



**MINISTRY OF FOREIGN AFFAIRS
OF DENMARK**
Invest in Denmark

WIND POWER OPPORTUNITIES IN DENMARK



**80% Power from Wind
in Denmark by 2030**

**100% Renewable
Energy**

PEDER BO SØRENSEN

- +10 years in Inward Investment and Renewable Energy & Windpower
- Special Advisor – Cleantech, Invest in Denmark
- Responsible for Wind Power Projects
- Active in China, Japan, Korea, India, Europe and North America
- Background from Science Park Aarhus, ABB, Finance



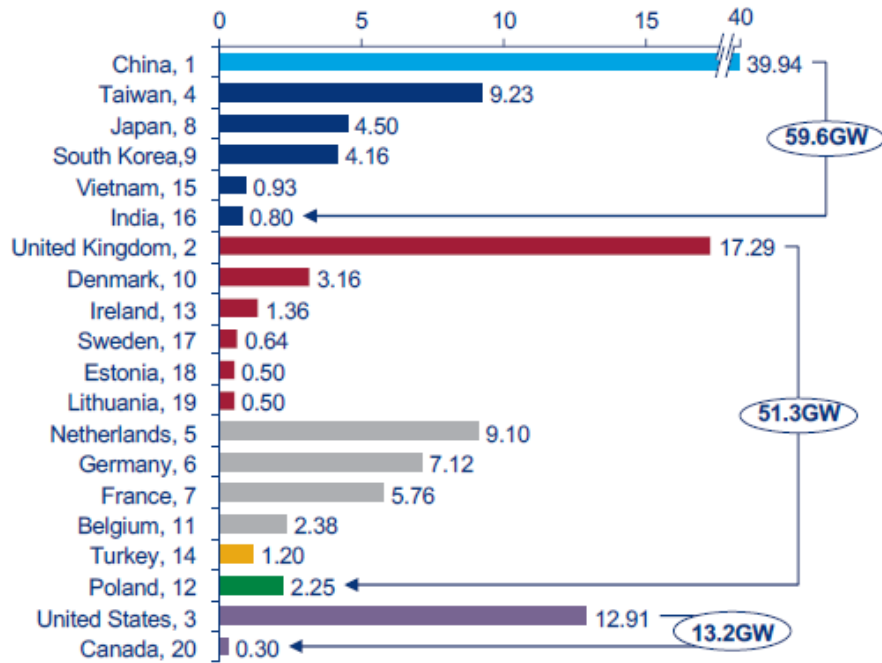
TRENDS - OFFSHORE

- Market Globalization
- Cost coming down
- Scale is important
- Internationalization of value chain
- Local content expanding

