Q B I S

Socioeconomic impacts of offshore wind

Executive presentation
Final draft

July 1st, 2020

Study background and objective

In 2018, Denmark signed a new energy agreement for three new offshore wind farms with a total capacity of at least 2.4 GW corresponding to all Danish households' total electricity consumption. In addition, in June of 2020, the Danish Government announced a new ambition to establish two energy islands in Denmark contributing with at least 5 GW offshore wind by 2030 as well as to advance the establishment of 1 GW offshore wind farm at Hesselo.

While the role of offshore wind in climate change mitigation and energy security is well understood, there has been less efforts to study the socio-economic impacts from the expansion of offshore wind in terms of economic value-added and jobs, particularly locally. As governments like the Danish are planning substantial expansions of offshore wind over the coming decade, they increasingly want to know what costs and benefits to expect from such investments.

The objective of this study is to help answer this question. First, through establishment of a full-scale cradle-to-grave model of a modern offshore wind farm in Europe, the study provides a reference model for estimating the socio-economic impacts of 1 GW offshore wind farm. Using Denmark as the example, the study lays out the detailed investment costs and the likely distribution of economic value-added and jobs, both in Denmark and abroad. Secondly, by taking an ethnographic approach, the study explores how offshore wind investments resonate through local port communities and supply chains involved in the installation and O&M of an offshore wind. Here the study focuses on four Danish ports which have been - or will be - instrumental in installing and servicing Denmark's largest offshore wind farms.

The study is financed by the Danish Maritime Fund. Danish Shipping, Wind Denmark, Danish Energy, Danish Maritime, Orsted, Vattenfall, Siemens Gamesa, MHI Vestas and the ports of Esbjerg and Ronne have been on the steering committee, while the study has been conducted by QBIS.

Executive summary 1:2

The offshore wind industry has been characterised by significant productivity improvements that have increased the economic return measured as megawatt (MW) per Euro invested, but also reduced the labour needed per MW. The study assesses that labour measured as Full Time Equivalents (FTEs) per MW has been reduced from nearly 19.0 FTEs per MW installed in 2010 to around 7.5 FTEs per MW installed in 2022.

When seen in isolation, productivity improvements such as these could result in reduced employment in the offshore wind industry. But the offshore wind industry has expanded heavily in the last ten years, from just under 1.0 GW to almost 25 GW, and in the next twenty, it is expected to further increase its capacity 15-fold. This has resulted in a cumulative increase in employment and economic returns from offshore wind at the same time. A win-win situation.

Case in point: In 2010, total offshore wind capacity in Europe was less than 1 GW. With nearly 19 FTEs per MW installed, the associated labour was around 19,000 FTEs. In 2019, total offshore wind capacity was nearly 23 GW and with an assessed around 10 FTEs per MW installed, the associated labour input was around 230.000 FTEs. Over the next 20 years, capacity is expected to increase 15-fold. This means that labour can increase up to 3.5 million FTEs if labour input equals 7.5 FTEs per MW as assessed for 2022.

Denmark was the first country to invest in offshore wind and through consistent Danish commitment and investments combined with skilled Danish businesses, the Danish offshore wind industry today has an assessed 40% market share of the European offshore market and the most complete supply chain in the world making Denmark a one-stop-shop for global offshore wind. This means that Danish offshore wind companies stand to gain massively from the potential 3.5 million FTEs.

The Danish market share implies that Danish offshore wind companies is assessed to receive an average of around 3.1 FTEs of each MW installed and operated in other EU countries than Denmark. Labour input from Danish subcontractors adds another 3.2 FTEs per MW, while labour input from spending of wages and salaries on food, housing, transportation, etc. adds yet another 2.8 FTEs per MW. Put differently, for every MW offshore wind farm installed and operated outside of Denmark but within Europe, total Danish labour input amounts to 9.1 FTEs per MW.

The continued expansion of Danish wind farms matters to the domestic offshore wind sector as well. When an offshore wind farm is installed and operated in Denmark, the Danish labour return is higher. Around 4.9 FTEs per MW are generated directly within the Danish offshore companies compared to 3.1 FTEs for offshore wind farms in other EU countries than Denmark. Adding labour inputs from subcontractors and spending of wages and salaries means that the labour input on a Danish offshore wind farm amounts to a total 14.6 FTEs, i.e. 60% more FTEs per MW compared to offshore wind farms installed and operated in Europe.

Offshore wind farms installed and operated in Denmark also have other important benefits. One example is within the installation and operation & maintenance (O&M) stages of an offshore wind farm, which involves extensive labour inputs and several localized opportunities, including for domestic installation and O&M ports. This is critical from a socioeconomic perspective as offshore wind ports are often located within coastal communities removed from the host nation's main economic centres. While ports often employ few people directly, they are an important part of the municipal economy, generating substantial economic activity and local jobs in the hinterland.

The model assesses that a 1 GW Danish offshore wind farm will generate around EUR 5 million (one-off) to the installation port, while an O&M port is assessed to receive around EUR 0.5 million EUR per year, which is equivalent to EUR 12.5 million over the anticipated 25-year lifetime of an offshore wind farm.

In addition, the appointment of a local installation or O&M port also creates opportunities for local suppliers and workers within the port region itself, ranging from local shipyards, steel manufacturers and electricians to local restaurants, hotels and catering companies. Depending on the share of the total work gained by these local suppliers, the study assesses that a 1 GW Danish offshore wind farm may generate a total of between EUR 11-28 million in turnover and between 30-96 FTEs to the local installation port and suppliers combined. An O&M contract is assessed to generate between EUR 3.2-9.1 million in turnover and between 59-81 FTEs each year over a period of 25 years to the local O&M port and suppliers combined.

Executive summary 2:2

To better understand how offshore wind investments resonate through local port communities beyond the time-bound outputs from a single offshore wind farm investment, the study reviews the experiences of four Danish installation and O&M ports given in terms of Esbjerg, Grenaa, Ronne and Hvide Sande. Based on a combination of interviews and field studies, the study presents a five-staged model for how offshore wind can impact local installation and O&M port communities over time – from preparation and implementation to conversion, internationalization and, ultimately, transformation.

The most notable example of how Danish offshore wind investments can contribute to transforming local port communities over time is the case of Esbjerg. Once Denmark's leading service hub for the oil and gas sector, the Port of Esbjerg has transformed into a global hub for offshore wind over the past two decades. This transformation was kickstarted by Denmark's first large-scale investments in offshore wind farm with Horns Rev 1 in 2001; an investment which launched a year-long port expansion project within the port and resulted in Esbjerg winning a long string of offshore wind projects in the North Sea.

Since 2001, the Port of Esbjerg has been involved in more than 50 European wind farm projects and 55% of accumulated European offshore wind capacity. One of the main spin-offs from the first Danish offshore wind farms in Esbjerg was that it enabled local companies to test and transfer their experiences from oil and gas to a new sector; pursue growth in new markets and diversify their business strategy, also well beyond Denmark's borders. As a result, Esbjerg is now home to around 250 suppliers to the global offshore wind sector such as Semco Maritime, Esvagt, NorSea Denmark, Ocean Team Group, Jutlandia and many more.

Another example highlighted in the study is Grenaa, which was appointed as installation and O&M port for Anholt wind farm. Unlike Esbjerg, Grenaa's experiences from Anholt has not yet converted into a similar transformation of the local economy. This underline both the risks and challenges involved for offshore wind ports, who often must make sizable upfront investments to meet the offshore wind sector's requirements. From the perspective of local port economies, a positive return from offshore wind farms relies heavily on the ability of the port and local suppliers to attract a continuous portfolio of projects. Following the commissioning of Anholt in 2013, the port of Grenaa had to change its strategy to pursue growth in adjacent sectors which could benefit from some of the same facilities, competences and references gained during Anholt.

This has since led to several high-profile projects, which has generated substantial turnover for both the port and local suppliers – projects that according to the port would not have been possible without the experiences from Anholt. As for the local suppliers involved in the installation of Anholt, the exposure to an international customer segment with stringent standards in terms of quality, safety and documentation has been the most important spin-off effect from Anholt.

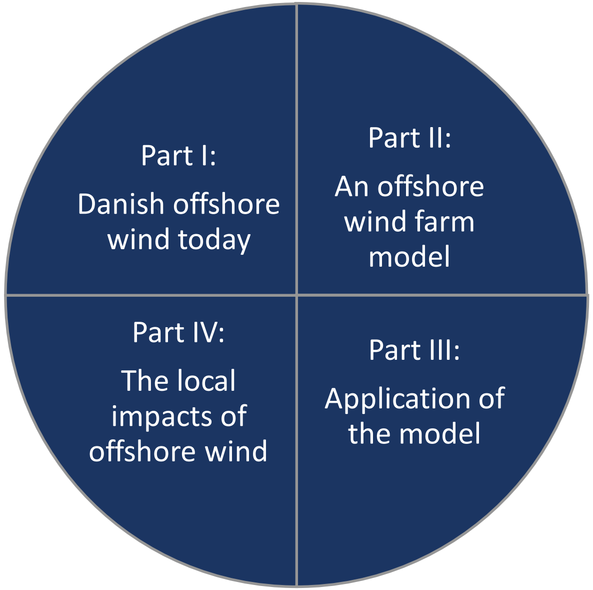
Based on these observations, the study reverts to the initial question: What socio-economic impacts can be expected from Denmark's future offshore wind investments? Applying the model to Thor, it is assessed that the 0.8-1.0 GW planned offshore wind farm can be associated with a direct labour input of around 5,234 FTEs in the capex phase, 1,987 FTEs over the 25-year long opex phase and around 546 FTEs in the decommissioning phase, i.e. a total direct labour input of around 7,768 FTEs. The Danish share of this labour input is assessed to be around 4,127 FTEs. Labour inputs from Danish subcontractors is assessed to add another 4,472 FTEs, while labour input from spending of wages and salaries on food, housing, transportation, etc. adds yet another 3,828 FTEs. In summary, a total Danish labour input of around 12,428 FTEs.

