CBS CASE COMPETITION 2023

Vestas

Vestas – PtX Strategy to Venture into the Future of Green Hydrogen

Piloting the energy transformation as the undisputed market leader

Presented by

Causeway Consulting


Helena Chen


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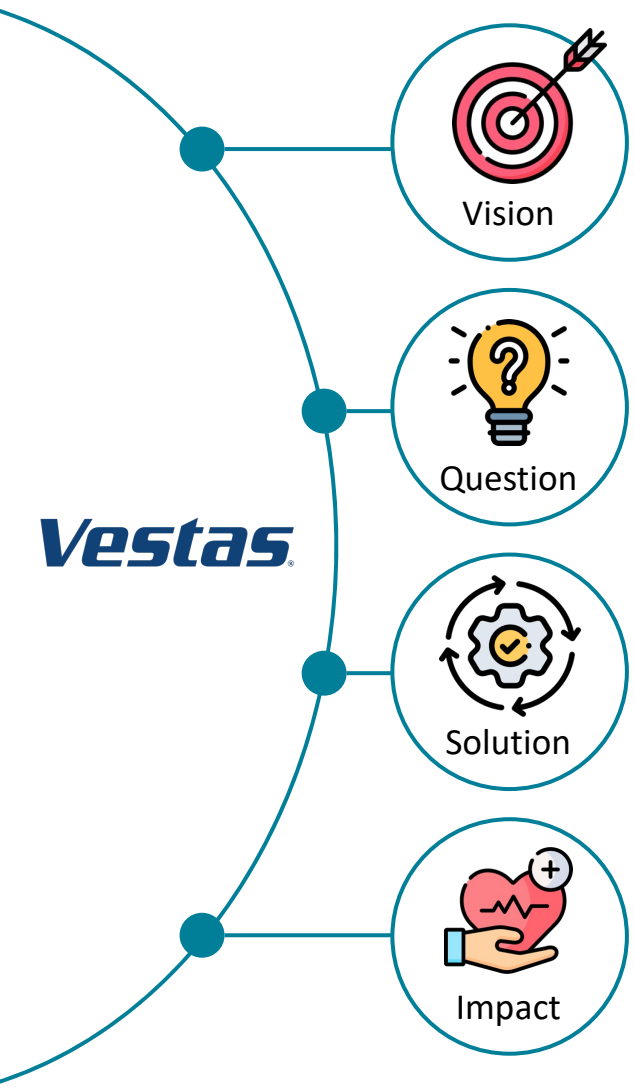
With our PtX strategy, Vestas' long-term vision of creating value through customer-centric solutions is no longer a dream but a reality



To leverage Vestas' position as a global leader in wind power plant solutions to create new businesses from Power-to-X, helping the world advance towards sustainability ambitions

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

The "PtX" Strategy

PILOTING	**TOGETHER**	**Xcceleration**
in EU Market	We Join Forces	to Green Hydrogen

12%	**13% EBIT margin**	**20% ROCE**
EU green hydrogen production directed supported by us by 2030	By 2030	By 2030

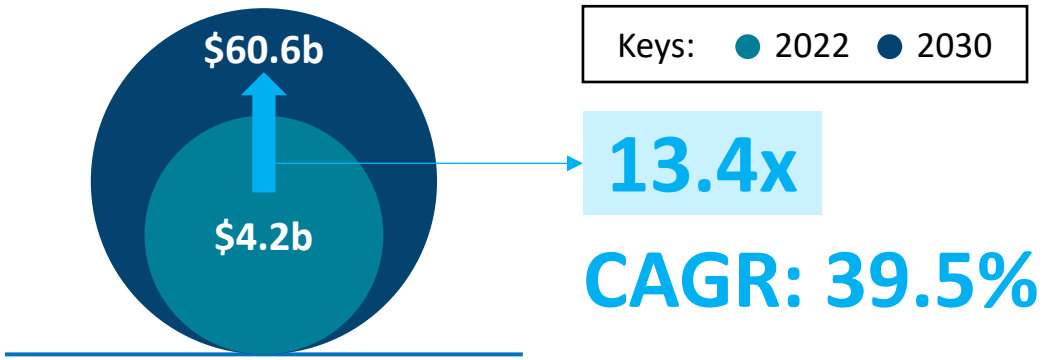
Insights

Helena Chen

Vestas' core competencies enable it to pursue high-growth opportunities in PtX

Green hydrogen market in the global landscape

Global green hydrogen market revenue (USD)



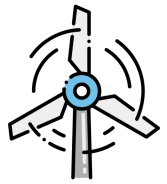
Favourable growth drivers

Green fuel demand
Surging needs for clean fuel

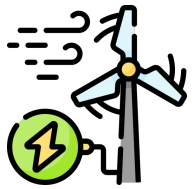
Sustainability goals
Global policy-making efforts

Future outlook is promising in the global green hydrogen market with high growth potential, market demand, and favourable sustainability policies.

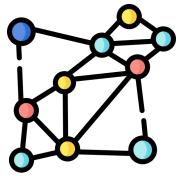
Vestas' strong existing capabilities



Global market leader
#1 wind power player,
17.7% global market share



Technical know-how
Wind energy expertise,
144+ GW under operation



Extensive partnership network
Including manufacturers, project developers, energy utilities, etc.

Technology & innovation
Specialised R&D teams
to spark novel ideas

Vestas' can consider leveraging their key competencies in the renewable energy sector to **pursue PtX innovations for value-added purpose**.

Source(s): GWEC Market Intelligence, IEA, Vestas

Power-to-X value chain at a glance: Which parts should Vestas play a primary role?

Power-to-X	1. Development	2. Design	3. Supply	4. Construction	5. Operations	6. Service
 **Green hydrogen key activities**	• Finding the optimal land • Making geographical assessments • Obtaining various permits • Securing financing	• Determining the number of turbines and the size and type of electrolysers • Modelling and designing all components of the plant	• Supplying wind turbines, solar panels, batteries, electrolysers • Providing energy management hardware and software components	• Hiring subcontractors to build roads • Installing cables in the ground or ocean, • Supporting integrating activities	• Monitoring daily operations and performance • Planning service schedules and contracts • Making continuous plant optimisation	• Monitoring site performance and condition of systems • Performing maintenance, including replacement and repair services

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 **Vestas' technical know-how**	• Strong track record of developing and implementing wind energy projects	• Engineering capabilities to design and optimize complex systems	• Experience in supplying commercial wind turbines • Manufacturing does not translate to Pt2	• Limited expertise as it is usually taken care of by end-customers • Not a subject expert of electrolysers	• Limited expertise as operations is not a core business • Little to no knowledge of plant operations	• Constant improvement in maintenance, replacement, and repair services as a key business focus

Source(s): IEA, Vestas

Opportunities for common value creation with Vestas' technical know-how

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Translation of Vestas' technical know-how in **development, design, and service is straightforward**, hence are areas that Vestas can **bring the most value to**.

Source(s): IEA, Vestas

Limited focus should be given to relatively less value-added activities

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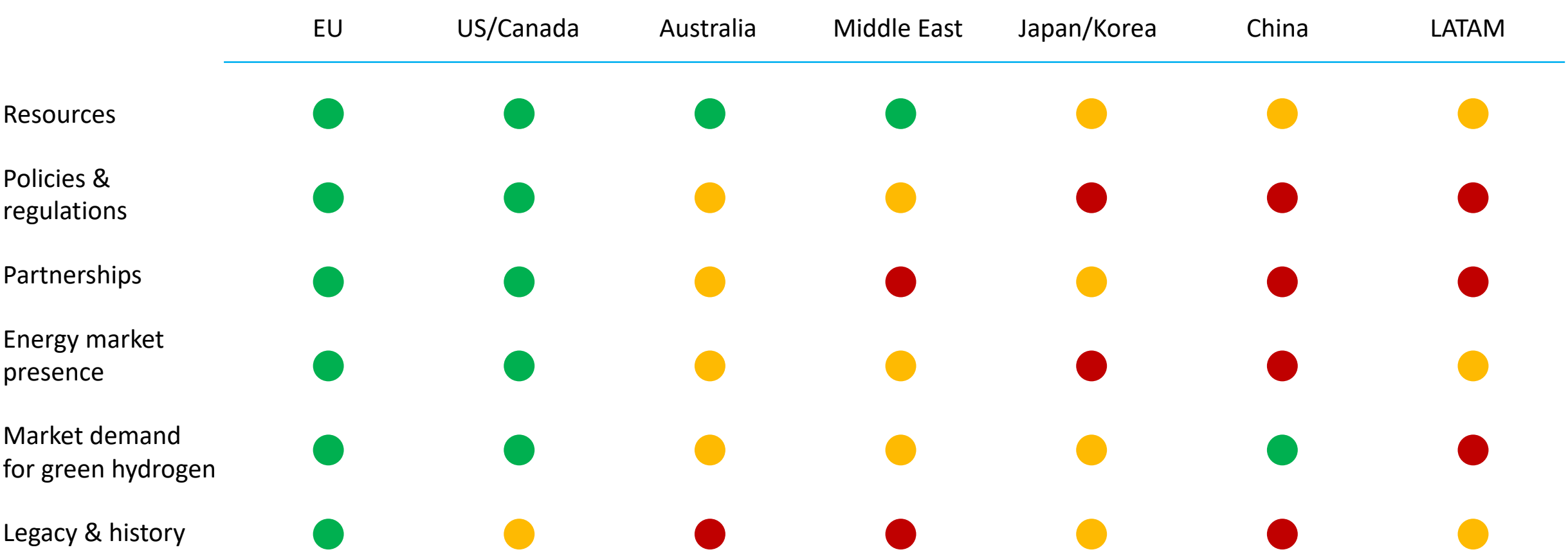
Since **supply, construction, operations** are crucial to delivering a **holistic solution to end customers**, our **strategic partners must possess these competencies.**

Source(s): IEA, Vestas

Which regions should Vestas focus on at the pilot stage and in the long run?



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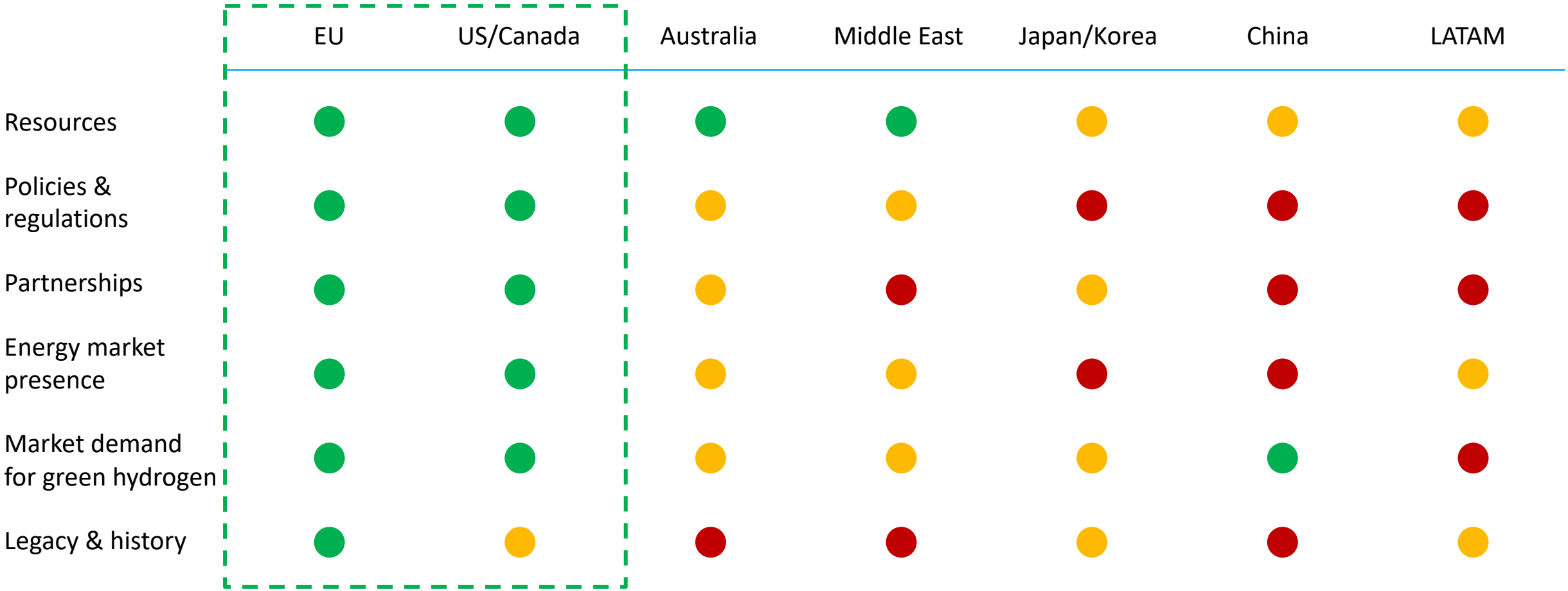

Both the **EU** and **US/Canada markets** are highly **favourable and viable market entry options** for Vestas.

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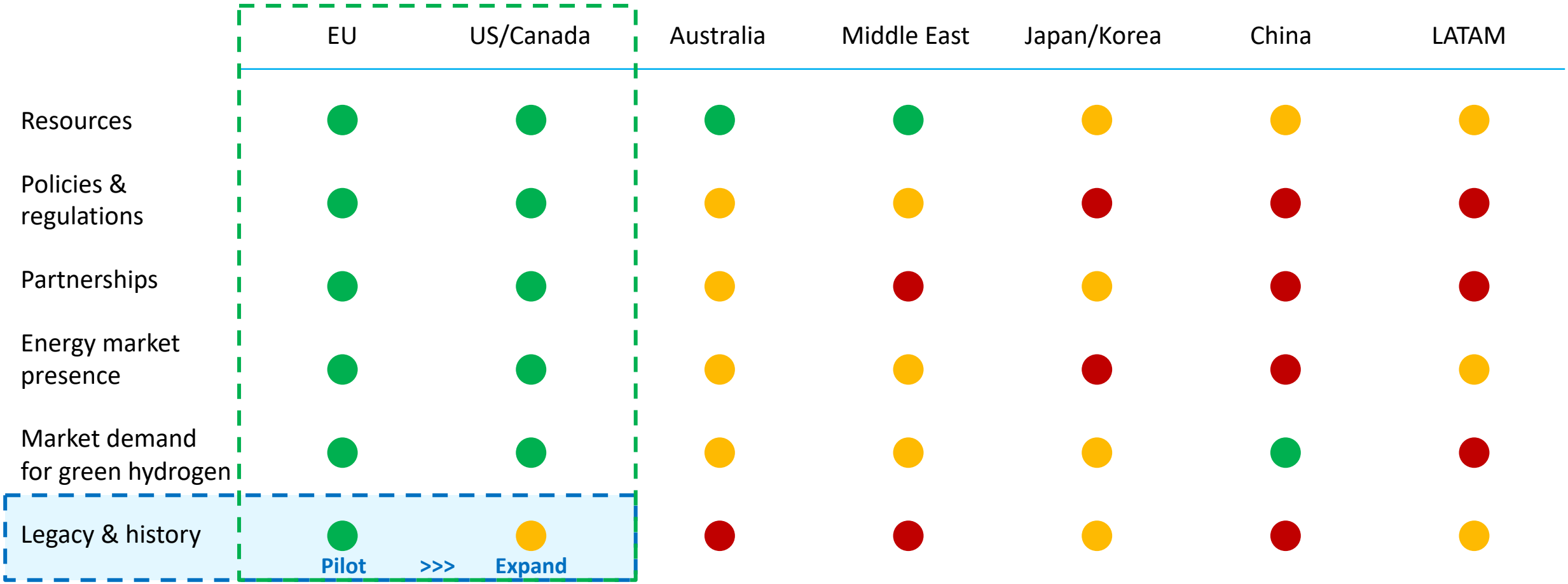

As Vestas has a **longstanding presence in EU**, **piloting** market entry in EU as the starting point, then **expanding** to US/Canada can **reduce significant risks**.