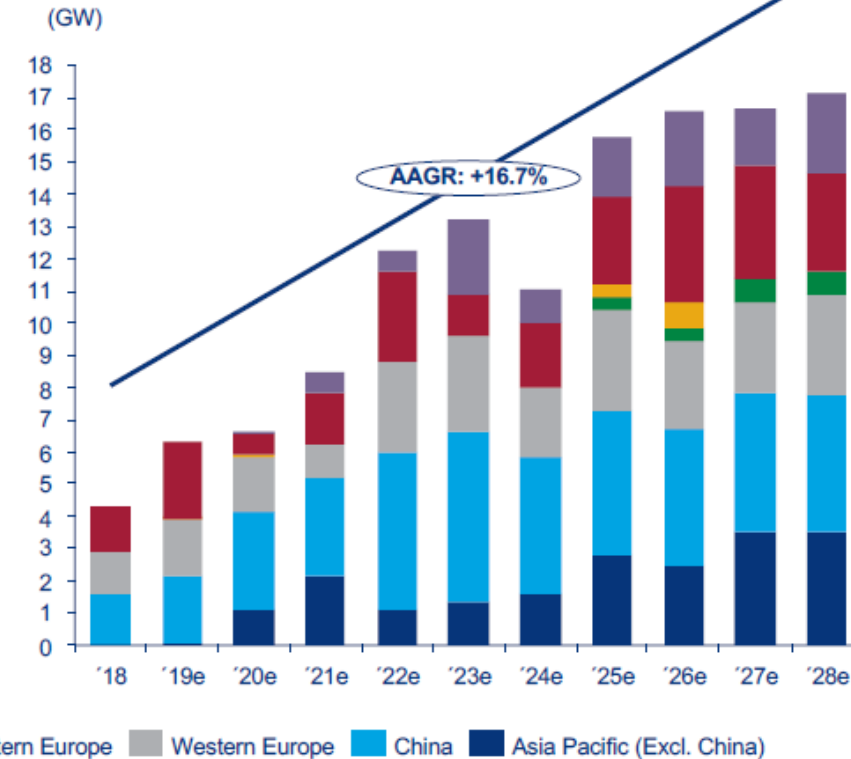


GLOBAL OFFSHORE WIND FORECAST - GLOBALIZATION

Offshore top 20 markets: New capacity '19e-'28e



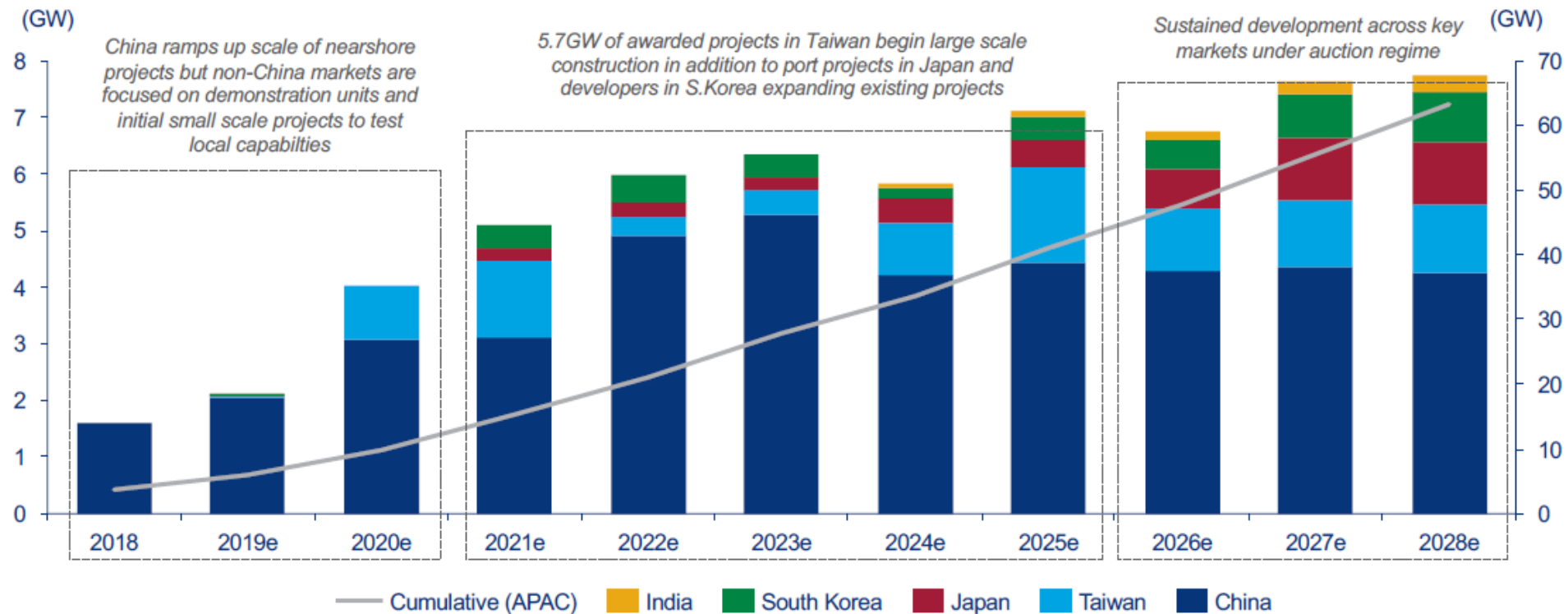
Offshore market forecasts: 2018-2028e





APAC OFFSHORE WIND FORECAST - EXPANSION

APAC offshore wind power outlook, 2017-2027e

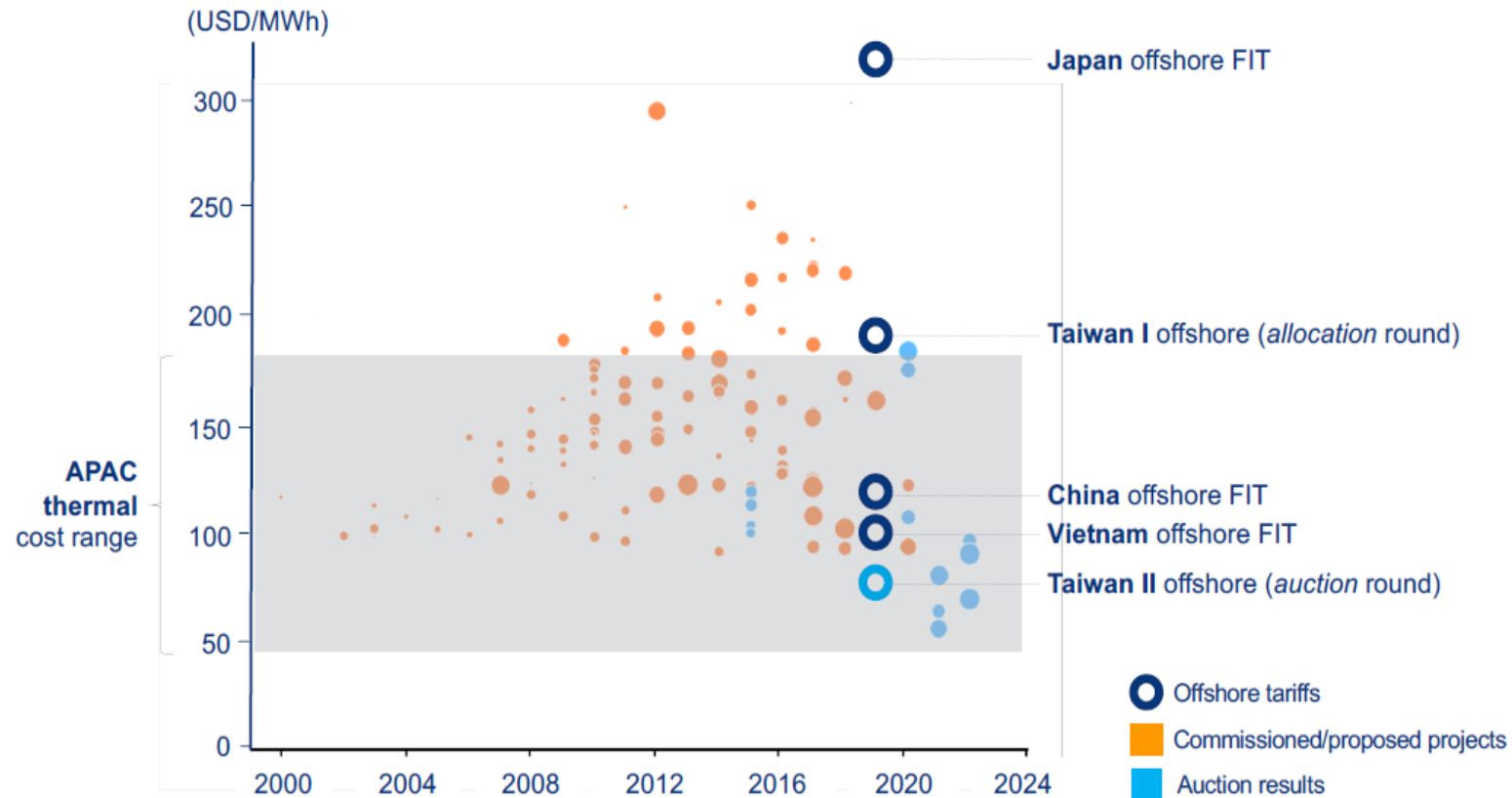




OFFSHORE WIND PRICES IS COMING DOWN

Awarded offshore wind prices are increasingly competitive with thermal prices

Global offshore wind tariffs versus APAC offshore wind tariffs



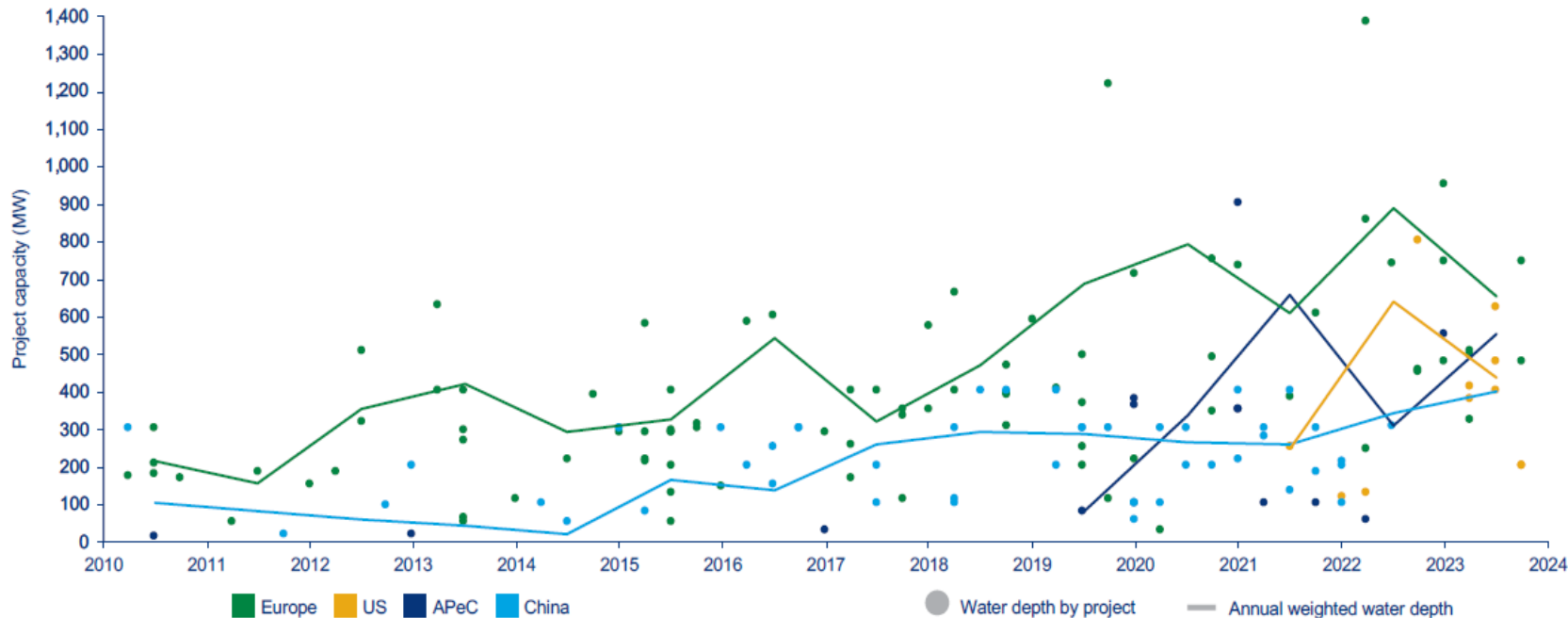


SCALE OF PROJECTS INCREASING AND GROWING TURBINE SIZE

Growth in average project size in emerging markets sparks value chain localization