A part of this labour input will go to the installation and O&M ports. If Esbjerg is selected as installation port, the assessed potential varies between EUR 233-379 million in direct, indirect and induced turnover from supplier contracts and around 666-1,084 FTEs in associated direct, indirect and induced labour inputs. If either Thuboron, Thorsminde or Hvide Sande is selected as O&M port, the assessed potential varies between EUR 3.3-9-5 million in direct, indirect and induced turnover and 61-84 FTEs in associated direct, indirect and induced labour input per year over a 25-years period. The high potential corresponds to around EUR 83-237 million and 1,527-2,109 FTEs over the 25-year O&M period.

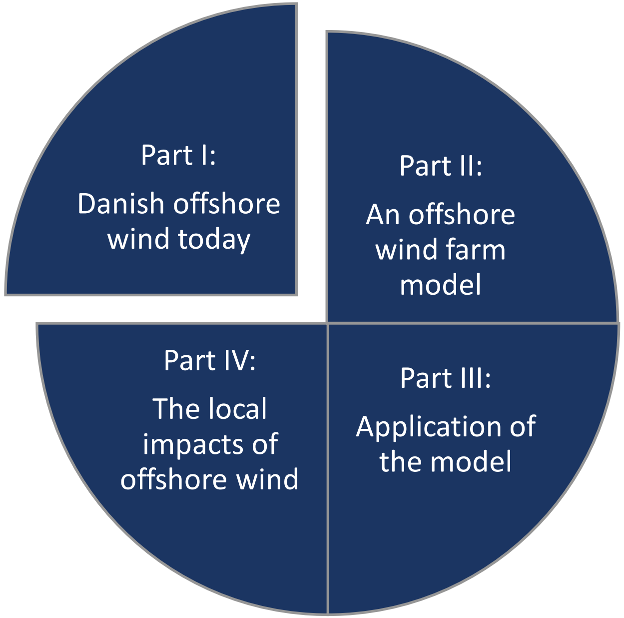
Beyond number of jobs created per MW, Denmark's next generation of offshore wind farms may however also help local ports attract new inwards investments, upskill and internationalize local suppliers and lead to more diversified and resilient port economies. Learnings from the empirical case studies also suggest that this transformation will not happen automatically, rather it requires a proactive effort by both ports and local suppliers. As offshore wind can be both a challenging and risky affair for local ports and suppliers, a long-term vision for offshore wind and clear policy commitments is a conducive factor to success.

The study consists of IV parts

- Part I: Danish offshore wind today
  - Turnover and market share of Danish offshore wind
- Part II: An offshore wind farm model
  - Structure and key results of the model
- Part III: Application of the model
  - The offshore wind model is used to simulate economic impacts of Thor, Kriegers Flak, Horns Rev III, and Bornholm and North Sea energy islands.
- Part IV: The local impacts of wind
  - Cases on how offshore wind resonate through local societies

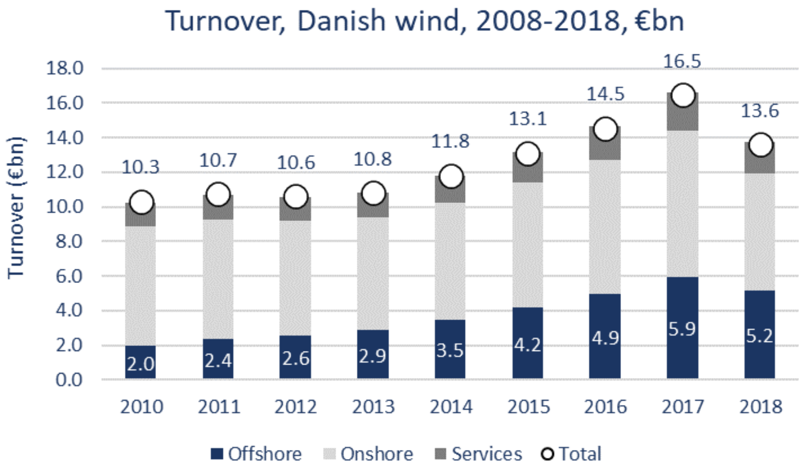


Part I:
Danish offshore wind today



Danish wind is increasingly getting its turnover from offshore wind

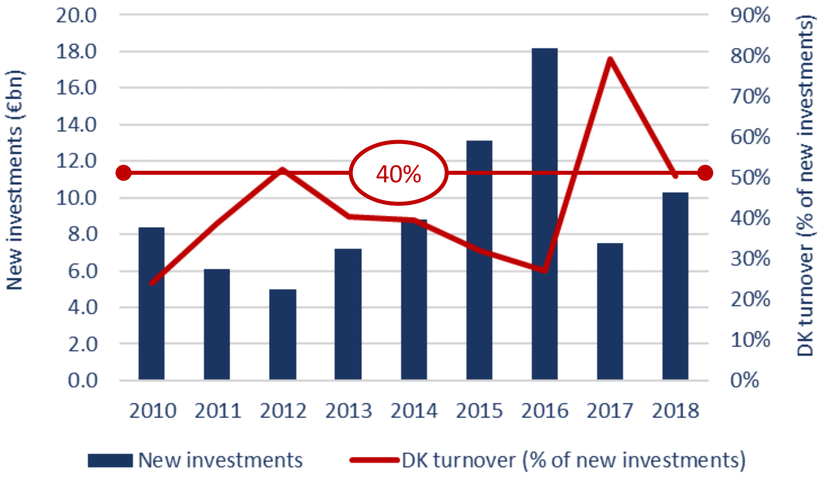
- In April 2020, Wind Denmark asked its members to assess the share of their turnover accruing from offshore, onshore and services in 2020, 2015 and 2010.
- **The results indicate a doubling in the share of turnover from offshore from around 20% in 2010 to around 40% in 2020.**
- Applying the survey results to Wind Denmark's annual industry statistics suggests that turnover from offshore wind has increased from around EUR 2.0 billion in 2010 to around EUR 5.2 billion in 2020 corresponding to an increase of EUR 3.2 billion.
- As total turnover has increased from around EUR 10.3 million in 2010 to EUR 13.6 million corresponding to an increase of around EUR 3.3 billion, this means that offshore wind solely has driven the increase in turnover for Danish wind companies.



Source: Wind Denmark member survey, April 2020, and Wind Denmark (2020b).

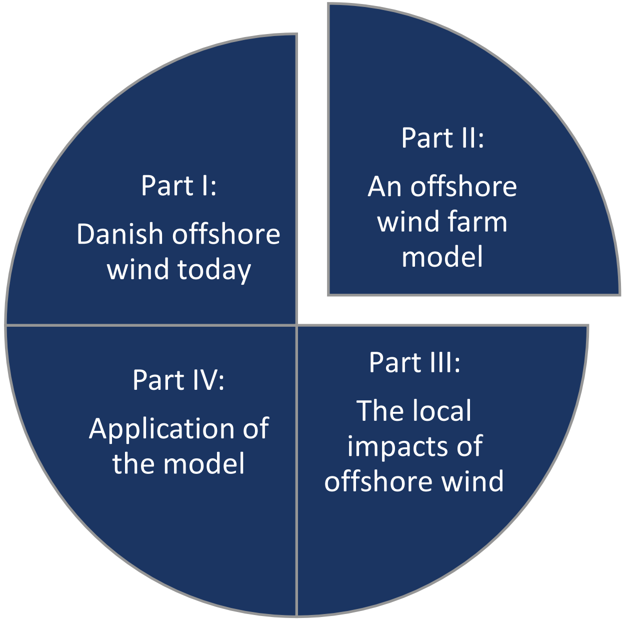
Danish offshore wind turnover assessed to constitute around 40% of the new assets financed in Europe from 2010 to 2018

- According to Wind Europe, European countries spent around 85 €bn on new offshore investments from 2010 to 2018.
- As a rough indicator of Danish market share, it is assessed based on Wind Denmark's member survey (see slide 3) that Danish wind companies' offshore turnover constituted an average of 40% of these investments, cf. figure.
- Market players state that Denmark is considered to have the biggest and most comprehensive offshore wind supply chain in the world and consequently, the key sourcing hub for offshore wind farms. The rough indicator of Danish market share of around 40% support this statement.
- As Denmark's share of total cumulative European installed capacity in 2019 only was around 8%, it follows that Danish offshore wind turnover primarily must come from foreign offshore investments making Danish offshore wind a strong export sector.

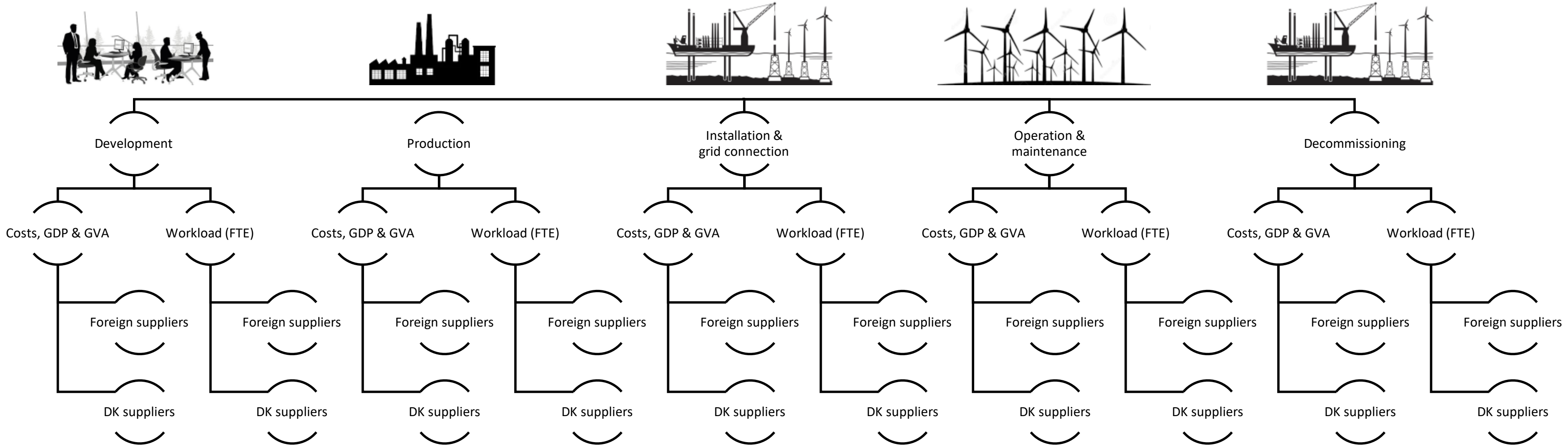


Source: WindEurope (2020a and 2020b) and Wind Denmark member survey, April 2020.