Which business model or strategic partnership should Vestas adopt?

	Joint Venture	Project Consortia	Typical transactional model
Risk diversification	Across few players	Across many players	Sole responsibility
Technical know-how synergies	From a few specialists	From many experts	Requires in-house expertise
Business sustainability	Possibly long-term	Project-based	Possibly long-term
Decision-making flexibility	Fair share of say	Requires consensus from many players	Full autonomy
Capital capacity	Few financing options	Diverse financing options	Limited financing options
Speed of set-up	Reasonably quick	May be hindered by communication	Takes time to acquire expertise

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Joint venture will be Vestas' go-to choice, considering its **existing capabilities** and **market requirements for the green hydrogen industry**.

Source(s): Deloitte

Key insights in a nutshell

Vestas

Vision

To leverage Vestas' position as a global leader in wind power plant solutions to create new businesses from Power-to-X, helping the world advance towards sustainability ambitions

Insights

Company & market analysis

Vestas can **leverage its strong existing competencies** to pursue **high-growth value-added opportunities** in the global green hydrogen market.

Value chain analysis

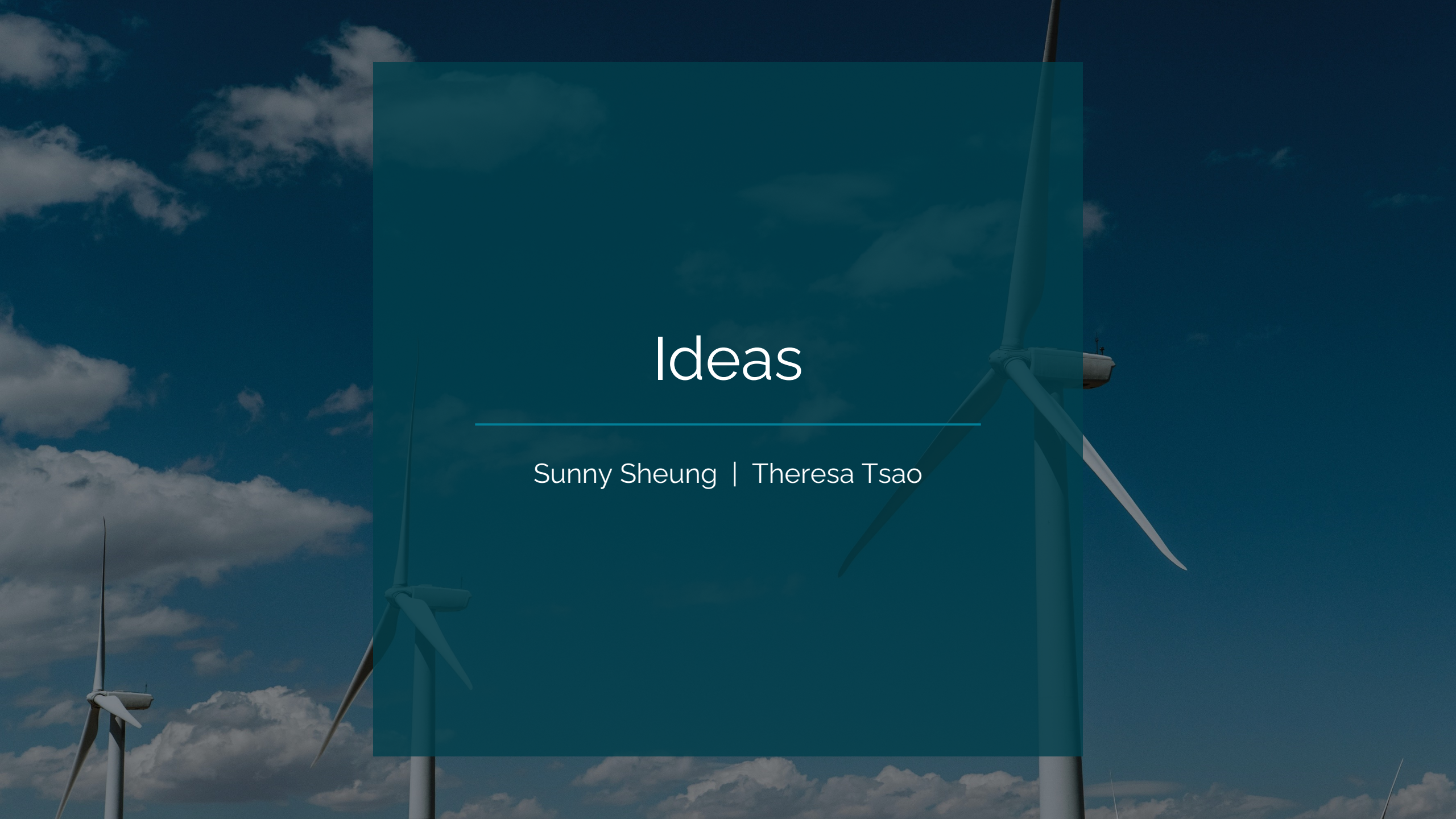
Vestas' technical know-how enables it to play a **primary role** in **development, design, and services**, while **strategic partners** in **supply, construction, and operations** should be identified.

Regional analysis

Piloting market entry in EU to identify key strategic partners, then **expanding to US/Canada** in the long run can alleviate associated green hydrogen market entry risks.

Strategic model analysis

Joint venture is the most suitable strategic partnership for Vestas to tap into the PtX market, taking into consideration all previous analyses.



Ideas

Sunny Sheung | Theresa Tsao

The key challenges Vestas face in the focused value chain points drive the need for a regional market entry approach through a partnership model

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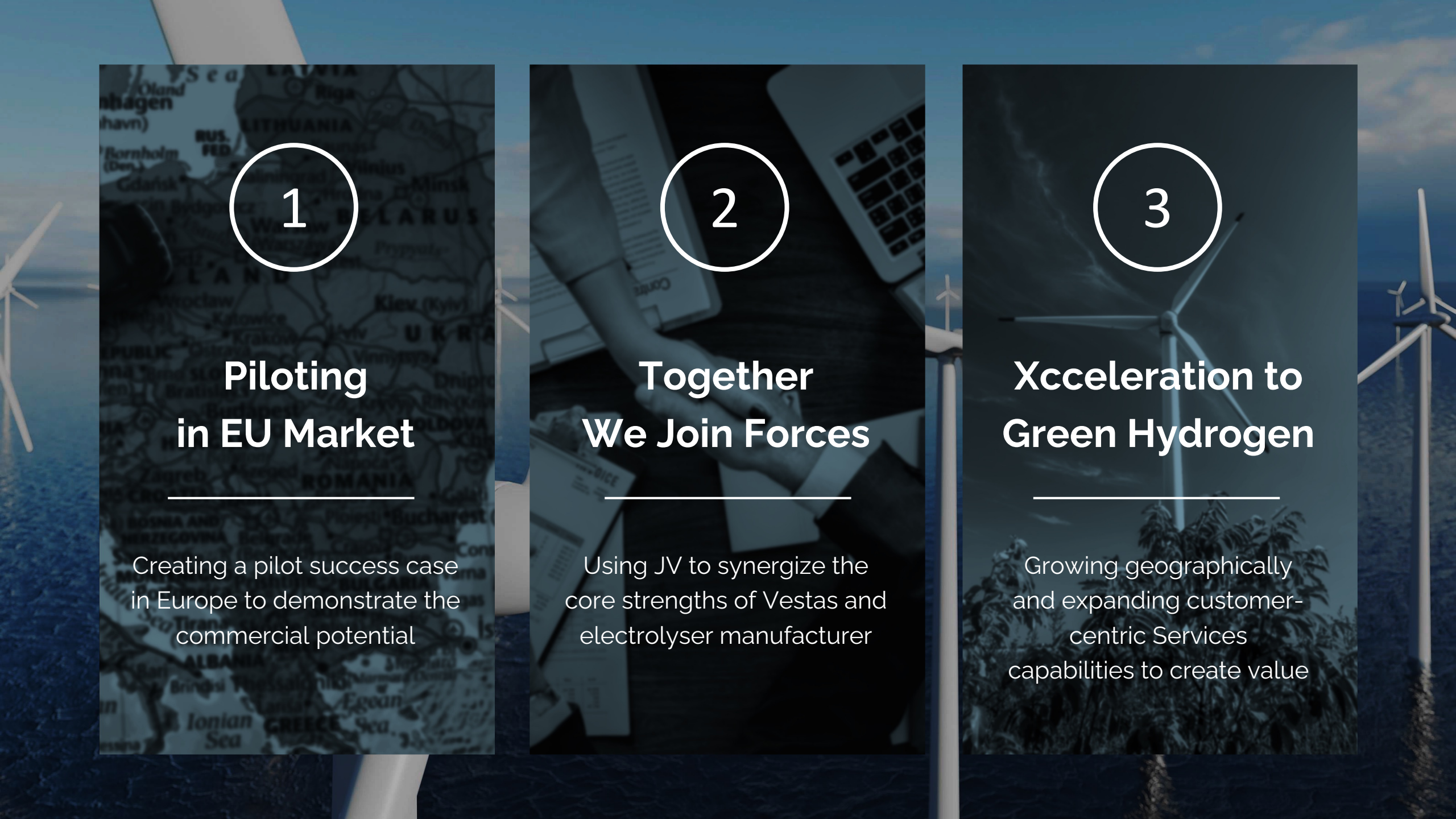
 **Key difficulties**	• **Regulatory environment and policies** • **Financing**	• **Limited electrolysis knowledge**				• **Limited electrolysis knowledge**

Vestas should collaborate with an electrolyser manufacturer to deliver a fully comprehensive, holistic PtX solution.



1

Piloting in EU Market

Creating a pilot success case in Europe to demonstrate the commercial potential

2

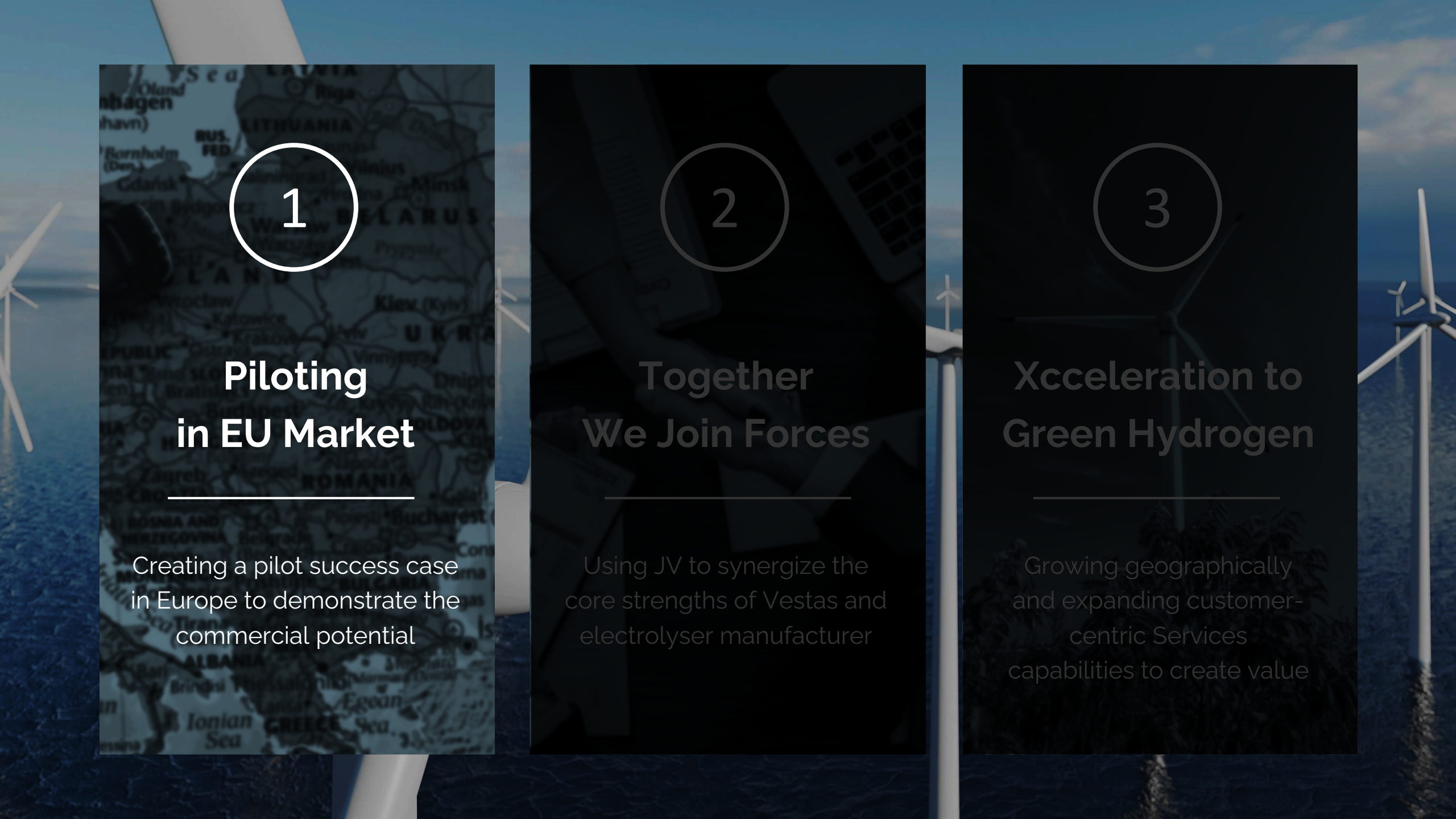
Together We Join Forces

Using JV to synergize the core strengths of Vestas and electrolyser manufacturer

3

Xcceleration to Green Hydrogen

Growing geographically and expanding customer-centric Services capabilities to create value



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Pilot in EU with a parallel focus on the onshore and offshore PtX operation

Why both onshore and offshore

Long term business sustainability

Leading market position in both product types

Capabilities in refining existing underutilised plants to compliment *Service*

Greater potential for _offshore_ PtX

Lowest costs associated with Hydrogen production
→ Higher demand

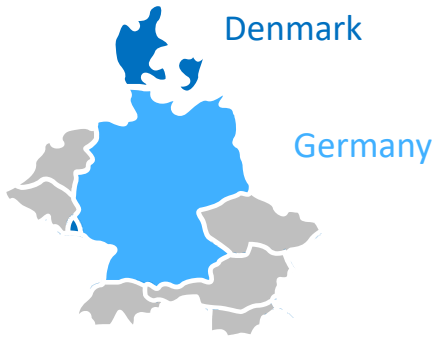
High expected growth level for wind energy

Target market evaluation

Europe has a more favourable political environment with more potential partners.