Larger project sizes challenge smaller players in the value chain, but also facilitates O&M cost-out and offers economies of scale while motivating innovative solutions, particularly related to logistics and transmission.

Project size by region, 2010 to 2023



Note: Demonstrators and repowering projects are excluded. Based on the year a project becomes fully grid-connected.

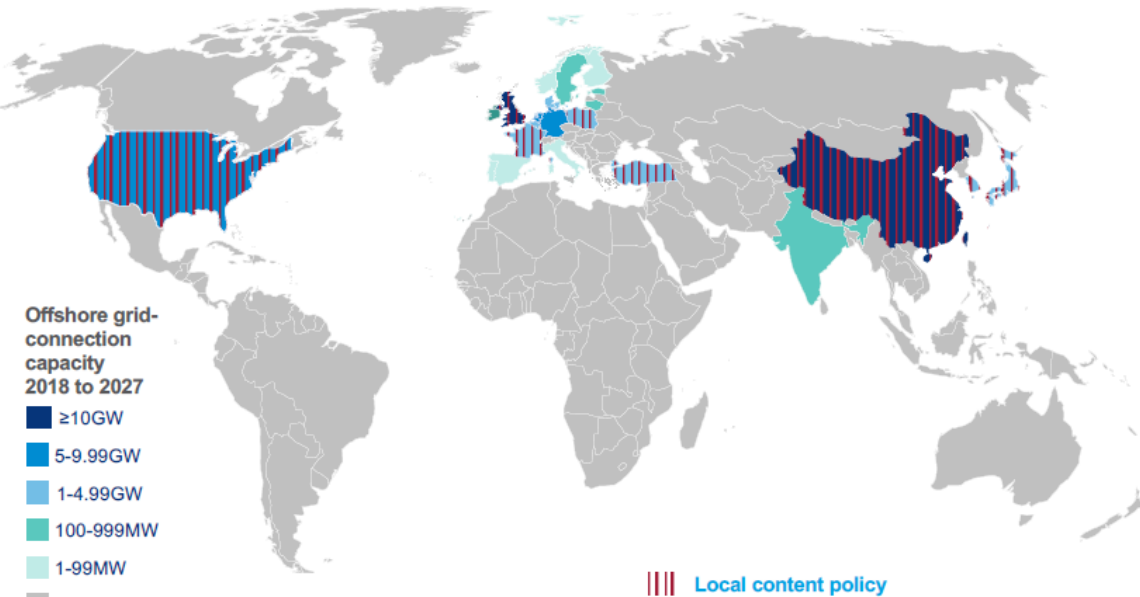


LOCAL CONTENT MEANS INTERNATIONALIZATION AND LOCAL SUPPLY CHAIN

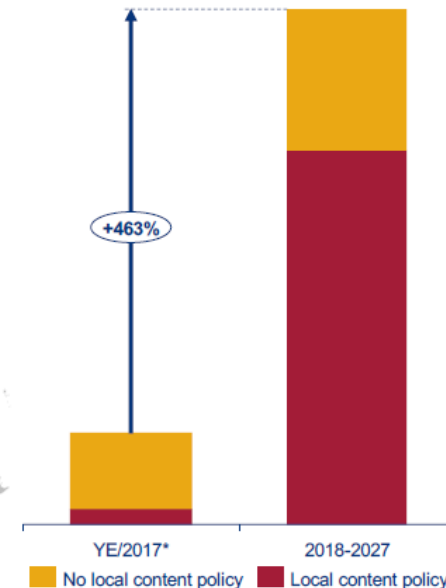
72% of future offshore capacity will be exposed to local content policies

While local content is achievable through existing infrastructure, the industry must establish a durable and capable supply chain that can be an outlet for the technological innovations and cost-out gains from Europe.