Part II: An offshore wind farm model



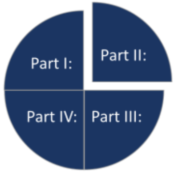
The offshore wind farm model
- for offshore wind farms of 0.8-1.0 GW in Europe



Costs, GDP & GVA: Direct-Indirect-Induced + Location (port and first tier suppliers)

Workload (FTE): Direct-Indirect-Induced + Location (port and first tier suppliers) + Profession + Salary

Note:
FTE: Full-Time Equivalent
GDP: Gross Domestic Product
GVA: Gross Value Added

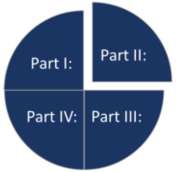


Result 0:

CAPEX + DEPEX = 3.038 million EUR/MW and 3,038 million EUR/GW
OPEX = 0.048 million EUR/MW/year and 1.188 million EUR/GW/25 years

	Phase 1 Development[1] CAPEX			**Phase 2A** Production Wind turbines CAPEX			**Phase 2B** Production Balance of plant CAPEX			**Phase 3** Installation & grid connection CAPEX			**Phase 4** Operation & maintenance OPEX			**Phase 5** Decommissioning[1] DEPEX			Total		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
CAPEX and DEPEX (million EUR/MW)	0.145	0.145	0.145	1.250	1.260	1.270	0.771	0.813	0.855	0.330	0.429	0.523				0.392	0.392	0.392	2.887	3.038	3.184
CAPEX and DEPEX (million EUR/GW)	145	145	145	1,250	1,260	1,270	771	813	855	330	429	523				392	392	392	2,887	3,038	3,184
CAPEX and DEPEX (million DKK/GW)	1,080	1,080	1,080	9,338	9,412	9,486	5,760	6,073	6,387	2,465	3,204	3,906				2,925	2,925	2,925	21,568	22,694	23,784
OPEX (million EUR/MW/year)													0.033	0.048	0.090				0.033	0.048	0.090
OPEX (million EUR/GW/25 years)													819	1,188	2,259				819	1,188	2,259
OPEX (million DKK/GW/25 years)													6,115	8,871	16,875				6,115	8,871	16,875
Time	12-30 months			6 months						6 months			25 years			6-36 months					

Note: 1,000 MW, 10 MW turbines, 30 m water depth, 60 km from shore, project life 25 years and commissioned in 2022.
Sources: QBIS based on Orsted, Vattenfall, Siemens Gamesa, Semco and BVG Associates (2016 and 2019).



Check I

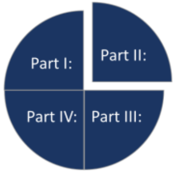
Distribution of costs across phase 1-5 of an offshore wind farm

- The studies by BVG Associates (2016) and BVG Associates (2019) both have significantly higher total costs than this study. EUR 5.40 billion and EUR 5.51 billion versus EUR 4.23 billion. (1)
- The differences stem from "Installation & Grid Connection" and "Operation & Maintenance" and explain the differences in the otherwise relatively even distribution of costs. Among plausible causes could be contractual and productivity differences. The studies by BVG Associates (2016 and 2019) are both mirroring UK and Scottish offshore farms, while this study mirrors European offshore farms. (2)
- Despite the study by BVG Associates (2016) covers 0.5 GW, it has similar total costs as the study by BVG Associates (2019) covering 1.0 GW. It seems unlikely that differences in water depth (45m versus 30m) and commissioning year (2020 versus 2022) can explain this. (3)

	Phase 1 Development	**Phase 2A** Production Wind turbines	**Phase 2B** Production Balance of plant	**Phase 3** Installation & grid connection	**Phase 4** Operation & maintenance (25 years)	**Phase 5** Decommis-sioning	**Total**
	CAPEX	CAPEX	CAPEX	CAPEX	OPEX (2)	DEPEX	
BVG Associates (2016) (%)	3%	25%	17%	11%	40%	4%	100%
BVG Associates (2019) (%)	3%	22%	13%	14%	41%	7%	100%
QBIS (%)	3%	30%	19%	10%	28%	9%	100%
							(1)
BVG Associates (2016) (billion EUR)	0.16	1.35	0.92	0.59	2.16	0.22	5.40
BVG Associates (2019) (billion EUR)	0.14	1.20	0.72	0.78	2.26	0.40	5.51
QBIS (billion EUR)	0.14	1.26	0.81	0.43	1.19	0.39	4.23

Note: (3)
- BVG (2016): 500 MW, 8 MW turbines, 45 m water depth, 40 km from shore, 25 years project life and commissioned in 2020.
- BVG (2019): 1,000 MW, 10 MW turbines, 30 m water depth, 60 km from shore, 25 years project life and commissioned in 2022.
- QBIS: 1,000 MW, 10 MW turbines, 30 m water depth, 60 km from shore, 25 years project life and commissioned in 2022.

Sources: QBIS based on Orsted, Vattenfall, Siemens Gamesa, Semco and BVG Associates (2016 and 2019).

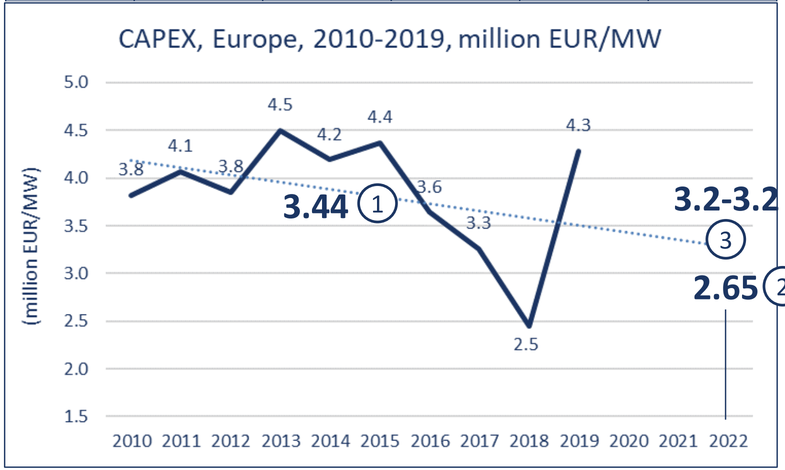


Check II

Comparison of CAPEX with other offshore wind farms in Europe

- According to WindEurope, from 2010 to 2019, 24.6 GW of new offshore wind capacity was installed in Europe at a total cost of EUR 84.6 billion and corresponding to an average capex of **3.44** million EUR per MW. Approximately 81% of this new capacity was installed in the UK and Germany. (1)
- In comparison, this study estimates an average capex of around **2.65** million EUR per MW. (2)
- However, despite significant variation, the trend in the unit costs of new installed capacity is downward, cf. dotted trendline in figure, and in this study's commissioning year of 2022, the trendline is not so far to the unit cost of this study. (3)
- Excluding the 2019 new offshore wind farms means with a capex of 4.3 million EUR per MW means that the trendline becomes more or less equal to the 2.65 million EUR per MW in 2022 assessed by the model.

Phase 1 Development	**Phase 2A** Production Wind turbines	**Phase 2B** Production Balance of plant	**Phase 3** Installation & grid connection		**Phase 5** Decommis-sioning



Source: WindEurope (2020a and 2020b) and QBIS based on Orsted, Vattenfall, Siemens Gamesa, Semco and BVG Associates (2016 and 2019).

Check III

Comparison of CAPEX and OPEX with Danish Energy Agency’s Technology Catalogue

- CAPEX: Danish Energy Agency (DEA) estimates CAPEX of **2.130** million EUR/MW in 2020 for phase 2 (production) and 3 (installation and grid connection), while this study’s corresponding estimate is **2.502** million EUR/MW. The difference should be understood in the light of DEA’s estimate targeting Danish offshore wind farms with relatively lower costs due to the framework conditions and favourable Danish offshore wind sites, while this study’s estimate targets an average European offshore wind farm. (1)
- CAPEX: A striking feature are the differences in cost estimates between phase 2 and 3. A part of the explanation is DEA using different phase definitions than this study, but also its estimates of turbines are considerable lower than this study. We are in dialogue with DEA about the differences. (2)
- OPEX: DEA’s estimate of 0.055 million EUR/MW is primarily based on interview with Vattenfall. This study’s estimate predicts a slightly lower OPEX of 0.048 million EUR/MW due to expected productivity and efficiency improvements in the coming years. (3)

(million EUR/MW)	**Phase 1** Development CAPEX	**Phase 2A** Production Wind turbines CAPEX	**Phase 2B** Production Balance of plant CAPEX	**Phase 3** Installation & grid connection CAPEX	**Phase 4** Operation & maintenance OPEX	**Phase 5** Decommis-sioning DEPEX	**Total** ∑
CAPEX and DEPEX							
QBIS	0.145	1.260	0.813	0.429		0.392	3.038
QBIS		1.260	0.813	0.429 (2)			2.502 (1)
Danish Energy Agency		0.790		1.340			2.130
OPEX							
QBIS					0.048 (3)		0.048
Danish Energy Agency					0.055		0.055

Sources: DEA (2020) and QBIS based on Orsted, Vattenfall, Siemens Gamesa, Semco and BVG Associates (2016 and 2019).