1. Diverse resources
2. Favourable policies & regulations
3. High partnership feasibility
4. Strong energy market presence
5. Growing demand for green hydrogen
6. Longstanding legacy and history

Vestas has vast experience in the EU, including Denmark and Germany



Why Germany – onshore

Rapid Growth

- Most new wind installations in the EU in 2021
- High domestic demand (net importer of green H_2)

Policy Support

- Euro 7 Billion government investments

Heritage & History

- 37 years of local experience

Why Denmark – offshore

Underutilised Capacity

- 17-27 GW offshore planned capabilities to be utilised

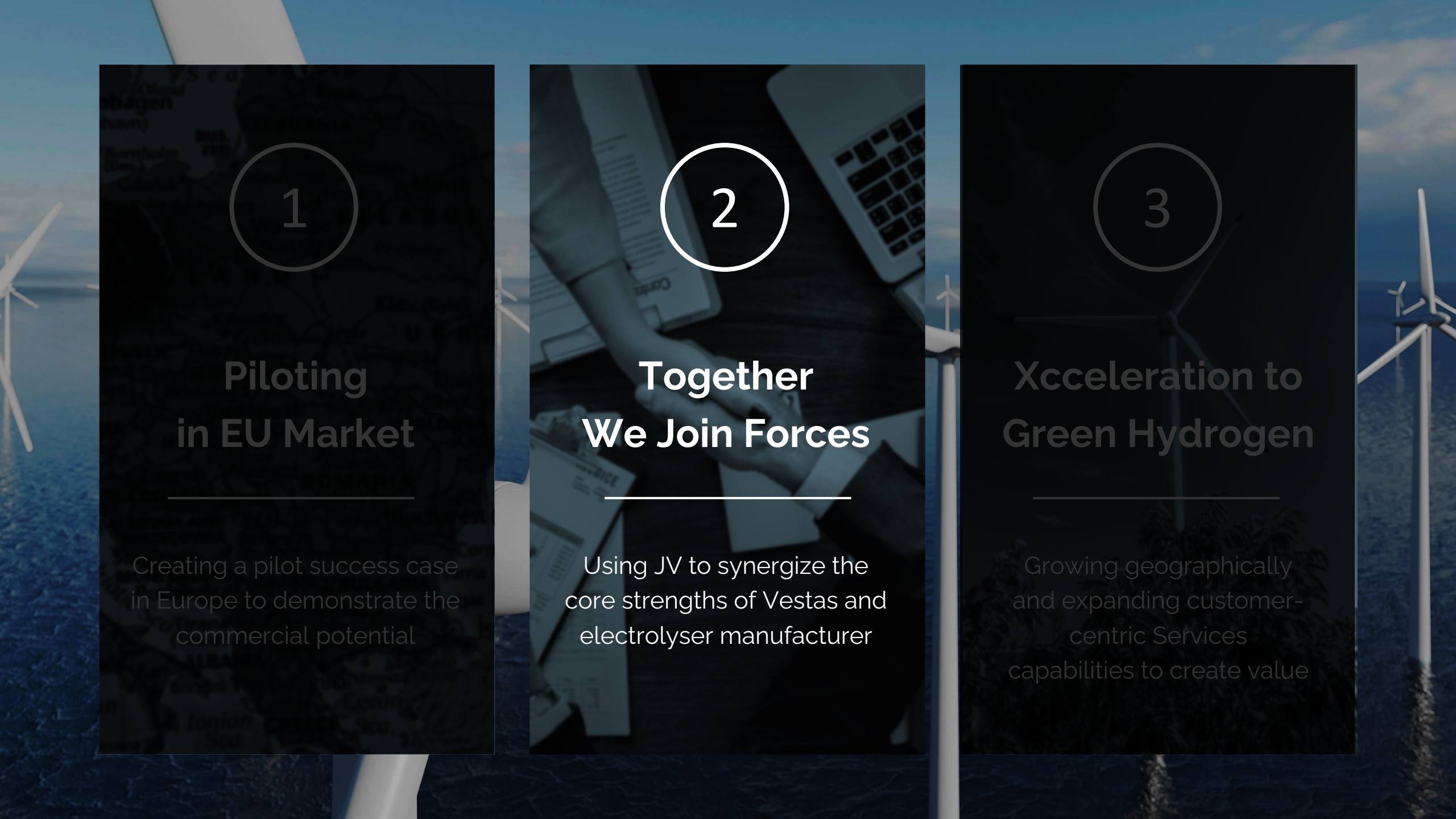
Potential Partners

- High number of companies across various relevant industries

Demand for Green H_2

- 4-6 GW of electrolysis capabilities expected by 2030

Source(s): Danish Ministry of Climate, Energinet, Ramboll, WindEurope



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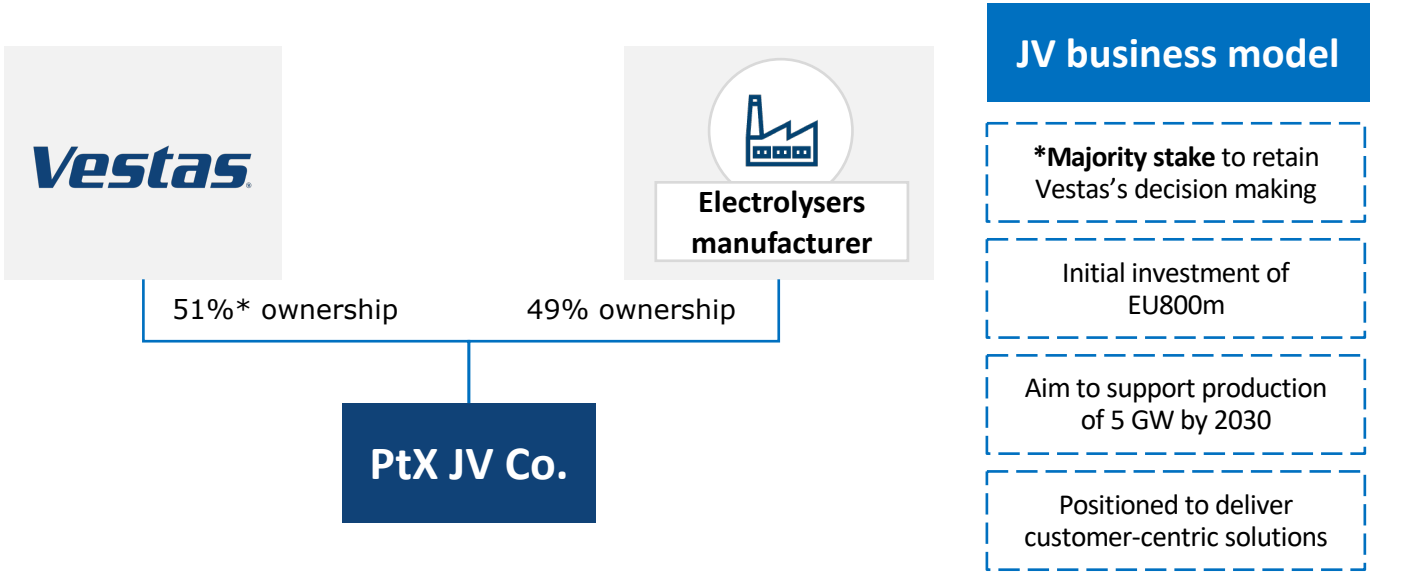
Launching a partnership via Joint Venture (JV) to embark its PtX journey

Why form a Joint Venture

- Track record of previous **JV success with Mitsubishi**
- Close knowledge gap by utilizing partner's **PtX competencies and strength**
- **Fast entry** to PtX market
- Achieve **scalability** for lower individual capital requirement and cost
- Develop **Vestas's in-house electrolysis capability** for future market opportunities

Illustrative structure of the JV



JV business model

- ***Majority stake** to retain Vestas's decision making
- Initial investment of EU800m
- Aim to support production of 5 GW by 2030
- Positioned to deliver customer-centric solutions

Key activities to pilot

- Identify under-utilized plants from current customers
- Pitch to customer on adding an electrolyser to their plant
- Upon success, we will have a success PoC of the PtX
- Would also service our client to maximise its capacity

Source(s): Hydrogen Europe

Leverage on Joint Venture (JV) to build core capabilities for PtX

Criteria for choices of partners

- Financial position
- Geographical location
- Size
- Expertise

Potential JV Candidates

Manufacturer of electrolysers

GREEN HYDROGEN SYSTEMS — Danish standardised and modular electrolysers

nel — Norwegian Alkaline and Proton Exchange Membrane water electrolysis

ITM POWER — UK manufacturer of PEM electrolysers

Potential partners to complete value chain

Manufacturers and subcontractors	End-users of PtX plant	End-users of hydrogen
EUROWIND ENERGY A/S	Everfuel	MAERSK
winergy	REintegrate	LKAB
FairWind		RioTinto

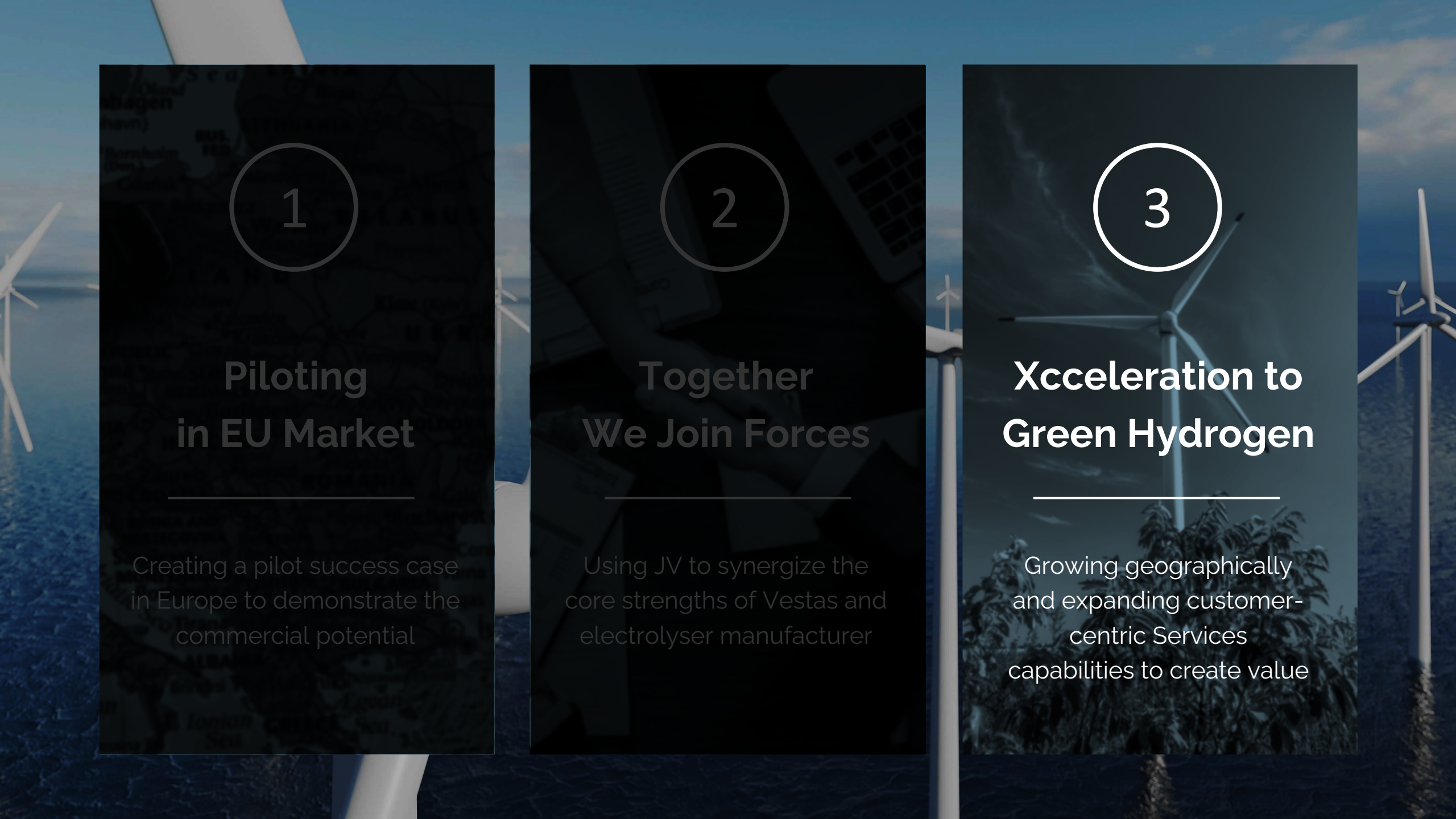
Financing Method

Investment uncertainty adds difficulty to financing

- **Capital contributed by each JV entity**
- **Vestas Ventures**
- Government support
- Other parties

Vestas should leverage on its existing capabilities in the PtX JV's value chain

Power-to-X JV	1. Development	2. Design	3. Supply	4. Construction	5. Operations	6. Service
JV's stakeholders	**Each party's contribution to value chain**					
Vestas	• Land & permit sourcing • Financing	• Planning and modeling for PtX plant	Contribute existing relationships including manufacturers, subcontractors and end-customers			• Maintenance • Quality and risk control
Electrolysers manufacturer	• Regulatory understanding • Financing	Planning of PtX system integration	Supply of Electrolysis			Limited support over electrolysis maintenance
External participating parties			Outsourced manufacturer	End-users of PtX plant		
Challenges mitigated	Financing Regulatory risk	PtX knowledge				PtX knowledge



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Longer term – Geographic scale-up and expand service offerings to build visibility to future pipeline and orders

Opportunity to expand into US Market

USA Domestic Production Falls Short of Demand

Demand Growth (2020-2030) **54% CAGR** > Supply Growth (2020-2030) **38% CAGR**

Vestas' Local Market Presence

2,275 MW Deliveries in 2022
Largest single market

US PtX Market Condition

Regulation
tax-reduction on production of green H_2

Demand for synthesised products
Contributed by diversified mix of economic sectors

Targeted to launch scaling-up initiatives in US by 2028

Upcoming Pipeline

Enables Direct Electrolysis and Synthesis on site

- More flexible forms of storage and transportation
- Cater to the demands of more customers

