
WIND
An intelligent way of using the world's endless potential. Wind power with wpd.
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think energy

Project Development wpd offshore projects

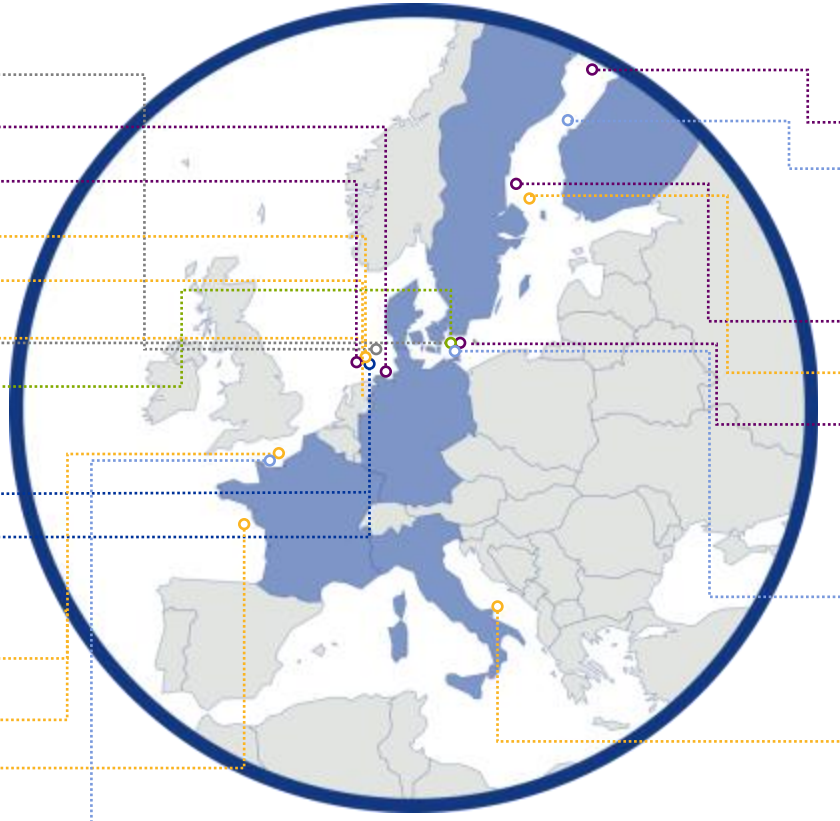
wpd think energy

GERMANY

- Butendiek (288 MW)
- Nordergründe (110 MW)
- Kaikas (580 MW)
- Aiolos (700 MW)
- Apollon (400-600 MW)
- Notos (318 MW)
- Baltic 1 (48,3 MW)*
- Baltic 2 (288 MW)*
- Hohe See (400 MW)*
- He Dreiht (595 MW)*

FRANCE

- Courseulles(450 MW)
- Fécamp (498 MW)
- Vendée (500 MW)
- 3 other projects (1,500 MW)



FINLAND

- Suurhiekka (480 MW)
- Korsnäs (720 MW)

SWEDEN

- Storgrundet (350 MW)
- Finngrunden (up to 1,500 MW)
- Kriegers Flak II (640 MW)*

DENMARK

- Kriegers Flak III (570 MW)

ITALIEN

- Gargano Sud (342 MW)

1 project with a capacity of 48.3 MW in operation

2 projects with a capacity of 576 MW under construction

3 projects with a capacity of ~ 1,100 MW consented and under procurement

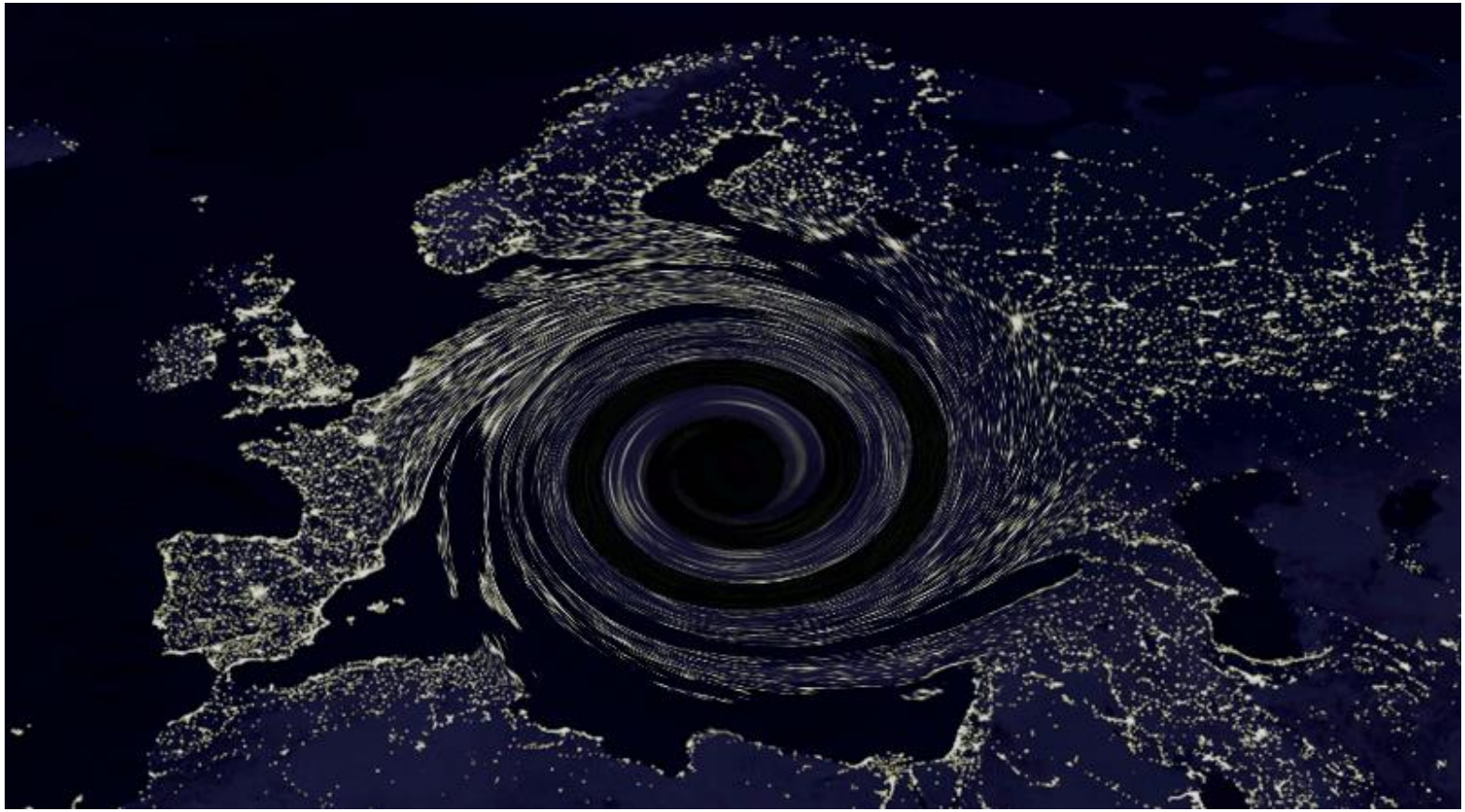
4 projects with a capacity of ~ 2,100 MW consented