Results I: Lifetime costs, GDP and supplier contracts

- **Lifetime costs** are assessed to around DKK 31.6 billion for 1GW. (1)
- **GDP** is assessed to around DKK 9.8 billion (31% of lifetime costs) for EU offshore wind and around DKK 20.3 billion (64% of lifetime costs) for DK offshore wind. (2)
- **Supplier contracts** is assessed to DKK 29.6 billion for both EU and DK offshore wind. (3)
- **DK supplier contracts** are assessed to around DKK 10.3 billion (35% of investment costs) for EU offshore wind and around DKK 16.8 billion (57%) for DK offshore wind. (4)

(million DKK per GW)	**Phase 1** Development CAPEX	**Phase 2A** Production Wind turbines CAPEX	**Phase 2B** Production Balance of plant CAPEX	**Phase 3** Installation & grid connection CAPEX	**Phase 4** Operation & maintenance (25 years) OPEX	**Phase 5** Decommis-sioning DEPEX	**Total**	
Lifetime costs								
- CAPEX, DEPEX and OPEX	1,080	9,412	6,073	3,204	8,871	2,925	31,565	(1)
GDP								
- Wind farm in EU	440	4,802	1,865	235	1,399	1,097	9,837	(2)
- Wind farm in DK	696	5,738	3,199	1,020	7,927	1,755	20,335	
Supplier contracts – EU offshore wind								
- All suppliers	1,029	9,412	6,073	3,040	7,374	2,633	29,561	(3)
- DK suppliers – all	336	4,409	1,890	686	2,352	658	10,331	(4)
Supplier contracts – DK offshore wind								
- All suppliers	1,029	9,412	6,073	3,040	7,374	2,633	29,561	(3)
- DK suppliers	591	5,267	2,896	695	5,987	1,316	16,753	(4)

Source: QBIS based on Statistics Denmark, Orsted, Vattenfall, Siemens Gamesa, Semco, BVG Associates (2016 and 2019), WindEurope (2020a and 2020b) and member survey data from Wind Denmark.

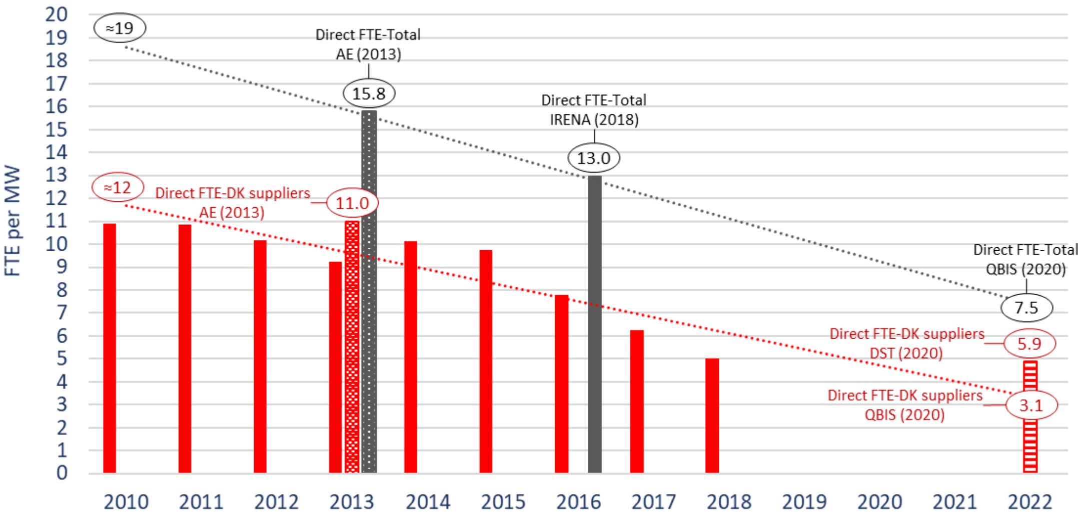
Result II: Labour needed for 1GW 1:2

(Full Time Equivalents)

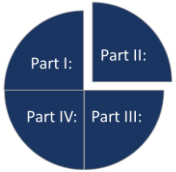
- The offshore wind industry has been characterised by significant productivity improvements that have increased the economic return measured as megawatt (MW) per Euro invested, but also reduced the labour needed per MW. The study assesses that labour measured as Full Time Equivalents (FTEs) per MW has been reduced from nearly 19.0 FTEs per MW in 2010 to around 7.5 FTEs per MW in 2022, see figure.

- In isolation, this would have reduced employment in the offshore wind industry. But the offshore wind industry has expanded heavily in the last ten years, from just under 1.0 GW to almost 25 GW, and in the next twenty, it is expected to further increase its capacity 15-fold. This means that both employment and economic return of offshore wind increase at the same time. A win-win situation.

- Case in point: In 2010, total offshore wind capacity in Europe was less than 1 GW. With nearly 19 FTEs per MW installed, the associated labour was around 19,000 FTEs. In 2019, total offshore wind capacity was nearly 23 GW and with an assessed around 10 FTEs per MW installed, the associated labour input was around 230.000 FTEs. Over the next 20 years, capacity is expected to increase 15-fold. This means that labour can increase up to 3.5 million FTEs based on 7.5 FTEs required per MW in 2022.



Source: QBIS based on AE (2013), IRENA (2018b), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020) and Wind Denmark (2020).



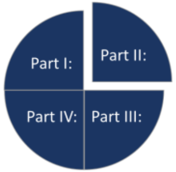
Result II: Labour needed for 1GW 2:2

(Full Time Equivalents)

- **Total direct labour** is assessed to 9,451 FTEs. (1)
- **Suppliers' direct labour** is assessed to between 8,991 FTE corresponding to around 95% of total FTEs. (2)
- **DK suppliers' labour for EU offshore wind** is assessed to 3,133 direct FTEs corresponding to around 35% of total FTEs. In addition, DK suppliers can generate 3,190 indirect FTEs and 2,767 induced FTEs. I.e. a potential total of 9,090 FTEs. (3)
- **DK suppliers' labour for DK offshore wind** is assessed to 4,923 direct FTEs corresponding to around 56% of total FTEs. In addition, DK suppliers can generate 5,184 indirect FTEs and 4,451 induced FTEs. I.e. a potential total of 14,558 FTEs. (4)

(Full Time Equivalent-FTE)	**Phase 1** Development CAPEX	**Phase 2A** Production Wind turbines CAPEX	**Phase 2B** Production Balance of plant CAPEX	**Phase 3** Installation & grid connection CAPEX	**Phase 4** Operation & maintenance (25 years) OPEX	**Phase 5** Decommis-sioning DEPEX	**Total**	
Total farm direct labour - EU and DK offshore wind								
Direct	574	2,655	2,820	781	1,907	713	9,451	(1)
Suppliers' direct labour - EU and DK offshore wind								
Direct	547	2,655	2,820	741	1,585	642	8,991	(2)
DK suppliers labour – EU offshore wind (excl. Denmark)								
Direct	178	1,244	878	167	506	160	3,133	(3)
Indirect	99	1,287	680	210	713	202	3,190	
Induced	127	1,208	478	183	595	175	2,767	
Total	404	3,739	2,036	560	1,813	377	9,090	
DK suppliers labour – DK offshore wind								
Direct	314	1,486	1,345	169	1,287	321	4,923	(4)
Indirect	174	1,538	1,042	213	1,814	403	5,184	
Induced	224	1,443	733	185	1,515	351	4,451	
Total	713	4,467	3,119	568	4,616	1,075	14,558	

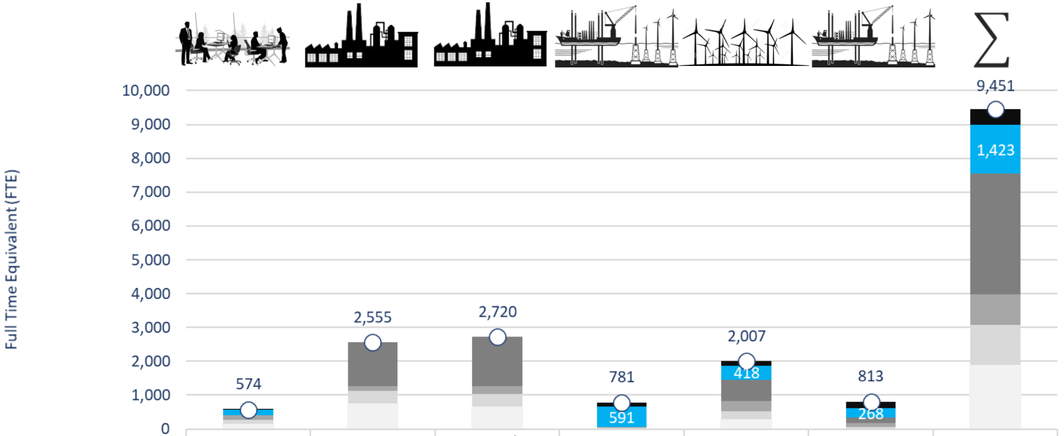
Source: QBIS based on Statistics Denmark, Orsted, Vattenfall, Siemens Gamesa, Semco, BVG Associates (2016 and 2019) and IRENA (2018b).



Result III: Labour according to profession

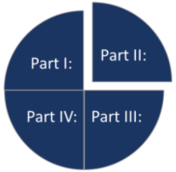
(Full Time Equivalents)

- **Operators** include drilling, crane, cable ploug, trenching ROV and jetting system operators. Operators have a total assessed labour input of around 467 FTEs per GW with highest input intensity in phase 3-5.
- **Ship crews** only includes ship crews. Ship crews have a total assessed labour input of around 1,423 FTEs with highest input intensity in phase 3-5.
- **Workers and technicians** include factory and civil workers and different types of technicians. They have a total assessed labour input of around 3,575 FTEs with highest input intensity in phase 2 and then phase 4-5.
- **Engineers** include electric, telecommunication, computer, material, industrial, mechanical, naval and civil engineers. Engineers have total assessed labour input of 917 FTEs and are required in all five phases of an offshore wind farm, however with relatively highest input intensity in phase 4.
- **Outdoor experts** include logistics, geotechnical, health & quality, safety, environmental, sociological, marine, biology, fishing site security experts. Outdoor experts have a total assessed labour input of around 1,186 FTEs and are like engineers also required in most phases however relatively most during phase 2A and 4.
- **Indoor experts** include administrative, accounting, marketing, taxation, regulation & standardisation and financial experts. Indoor experts have a total assessed labour input of around 1,882 FTEs with highest input intensity in phase 2A and then phase 2B and 4.



	P1 - Development	P2A - Wind turbines	P2B - Balance of plant	P3 - Installation	P4 - O&M	P5 - Decommis-sioning	Total
Operators	12	0	0	126	127	202	467
Ship crews	146	0	0	591	418	268	1,423
Workers + technicians	10	1,293	1,459	2	636	176	3,575
Engineers	136	126	222	30	297	106	917
Outdoor experts	113	379	378	16	239	61	1,186
Indoor experts	157	757	662	16	291	0	1,882
Total	574	2,555	2,720	781	2,007	813	9,451

Source: QBIS based on Statistics Denmark, Orsted, Vattenfall, Siemens Gamesa, Semco, BVG Associates (2016 and 2019) and IRENA (2018b).