Future outlook by 2028

Establish customer-centric solutions and creating values

Encourage further developments into the Green H_2 market

Source(s): The International Council on Clean Transportation

Implementation, Impact

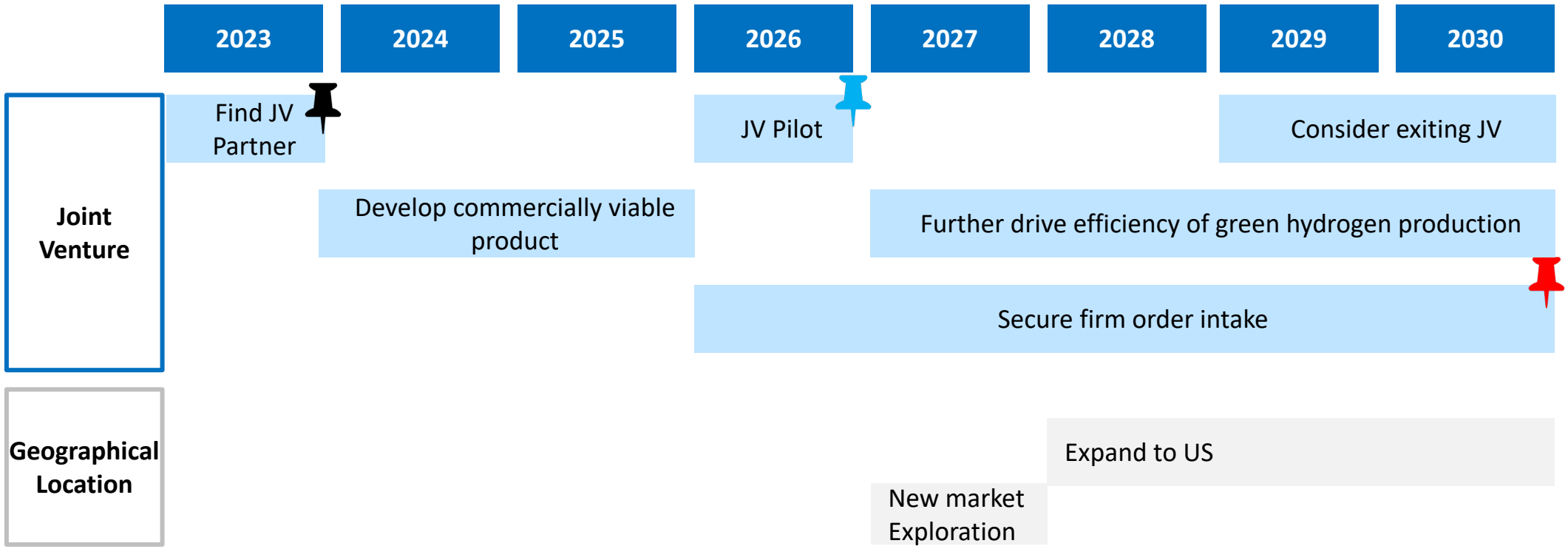
Lawrence Chan

In order to succeed, Vestas must succeed on multiple fronts

A battle on many fronts

- Planning of JV
- JV POC launch
- Development of in-house electrolysis capability
- New market identification
- Exit opportunity of JV

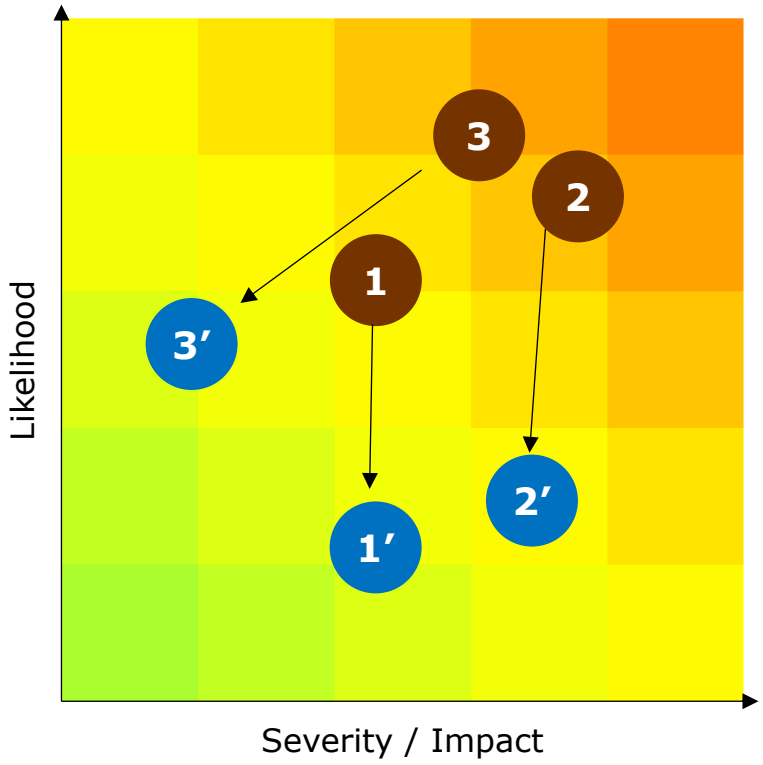
Implementation Plan



Must Win Battles

- Find partner
- Develop commercially viable product at price parity with grey hydrogen
- Account for 12% of all Western Green Hydrogen Production

There are 3 key concerns Vestas must consider



RISKS

1. Not being able to secure a suitable partner for Joint Venture
2. Joint Venture Risks: Issues such as conflicts in strategic direction or partner opportunism
3. Slower than expected growth in complimentary industries: slower demand for turbines

MITIGATION

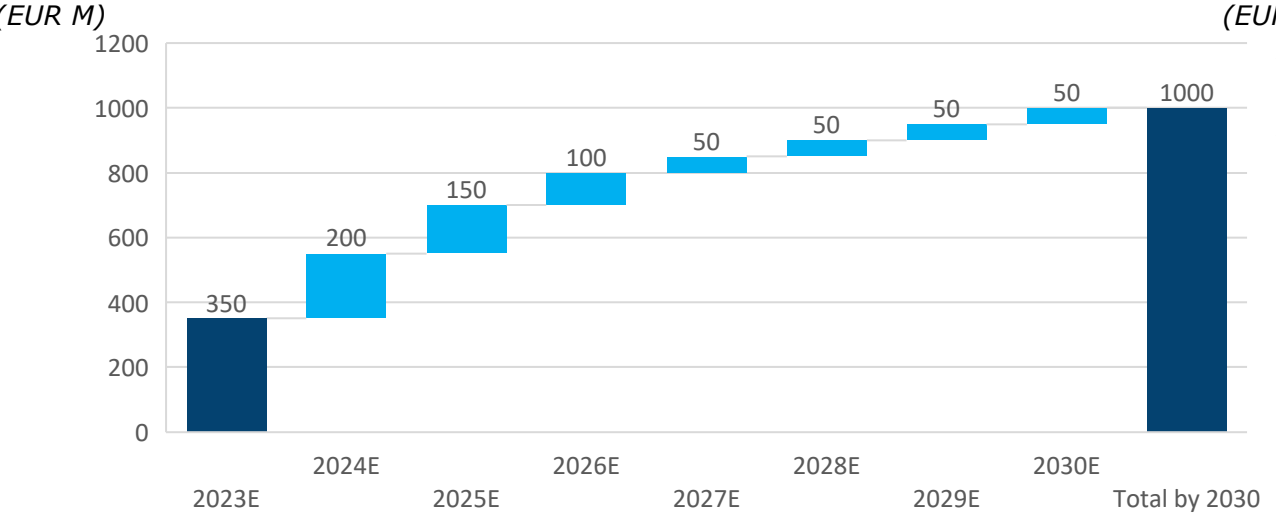
1’ Extra time and buffer has been allocated to mitigate the impact of this risk

2’ Take extra precaution before establishing joint venture (eg. Non-Compete Agreement)

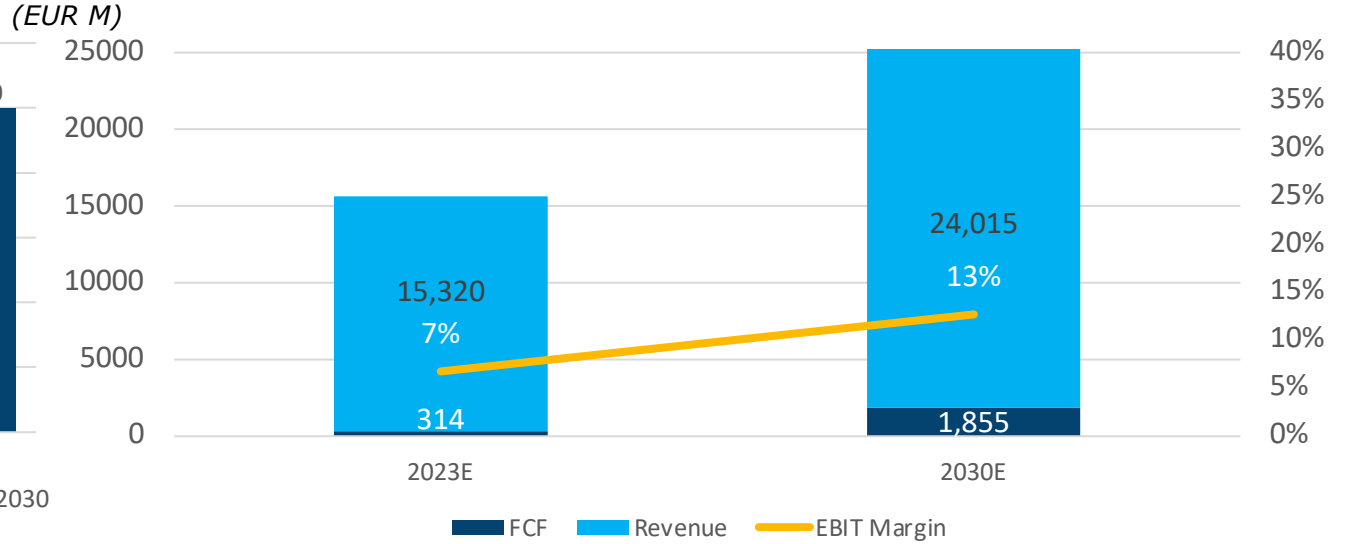
3’ Use our scale to negotiate off-take agreements on behalf of our clients as a complimentary Project Development offering

Our proposal meets all of Vestas targets without need for external financing

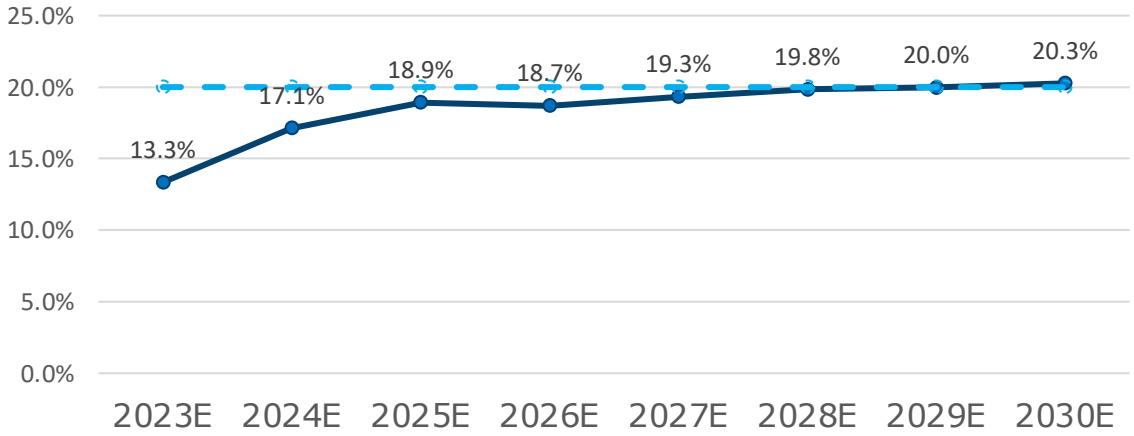
Our proposal involves EUR800M in upfront R&D, with 50M recurring cost to improve efficiency



This translates to stable topline growth and margin expansion, while maintaining positive FCF



Achieving ROCE of at least 20% starting as early as 2029

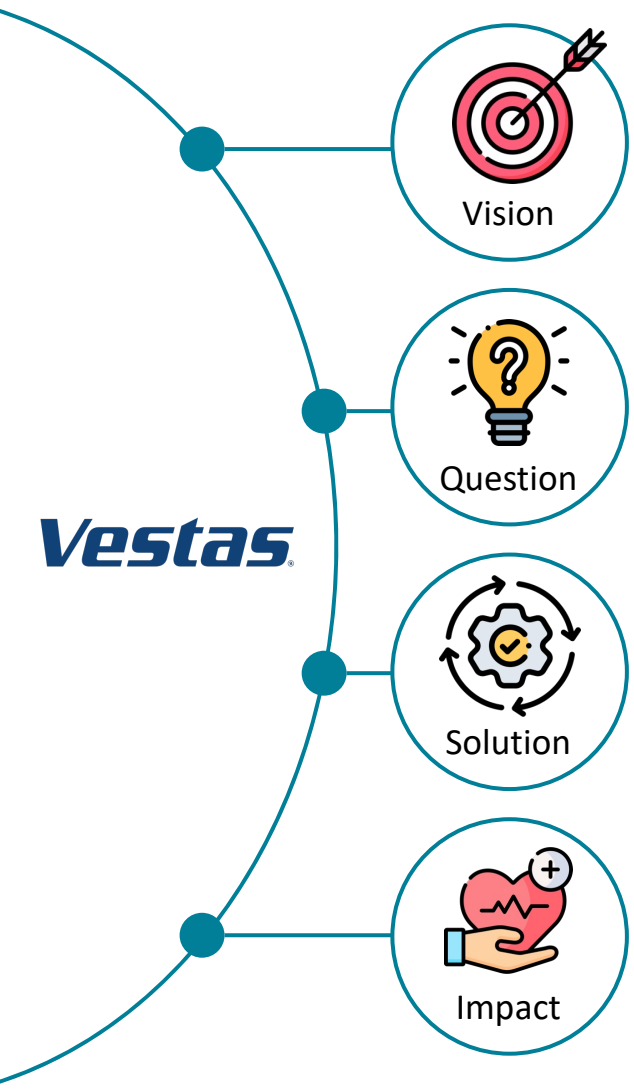


Key Assumptions:

1. Growth rates generally in line with company guidance
2. Conservative estimates on government subsidy/support
3. -10% CAGR in turbine equipment prices
4. EBIT margin of Power Solutions<EBIT margin of PtX (service based)<EBIT margin of Service
5. NWC increases as company prioritizes growing service segment (less advance payments/contract liability)

Source(s): Case, Annual Report

With our PtX strategy, Vestas' long-term vision of creating value through customer-centric solutions is no longer a dream but a reality