8 projects with a capacity of ~ 4,800 MW (net) in advanced permission process

5 projects with a capacity of ~ 2,600 MW (net) in early stage of permission process

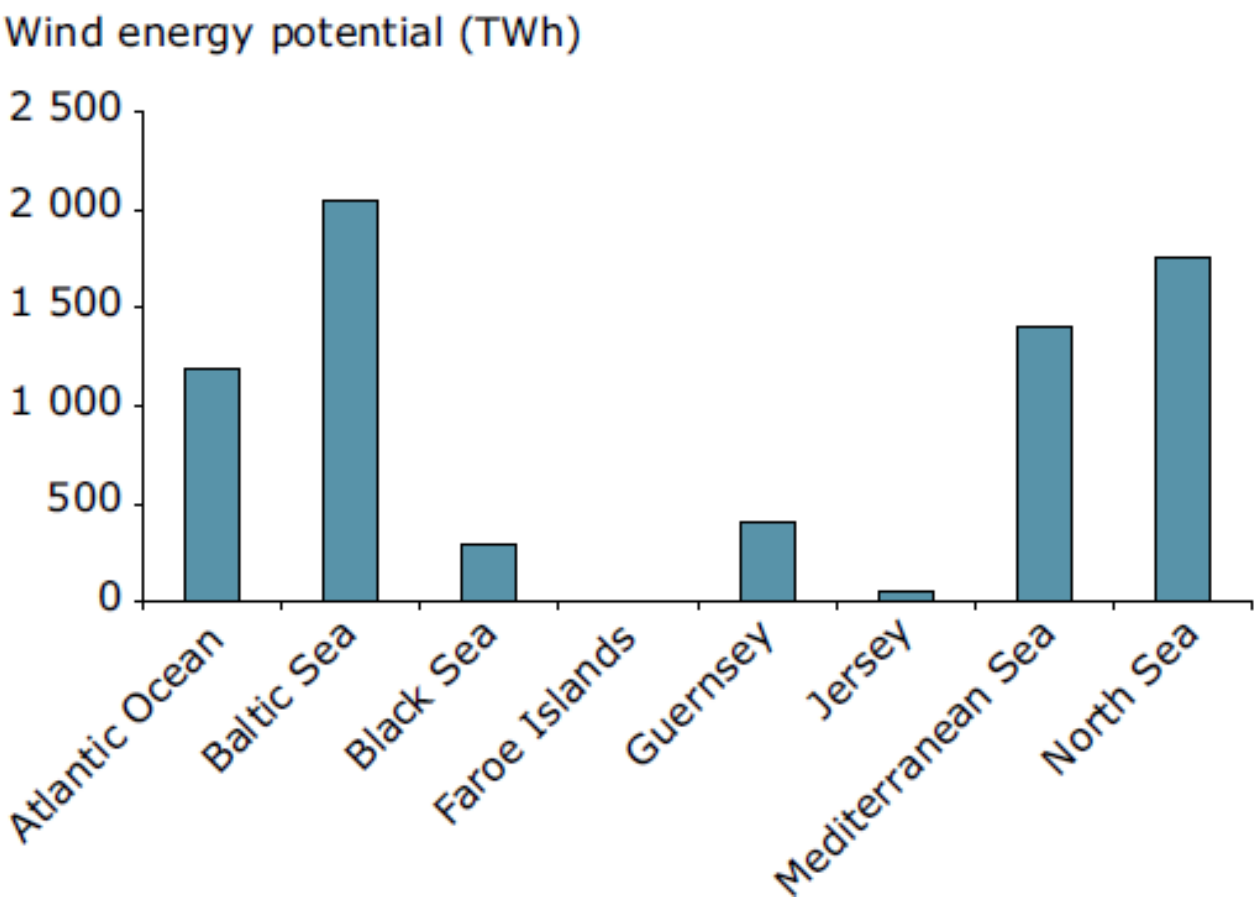
* Sold – wpd was further involved by cooperation agreement

Europa needs 2900-3400 TWh new carbon free electricity production until year 2050.