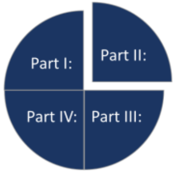
Result IV: Salaries for 1GW

(EUR million)

- **Total salary** is assessed to around EUR 732 million corresponding to around 577.000 DKK per FTI. (1)
- **Suppliers' salary** is assessed to around EUR 701 million. (2)
- **DK suppliers' salary for EU offshore wind** is assessed to EUR 265 million corresponding to around 38% of total supplier salaries. In addition, indirect and induced salaries can potentially add EUR 235 million and EUR 186 million. I.e. a potential total of EUR 686 million. (3)
- **DK suppliers' salary for DK offshore wind** is assessed to EUR 415 million corresponding to around 59% of total supplier salaries. In addition, indirect and induced salaries can potentially add EUR 383 million and EUR 298 million. I.e. a potential total of EUR 1,095 million. (4)

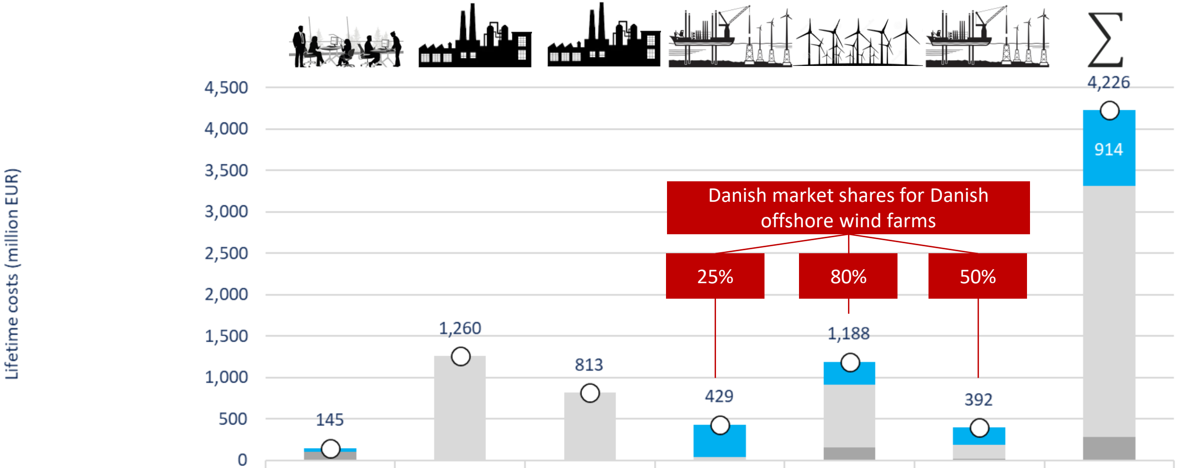
(EUR million)	**Phase 1** Development CAPEX	**Phase 2A** Production Wind turbines CAPEX	**Phase 2B** Production Balance of plant CAPEX	**Phase 3** Installation & grid connection CAPEX	**Phase 4** Operation & maintenance (25 years) OPEX	**Phase 5** Decommis-sioning DEPEX	**Total**	
Total direct salaries - EU and DK offshore wind								
Direct	45	215	228	66	111	66	732	(1)
Suppliers' direct salaries - EU and DK offshore wind								
Direct	43	215	228	63	92	59	701	(2)
DK suppliers' salaries – EU offshore wind (excl. Denmark)								
Direct	14	101	71	22	43	14	265	(3)
Indirect	7	96	48	16	54	15	235	
Induced	8	74	45	11	37	11	186	
Total	29	271	165	49	133	39	686	
DK suppliers' salaries – DK offshore wind								
Direct	25	121	109	23	111	27	415	(4)
Indirect	12	115	74	16	136	30	383	
Induced	14	89	69	11	93	22	298	
Total	50	324	252	50	340	79	1,095	

Source: QBIS based on Statistics Denmark, Orsted, Vattenfall, Siemens Gamesa, Semco, BVG Associates (2016 and 2019) and IRENA (2018b).



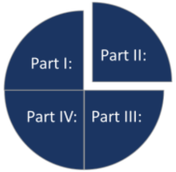
Result V: Lifetime costs according to industry
(million EUR)

- **Maritime suppliers** include shipping companies such as operating installation vessels (e.g. Swire Blue Ocean and Boskalis) and O&M vessels (e.g Esvagt, MH-O&, Acta Marine and Northern Offshore Services). Maritime suppliers are assessed to get around EUR 914 million corresponding to around 23% of total lifetime costs.
- **Windmill suppliers/operators** include MHI Vestas, Siemens Garmesa or other windmill producers/operators as well as all their sub-suppliers. Such suppliers are assessed to get around EUR 3,033 million corresponding to around 70% of total lifetime costs.
- **Developers/consultants** include Orsted, Vattenfall and other developers as well as external consultants assisting with developing a farm. Developers/consultants are assessed to get around EUR 279 million corresponding to around 6% of total lifetime costs.



	P1-Development	P2A - Wind turbines	P2B-Balance of plant	P3-Installation	P4-O&M	P5-Decommissioning	Total
Maritime suppliers	40	0	0	394	277	203	914
Wind mill suppliers/operators	0	1,260	813	33	757	169	3,033
Developers/Consultants	105	0	0	2	154	19	279
Total	145	1,260	813	429	1,188	392	4,226

Source: QBIS based on Statistics Denmark, Orsted, Vattenfall, Siemens Gamesa, Semco, BVG Associates (2016 and 2019) and IRENA (2018b).



Result VI: Local impacts (ports)

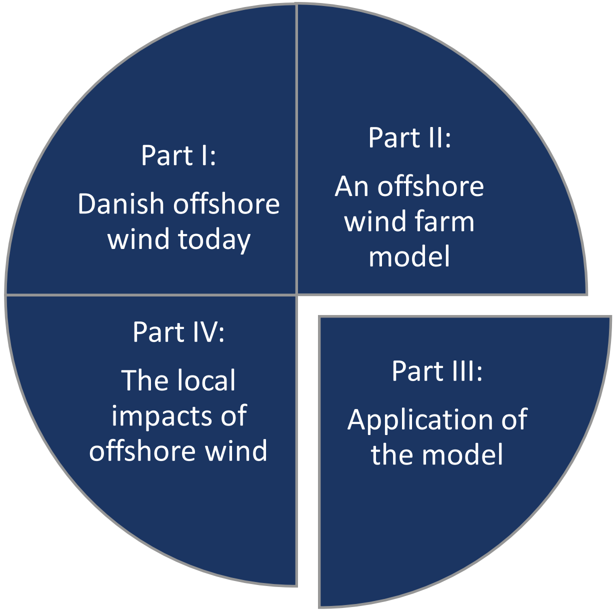
Suppliers, contractors, developers and operators

- **Phase 3-5** are identified as the phases with potential for local work. Except for Esbjerg, this potential is primarily considered feasible, if it is a Danish offshore wind farm.
- **Phase 3** is assessed to generate around EUR 10.6 million and 30 FTEs, if the port is the only contractor to the wind farm. If local businesses are able to get another **5%** of sub-supplier contracts, phase 3 can generate around EUR 28.0 million and 96 FTEs. For Esbjerg, this percentage is expected to be between **35%-57%** and also valid for direct contracts.
- **Phase 4** is assessed to generate around EUR 3.2 million and 59 FTEs, if the port is the only contractor to the wind farm. If local businesses are able to get another **15%** of sub-supplier contracts, phase 4 can generate around EUR 9.1 million and 81 FTEs. Over 25 years, this will generate around EUR 227 million and 2,024 FTEs. As Phase 3, the potential is much higher for Esbjerg.
- **Phase 5** is similar to phase 3 (just reversed) and assessed to generate around EUR 10.7 million and 29 FTEs, if the port is the only contractor to the wind farm. If local businesses are able to get another **5%** of sub-supplier contracts, phase 5 can generate around EUR 25.0 million and 81 FTEs. As Phase 3, the potential is much higher for Esbjerg.

	Phase 3 Installation & grid connection				**Phase 4** Operation & maintenance				**Phase 5** Decommissioning				Total			
	EUR million		FTE		EUR million		FTE		EUR million		FTE		EUR million		FTE	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Other ports	1.2%	5.0%	1.2%	5.0%	1.4%	15%	1.4%	15%	1.4%	5%	1.4%	5%				
Direct	5.0	5.0	9	9	0.5	0.5	46	46	5.0	5.0	8	8	10.5	10.5	63	63
Indirect	3.3	13.7	11	47	0.4	4.0	1	13	3.4	11.9	11	40	7.1	29.5	24	100
Induced	2.3	9.4	10	41	2.3	4.5	11	22	2.3	8.1	9	33	6.9	22.0	31	95
Total per year	10.6	28.0	30	96	3.2	9.1	59	81	10.7	25.0	29	81	24.4	62.1	118	258
Total 25 years	10.6	28.0	30	96	80	227	1,466	2,024	10.7	25.0	29	81	101	280	1,525	2,201
Esbjerg	35%	57%	35%	57%	35%	57%	35%	57%	35%	57%	35%	57%				
Direct	142	232	259	422	16	23	25	36	141	201	226	323	299	455	511	781
Indirect	96	156	326	531	11	15	36	51	95	135	319	455	201	306	681	1,036
Induced	66	107	284	462	7	10	30	43	65	92	266	380	138	209	580	884
Total per year	304	495	869	1,415	34	48	91	130	301	428	812	1,157	638	971	1,772	2,702
Total 25 years	304	495	869	1,415	842	1200	2,274	3,241	301	428	812	1,157	1,447	2,123	3,955	5,813

Source: QBIS based on Statistics Denmark, Orsted, Vattenfall, Siemens Gamesa, Semco and BVG Associates (2016 and 2019).