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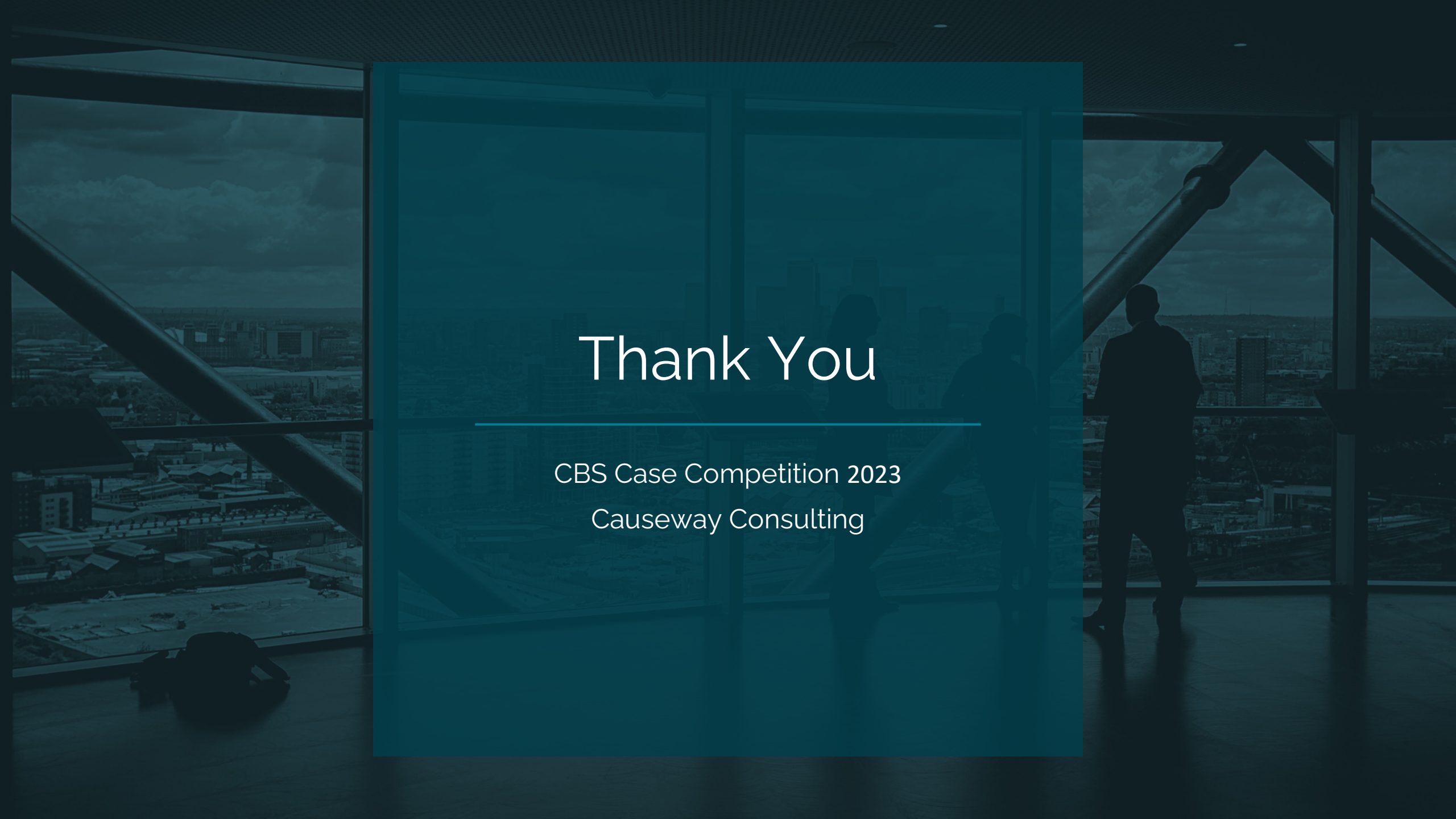


Thank You

CBS Case Competition 2023

Causeway Consulting

Slides Navigator

Main deck:

Appendices:

Financials: Sales Model

Sales Model		2018	2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E	NOTES	
Segment 1	**Power Solutions**	8,465	10276	12,764	13103	11331	**11558**	**11789**	**12025**	**12205**	**12388**	**12574**	**12762**	**12954**		STEP
	Power Solutions Growth		*21.39%*	*24.21%*	*2.66%*	*-13.52%*	2.00%	2.00%	2.00%	1.50%	1.50%	1.50%	1.50%	1.50%	growth taper down	-0.5%
	EBIT Margin	*8.90%*	*7.20%*	*3.10%*	*1.50%*	*-13.34%*	1.47%	3.47%	4.47%	4.47%	4.47%	4.47%	4.47%	4.47%	Normalized margins after price pressures dissipate	
Segment 2	**Service**	1,669	1,871	2,055	2484	3155	**3762**	**4486**	**5349**	**6218**	**7041**	**7762**	**8324**	**8677**		STEP
	Service Growth		*12.10%*	*9.83%*	*20.88%*	*27.01%*	19.24%	19.24%	19.24%	16.24%	13.24%	10.24%	7.24%	4.24%	Guidance, Continued growth given company focus, taper back to growth rate starting by 2026	-3.0%
	EBIT Margin	*25.20%*	*25.80%*	*27.60%*	*24.10%*	*21.39%*	23.00%	24.00%	24.50%	24.50%	24.50%	24.50%	24.50%	24.50%	Guidance, higher margins	STEP
	Revenue per MW (M EUR)	*0.71*	*0.68*	*0.86*	*1.12*	*1.29*	*0.99*	*0.89*	*0.80*	*0.72*	*0.65*	*0.58*	*0.53*	*0.47*	cost of turbine equipment is expected to fall by 10% a year given historical trends (reglobal)	*-10%*
	2030 Western Green Hydrogen Capacity (MW)													42,000.00	https://hydrogeneurope.eu/green-h2-costs-to-fall/	
	Potential Market (EUR Millions)													19,862.24		
	Target Market Penetration											5%		12%	Vestas has 17% market share in wind energy in Europe	
Segment 3	**PTX**									**823.75**	**904.47**	**993.11**	**2,170.74**	**2,383**	working backwards from 2030 potential market	
	PTX growth										9.80%	9.80%	9.80%	9.80%	CAGR from case	STEP
	EBIT Margin									6.49%	8.49%	10.49%	12.49%	14.49%	margin will slowly increase as solution is adopted	2.0%

Sources: Company filings, case

Financials: FCF Model

FCF Model	2018	2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E	NOTES
Revenue	10,134	12,147	14,819	15,587	14,486	15,320	16,275	17,374	19,246	20,334	21,329	23,257	24,015	
Revenue growth		*19.86%*	*22.00%*	*5.18%*	*-7.06%*	*5.76%*	*6.23%*	*6.75%*	*10.78%*	*5.65%*	*4.90%*	*9.04%*	*3.26%*	
EBIT	921	1,004	698	289	-1,596	1,035	1,486	1,848	2,123	2,356	2,568	2,881	3,050	
EBIT margin	*9.09%*	*8.27%*	*4.71%*	*1.85%*	*-11.02%*	*6.76%*	*9.13%*	*10.64%*	*11.03%*	*11.59%*	*12.04%*	*12.39%*	*12.70%*	
Less: Tax	-202	-231	-79	-14	525	-238	-342	-425	-488	-542	-591	-663	-702	
NOPAT	719	773	619	275	-1,071	797	1,144	1,423	1,634	1,814	1,977	2,218	2,349	
Effective Tax Rate	*21.93%*	*23.01%*	*11.32%*	*4.84%*	*32.89%*	*23.01%*	*23.01%*	*23.01%*	*23.01%*	*23.01%*	*23.01%*	*23.01%*	*23.01%*	*Pre-COVID tax rate*
Plus: depreciation and amortization (adjustment for non cash items)	716	546	684	982	1,088	682	725	774	857	905	950	1,035	1,069	
Depreciation as a % of revenue	*7.07%*	*4.49%*	*4.62%*	*6.30%*	*7.51%*	*4.45%*	*4.45%*	*4.45%*	*4.45%*	*4.45%*	*4.45%*	*4.45%*	*4.45%*	*Depreciation as a % of sales 2% lower than Capex*
Less: capex	-603	-840	-853	-1,106	-948	-988	-1,050	-1,121	-1,242	-1,312	-1,376	-1,501	-1,549	
Less: R&D Expenditures for PTX	0	0	0	0	0	-350	-200	-150	-100	-50	-50	-50	-50	R&D spent on developing expertise of integrating renewable energy production into electrolysis, subsequent recurring investment is to refine efficiency
Capex as a % of revenue	*5.95%*	*6.92%*	*5.76%*	*7.10%*	*6.54%*	*6.45%*	*6.45%*	*6.45%*	*6.45%*	*6.45%*	*6.45%*	*6.45%*	*6.45%*	*Average*
Plus: Changes in NWC	-56	457	456	78	-300	173	102	13	-3	71	46	32	36	Less advanced payments (contract liabilities) as services become a bigger part of the business
Unlevered Free Cash Flow	**776**	**936**	**906**	**229**	**-1,231**	**314**	**720**	**939**	**1,146**	**1,428**	**1,546**	**1,735**	**1,855**	
ROCE	20.5%	20.1%	10.1%	4.2%	-24.3%	13.3%	17.1%	18.9%	18.7%	19.3%	19.8%	20.0%	20.3%	

Sources: Company filings, case

Financials: Balance Sheet Forecast

Balance Sheet Balance Sheet as of:	Dec-31-2017	Dec-31-2018	Dec-31-2019	Dec-31-2020	Dec-31-2021	Dec-31-2022	Dec-31-2023	Dec-31-2024	Dec-31-2025	Dec-31-2026	Dec-31-2027	Dec-31-2028	Dec-31-2029	Dec-31-2030	
Currency	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	*EUR*	Notes
ASSETS															
Cash And Equivalents	3,653.0	2,918.0	2,888.0	3,063.0	2,420.0	2,378.0	2,691.53	3,411.77	4,350.42	5,496.60	6,924.82	8,471.23	10,206.08	12,060.78	
Short Term Investments	7.0	422.0	173.0	111.0	116.0	0	138.2	138.2	138.2	138.2	138.2	138.2	138.2	138.2	
Total Cash & ST Investments	**3,660.0**	**3,340.0**	**3,061.0**	**3,174.0**	**2,536.0**	**2,378.0**	**2,829.7**	**3,549.9**	**4,488.6**	**5,634.8**	**7,063.0**	**8,609.4**	**10,344.2**	**12,198.9**	
Accounts Receivable	1,226.0	1,297.0	1,988.0	2,313.0	2,758.0	2,679.0									
Other Receivables	424.0	603.0	877.0	1,102.0	1,207.0	1,272.0									
Total Receivables	**1,650.0**	**1,900.0**	**2,865.0**	**3,415.0**	**3,965.0**	**3,951.0**	**3,618.3**	**3,843.8**	**4,103.4**	**4,545.7**	**4,802.5**	**5,037.6**	**5,493.0**	**5,671.9**	
As a % of Revenue		*19%*	*24%*	*23%*	*25%*	*27%*	24%	*24%*	*24%*	*24%*	*24%*	*24%*	*24%*	*24%*	
Inventory	2,696.0	2,987.0	4,098.0	5,289.0	5,673.0	6,373.0									
As a % of Revenue		*29%*	*34%*	*36%*	*36%*	*44%*									
Other Current Assets	-	328.0	418.0	369.0	690.0	926.0									
Total Current Assets	**8,006.0**	**8,555.0**	**10,442.0**	**12,247.0**	**12,864.0**	**13,628.0**	**13,221.4**	**14,045.7**	**14,994.1**	**16,610.4**	**17,548.6**	**18,407.8**	**20,072.0**	**20,725.5**	
As a % of Revenue		*84%*	*86%*	*83%*	*83%*	*94%*	86%	*86%*	*86%*	*86%*	*86%*	*86%*	*86%*	*86%*	
Gross Property, Plant & Equipment	3,139.0	3,456.0	3,993.0	4,542.0	4,961.0	4,961.0									
Accumulated Depreciation	(1,892.0)	(2,138.0)	(2,322.0)	(2,520.0)	(2,870.0)	(3,209.0)									
Net Property, Plant & Equipment	**1,247.0**	**1,318.0**	**1,671.0**	**2,022.0**	**2,091.0**	**1,752.0**	**1,873.2**	**1,827.3**	**1,950.6**	**2,160.9**	**2,283.0**	**2,394.8**	**2,611.3**	**2,696.3**	
As a % of Revenue		*13%*	*14%*	*14%*	*13%*	*12%*	12%	*11%*	*11%*	*11%*	*11%*	*11%*	*11%*	*11%*	*lower PPE due*
Long-term Investments	376.0	472.0	445.0	226.0	790.0	829.0	552.4	568.5	593.2	666.6	641.9	604.5	614.9	624.2	
Goodwill	304.0	379.0	386.0	1,274.0	1,508.0	1,514.0	1,710.90	1,890.90	2,025.90	2,115.90	2,160.90	2,205.90	2,250.90	2,295.90	
Other Intangibles	597.0	717.0	822.0	1,614.0	1,554.0	1,551.0	1,901.0	2,101.0	2,251.0	2,351.0	2,401.0	2,451.0	2,501.0	2,551.0	
Deferred Tax Assets, LT	218.0	281.0	324.0	335.0	378.0	497.0	363.0	363.0	363.0	363.0	363.0	363.0	363.0	363.0	
Other Long-Term Assets	123.0	177.0	241.0	442.0	463.0	319.0	328.4	328.4	328.4	328.4	328.4	328.4	328.4	328.4	
Total Assets	**10,871.0**	**11,899.0**	**14,331.0**	**18,160.0**	**19,648.0**	**20,090.0**	**19,950.4**	**21,124.7**	**22,506.2**	**24,596.2**	**25,726.8**	**26,755.4**	**28,741.5**	**29,584.3**	
LIABILITIES															
Accounts Payable	2,660.0	2,417.0	3,119.0	3,608.0	4,286.0	4,089.0	4,050.1	4,302.6	4,593.1	5,088.2	5,375.6	5,638.8	6,148.6	6,348.8	
As a % of Revenue		*24%*	*26%*	*24%*	*27%*	*28%*	26%	*26%*	*26%*	*26%*	*26%*	*26%*	*26%*	*26%*	
Curr. Port. of LT Debt	-	-	101.0	377.0	560.0	106.0	286.0	286.0	286.0	286.0	286.0	286.0	286.0	286.0	
Curr. Port. of Leases	-	-	58.0	110.0	144.0	142.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	132.0	
Curr. Income Taxes Payable	108.0	112.0	128.0	86.0	75.0	58.0	94.5	99.2	104.2	109.4	114.9	120.6	126.6	133.0	
Unearned Revenue, Current	3,082.0	4,202.0	5,020.0	5,613.0	6,180.0	6,937.0	5,937.5	5,937.5	5,937.5	5,937.5	5,937.5	5,937.5	5,937.5	5,937.5	
Other Current Liabilities	683.0	674.0	921.0	1,438.0	1,455.0	2,181.0	1,691.3	1,691.3	1,691.3	1,691.3	1,691.3	1,691.3	1,691.3	1,691.3	
Total Current Liabilities	**6,533.0**	**7,405.0**	**9,347.0**	**11,232.0**	**12,700.0**	**13,513.0**	**12,191.4**	**12,448.6**	**12,744.1**	**13,244.5**	**13,537.3**	**13,806.3**	**14,322.1**	**14,528.6**	
Long-Term Debt	497.0	498.0	521.0	531.0	331.0	1,828.0	1,828.0	1,728.0	1,628.0	1,528.0	1,428.0	1,328.0	1,228.0	1,128.0	
Long-Term Leases	0	0	140.0	336.0	401.0	351.0	307.0	348.8	351.9	339.7	336.8	344.3	343.2	341.0	
Def. Tax Liability, Non-Curr.	61.0	120.0	147.0	158.0	362.0	158.0	189.0	202.8	214.0	225.2	197.8	205.7	209.1	210.3	
Other Non-Current Liabilities	600.0	700.0	798.0	1,200.0	1,157.0	1,060.0	983.0	1,039.6	1,087.9	1,065.5	1,047.2	1,044.6	1,057.0	1,060.4	
Extra-ordinary Non-Current Liabilities	68.0	72.0	33.0	0	0	120.0	645.4	713.1	941.0	1,647.9	1,603.4	1,373.9	1,810.8	1,362.2	
Total Liabilities	**7,759.0**	**8,795.0**	**10,986.0**	**13,457.0**	**14,951.0**	**17,030.0**	**16,143.8**	**16,480.8**	**16,966.9**	**18,050.7**	**18,150.5**	**18,102.9**	**18,970.1**	**18,630.6**	
Common Stock	29.0	28.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	
Additional Paid In Capital	0	0	0	0	0	0									
Retained Earnings	3,046.0	3,042.0	3,333.0	4,773.0	4,635.0	3,002.0	3,799.05	4,645.79	5,549.70	6,551.05	7,585.90	8,670.29	9,824.98	11,013.64	
Treasury Stock	0	0	0	0	0	0									
Comprehensive Inc. and Other	37.0	22.0	(67.0)	(146.0)	22.0	15.0	(19.5)	(28.9)	(37.4)	(32.5)	(13.5)	(19.5)	(25.2)	(26.2)	
Total Common Equity	**3,112.0**	**3,092.0**	**3,293.0**	**4,654.0**	**4,684.0**	**3,044.0**	**3,806.5**	**4,643.9**	**5,539.3**	**6,545.6**	**7,599.3**	**8,677.8**	**9,826.8**	**11,014.5**	
Minority Interest	-	12.0	52.0	49.0	13.0	16.0	0	0	0	0	(23.1)	(25.3)	(55.3)	(60.8)	
Total Equity	**3,112.0**	**3,104.0**	**3,345.0**	**4,703.0**	**4,697.0**	**3,060.0**	**3,806.5**	**4,643.9**	**5,539.3**	**6,545.6**	**7,576.3**	**8,652.5**	**9,771.4**	**10,953.7**	
Total Liabilities And Equity	**10,871.0**	**11,899.0**	**14,331.0**	**18,160.0**	**19,648.0**	**20,090.0**	**19,950.4**	**21,124.7**	**22,506.2**	**24,596.2**	**25,726.8**	**26,755.4**	**28,741.5**	**29,584.3**	