Källa: Staffan Jacobsson, professor miljösystemanalys Chalmers tekniska högskola

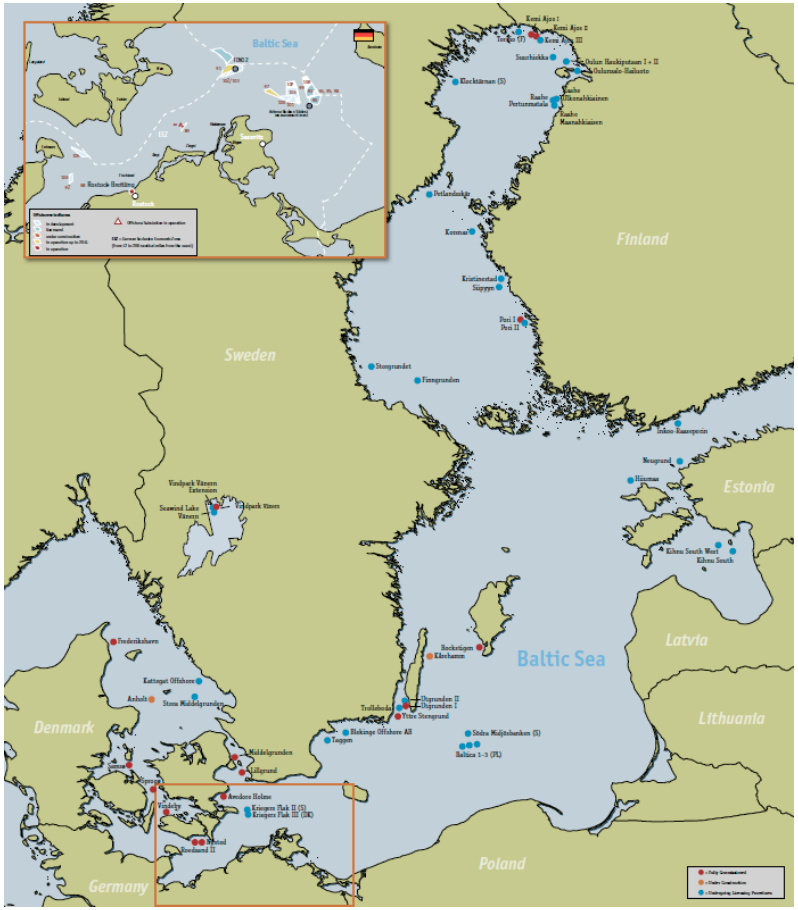
New market opportunities
- summary ”technical potential”



Unrestricted technical offshore wind potential in offshore areas 10-30 kilometres from the coast

Source: EEA, 2008

Baltic pipeline
Large portfolio of projects under development



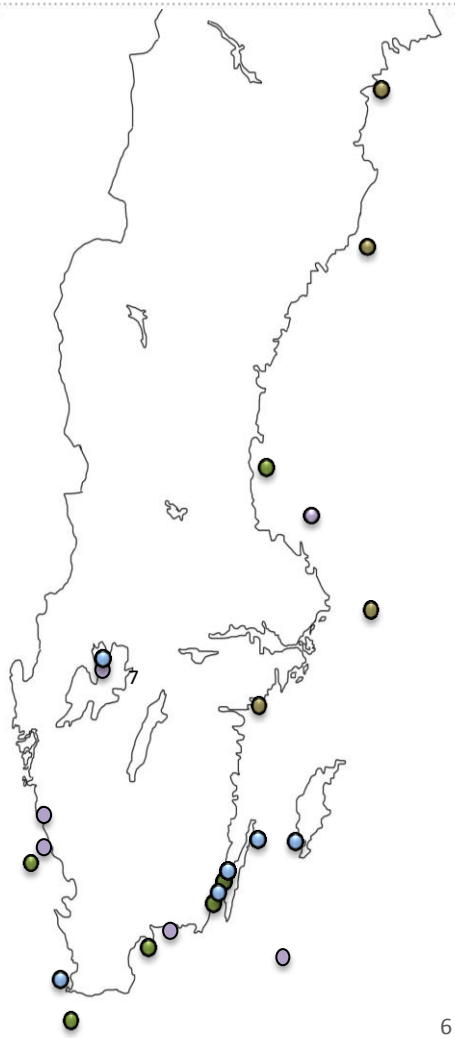
Baltic pipeline (a few in operation, main part under development)

Denmark	~ 1400 MW (new tender)
Estonia	~ 2000 MW
Finland	~ 4000 MW
Germany (Baltic Sea)	~ 2300 MW
Poland	~ 900 MW
Sweden	~ 9000 MW
Potential:	**~ 19600 MW**