Part III: Application of the model



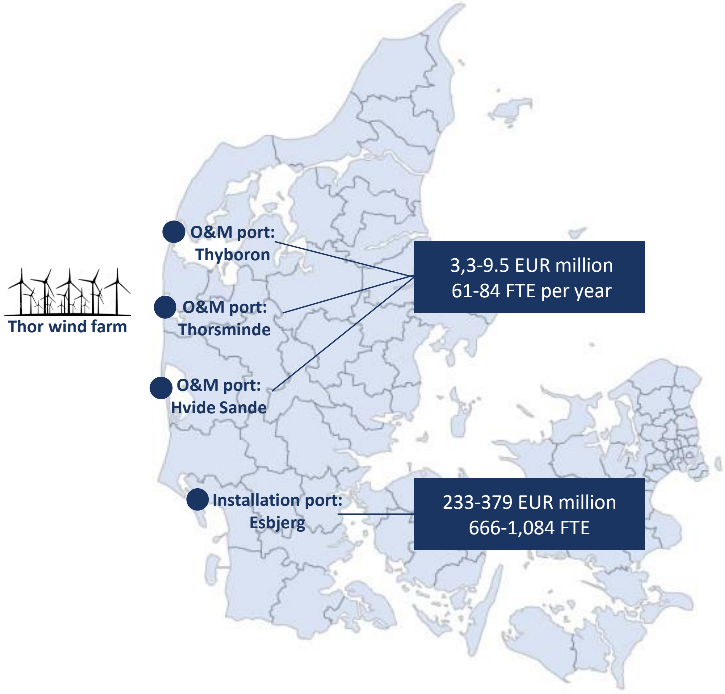
Thor offshore wind farm

800-1,000 MW, +20 km offshore

	CAPEX	OPEX	DEPEX	TOTAL
Offshore wind farm	(0.85)	(1.16)	(0.85)	
- Costs (EUR million)	2,028	1,238	300	3,565
- Costs (EUR million/MW)	2.25[1]	1.38	0.33	3.96
- Labor - direct all (FTE)	5,234	1,987	546	7,768
- Labor - direct DK (FTE)	2,540	1,341	246	4,127
- Labor - indirect + induced DK (FTE)	4,254	3,469	578	8,301

	Installation port: Esbjerg				**O&M port:** Thuboron, Thorsminde or Hvide Sande			
	EUR million		FTE		EUR million		FTE	
	Low	High	Low	High	Low	High	Low	High
Share of contracts	35.0%	57%	35.0%	57%	1.4%	15%	1.4%	15%
Direct	109	178	199	324	0.6	0.6	48	48
Indirect	73	120	250	407	0.4	4.2	1	14
Induced	50	82	217	354	2.4	4.7	12	23
Total	233	379	666	1,084	3.3	9.5	61	84
Total (25 years)	233	379	666	1,084	83	237	1,527	2,109

[1] Expected capex of 2.13 million EUR per MW (DEA 2020) plus development costs.

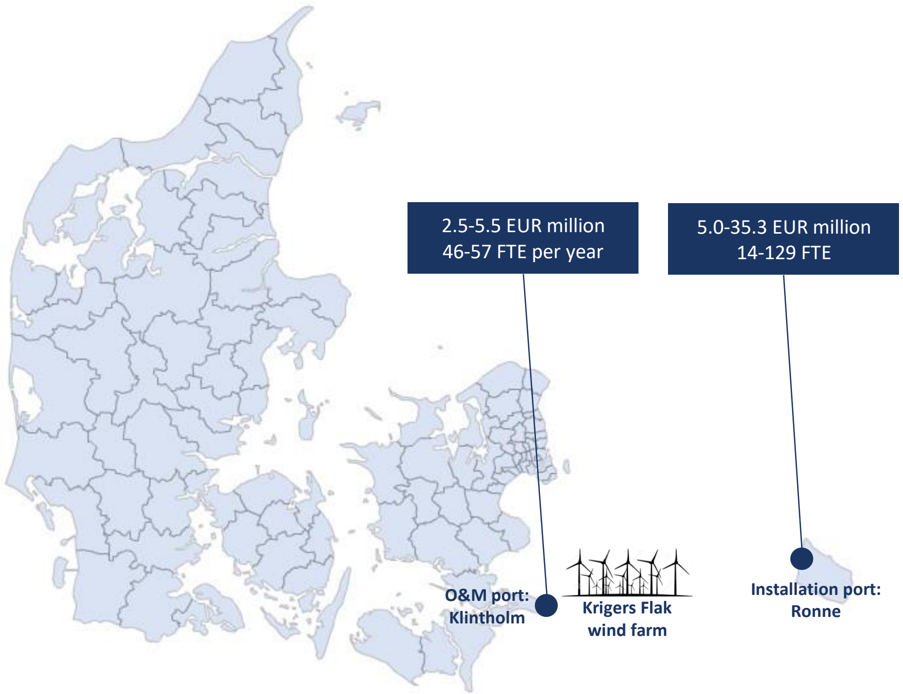


Kriegers Flak offshore wind farm

600 MW, 15-40 km offshore

	CAPEX		OPEX		DEPEX		TOTAL	
Offshore wind farm	(0.79)		(1.31)		(0.74)			
- Investment costs (EUR million)	1,260		937		186		2,384	
- Investment costs (EUR million/MW)	2.08[1]		1.55		0.31		3.94	
- Work load direct all (FTE)	3,221		1,252		306		4,778	
- Work load direct DK (FTE)	1,578		1,016		153		2,747	
- Work load indirect + induced DK (FTE)	3,164		2,014		813		5.607	
	Installation port: Ronne				**O&M port:** Klintholm			
	EUR million		FTE		EUR million		FTE	
	Low	High	Low	High	Low	High	Low	High
Share of contracts	1.2%	15%	1.2%	15%	1.4%	10%	1.4%	10%
Direct	2.4	2.4	4	4	0.4	0.4	36	36
Indirect	1.6	19.6	5	67	0.3	2.1	1	7
Induced	1.1	13.4	5	58	1.8	3.0	9	14
Total	5.0	35.3	14	129	2.5	5.5	46	57
Total (25 years)	5.0	35.3	14	129	63	138	1,157	1,436

[1] Expected capex of 1.97 million EUR per MW (DEA 2020) plus development costs.



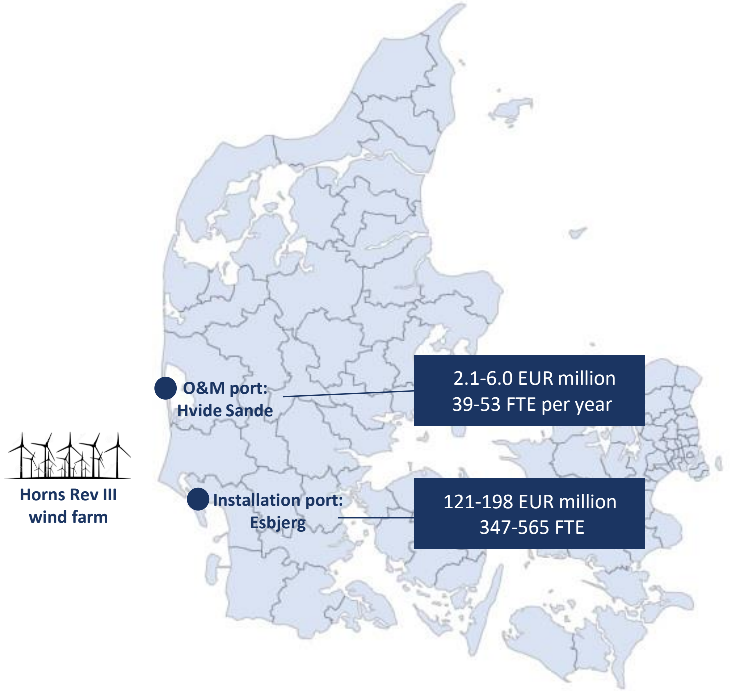
Horns Rev III offshore wind farm

406 MW, 20 km offshore

	CAPEX	OPEX	DEPEX	TOTAL
Offshore wind farm	(0.98)	(1.62)	(0.98)	
- Investment costs (EUR million)	1,056	782	156	1.994
- Investment costs (EUR million per MW)	2.60[1]	1.93	0.39	4.91
- Work load direct all (FTEs)	2,729	1,255	285	4,269
- Work load direct DK (FTEs)	1,329	847	128	2,300
- Work load indirect + induced DK (FTEs)	2,218	2,191	301	4.711

	Installation port: Esbjerg				**O&M port:** Hvide Sande			
	EUR million		FTEs		EUR million		FTEs	
	Low	High	Low	High	Low	High	Low	High
Share of contracts	35%	57%	35%	57%	1.4%	15%	1.4%	15%
Direct	57	93	104	169	0.4	0.4	30	30
Indirect	38	62	130	212	0.2	2.6	1	9
Induced	26	43	113	185	1.5	3.0	8	14
Total	121	198	347	565	2.1	6.0	39	53
Total (25 years)	121	198	347	565	53	149	965	1,332

[1] Capex of 2.46 million EUR per MW (DEA (2020)) plus development costs.