Sources: Company filings, case

Financials: Income Statement Forecast

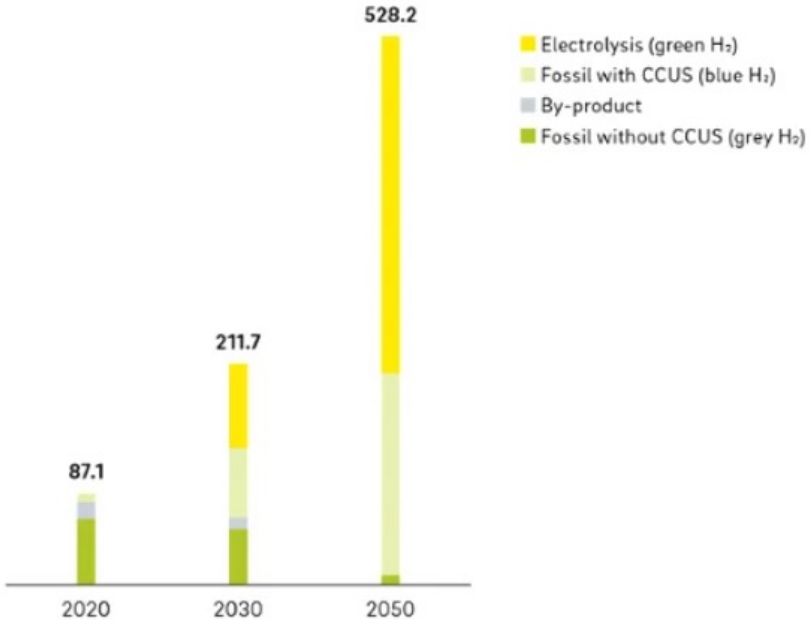
mEUR	2018	2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E	NOTES
Income statement														
Revenue	10,134	12,147	14,819	15,587	14,486	15,320	16,275	17,374	19,246	20,334	21,329	23,257	24,015	
EBIT before special items	959	1,004	750	428	-1,152	1,035	1,486	1,848	2,123	2,356	2,568	2,881	3,050	
Margin	*9.46%*	*8.27%*	*5.06%*	*2.75%*	*-7.95%*	*6.76%*	*9.13%*	*10.64%*	*11.03%*	*11.59%*	*12.04%*	*12.39%*	*12.70%*	
Net Income to Company	683	700	771	143	-1572	797	847	904	1001	1058	1110	1210	1249	
Margin	*6.74%*	*5.76%*	*5.20%*	*0.92%*	*-10.85%*	*5.20%*	*5.20%*	*5.20%*	*5.20%*	*5.20%*	*5.20%*	*5.20%*	*5.20%*	
Minority Interest	12	52	49	13	16					(23.06)	(25.32)	(55.34)	(60.76)	
Net Income	695	752	820	156	-1556	797	847	904	1001	1035	1084	1155	1189	

Sources: Company filings, case

Green hydrogen market dynamics

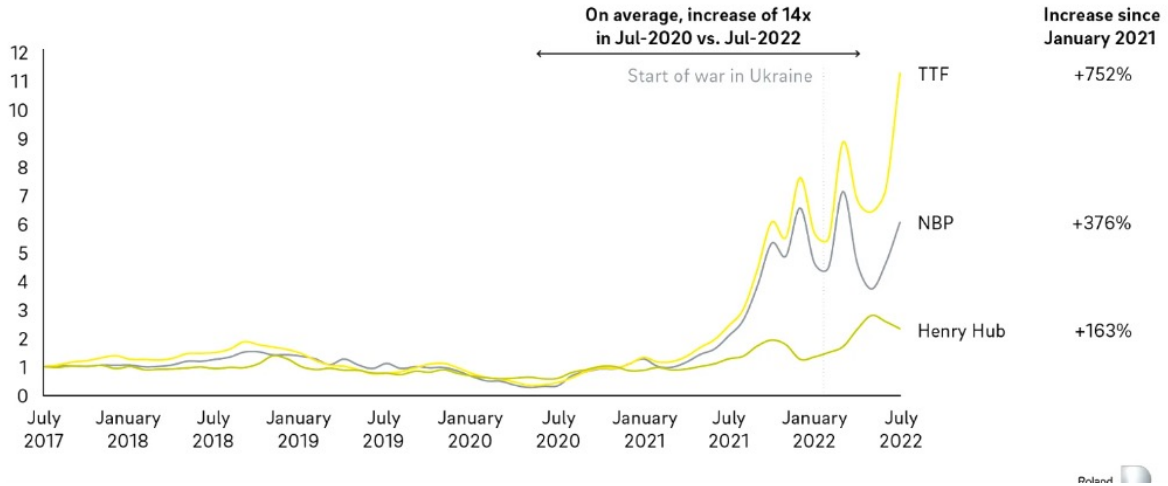
Green hydrogen is expected to be a key component of the future energy mix globally and in the UK

IEA NZE Scenario Hydrogen Outlook, 2020-50 [Mt H_2]



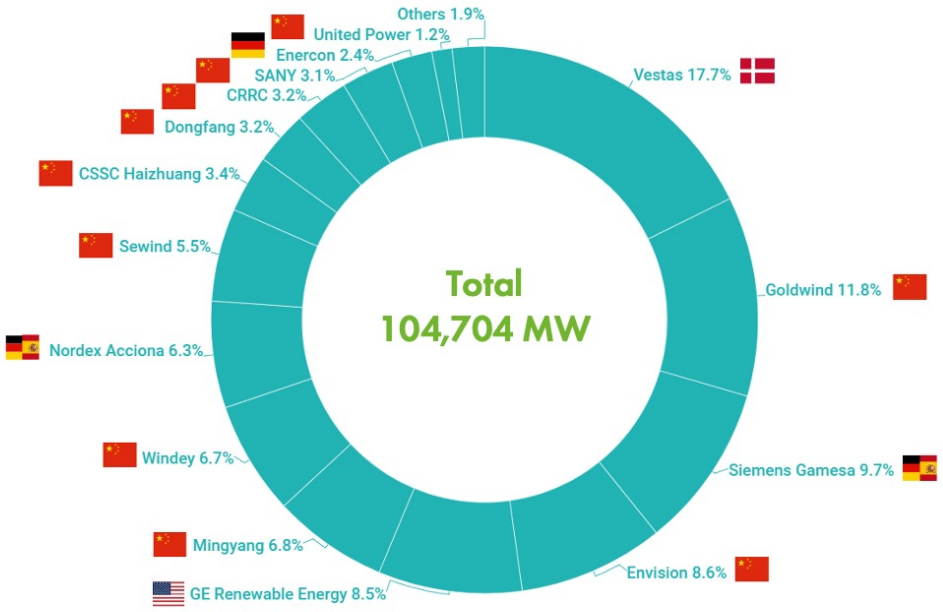
Surging natural gas prices make green hydrogen more cost competitive to grey hydrogen

Prices of natural gas [various units, Indexed, Jul 2017 = 1]



Source(s): GWEC Market Intelligence, Vestas

Vestas' key competencies



Source: GWEC Market Intelligence, May 2022

STRONG VALUE PROPOSITION WITH DEVELOPMENT

Technical capabilities, financial strength and global reach build competitive advantage

Technical expertise

- Extensive wind database
- +124 GW under operation
- Ongoing met mast campaigns
- Micro-siting expertise
- Grid capabilities
- Site optimisation for Vestas' technology

Financial strength

- Grid bonds
- Warranties
- Balance sheet to support acquisitions
- Financial solutions
- Establish offtake

Global reach

- Installations in more than 85 countries
- Access to pipeline worldwide
- Point of contact for global energy players
- Institutional relations

Regional analysis: Resources and infrastructure

	EU	US/Canada	Australia	Middle East	Japan/Korea	China	LATAM
Resources							
Elaboration	• Access to abundant wind resources both onshore and offshore • Robust transmission and distribution infrastructure to support integration of renewable energy and green hydrogen	• Access to abundant wind resources both onshore and offshore • Access to abundant land availability • Developed transmission and distribution infrastructure to support integration	• Access to abundant wind resources both onshore and offshore • Developed transmission and distribution infrastructure to support integration	• Favourable climate for renewable energy • Existing infrastructure and expertise in the oil and gas sector enables energy transition • Developed transmission and distribution infrastructure to support integration	• Limited land availability for wind turbines • Robust transmission and distribution infrastructure to support integration of renewable energy and green hydrogen	• Primarily domestic access to renewable energy resources • Developed transmission and distribution infrastructure to support integration of renewable energy and green hydrogen	• Yet to be developed transmission and distribution infrastructure, hindering the growth and integration of renewable energy and green hydrogen

Source(s): IEA, Market intelligence, McKinsey, PwC, Vestas

Regional analysis: Policies and regulations

	EU	US/Canada	Australia	Middle East	Japan/Korea	China	LATAM
Policies & regulations							
Elaboration	• Ambitious production targets: 40GW of renewable hydrogen by 2030 • Supportive regulatory environment: Renewable Energy Directive, the Clean Energy Package • Emissions Trading Scheme, carbon pricing mechanism incentivize the transition	• Biden administration has set a goal of reducing greenhouse gas emissions by 50-52% below 2005 levels by 2030 • Clear regulatory framework for green hydrogen and production roadmap • Passed tax subsidy laws for green hydrogen production	• Goal of producing hydrogen at a cost of under $2 per kilogram by 2030, with a focus on green hydrogen • Australian Renewable Energy Agency and the Clean Energy Finance Corporation to support the development • Lack of a clear policy framework and support	• United Arab Emirates and Saudi Arabia, have announced plans to develop green hydrogen projects • Regulatory environment for renewable energy varies across the region, with some countries offering generous incentives and others offering little support	• Japan aims to produce 300,000 tonnes of hydrogen per year by 2030 • Korea aims to produce 5.5 million tonnes of hydrogen per year by 2040 • Complex regulatory environment with stringent permitting processes and a lack of clarity on regulations	• Goal of producing 5 million tonnes of hydrogen per year by 2025, with a focus on green hydrogen • Policies to support the development, including feed-in tariffs, tax incentives, and subsidies • Complex permitting processes and restrictions on foreign investment	• Only few countries support development: Chile and Argentina announced plans to develop green hydrogen • Regulatory environment varies widely across the region, with some countries offering generous incentives and others offering little support

Source(s): IEA, Market intelligence, McKinsey, PwC, Vestas

Regional analysis: Partnerships potential and feasibility

	EU	US/Canada	Australia	Middle East	Japan/Korea	China	LATAM
Partnerships							
Elaboration	• Several established players in the hydrogen sectors, partnerships/ collaborations are feasible • Several partnerships and initiatives in place: European Clean Hydrogen Alliance and the European Hydrogen Backbone	• Presence of established players in the hydrogen sector • Potential partners across various disciplines, including energy companies, technology companies, natural gas companies, research institutions, universities	• Few established players in the hydrogen sector • Potential partners are smaller in scale and yet to develop mature technologies, although high growth potential is shown	• Few established players in the hydrogen sector • Political instability in the region could pose challenges for partnerships and collaborations	• Several established players in the hydrogen sector, making partnerships and collaborations more feasible • Regulatory environment and stringent government policies can be challenging for foreign companies	• Self-sufficient mindset hinders partnership opportunities • Regulatory environment and government policies can be challenging for foreign companies, making partnerships and collaborations difficult	• Few established players in the hydrogen sector • Political instability in the region could pose challenges for partnerships and collaborations

Source(s): IEA, Market intelligence, McKinsey, PwC, Vestas

Regional analysis: Vestas' presence in the energy market

	EU	US/Canada	Australia	Middle East	Japan/Korea	China	LATAM
Energy market presence							
Elaboration	• Strong presence in the European wind energy market, with a market share of around 20% in 2020 • Installed more than 60 GW of wind capacity in Europe, • Has manufactur-ing facilities and service centers	• Strong presence in the North American wind energy market, with a market share of around 17% in 2020 • Installed more than 20 GW of wind capacity • Has manufactur-ing facilities and service centers	• Growing presence in the Australian wind energy market, with several projects underway • Vestas secured an order in Australia for a 453 MW project in Victoria	• Growing presence in the Middle East windwind energy market, with several projects underway in Saudi Arabia, Jordan, the UAE • Vestas secured an order for a 415 MW project in Saudi Arabia	• Relatively small presence in the Japanese and Korean wind energy markets, but involved in several projects • Announced plans to establish a regional hub in Japan to support the growing offshore wind market	• Limited presence in the Chinese wind energy market, which is dominated by local manufacturer s such as Goldwind and Envision • Vestas announced plans to establish a joint venture with Chinese manufacturer CRRC	• Growing presence in the Latin American wind energy market, with several projects underway in Mexico, Brazil, Chile • Vestas secured an order for a 359 MW project in Mexico

Source(s): IEA, Market intelligence, McKinsey, PwC, Vestas

Regional analysis: Market demand for green hydrogen

	EU	US/Canada	Australia	Middle East	Japan/Korea	China	LATAM
Market demand for green hydrogen							
Elaboration	• Several funding programs in place to support the development industry • Ambitious climate targets, coupled with the growing demand for, are likely to drive the demand for green hydrogen	• Focus on decarbonize-tion technologies, such as carbon capture and storage, may push market demand for green hydrogen	• Market demand for green hydrogen in Australia may be limited by the country's relatively small population and limited existing infrastructure	• Market demand for green hydrogen may be limited due to the region's reliance on fossil fuel exports • Market demand may be limited by the availability of suitable land resources for product utilization	• Strong focus on decarbonize-tion, several initiatives and funding programs in place to support the development • Market demand may be limited by the availability of suitable land resources for product utilization	• Efforts to reduce its carbon emissions and improve air quality are likely to drive the demand for green hydrogen • Several policies and incentives to support the development of the green hydrogen industry	• Market demand may be limited by the relatively slow pace of and the availability of suitable land resources for product utilization

Source(s): IEA, Market intelligence, McKinsey, PwC, Vestas

Regional analysis: Vestas' legacy and history

	EU	US/Canada	Australia	Middle East	Japan/Korea	China	LATAM
Legacy & history							
Elaboration	• Home region • Has been active since the 1980s and has a strong reputation for innovation and quality • Installed more wind turbines than any other company • Significant market presence and a long history of successful projects	• Established a reputation for innovation and quality in the US market and has delivered several large-scale projects • Is relatively new in the Canadian market	• Is relatively new in the Australian market • Has delivered several successful wind energy projects	• Has not had as much of a presence in the Middle East as some other regions • Has only been active in the Middle East region for several years, with a focus on projects in Saudi Arabia and the UAE	• Has been present in Japan for over a decade and established a reputation for delivering high-quality, reliable wind energy solutions • Expanded presence in South Korea in recent years, with several successful projects	• Is relatively new in the Chinese market • Established few successful partnerships in China, including a joint venture with Huadian that has delivered large-scale wind energy projects	• Has been present in the LATAM region since the early 2000s • Delivered several successful projects in the region, particularly in Brazil and Mexico

Source(s): IEA, Market intelligence, McKinsey, PwC, Vestas

Why not China? Institutional details

- **State Owned Enterprises (SOEs):** Foreign firms can only buy up to 25% of these firms unless converted to a Foreign Invested Enterprise (FIE).
- **Domestic Firm:** Firms owned by domestic investors. Conversion to FIE needed if 25% limit exceeded.
- **FIE:** Foreigners can invest without limit, but government approval needed for merger.
- Conversion to FIE requires government approval.
- Laws promote joint ventures.
- Rigidity of govt. scrutiny is by 3 groups of industries: encouraged, restricted, and prohibited (see “Catalogue for the Guidance of Foreign Investment Industries”): http://english.mofcom.gov.cn/article/policyrelease/aaa/201203/20120308027837.shtml
- China remains an evolving and dynamic marketplace. Expect these rules to change over time.

