free cash flow before acquisitions of subsidiaries and financial investments	(953)	183	56[2]	94	418
Free cash flow	(874)	57	476	332	(69)

[1] Comparative figures for 2021 have been adjusted following the accounting policy change for configuration and customisation cost in cloud computing arrangements, refer to note 7.2.
[2] Comparative figures have been restated to reflect change in classifications of investments. Comparative figures from 2018 to 2019 have not been restated.

Financial rations[2]

	2022	2021[1]	2020	2019	2018
Gross margin (%)	0.8	10.0	10.4	14.5	16.1
EBITDA margin (%) before special items	(0.4)	8.6	9.4	12.8	13.8
EBIT margin (%) before special items	(8.0)	2.8	5.1	8.3	9.5
EBITDA margin (%)	(1.2)	8.0	9.3	12.8	13.6
EBIT margin (%)	(11.0)	1.9	4.7	8.3	9.1
Return of capital employed (ROCE) (%)	(18.5)	4.5	13.5	19.7	20.4
Net interest-bearing debt/EBITDA before specialitems	NA[4]	(0.9)	(1.4)	(1.6)	(2.2)
Solvency ratio (%)	15.2	23.9	25.9	23.3	26.1
Return on equity (%)	(43.9)	3.6	21.4	22.1	22.6
Share ratios					
Earnings per share (EUR)	(1.6)	0.1	0.8[5]	3.6	3.4
Book value per share (EUR)	3.0	4.7	4.7[5]	16.8	15.1
P/Eratio	(17.4)	2002	49.6	25.4	19.3
Dividend per share (EUR)	–[6]	0.1	0.23[5]	1.06	1.00
Payout ratio (%)	–[6]	36.0	30.0	30.0	30.0
Share price at the end of the period (EUR)	272	26.9	38.7[5]	90.1	65.9
Number of shares at the end of the period	1,009,867,260	1,009,867,260	1,009,867,260[5]	198,901,963	205,696,003

Operational key figures

	2022	2021	2020	2019	2018
Order intake (bnEUR)	11.9	11.6	12.7	13.8	10.6
Order intake (MW)	11,189	13,896	17.249	17,877	14.214
Order backlog - wind turbines (bnEUR)	19.1	18.1	19.0	16.0	11.9
Order backlog - wind turbines (MW)	19,623	21,984	24,630	20,974	15,646
Order backlog - service (bnEUR)	30.4	27.8[7]	23.9	17.8	14.3
Produced and shipped wind turbines (MW)	13,106	17.845	17.055	12,618	10,676
Produced and shipped wind turbines [number)	3,126	4,456	5,239	4,185	3,729
Deliveries (MW)	13,328	16,594	17.212	12,884	10,847

[3] The ratios have been calculated in accordance with the guidelines from "Finansforeningen" (The Danish Finance Society) (Recommendations and Financial ratios).
[4] The ratio of net interest-bearing debt to EBITDA cannot be calculated as at 31 December 2022 as the EBITDA is negative.
[5] As of 28 April 2021, a share split at a ratio of 1:5 of the Vestas share was carried out. Comparative figures for 2020 have been restated. Comparative figures from 2018 to 2019 have not been restated.
[6] Based on proposed dividend.
[7] The number disclosed in the 2021 annual report for the Service order backlog has been corrected from EUR 29.2b to EUR 27.8bn.

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