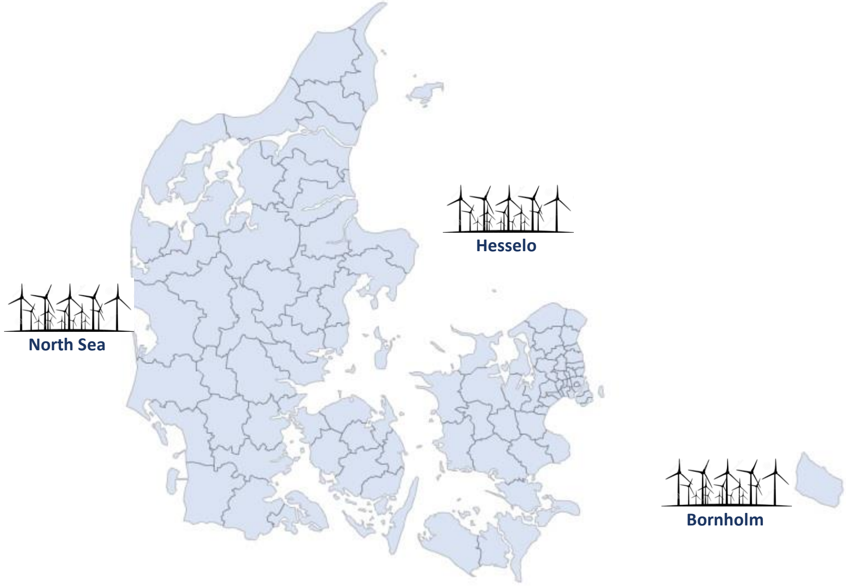


Energy islands plus Hesselo

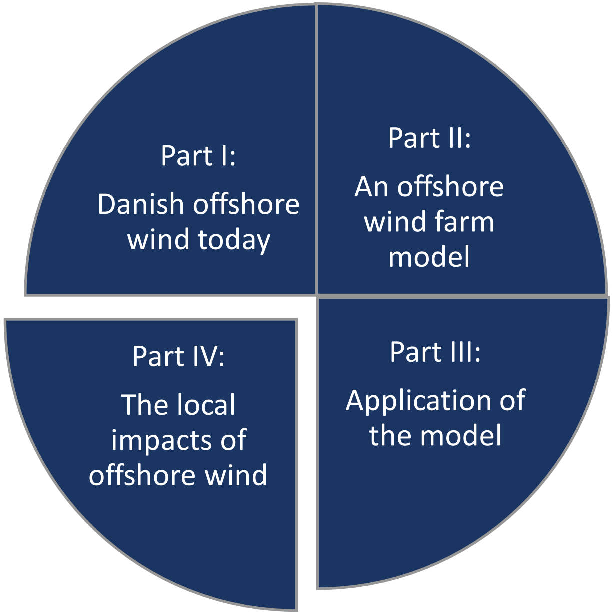
6 GW at Bornholm, North Sea and Hesselo

	CAPEX		OPEX		DEPEX		TOTAL	
Offshore wind farm	(0.85)		(1.16)		(0.85)			
- Investment costs (EUR million)	34,892		13,250		3,642		51,783	
- Investment costs (EUR million per MW)	2.25		1.38		0.33		3.96	
- Work load direct all (FTEs)	34,550		11,014		3,278		48,842	
- Work load direct DK (FTEs)	16,931		8,943		1,639		27,512	
- Work load indirect + induced DK (FTEs)	14,100		23,127		3,852		55,340	
	Installation ports:				**O&M ports:**			
	EUR million		FTEs		EUR million		FTEs	
	Low	High	Low	High	Low	High	Low	High
Share of contracts	1.2%	10%	1.2%	10%	1.4%	10%	1.4%	10%
Direct	25.3	25.3	46	46	3.8	3.8	319	319
Indirect	17.1	139.9	58	476	2.6	18.5	9	62
Induced	11.7	95.6	50	414	15.9	26.3	80	124
Total	54.1	260.9	155	936	22.2	48.6	407	505
Total (25 years)	54.1	260.9	155	936	556	1,215	10,182	12,634

[1] Capex of 2.13 million EUR per MW (DEA (2020)) plus development costs.



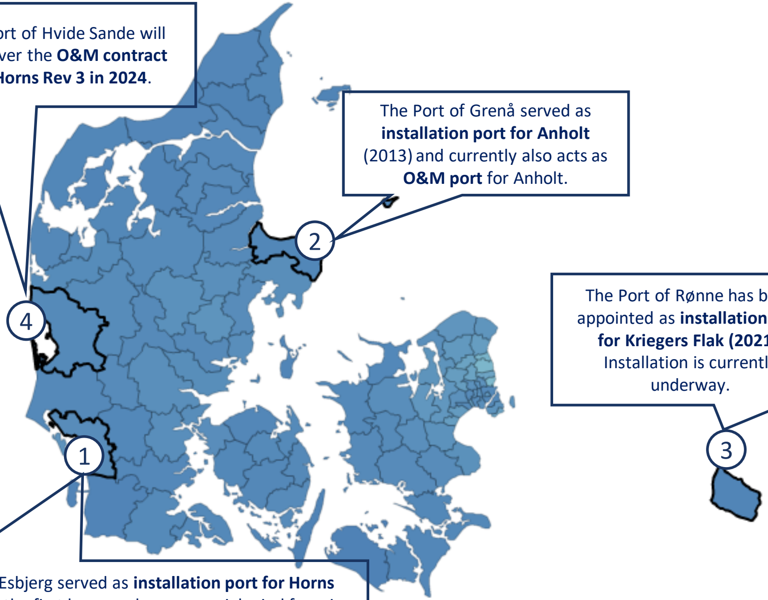
Part III:
The local impacts of wind



Ports act as important gateways to local development in coastal communities

- Ports play a crucial role in ensuring cost effectiveness of offshore wind projects across the full lifecycle. From a socio-economic perspective, ports also act **as important gateways** to local activity and job creation in remote coastal communities. [1]
- The installation and O&M phase involve **several localized operations** within and around ports, incl. shore-based logistics, warehousing, preassembly, regular turbine inspections etc.
- To understand how offshore wind resonate through local port communities over time, the study has collected experiences from **four port communities** and 20+ stakeholders involved in the installation and O&M of some of Denmark's biggest offshore wind farms to date

For a collection of case studies and video clips from local ports and businesses involved in past and current Danish offshore wind projects, please visit www.danishshipping.dk



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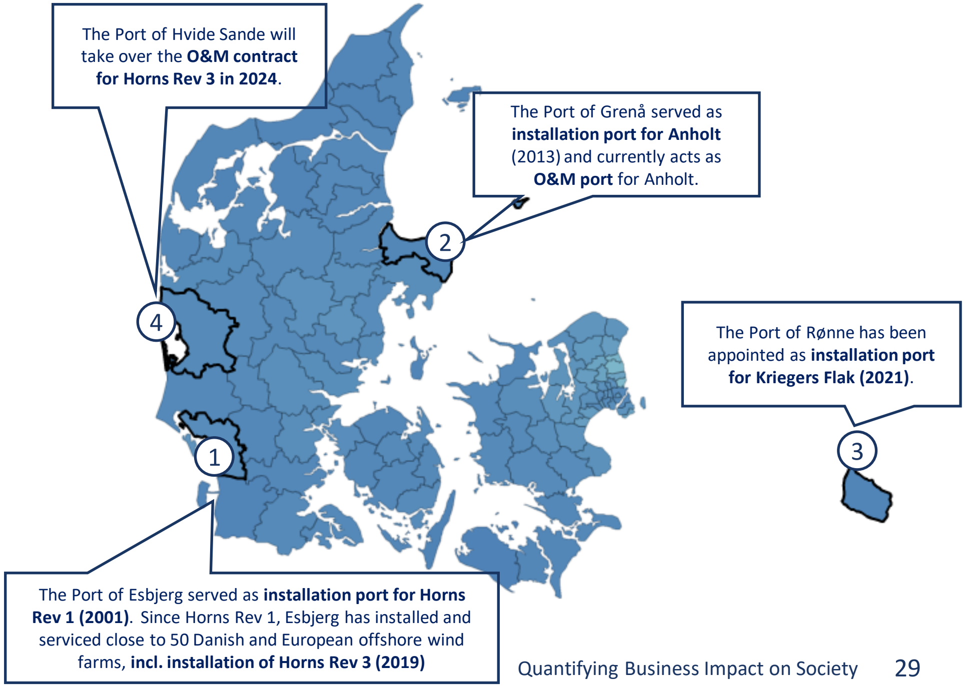
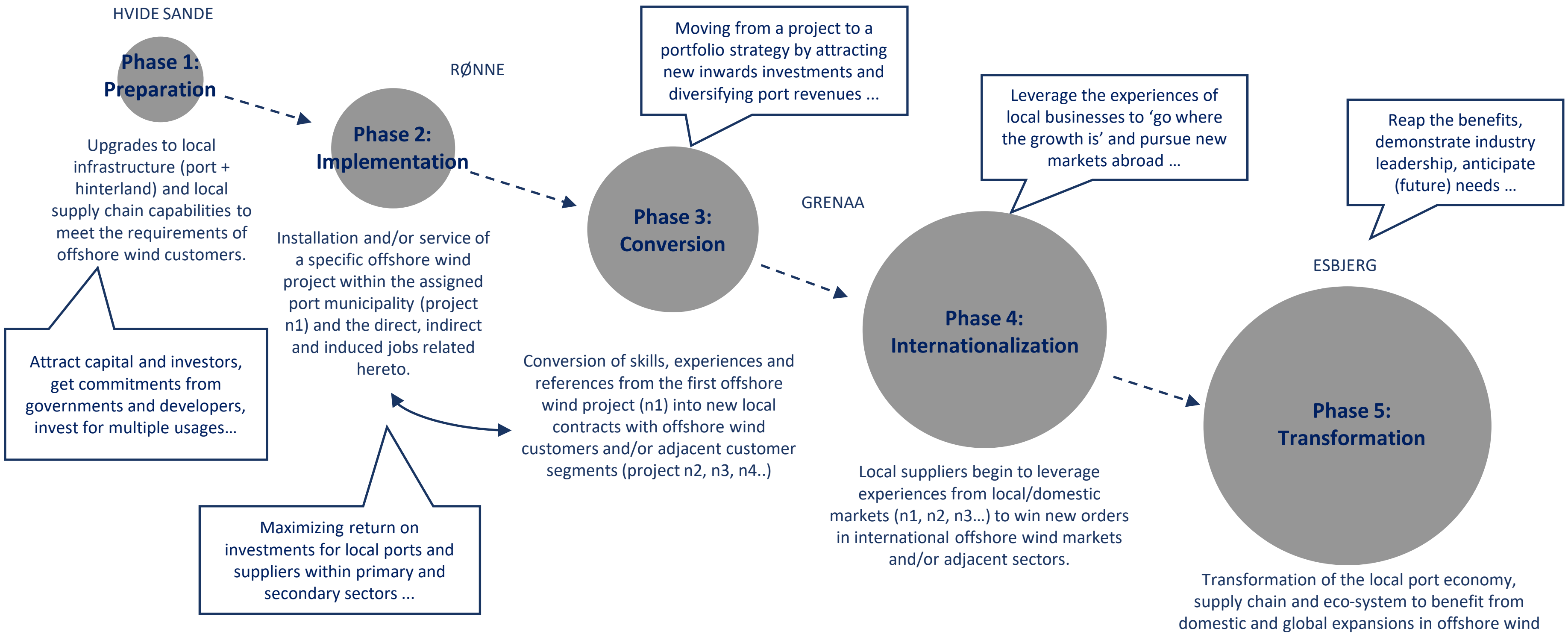


"The snowball effect"