Source(s): Translated from The Central People’s Government of the People’s Republic of China

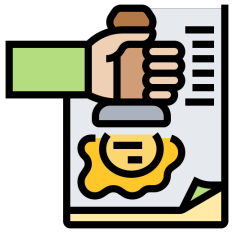
Risks alleviated by piloting entry in EU first then expanding business to US/Canada

1 Demand uncertainty

Difficult to forecast demand due to lack of consumer confidence in PtX solutions

Pilot success case provides exemplar to potential clients and drive up needs

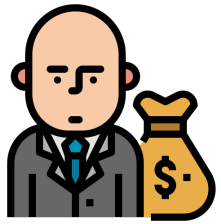
2 Regulatory uncertainty



Mismatch between government ambitions, actual policy support, and PtX project scalability

Pilot success case urges governments to consider passing more favourable policies

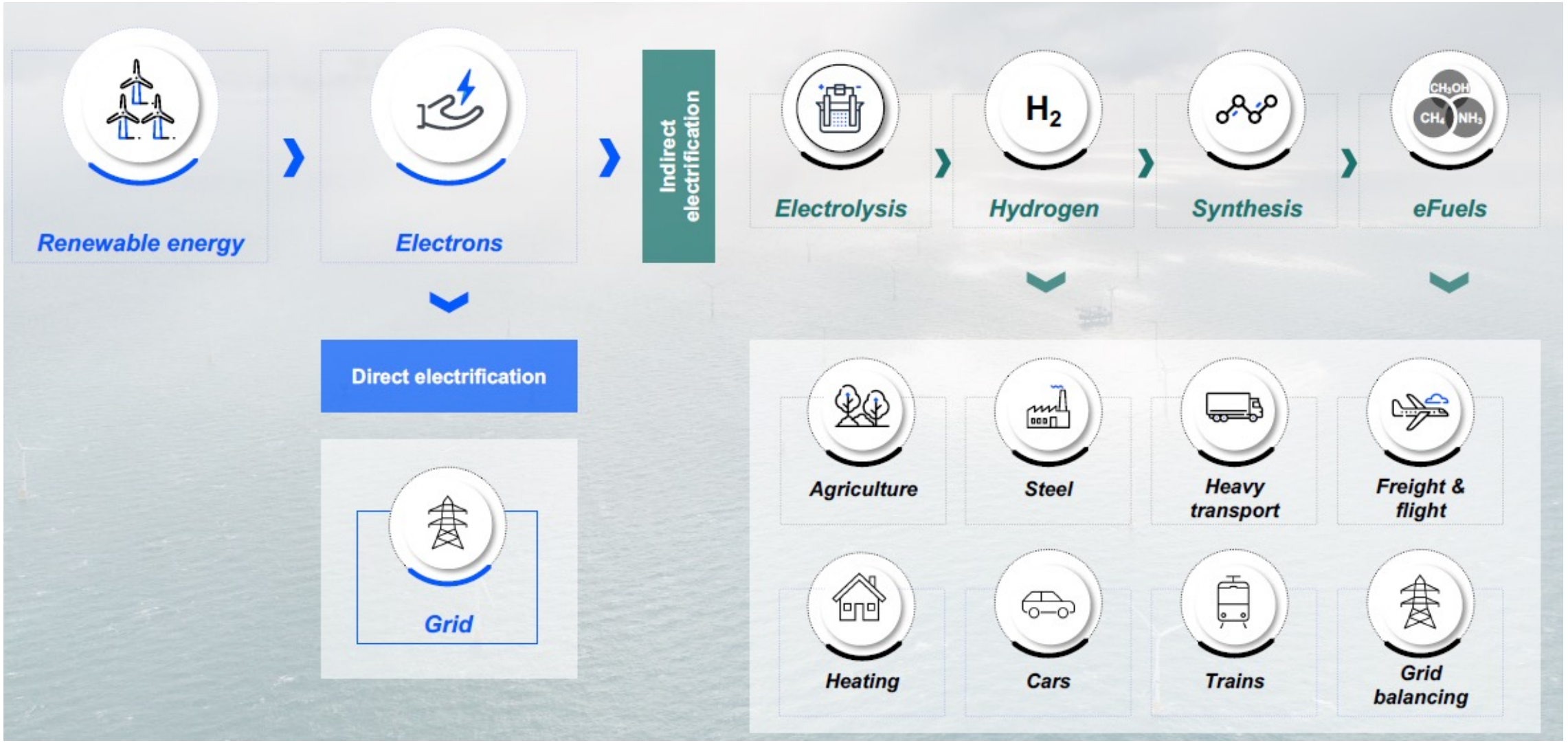
3 Investment horizon risks



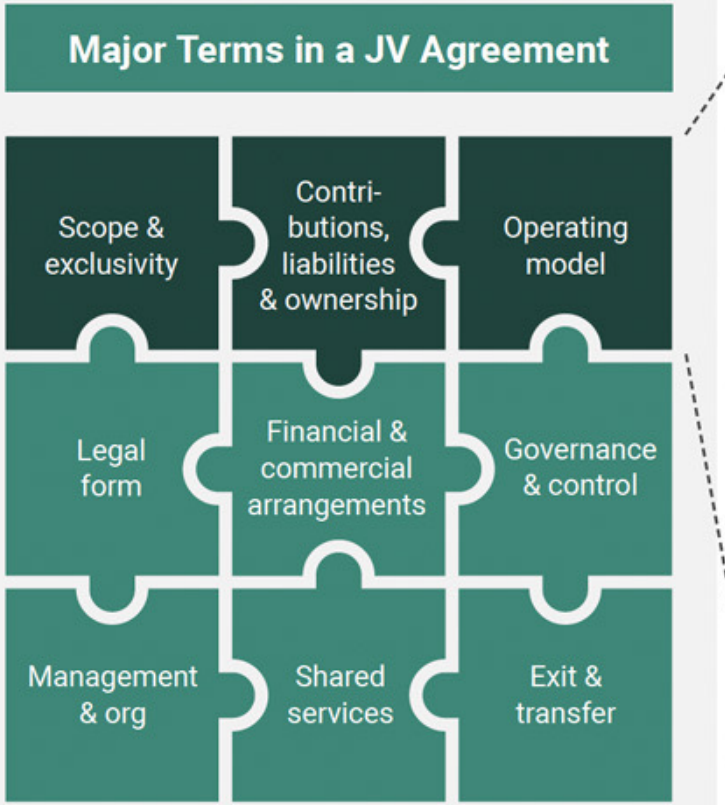
Investors are not convinced to put capital in projects due to unproven and uncertain returns

Pilot success case gives confidence to investors, securing larger future capital investments

Concept of PtX: Daily operations



Structure and considerations of Joint Venture



Key Questions (Sample)	
Scope & exclusivity	1. What products, services, markets, and customer segments are within the JV's authorized scope, versus out of scope? 2. Will the JV be the exclusive vehicle for all of the parent companies within this authorized scope, or will the parents be allowed to compete in certain areas with the JV? 3. How might the JV's scope evolve in the future, and is this anticipated evolution within or outside the venture's initial authorized scope?
Contributions, liabilities & ownership	1. What assets (e.g., capital, IP, physical assets, brands, customer lists, existing business lines) will each parent contribute to the JV? 2. Will either parent contribute existing liabilities to the JV and, if so, what? 3. What is the value of these contributions and liabilities, and what is the impact on ownership?
Operating model	1. How will the JV be designed, i.e., what assets and activities are "in" the JV, versus provided by the parents "to" the JV via service agreements? 2. What is the desired overall level of independence for the JV (in terms of people, culture, corporate processes and systems) – initially and over time?

Joint Ventures

Key features

- Enable firms to shares risks and resources to expand into international ventures
- Most joint ventures (JVs) involve a foreign company with a new product or technology and a host company with access to distribution or knowledge of local customs, norms or politics
- May experience difficulties in merging disparate cultures
- May not understand the strategic intent of partners or experience divergent goals

TRADITIONAL REASONS for Joint venture

- Sharing of resources and risks
- Host government requirements
- Overcoming strong nationalistic sentiments
- Quicker entry
- Benefit from partner's local knowledge

EMERGING REASONS

- Learning from one another
- Attain global scale economies
  - Raw material/ Component supply
  - Marketing and distribution
- Rising R&D costs and technological interdependence
  - Short product life cycles
- Industry convergence

Appendix – Strength of Denmark

Table 5 – PtX Competences

Project Developers	Technology Providers	Advisory Providers	OEMS	O&M
CIP (Copenhagen Infrastructure Partners)	Everfuel	COWI	Ballard Europe	A.P. Moller Maersk
Energinet	FLSmidth	FORCE Technology	Blue World Technologies	Ancotrans
Everfuel	Haldor Topsøe	NIRAS	DynElectro	DFDS
Gas Storage Denmark	IRD fuel cells	Rambøll	Everfuel	DGC (Dansk Gasteknisk Center)
Haldor Topsøe	REIntegrate	SWECO	FLSmidth	Energinet
Vestas Wind Systems	Vestas Wind Systems		Green Hydrogen Systems	Everfuel
Ørsted	Ørsted		Haldor Topsøe	Gas Storage Denmark
European Energy	Danfoss		IRD fuel cells	Ørsted
Eurowind Energy	Grundfos		Serenergy	DSV Panalpina
Siemens Gamesa	Electrochaea		Vestas Wind Systems	Andel
Shell Danmark	Hitachi		Danfoss	Norlys
Yara	MAN Energy solutions		Grundfos	Evergas
Ineos Oil & Gas Denmark	NEL Hydrogen		Svanehøj	Lauritzen Kosan (BW Epic Kosan)
	Siemens Gamesa		Alfa Laval Aalborg	Dangødning
	Wärstilä Danmark		Hitachi	Copenhagen Airport
	Ineos Oil & Gas Denmark		MAN Energy solutions	Alfa Laval Aalborg
			NEL Hydrogen	Shell Danmark
			Siemens Gamesa	Vattenfall
			Wärstilä Danmark	Ineos Oil & Gas Denmark
			Geopal Systems	Ultragas (Ultranav)

Note: Companies with foreign ownership Companies with Danish ownership

Competitors' Partnerships/Efforts in Green Hydrogen Space (1/3)

Company	Headline	Details	Benefits of Partnership	Ambitions
Siemens	Siemens Energy + industrial gas supplier Air Liquide announced a joint venture.	Siemens Energy (74.9%), Air Liquide (24.1%)	jointly apply for large projects funding under the EU's Green Deal and Important Project of Common European Interest (IPCEI)-scheme for hydrogen,	Air Liquide-H2V Capacity of 200 megawatts (MW) expected in the first phase. Planned commission in 2025
Nordex	Acciona, in 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.	50/50	Plug Power will serve as the preferred supplier of electrolyzer technology to the JV, with ACCIONA as the preferred clean electricity provider.	The goal is to reach a 20% market share of the green hydrogen business in Spain and Portugal by 2030, which will entail an initially planned investment of over €2 billion.
Longi	LONGi, announced the foundation of its subsidiary LONGi Hydrogen in March of 2021. The new subsidiary focuses on producing water electrolysis production equipment.			With a total investment up to RMB 3 billion, this project will build a new 300MW photovoltaic power plant and an electrolytic water hydrogen production plant to generation 618 million kWh green electricity and 20,000 tons green hydrogen per year. With the construction of digital and intelligent factories, the capacity of LONGi ALK electrolyzer will reach 1.5 GW by the end of 2022 and 5 GW by the end of 2025.
End users	Replacing 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.			

Competitors' Partnerships/Efforts in Green Hydrogen Space (2/3)

Company	Headline	Participated partners
Osted		

Green fuels for Denmark

The Green Fuels for Denmark project unites leading Danish companies to develop industrial-scale production of renewable hydrogen and sustainable e-fuels for road, maritime and air transport. By combining both supply and consumer side actors, the project seeks to develop 10MW electrolyser capacity by 2023, 250MW electrolyser capacity with e-fuel production by 2027, and a vision to scale up to 1.3GW by 2030. The electricity is to be sourced from offshore wind farms off the coast of Bornholm in the Baltic Sea. By then, the main part of renewable hydrogen will be combined with sustainably sourced carbon, to produce 250,000 tons of e-kerosene and e-methanol per year.

Westküste 100

Westküste 100 in Germany sets out to contribute in making industrial processes, aviation, construction and heating more sustainable, using renewable hydrogen at scale. The project consortium works to develop, build and operate a regional hydrogen economy at industrial scale, including a 30MW electrolyser system and with the goal of scaling up to 700MW hydrogen electrolysis. In the first step, renewable hydrogen from a 30MW electrolyser will replace current fossil hydrogen at the Heide Refinery in Schleswig-Holstein. Other elements in the project is the test of cavern-storage of hydrogen, test of a pipeline system and feasibility study of future e-fuel synthesis, including large-scale electrolysis. It is the first large-scale hydrogen project to receive funding from the German Reallabor funding program.