Source: www.wab.net

2.6 Status Sweden's offshore market

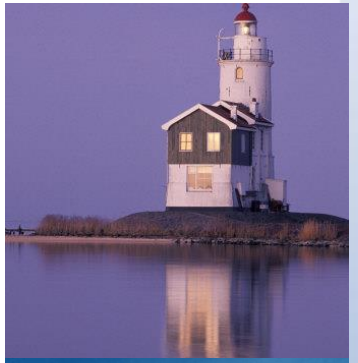
	Project	Developer	Nr WTG	Power [MW]	Production [GWh/år]
Constructed	Bockstigen	Private	5	2,75	7
	Utgrunden I	Vattenfall	7	10	38
	Yttre Stengrund	Vattenfall	5	10	30
	Lillgrund	Vattenfall	48	110	330
	Vindpark Vänern	Vindpark Vänern	10	30	90
	Kårehamn	E:ON Climate & Renewables Nordic	16	48	180
		SUM	***91***	***211 MW***	***675 GWh***
Permited	Stora Middelgrund	Universal Wind Offshore	110	800	3 000
	Kriegers Flak	Vattenfall	128	640	2 600
	Taggen	Wallenstam/Triventus/Vattenfall	83	415	1 000
	Trolleboda	Vattenfall	30	150	500
	Utgrunden II	E:ON Climate & Renewables Nordic	24	90	280
	Storgrundet	Storgrundet Offshore AB (wpd)	70	265	800
	Stenkalles grund	Rewind energy	20	90	200
		SUM	***465***	***2450 MW***	***8 380 GWh***
Application filed	Blekinge Offshore	Blekinge Offshore	500	2 500	8 000
	Finngrunden	Finngrunden Offshore AB (wpd)	185	1 300	5 500
	Hakefjorden	Göteborg Energi	13	59	225
	Kattegatt Offshore	Favonius	47	282	680
	Södra Midsjöbanken	E:ON Climate & Renewables Nordic	300	700	3 000
		SUM	***1 045***	***5040 MW***	***17 405 GWh***
Planning	Vindpark Marviken	Rewind energy	10-12	30-60	140
	Svenska Björn Offshore	Solid vind	66	660	1 054
	Petlansskär	Petlandsskär Vind AB	30	90	225
	Klocktärnan	NordanVind/WPD	132	660	1 900
		SUM	***228***	***1410 MW***	***3 319 GWh***



The new oil is above the **Sea**

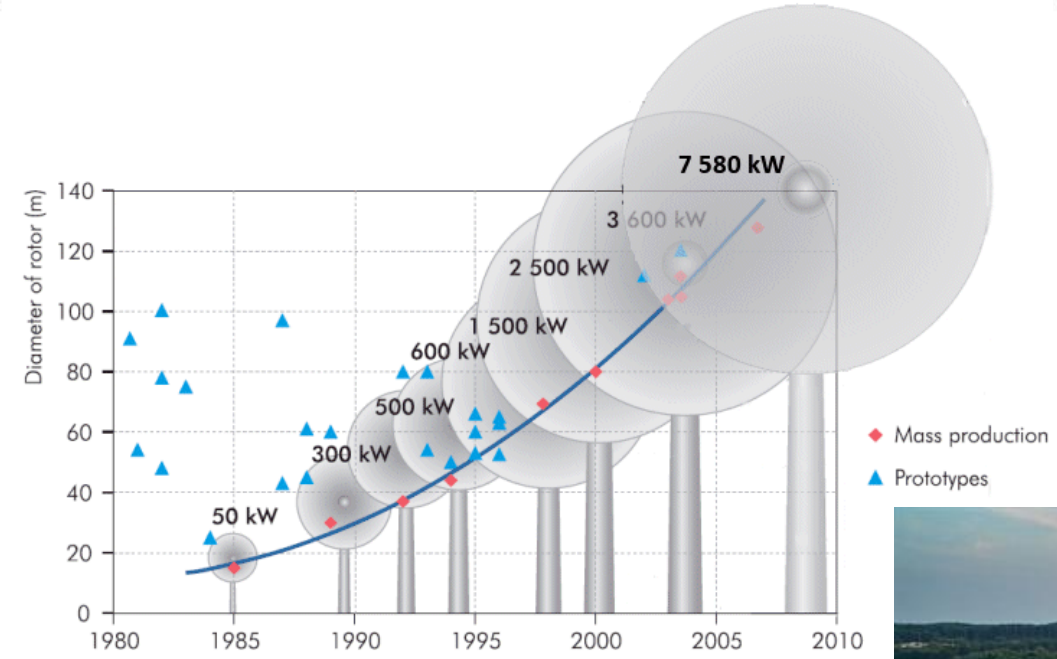
Case study Storgrundet: Technical Concept – "Offshore light"

Region	North Sea	Northern Baltic Sea
Distance to coast	Long	Moderate/short
Water depth range	20…40	5…25
Tide	Yes	No
Swell	Yes	No / insignificant
Max wave	High	Moderate
Mean wind	IEC I	IEC I/II
Extreme wind	IEC I	IEC I/II
Water salinity	High	Low
Salt spray	Yes	Insignificant
Corroding air	Yes	Insignificant?
Operating temp. range	-10…+30 C	**-30…+30 C**
Drift ice	No	**Yes**
Pack ice	No	**Yes**
Turbine design	Offshore	Onshore/ semi-offshore Cold Climate Version
Remuneration offshore	> 150 €/MWh	No offshore-specific remuneration system