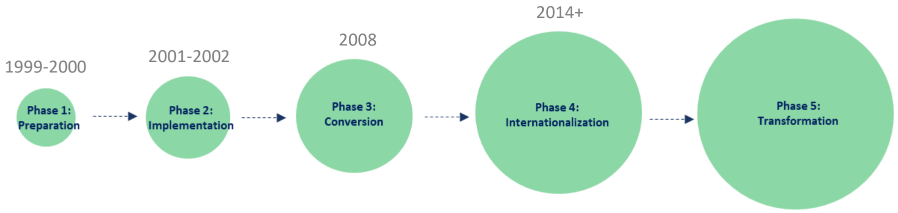
How early investments in offshore wind farms can transform local port communities over time



ESBJERG

Transforming the local port economy from O&G to a global hub for offshore wind

- Horns Rev 1 (2001) marked a **year-long and multi-billion DKK expansion process** within the Port of Esbjerg, transforming the port from a Danish O&G service center to a global offshore wind hub
- PoE has since **successfully converted** its investments and experiences from Horns Rev 1 to a continuous portfolio of offshore wind projects in the North Sea, making it second-to-none in offshore wind
- The transformation of PoE is mirrored by a **similar transformation** among Esbjerg-based suppliers, several of which began to diversify their strategies from O&G to offshore wind following the 2014 oil crisis
- The challenge for PoE ahead lies in attracting a **continuous flow of inwards investments** as the offshore supply chain is becoming increasingly globalized



See cases from Esbjerg at www.danishshipping.dk

1 million m2 the total size of the Port of Esbjerg's offshore wind area, making it among the leading offshore wind ports in the world.	**1.8 billion DKK** the total amount invested in the expansion of PoE since the first offshore wind contract with Horns Rev 1 in 2001.
55% the PoE has been involved in 55% of accumulated offshore wind capacity from 2001-2018 (~54 wind farms).	**25%** share of offshore wind in PoE's revenue. Since 2015, O&G has continued to decline, now accounting for just 10%.
~250 number of Esbjerg-based companies specialized in offshore wind (2017). 50% have adjacent businesses in O&G.	**40%** the current revenue share generated by global offshore wind projects for Esvagt, up from just 2-3% five years ago.

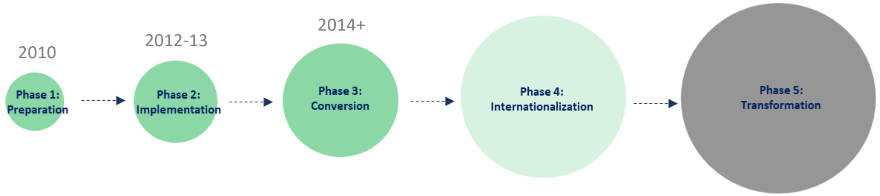
*"When your business only stands on one leg, **you are probably smart to be looking into something new**. ESVAGT's core competency was the quality of our crew. This is something we could take with us to offshore wind."*

Interview with ESVAGT (excerpt from Esbjerg case study)

GRENAA

Converting a one-off wind farm investment to a long-term growth strategy

- **Critical upgrades** to the port of Grenaa and local road infrastructure in 2010 helped Grenå secure the installation and O&M contract for Anholt
- Preparations in the port and hinterland, notably the establishment of **the local supplier network (DWP)**, helped secure maximum local value during implementation stage. Also strong focus on local suppliers from developers ("the Grenaa model")
- The conversion stage has **proven challenging** due to limited new inward investments → change of strategy by port and local suppliers to pursue growth in adjacent sectors and (increasingly) abroad
- Several examples of **local spin-offs from Anholt**, incl. Maersk Inspirer (and now Innovator), floating foundations and internationalization of suppliers



See video interviews and cases from Grenaa at www.danishshipping.dk

250 mio. DKK total investments on upgrading on Grenaa port (150 mio.) and local roads (100 mio.) for future offshore wind projects.	**~100 ships** the installation of Anholt involved more than 100 ships, 3,000 people and 2 million working hours acc. to Orsted.
450 mio. DKK the total contract value secured by members of the DWP supplier network during Anholt, the majority Grenå-based.	**x 10** to Grenaa-based Davai, Anholt has led to a ten-doubling of revenues from local offshore wind activities.
~6% the share of Grenaa port's revenue generated from O&M of Anholt today (a big drop from the installation phase).	**140 mio. DKK** as an example of a spin-off from Anholt, Maersk Inspirer created 140 mio. to local suppliers in Grenaa and Djursland.

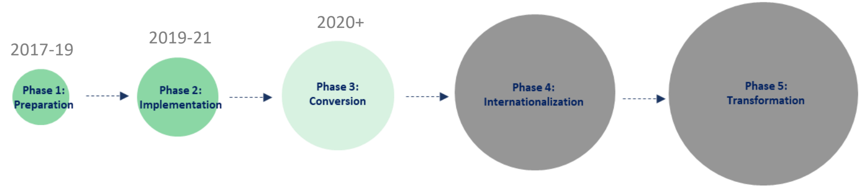
*"The most important spin-off from Anholt was that it helped our members **internationalize their business and order books**. The world has moved on since Anholt and the offshore wind sector has become increasingly global. Today our members are just as occupied with winning orders in the USA as they are in Denmark."*

- Interview with CEO of DWP (except from Grenå case study)

RONNE

Unlocking the future growth potential of offshore wind in the Baltic region

- Similar to the ports of Grenå and Esbjerg, Ronne's entrance into offshore wind was enabled by **substantial port upgrades** timed with the issuing of a new Danish offshore wind farm (Kriegers Flak)
- Ronne's **unique geographical location in the Baltic Sea** along with the port's preliminary experiences as service hub for Arkona wind farm (DE) made it an attractive choice for Siemens Gamesa
- The implementation of Kriegers Flak is already underway, promising to bring **local jobs and activity to the island** during its duration, see Part IV.
- The local port community of Ronne is already taking steps to **convert preliminary investments and experiences** (e.g. new facilities, skills, local supplier networks) to new opportunities in the Baltic Sea



See video interviews from Ronne at www.danishshipping.dk

500 mio. DKK

total investment by the port of Ronne in future-proofing the port, incl. for offshore wind projects in the Baltic Sea.

150,000 m2

size of the new port area for offshore wind. Water depth also increased to 11 m and quay carrying capacity to 50 tons.

Up to 85GW?

Acc. to Wind Europe offshore wind in the Baltics can increase from 2GW to 9GW by 2030 and up to 85GW by 2050.

2 GW

a proposal from the Danish government wants to convert Bornholm to an energy island with a 2GW offshore wind farm connected to Sealand and Poland.

16

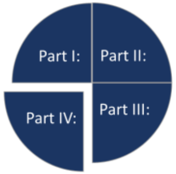
local companies form the new supplier network 'Offshore Center Bornholm' aimed at positioning Bornholm as an ambitious offshore player in the Baltics.

74 km

the distance from Ronne to Arcadis Ost (DE) where Ronne was appointed as pre-assembly port by MHI Vestas in 2020.

*"When I look at the Baltic Sea, I see a lot of big projects in Germany and Poland. **Our expectations of the added value this can bring to Bornholm in terms of jobs and growth are big**. The challenge is that we have a lot of competition and we would of course like to bring these jobs to Denmark."*

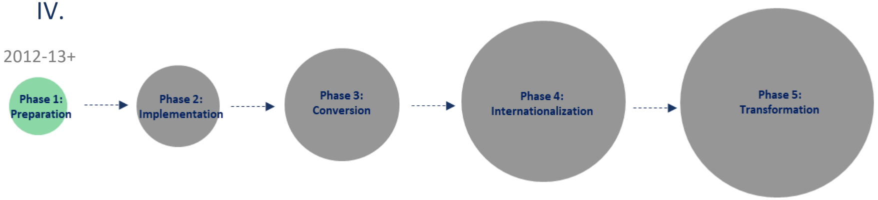
- Interview with the local mayor of Bornholm (excerpt from Ronne case study)



HVIDE SANDE

Carving a niche for smaller ports within offshore O&M

- Hvide Sande port is in the **early preparatory** stages with a set goal to transform the fishery port into a modern, diversified port specialized in O&M of offshore energy projects
- The port is homing in on **O&M as an attractive niche** for smaller and more agile ports. Similar to Rønne, an initial "test-run" as service hub for Horns Rev 3 helped land its first O&M contract from 2024
- One of the port's main strengths is the **strong hinterland of local suppliers**, incl. Hvide Sande Shipyard and the companies involved in Hvide Sande Service Group, many of which have benefited from the offshore wind success in neighboring municipalities (namely Esbjerg)
- According to Vattenfall, the O&M contract for Horns Rev 3 will lead to **25-30 permanent jobs** in Hvide Sande. However, due to the low O&M costs, the model only estimates around 19 direct FTEs. If 15% of sub-supplier contracts go to local companies, total FTE increases to 24-33 jobs see Part IV.



See cases from Hvide Sande at www.danishshipping.dk

# 5 Hvide Sande ranks as the 5th largest fishery port in Denmark. Until the mid-2000s fishery was the port's main income.	**150 million DKK** total investments in upgrading the port from a fishery port to a modern industrial port from 2011-2013.
Triple up the port upgrade has led to a tripling of port turnover, from 12 mio. DKK in 2010 to >40 mio. DKK in 2018.	**30 people** the number of service technicians hosted by Hvide Sande in a local port pavilion during the installation of Horns Rev 3.
25-30% the expected share from offshore wind of Hvide Sande port's turnover in 5-10 years, up from a modest 2-5% today	**33%** the share of revenue generated from offshore wind at Hvide Sande Shipyard, up from 5% just 10 years ago.

"We are very pleased with the Port of Hvide Sande. They have cheaper rates than some of the larger ports and there is a fantastic hinterland of local suppliers, incl. the shipyard in Hvide Sande. They are available, competent, friendly and provide good service. Some of the fixed ports are also good for O&M but they are expensive and big. Sometimes it's better from a customer perspective to be a big fish in a small pond."

- Interview with Ziton (excerpt from Hvide Sande case study)

Glimpse of local cases from study: Maritime and logistics companies among key vehicles for local value from offshore wind

ZITON

HVIDE SANDE
Shipyard · Steel · Service

NorSea

SEMCO maritime

VIKING
LIFE-SAVING EQUIPMENT

JUTLANDIA

ESVAGT

MHO-Co A/S

Ocean Team Group as

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Thank you for listening