Source(s): Company Website

Competitors' Partnerships/Efforts in Green Hydrogen Space (3)

Company	Details	Participated partners	Ambitions
Siemens Energy	- 1st: OffgridWind which pursues the implementation of a turbine concept that realizes electrolysis directly in the offshore wind turbine, thereby aiming for a high degree of efficiency - 2nd: develop a proton exchange membrane (PEM) electrolysis system optimally adapted to the offshore environment and tuned to the wind turbine - 3rd: conversion to more easily transportable, synthetic energy carriers and fuels, such as methane, methanol, and ammonia. The power-to-X products are produced via high-temperature electrolysis and CO2 extraction from the air or sea - 4th: TransferWind, addresses the transfer of knowledge to the public as well as the exchange of expertise across projects. At the same time, it also considers safety and environmental issues as well as infrastructure requirements	four joint projects with a total of 35 partners, including the Fraunhofer Gesellschaft institutes.	aims to couple offshore wind turbines with electrolyzers for direct conversion of the electricity into hydrogen

Source(s): Offshorewind

Proof of Concept: Exporting Hydrogen

Home › News and resources › News › Australia exports world's first shipment of liquified hydrogen to Japan

Australia is sending the world's first shipment of liquified hydrogen to Japan.

It is a major milestone in the A$500 million Hydrogen Energy Supply Chain (HESC) pilot project. The project is the first in the world to extract, liquefy and transport liquid hydrogen by sea to an international market.

The Suiso Frontier will transport the super-cooled liquid hydrogen from Victoria's Port Hastings to Kobe. The 116-metre vessel is the world's first purpose-built liquefied hydrogen carrier.

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Vestas's current development with hydrogen space

PtX Space

1. **Australia**
   Vestas Ventures invested in Australian electrolysis system manufacturer Hysata with AUD 42.5m (EUR 28.92m) in an A series funding round

2. **Spain**
   CIP and Vestas launch 2GW green hydrogen project, Project Catalina in Spain – powered by 5GW of wind and solar. The Catalina partners — including gas transmission system operator Enagás, power and gas utility Naturgy, and fertiliser producer Fertiberia — aim to begin construction of the 500MW first phase, powered by 1.7GW of wind and solar, by the end of next year

Hydrogen-powered offshore service vessel

- In 2022, Vestas collaborates with long-term supplier Windcat Workboats and launches the world's first hydrogen-powered crew transfer vessel powered by hydrogen in a combination with marine gas oil

- The vessel is projected to be powered mostly by grey hydrogen due to a lack of available green hydrogen in the amounts needed

- Through the pilot, Vestas aims to mature a pathway for green hydrogen in its offshore operations, that can be leveraged once green hydrogen has reached the required level of maturity

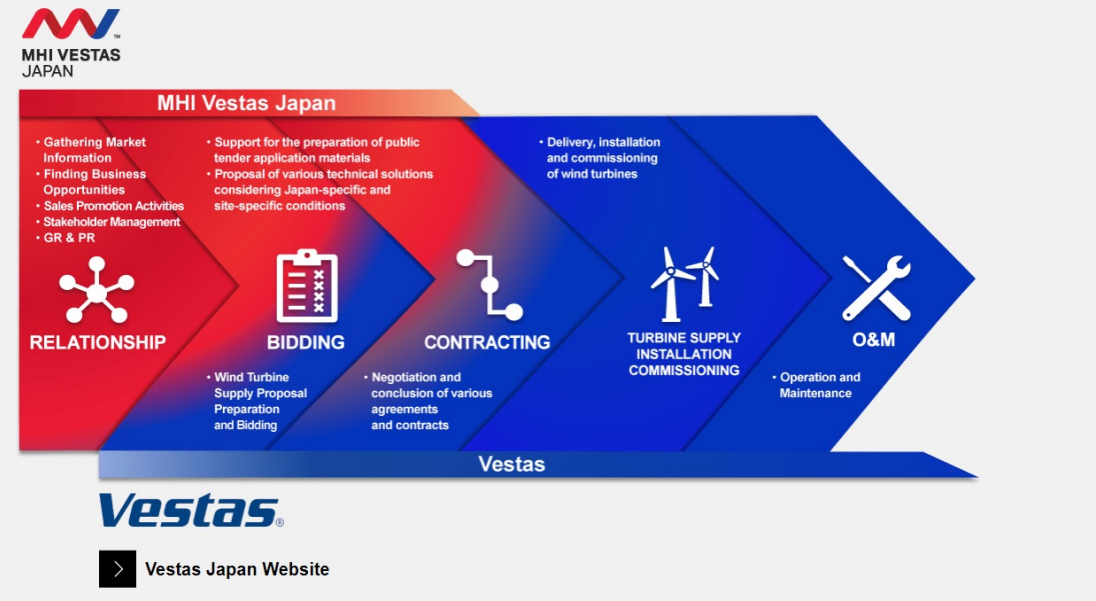
Source(s): https://energywatch.com/EnergyNews/Renewables/article14278893.ece; https://www.rechargenews.com/energy-transition/cip-and-vestas-launch-2gw-green-hydrogen-project-in-spain-powered-by-5gw-of-wind-and-solar/2-1-1161134

Vestas' JV experience

MHI Vestas Offshore Wind

- Formed in 2013
- 50% equal share by MHI and Vestas
- 2020 – Vestas fully acquired the JV; MHI acquired 2.5 percent in Vestas

- MHI will inject EUR 100m in cash into the JV and will inject another EUR 200m based on certain milestone achievements



Source(s): https://www.vestas.com/en/media/company-news/2013/vestas-and-mitsubishi-heavy-industries-form-a-joint-ven-c2964162

Example of Joint Venture in energy industry

- **Hydrogen joint venture formed in 2021**
    - JV aims for 20 percent hydrogen market share in Spain and Portugal
  - **Plug Power** - a comprehensive green hydrogen generation solution, including electrolyzer technology and liquefaction capabilities : preferred supplier of electrolyzer technology
  - **Acciona** - renewable energy plants : preferred supplier of clean electricity

- **Joint venture PtX Europe – equal share by both partners**
  - **H&R Group -** H&R to build Power-to-Liquids pilot plant
  - **Mabanaft** - supply its customers with CO_2-neutral E-Fuels

- **Joint venture to develop the project with an electrolyser capacity of 200MW close to Kristinestad**
  - Begin in 2024
  - Prime Green Energy Infrastructure Fund (PGEIF), CPC Finland

Source(s): https://www.renewable-energy-industry.com/countries/article-5834-plug-power-and-acciona-plan-hydrogen-joint-venture; https://www.mabanaft.com/en/news-info/current-news-and-press-releases/news-detail/hr-group-and-mabanaft-establish-new-joint-venture-to-market-PtX-products/

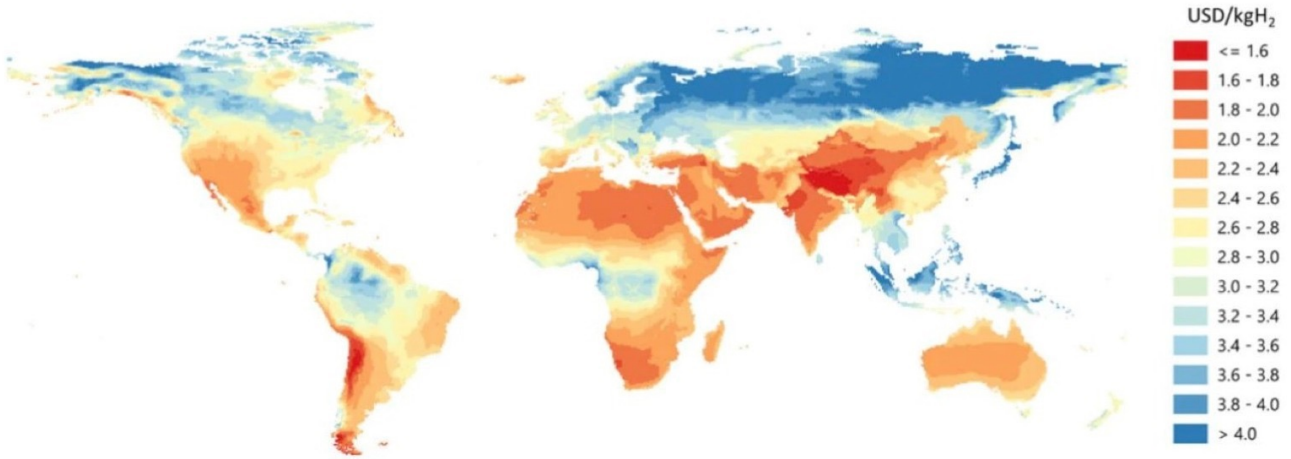
PtX Readiness

Table 2 – List of PtX technologies

Technology	Technology Readiness Level (Global)	Value Chain Step
Alkaline Electrolysis Cells (AEC)	9	Production
Proton Exchange Membrane (PEM)	8	Production
Solid Oxide Electrolysis Cell (SOEC)	7	Production
Methane synthesis	8-9	Production
Methanol synthesis	8	Production
DME (dimethyl ether) synthesis	3-9	Production
Fisher-Tropsch synthesis (FTS)	5-9	Production
Ammonia synthesis through Haber-Bosch process	9	Production
Ammonia synthesis through electrocatalytic nitrogen reduction reaction	4	Production
Hydrogen compression	9	Infrastructure
New hydrogen pipelines	9	Infrastructure
Retrofitting of natural gas pipelines to hydrogen	9	Infrastructure
Road and rail transportation of gaseous and liquid hydrogen	9	Infrastructure
Hydrogen shipping	8	Infrastructure
Hydrogen geological storage	9	Infrastructure
Hydrogen storage tanks	9	Infrastructure
Liquid electro-fuels shipping	8-9	Infrastructure
Solid Oxide Fuel Cell (SOFC)	8-9	Demand
Proton Exchange Membrane (PEM) Fuel Cell	9	Demand
Molten Carbonate Fuel Cell (MCFC)	7	Demand
Phosphoric Acid Fuel Cell (PAFC)	7	Demand
Direct Ammonia Fuel Cell (DAFC)	7	Demand
Direct Methanol Fuel Cell (DMFC)	9	Demand
2-stroke methanol dual fuel engine for marine transportation	9	Demand
Retrofitting of 2-stroke engines for marine transportation to methanol	9	Demand
2-stroke ammonia dual fuel engine for marine transportation	5	Demand
4-stroke ammonia dual fuel engine for marine transportation	5	Demand
Retrofitting of 2 and 4-stroke engines for marine transportation to ammonia	5	Demand

Green hydrogen production based on intermittent renewable energies, like wind and solar, is the alternative solution that enables nations with limited access to natural gas reserves to produce their own hydrogen. However, as shown by Figure 11 the price at which countries are able to produce green hydrogen still differs significantly due a range of factors.

Figure 11 – IEA green hydrogen costs from hybrid solar PV and onshore wind systems in 2050



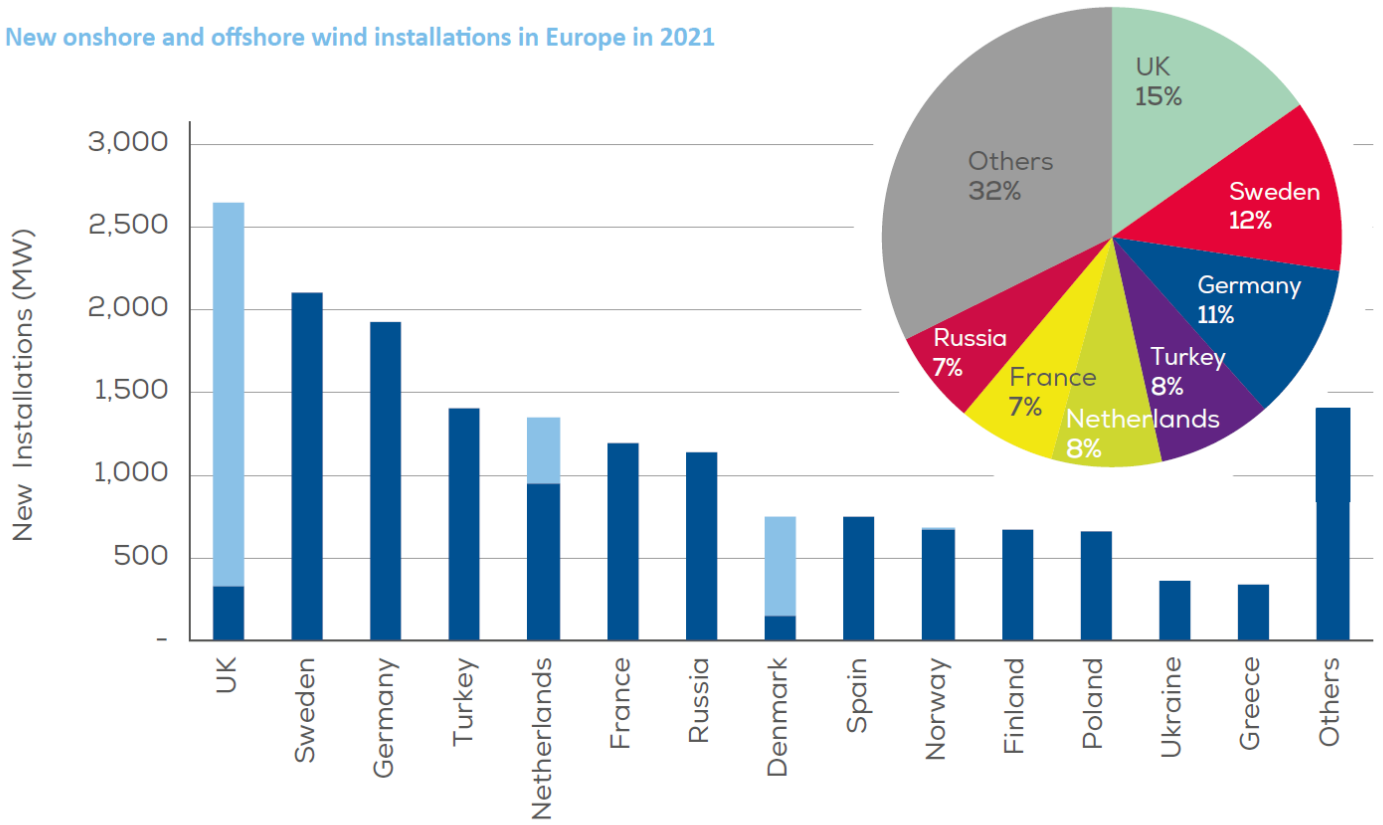
Source: IEA (2019), *The Future of Hydrogen*

The cost of the green hydrogen primarily depends on three factors:

- Technological learning rate of electrolysis
- Cost of renewable energy
- Load-factor assumptions

Source(s): IEA

New onshore and offshore wind installations in Europe in 2021



	UK	Sweden	Germany	Turkey	Netherlands	France	Russia	Denmark	Spain	Norway	Finland	Poland	Ukraine	Greece	Others
Offshore	2,317	-	-	-	392	-	-	605	-	4	-	-	-	-	-
Onshore	328	2,104	1,925	1,400	952	1,192	1,139	149	750	672	671	660	359	338	1,402
Total	**2,645**	**2,104**	**1,925**	**1,400**	**1,344**	**1,192**	**1,139**	**754**	**750**	**676**	**671**	**660**	**359**	**338**	**1,402**

Source: WindEurope

Source(s): WindEurope