- North Sea turbines are over dimensioned – and too expensive – for Northern Baltic
- Design Basis for foundations and other marine structures: very different from the North Sea
- Accessibility, O&M vessels, O&M strategy etc. need to be studied from fresh perspective
- Realizing of the first project will open up opportunities for repetition & exports

Turbine development



Source: International Energy Agency (IEA)

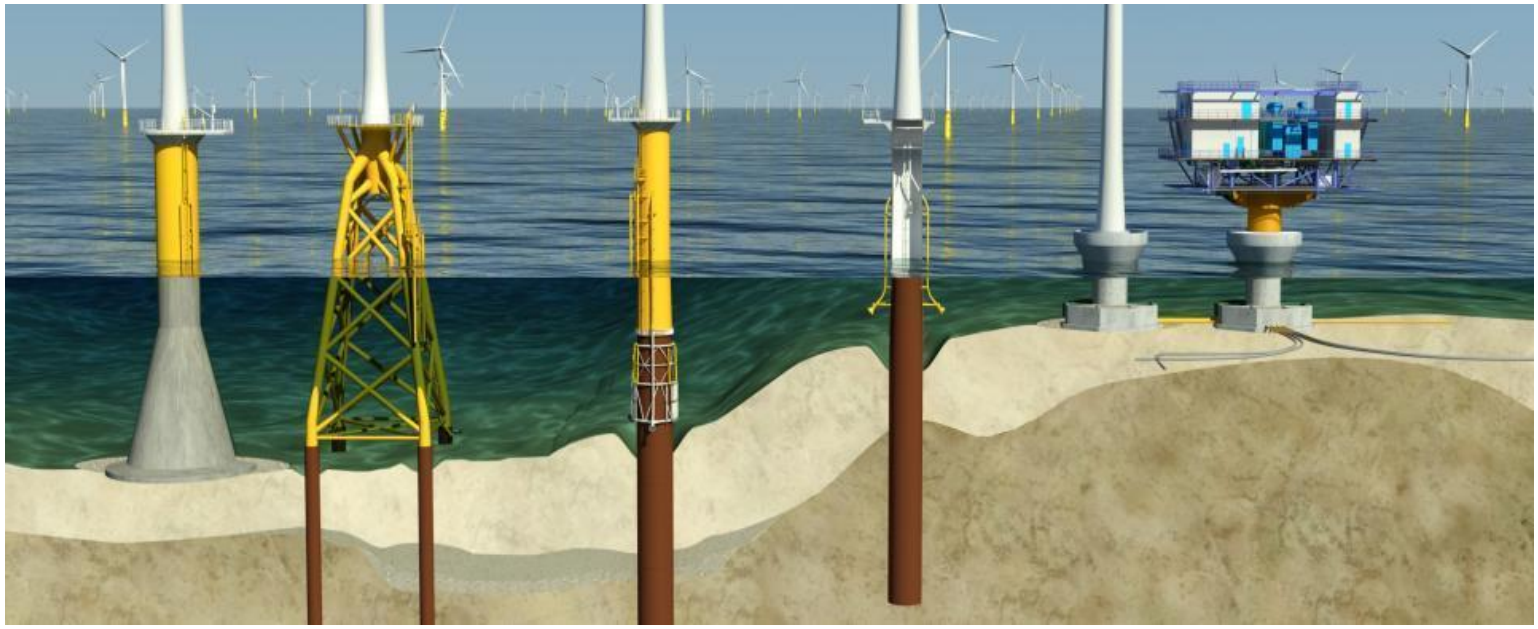
= increased need for distance between turbines

= increased efficiency per m^2 footprint

2013, Samsung S7.0 , 171m, 7MW

Foundations

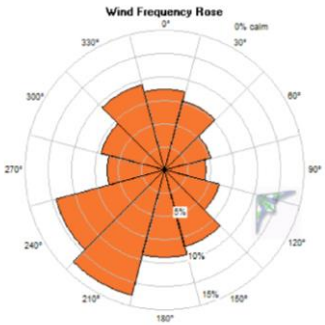
- GBS structure
  - Steel
  - Concrete
- Hammerd Monopile
- Drilled monopile
- Jacket structures
- Tripod
- Quadropod
- Floating



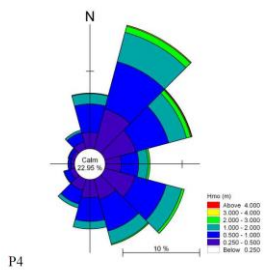
Case study Storgrundet:
– Project data

	Storgrundet
Capacity:	265-350MW
No. turbines:	70
Production:	0,9-1,2 TWh/år
Distance to shore:	11 km
Average wind:	8,6 m/sek
Full load hours:	4200h
Water depth:	10 - 22 m
Start of construction:	2018