Local content requirements for offshore in established and emerging markets



Outlook by local content requirements



Note: *YE/2017 refers to cumulative capacity grid-connected by the end of 2017. US local content policies are state-level, not national. Not two local content policies are identical, and its implications will therefore vary accordingly.



**MINISTRY OF FOREIGN AFFAIRS
OF DENMARK**
Invest in Denmark

DENMARK



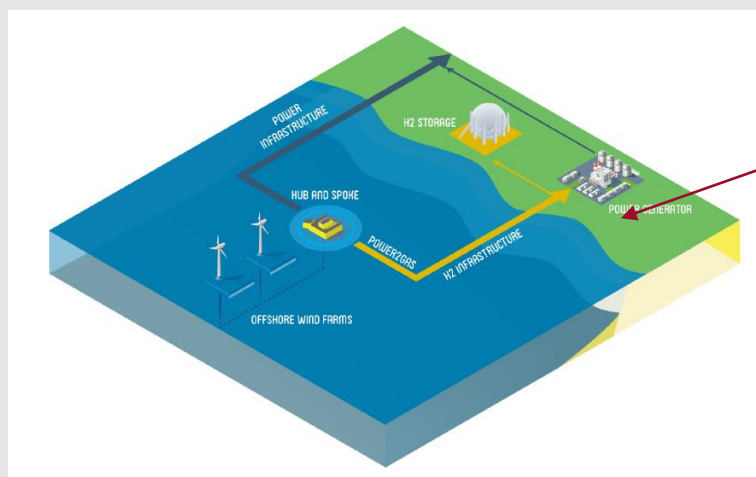
WHY DENMARK?

- Denmark is **the global centre for wind turbine business and technology development** – onshore and offshore
- Favorable **framework conditions** with supportive and stable political climate
- **Growing market** with many business opportunities in Europe and Denmark
- Access to the entire **wind energy supply chain**
- **Excellent facilities for R&D** and testing
- **Large talent base** due to 40 years of experience

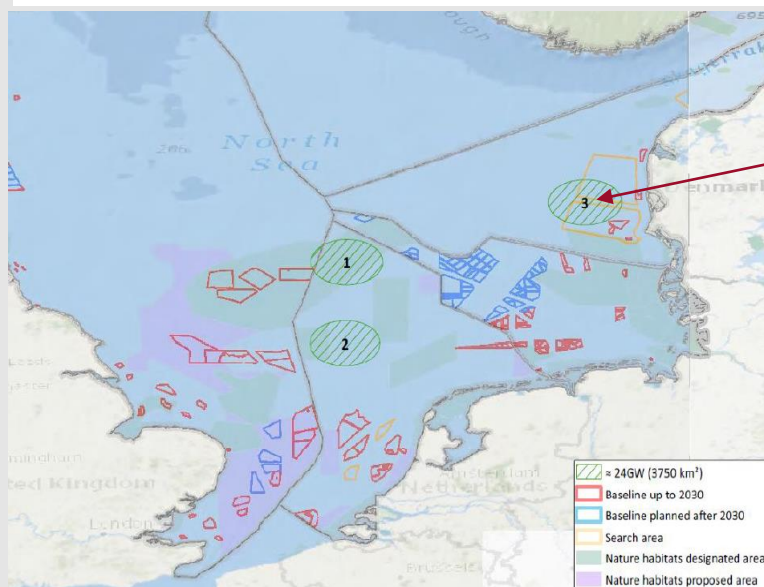


NORTH SEA POTENTIAL

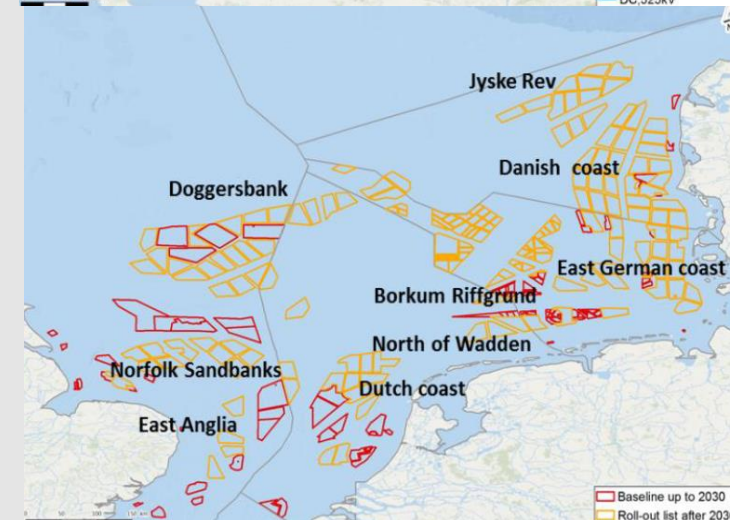
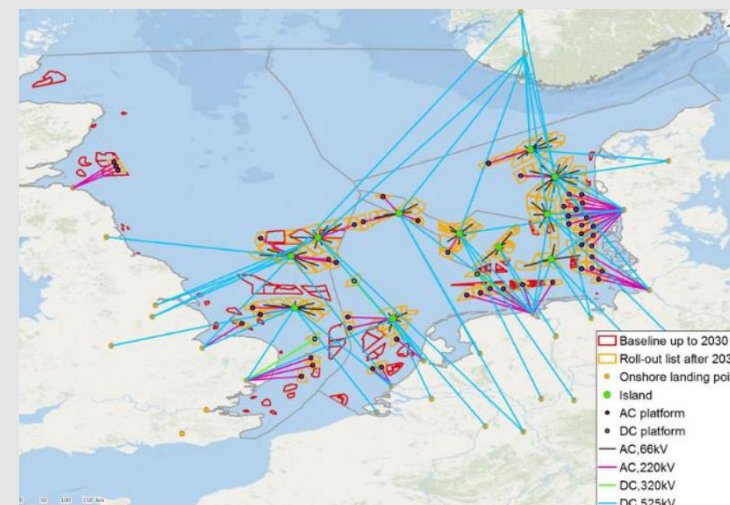
– 70 TO 150 GW CAPACITY BY 2040



Power Hub Island



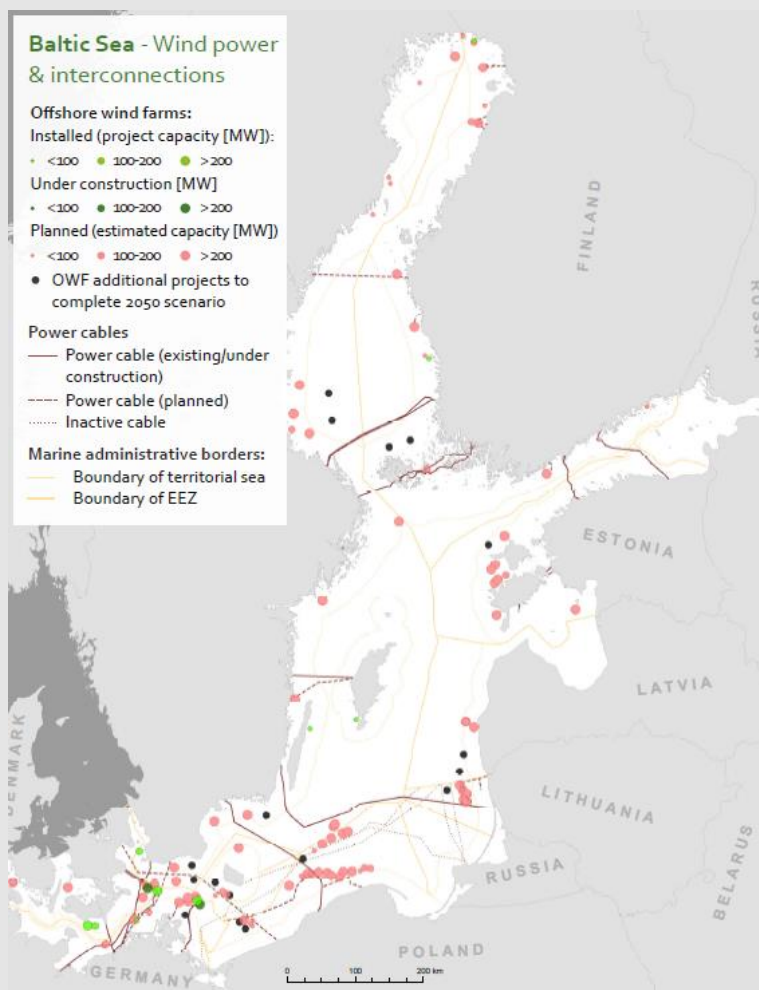
Very Large potential in Danish Part



Source: Energinet and Northseawindpowerhub.eu

BALTIC SEA POTENTIAL

– 9.5 GW CAPACITY BY 2030 AND 35GW BY 2050



Country	BIG 2030 Upside	Additional 2030 2045	Further before 2050	
Denmark	1,696	648	2,000	4,344
Germany	3,305	204	1,000	4,509
Sweden	472	6,048	4,500	11,020
Finland	616	0	1,500	2,116
Poland	2,232	3,076	2,000	7,308
Estonia	900	0	1,000	1,900
Lithuania	300	1,548	500	2,348
Latvia	0	0	1,500	1,500
Total	9,521	11,524	14,000	35,045

Source: Baltic InteGrid, BVG



NEW ENERGY AGREEMENT

- Energy Agreement reached in June 2018 by all parties in the Parliament
- Commitment to net zero emissions in society by 2050 at the latest
- The effect will be 100% RE in electricity by 2030 equal to 80% wind power
- The agreement includes initiatives on RE deployment, system integration, R&D, EVs etc.





MINISTRY OF FOREIGN AFFAIRS
OF DENMARK
Invest in Denmark

7 OUT OF TOP 10 TURBINE OEM'S HAVE PRESENCE IN DENMARK TOP GLOBAL OFFSHORE DEVELOPERS PRESENT

Vestas

SIEMENS Gamesa
RENEWABLE ENERGY

GOLDWIND

GE Renewable Energy

MHI VESTAS OFFSHORE WIND

Envision

SUZLON

NORDEX
We've got the power.