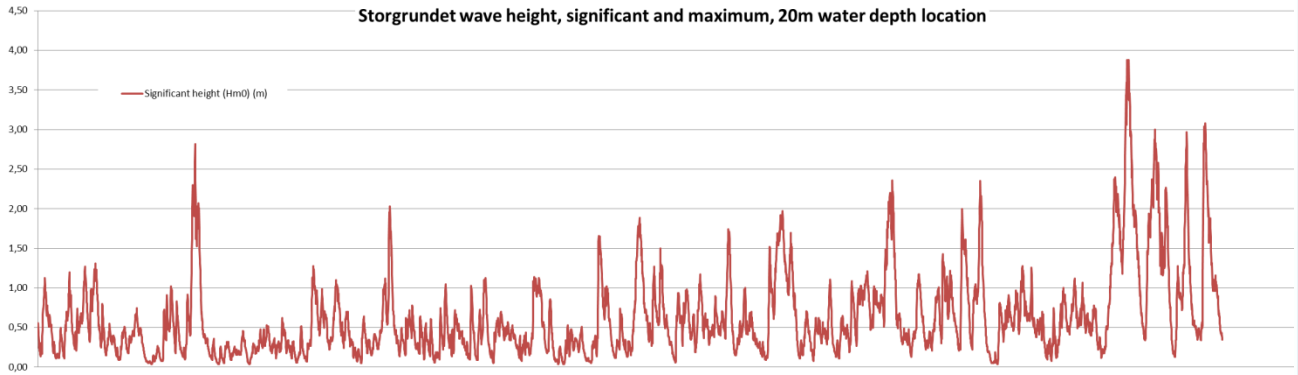
Case study Storgrundet:
– Met ocean conditions



Long term corrected wind rose



Calculated wave rose



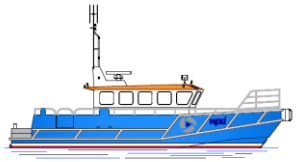
Measured wave conditions may-mid december (2012)

Hs (6h)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0,5	59,2	62,1	67,2	70	78,8	81,1	80,4	73	60,1	57,9	52,3	57,6
0,8	80,1	84,1	86,3	85,6	92,2	94,4	93,8	92,4	82	79,3	77,7	78,9
1	87,6	90,4	91,3	90,8	95,3	97,4	96,9	96,4	88,5	85,3	85,6	86,6
1,1	89,6	92	92,6	92,3	96,5	98,1	98	97,8	91	88,4	88,2	88,9
1,25	91,7	93,9	94,5	94	97,8	99	98,6	98,7	94,6	91,9	90,8	91,3
1,5	94,4	95,6	97,2	96,2	99	99,6	99,5	99,4	97,4	95,2	94,3	94,1
2	97,4	98,2	99,1	98,4	99,8	100	100	99,9	99	98,5	97,4	97,3
2,25	98,5	98,8	99,6	99	99,9	100	100	100	99,4	99,1	98,2	97,8
2,5	98,9	99,4	99,9	99,3	99,9	100	100	100	99,8	99,5	98,8	98,4

Calculated wave exceedance table (will be updated based on ongoing measurements)

Installation and operation differences

Baltic Sea



North Sea

Technology shifts occurs everywhere

- *The Baltic development needs simplification*

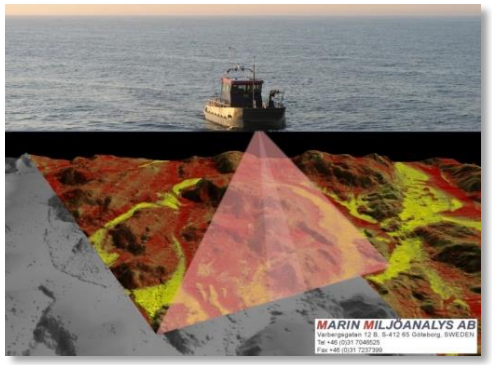
Case study Storgrundet:
"Offshore light" – significant cost reductions possible

"Offshore light" in numbers – Cost comparison between "North Sea" and "Baltic Sea"

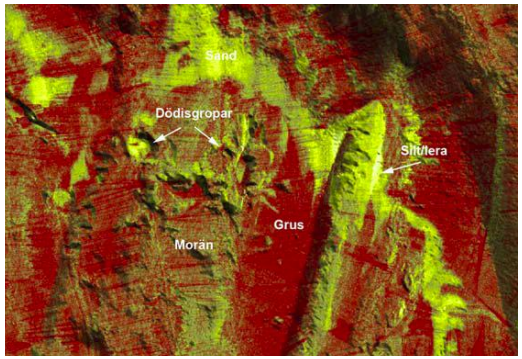
• Turbines	- 40 %	*Class II turbines*
• Installation cost	- 60%	*Smaller turbines, lower waves -> simpler installations concepts*
• Investment cost €/kWh	- 28%	*Good wind conditions combined with lower capital costs*
• O& M	- 30%	*Short distances to shore, smaller waves*

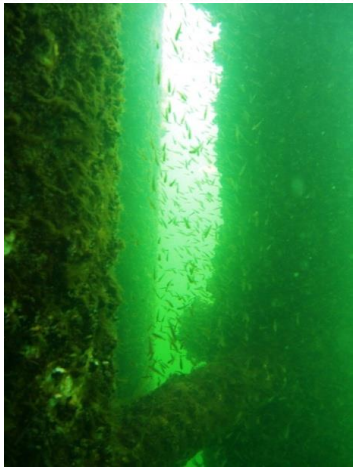
Planning of wind farms

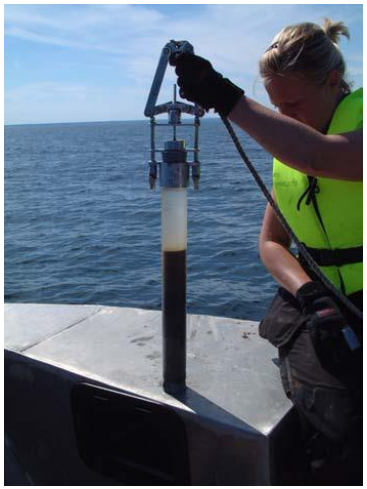
- **Site data**
  - ✓ Wind
  - ✓ Bathymetry
  - ✓ Soil conditions
  - ✓ Waves
  - ✓ Current
  - ✓ ice
  - ✓ Salinity
  - ✓ Water temp
  - ✓ Ship traffic



- **Grid connection point**
- **Harbours**
  - ✓ Installation
  - ✓ O&M (distance to shore)
- **Environmental conditions**
  - ✓ Benthos
  - ✓ Fish
  - ✓ Birds
  - ✓ Bats
  - ✓ Etc.