MINGYANG WIND POWER
明阳风电
地蕴天成·能动无限

上海电气
SHANGHAI ELECTRIC

Ørsted

VATTENFALL

CIP
COPENHAGEN INFRASTRUCTURE PARTNERS

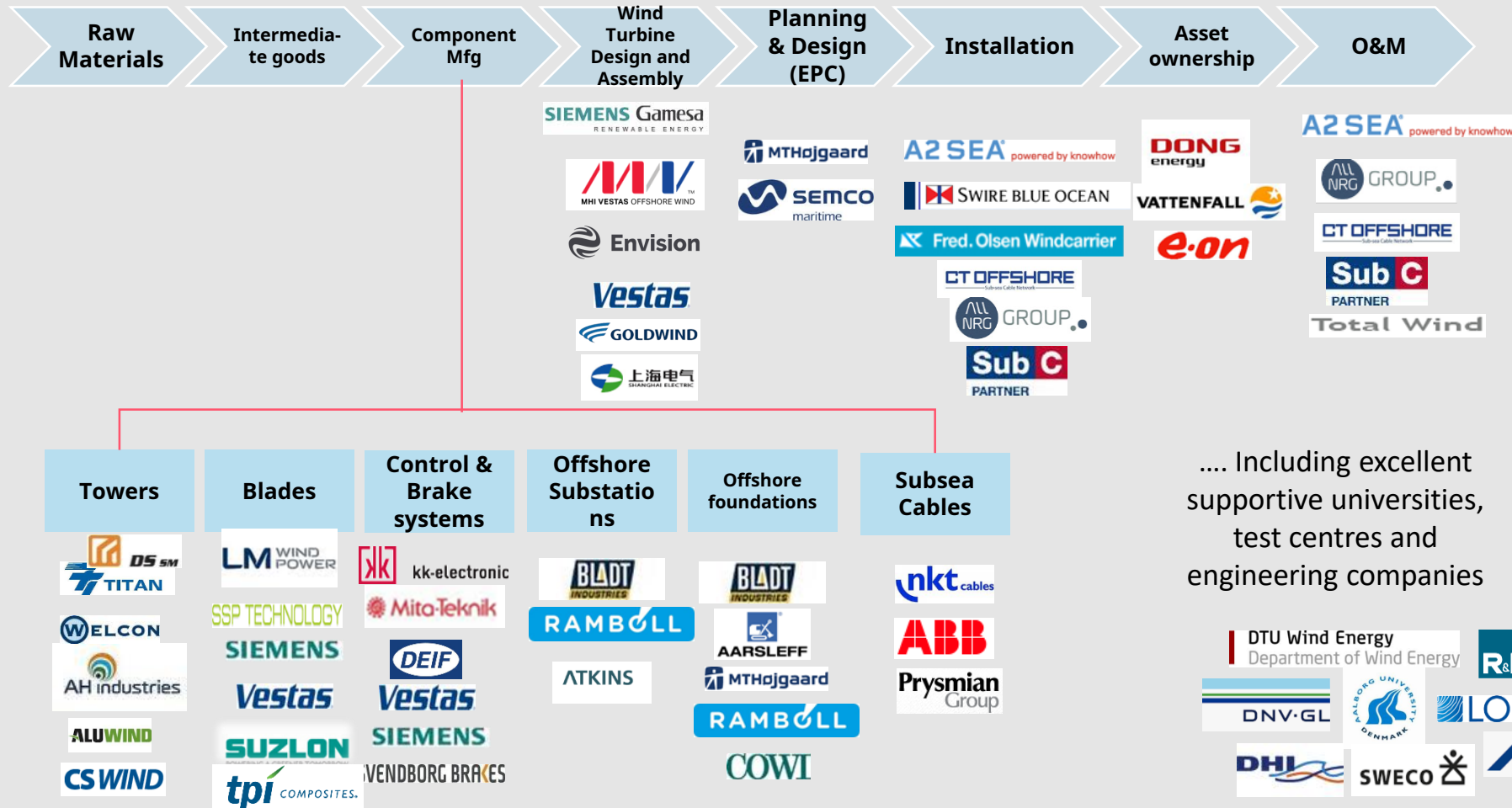
e-on

EUROPEAN ENERGY

HOFOR



OVERVIEW OF THE DANISH OFFSHORE WIND POWER INDUSTRY





OFFSHORE WIND PARKS IN DENMARK

Danish Offshore Windparks	Year in operation	MW	Number of turbines	Turbines	Owner (present)
Vindeby	1991	5	11	Bonus 0.45	Decommissioned by Ørsted in 2017
Tunø Knob	1995	5	10	Vestas V39 0.5	Ørsted
Middelgrunden	2000	40	20	Bonus 2	Middelgrunden & HOFOR (in 2018)
Horns Rev I	2002	160	80	Vestas V80 2	Vattenfall (60%) & Ørsted (40%)
Rønland I	2003	17	8	Vestas V80 2 & Bonus 2.3	Local Owners
Nysted	2003	165	72	Bonus 2.3	Pension DK (50%) Ørsted (42.75%) Stadtwerke Lübeck 7.25%
Samsø	2003	23	10	Bonus 2.3	Samsø Hawind acquired by Wind Estate in 2018
Frederikshavn	2003	7	3	Vestas V90 3 Bonus 2.3 Nordex 2.3	Ørsted
Horns Rev II	2009	209	91	Siemens 2.3	Ørsted
Avedøre Holme	2009/2010	11	3	Siemens 3.6	Ørsted
Sprogø	2009	21	7	Vestas V90 3	Acquired by European Energy in 2017
Rødsand II	2010	207	90	Siemens 2.3	EON (20%) SEAS NVE (80%)
Anholt	2013	400	111	Siemens 3.6	Ørsted (50%) PKA (20%) PensionDK (30%)
Nissum Bredning	2018	28	4	Siemens 7.0 154 DD	Nissum Bredning Vindmøllelaug (55%) and Jysk Energi (45%)
Horns Rev 3	2019	406	49	MHIVestas V164 8.3	Vattenfall

- Long history and experience
- First OWP is decommissioned
- Total Offshore Wind Capacity is 1,699 MW
- Major Owners are Ørsted and Vattenfall