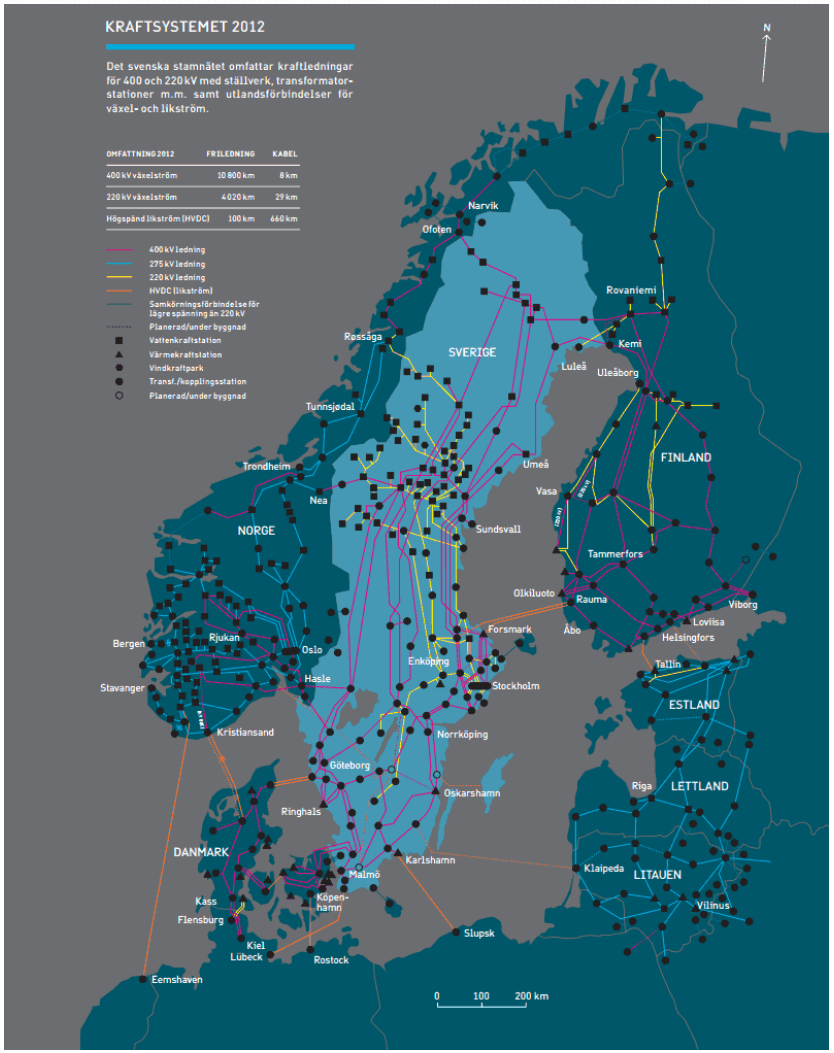






Electricity grid

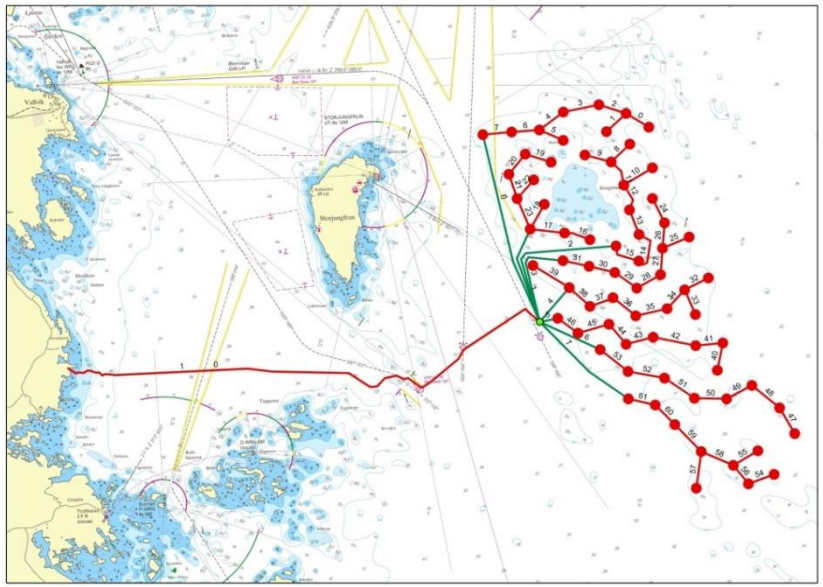
- Scandinavia have a strong and integrated grid
- Several connectors between the countries in the Baltic sea.
  - New connectors are planned
- Future offshore super grid?