OFFSHORE WIND PROJECTS

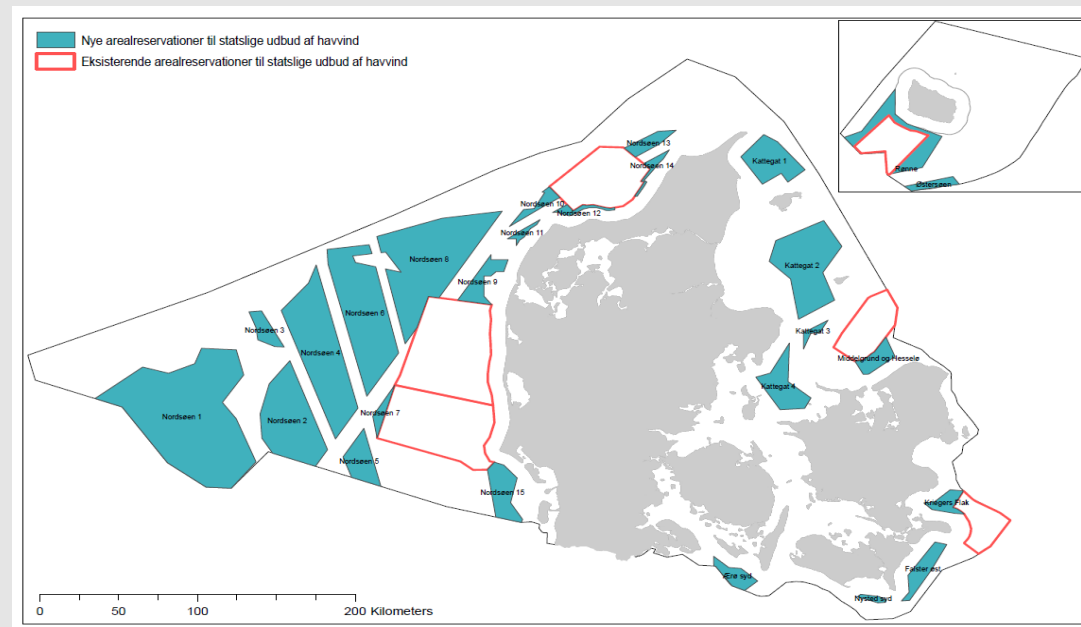
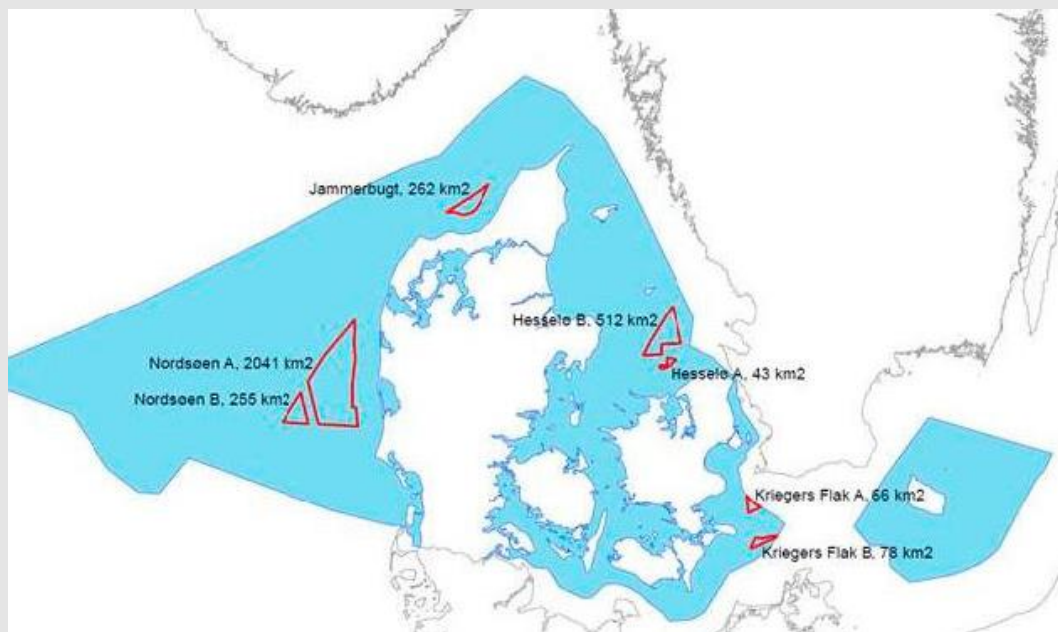
Offshore Wind Projects		Installation Year	MW	Number of turbines	Turbines	Developer	Comments
Kriegers Flak	■	2020 - 2021	604,8	72	SWT 8.4 167	Vattenfall	tender won in 2016
Vesterhavn Nord	■	2022?	180	21	SWT 8.4 167?	Vattenfall	tender won in 2016
Vesterhav Syd	■	2022?	170	20	SWT 8.4 167?	Vattenfall	tender won in 2016
Omø Syd	■	-	200-320	< 80	-	European Energy	open door
Jammerland Bugt	■	2024	240	34 - 60	3-7 MW	European Energy	open door
Frederikshavn	■	-	< 50	5	-	European Energy	pre- open door
Mejl Flak	■	-	60 - 120	20	-	European Energy	open door
Lillebælt	■	-	100 - 160	20 - 44	-	Sønderborg Forsyning	open door
Nordre Flint	■	-	160			HOFOR	Open door – EIA end of 2020
Aflandshage	■	-	250			HOFOR	Open door – EIA end of 2020
THOR	■	2024	800-1000		+ 10MW		Tender in 2019
2018 Energy Agreement Tender II	■	2026?	800				Tender in 2021
2018 Energy Agreement Tender III	■	2029?	800				Tender in 2023

- 955 MW are under preparation
- 2,400 MW are part of the 2018 Energy Agreement
- Approximately 860 MW are open door projects in investigation phase

- Projects on-going
- Open door projects under investigation
- 2018 Energy Agreement coming tenders



FUTURE OFFSHORE WIND POSSIBILITIES IN DENMARK





MINISTRY OF FOREIGN AFFAIRS
OF DENMARK
Invest in Denmark

WORLD CLASS R&D INSTITUTIONS SUPPORT AND DRIVE TECHNOLOGY DEVELOPMENT



Sweden

Germany



MINISTRY OF FOREIGN AFFAIRS
OF DENMARK
Invest in Denmark

R&D – TECHNOLOGY DEVELOPMENT

EXAMPLES OF PROJECTS FUNDED BY THE DANISH ADVANCED TECHNOLOGY FOUNDATION, NOW PART OF THE INNOVATION FUND DENMARK



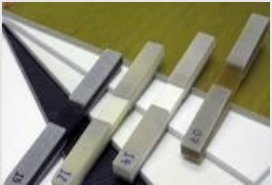
Off-shore turbines at deeper water

Vestas, LORC, MTH, DNV,
Bladt Risø, Aalborg University
Total budget: Over Euro 10m



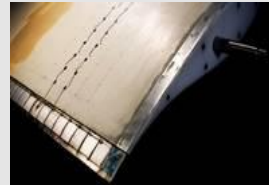
New yaw systems

Svendborg Brakes, DTU Mekanik,
Kirkholm Mekanik
Total budget: Approx. Euro 8m



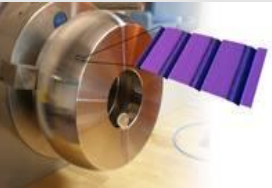
Blade King

LM, Comfill, Risø, Aalborg University
Total Budget: Over Euro 8m



Blades with active flaps

Vestas, Risø, DTU Mekanik
Total budget: Euro 4m



Multi-functional surfaces

Vestas, Strecon, Image
meterology
DTU Mekanik
Total budget: Approx. Euro 2m



Storage, control and power output

Vestas, Aalborg University,
Skovgaard Invest
Total budget: Approx. Euro 8m



Built-in laser-based wind scanners

LM, NKT Photonics, Risø
Total Budget: Over Euro 3m



STRONG TALENT BASE



- Around 30,000 people work in the wind industry in Denmark
- A large number of experienced engineers, due to more than 40 years of experience in wind power and more than 20 years in offshore wind.
- Specialized curriculums at schools and universities in Denmark secures a stable flow of new talents.
 - DTU Wind DTU offers a complete two-year MSc programme in Wind Energy
http://www.dtu.dk/english/Education/msc/Programmes/wind_energy
 - Aalborg University has a MSc specialisation in Wind Power System (WPS) focuses on the electrical aspects of wind power systems www.en.aau.dk/education/master/energy-engineering/specialisations/wind-power-systems
 - Aarhus University School of Engineering conducts a summer school in Wind Power
<http://ase.au.dk/en/education/summer-schools/wind-power-summer-school/>



EXPANSION OF PROTOTYPE FACILITIES IN ØSTERILD AND HØVSØRE

Østerild - National Testcenter for large wind turbines

Denmark's National prototype test sites for offshore turbines up to 250 metres height. 7 test stands. Siemens, Vestas, Envision Energy, EDF/GE.

Expansion of test centre with 2 test stand put forward by government in January 2017. Height up to 330 metres at centre test stands. EIA in 2017. In operation in 2019

Høvsøre - Teststation for large wind turbines

National Test site for turbines up to 165 metres tip height. 5 test stands. Vestas, Siemens, Nordex/Acciona.

Expansion of test site with 2 test stands. Proposed by Government in January 2017. Height up to 200 metres at Centre test stands. EIA in 2017. In operation in 2019





OTHER TEST FACILITY INVESTMENTS

DTU Wind Tunnel

Denmarks National Wind tunnel 86 mio. DKK investment, Finalised in May 2017. Up to 105 m/s in windspeed.
Combined measurement of aerodynamics and noise.



LORC

LORC tests and demonstrates technology for harvesting renewable energy offshore. The Lindoe Nacelle Testing offers Functional tests and Highly Accelerated Lifetime Testing (HALT). Expansion with additional capacity on the way.





MINISTRY OF FOREIGN AFFAIRS
OF DENMARK
Invest in Denmark


COMPANIES TESTING IN FULL SCALE

Vestas

SIEMENS Gamesa
RENEWABLE ENERGY

 **Envision**


MHI VESTAS OFFSHORE WIND

 GE Renewable Energy

 **NORDEX**

 **EDF**
energies nouvelles



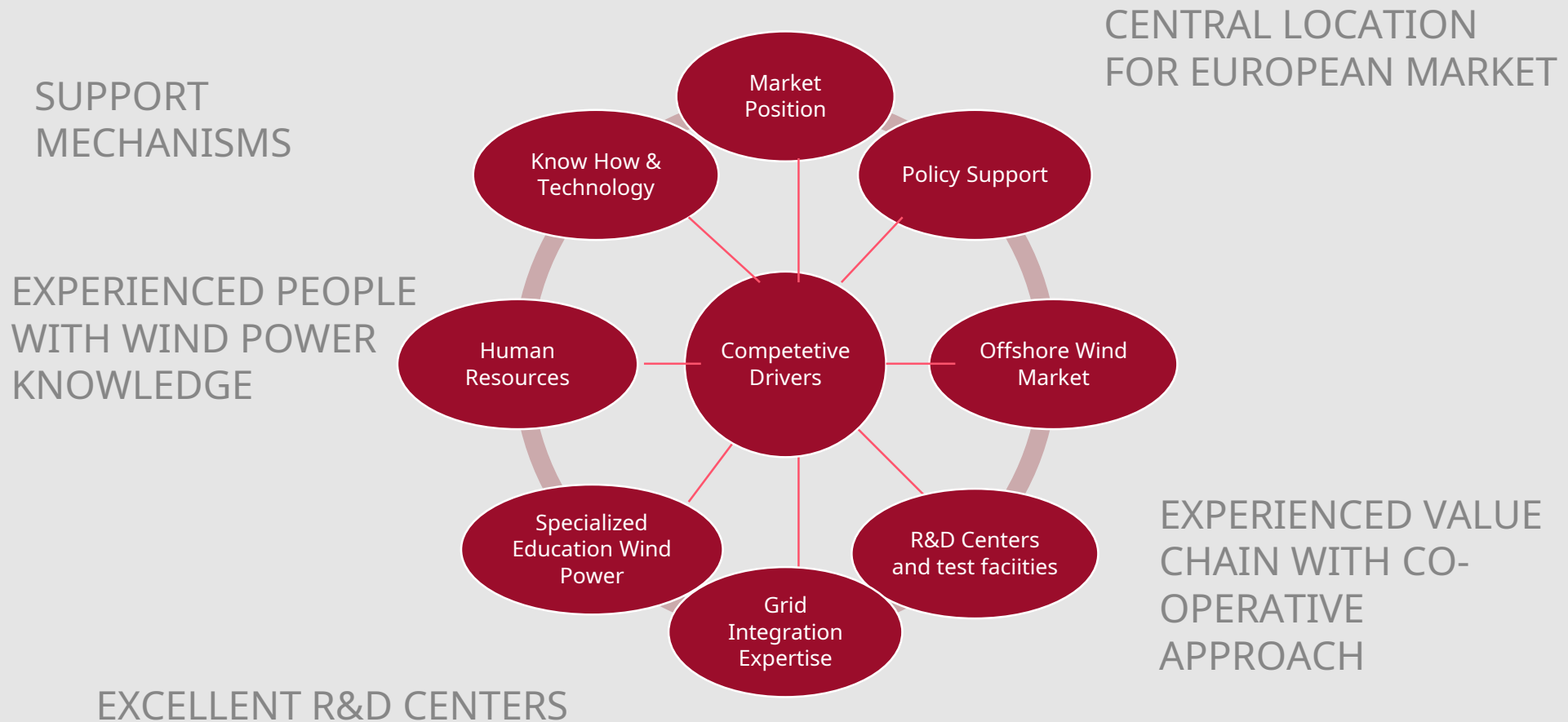


BUSINESS OPPORTUNITIES IN THE DANISH WIND INDUSTRY

- Using Denmark as **a platform for market entrance** to Northern Europe
- Using Denmark as **a hub for technology development** by tapping into the expertise
- **Leveraging existing expertise** by working closely together with Danish companies
- Gaining supremacy in the development of automation within **component manufacturing and smart grid solutions**



THE DANISH WIND POWER VALUE CHAIN REPRESENTS AN ATTRACTIVE CLUSTER FOR ENTRY TO THE EUROPEAN OFFSHORE MARKET



WIND EUROPE AND WIND DENMARK WILL DURING OFFSHORE WIND IN COPENHAGEN ORGANIZE EVENT FOR ASIA STAKEHOLDERS

- Global intergovernmental workshop
- High level investor / policy conference
- Emerging market overviews & partnership Sessions
- One-day fact finding mission to Esbjerg
- Middelgrunden offshore wind farm visit





**MINISTRY OF FOREIGN AFFAIRS
OF DENMARK**
Invest in Denmark

THANK YOU

Peder Bo Sørensen
pedsor@um.dk
www.investindk.com