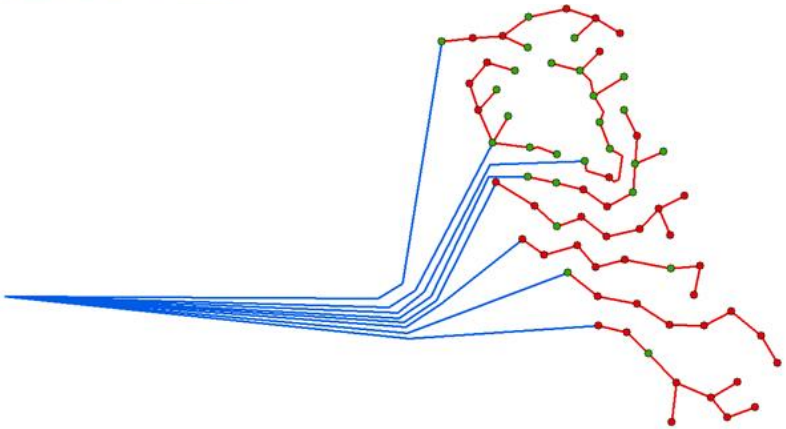


Electricity grid, offshore

(Storgrundet Offshore Wind Farm)

- Grid connection point
  - Onshore/Offshore
- Distance to grid connection point
  - Onshore/Offshore
- Capacity
  - Turbine capacity
  - Connector capacity
  - HVDC/HVAC
- Soil-, Wave- , Current- and Ice conditions
- Water/soil Temperature
  - Cable capacity
- Cable protection
- Redundancy
- Risks
  - Fishery
  - Ship traffic





Maritime spatial Offshore Wind/Grid Planning

- Marine spatial planning must be based on factual data / inventories
  - Wind resource (confirmed by measurements)
  - Subsea soil conditions
  - Hydrographic information
  - Environmental information
    - Benthos
    - Fish
    - Birds
    - etc.
- Marine spatial planning must have a **longtime perspective**. Decision today must coexist with investment taking place 10-15 yr. from now.
  - Technical development
  - Traditional solutions or flouting foundations.
  - Grid development – connection possibilities

Wish list from a developer perspective

1. Planning that is based on factual data, inventories and knowledge.

2. Plans drawn up in close consultation with industry.

3. Coordinated investigations/planning and common conclusion regarding effects

4. *Planning with a flexible approach (pragmatic) so we in future we can gain acceptance and adapt to new and more accurate knowledge.*
   - *Technology development and / or development of the power system will affect the choices of places in ways we can not define today.*

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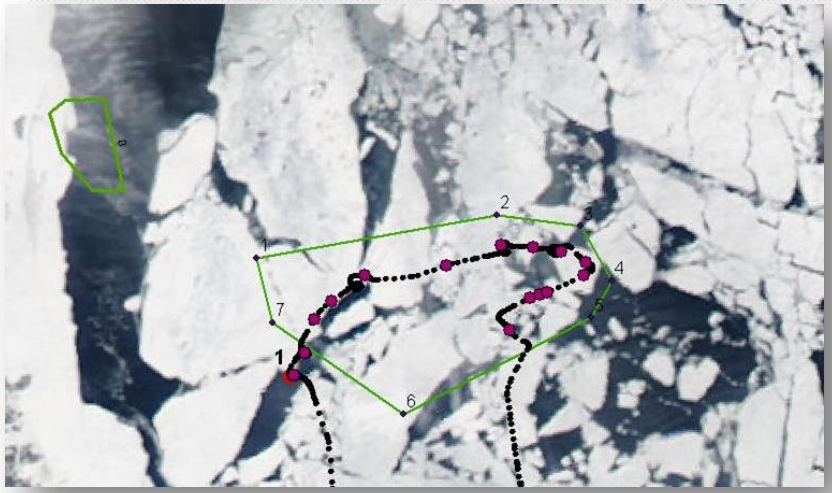
Ice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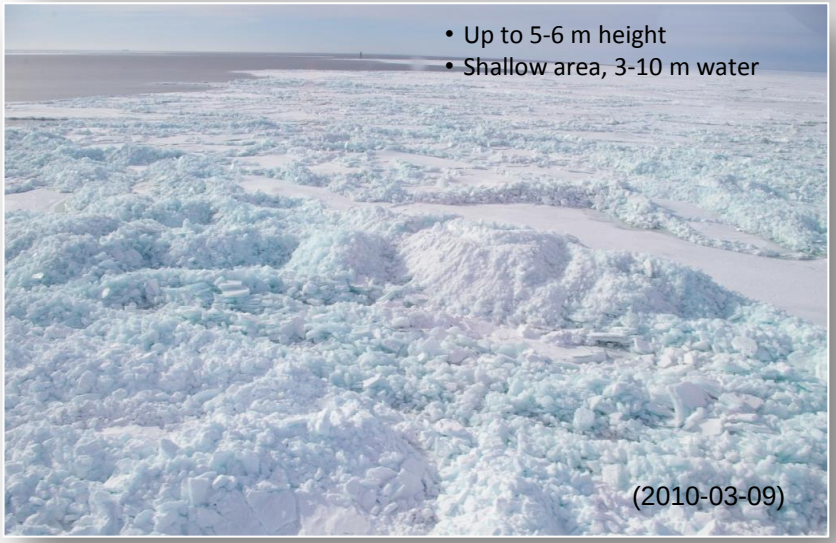
Ex. from Kemi in Finland


(2010-03-09)


• Up to 5-6 m height
• Shallow area, 3-10 m water
(2010-03-09)