Offshore Wind Technology

Thessaloniki, 10 October 2019

84th Thessaloniki International Fair

PAE RAE
ΡΥΘΜΙΣΤΙΚΗ ΑΡΧΗ ΕΝΕΡΓΕΙΑΣ
REGULATORY AUTHORITY FOR ENERGY

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Agenda

- Introduction to Aeolus
- Offshore Wind Developments and trends
- Global Status
- Costs
- Potential for Greece
- What does the future hold?

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ALL HATCHES TO BE CLOSED AT SEA

About me

- 12 years of offshore wind experience in project development, construction and operation.
- Worked for 3 years in Holland developing Belwind 1 and Luchterduinen projects.
- Worked as Senior Project Manager at Mott MacDonald for 6 years responsible for LTA financing and execution of EUR 4 billion of Offshore Wind projects.
- Since 2016 Director at Aeolus Ltd providing offshore wind advisory and project management services.

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About Aeolus

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Know-how

Past experience covers:

- Neart Na Gaiothe 450MW, UK (active)
- Gemini 600MW, Netherlands
- Borssele I,II 700MW, Netherlands
- Rampion 400MW, UK
- Fisherman's Energy 25MW, USA
- Formosa I,II 128MW, Taiwan
- Northwind 216MW, Belgium
- Nobelwind 165MW, Belgium
- Belwind 165MW, Belgium

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How everything started?

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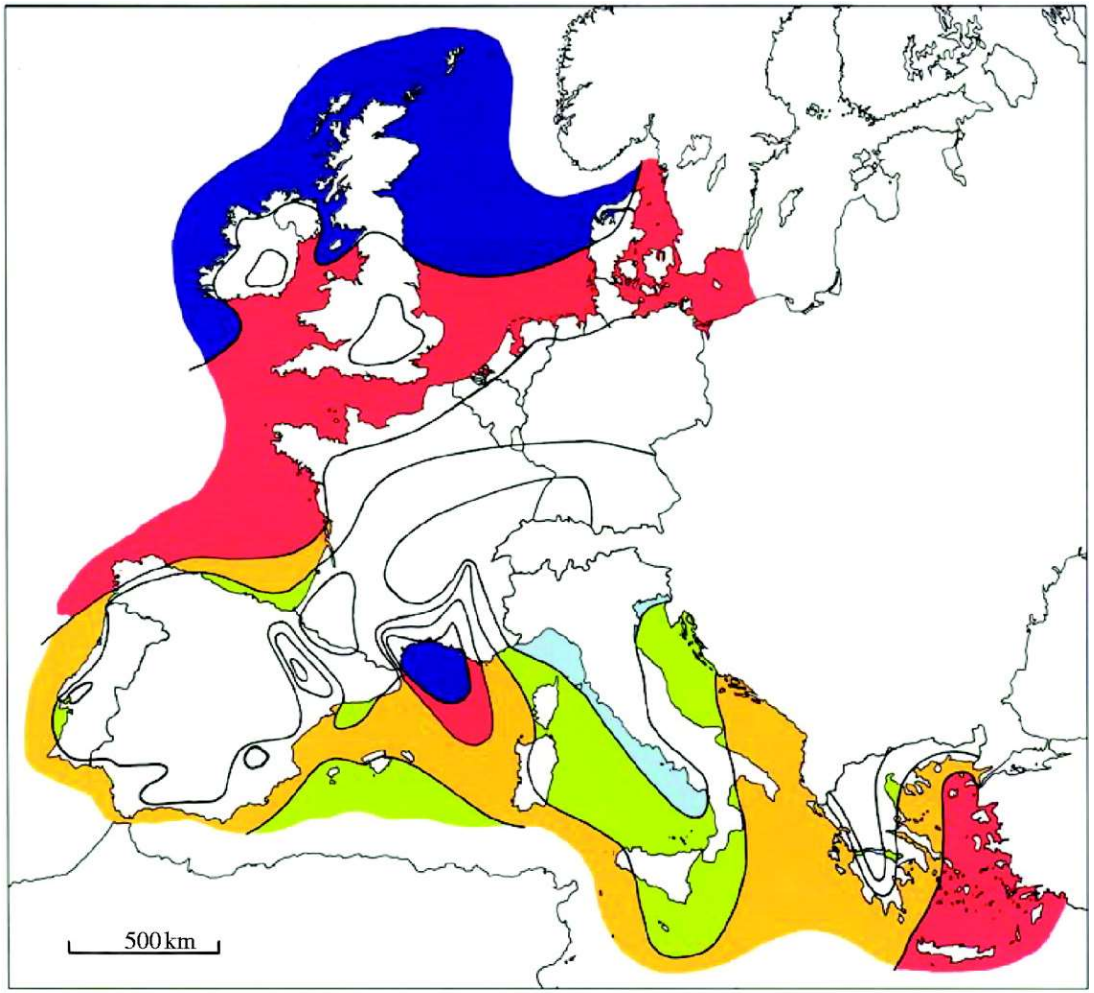
Wind resource



Source: European Wind Atlas Offshore

wind resources over open sea (more than 10 km offshore) for five standard heights										
	10 m		25 m		50 m		100 m		200 m	
	$m s^{-1}$	$W m^{-2}$	$m s^{-1}$	$W m^{-2}$	$m s^{-1}$	$W m^{-2}$	$m s^{-1}$	$W m^{-2}$	$m s^{-1}$	$W m^{-2}$
	>8.0	>600	>8.5	>700	>9.0	>800	>10.0	>1100	>11.0	>1500
	7.0–8.0	350–600	7.5–8.5	450–700	8.0–9.0	600–800	8.5–10.0	650–1100	9.5–11.0	900–1500
	6.0–7.0	250–300	6.5–7.5	300–450	7.0–8.0	400–600	7.5 – 8.5	450 – 650	8.0 – 9.5	600 – 900
	4.5–6.0	100–250	5.0–6.5	150–300	5.5–7.0	200–400	6.0 – 7.5	250 – 450	6.5 – 8.0	300 – 600
	<4.5	<100	<5.0	<150	<5.5	<200	<6.0	<250	<6.5	<300

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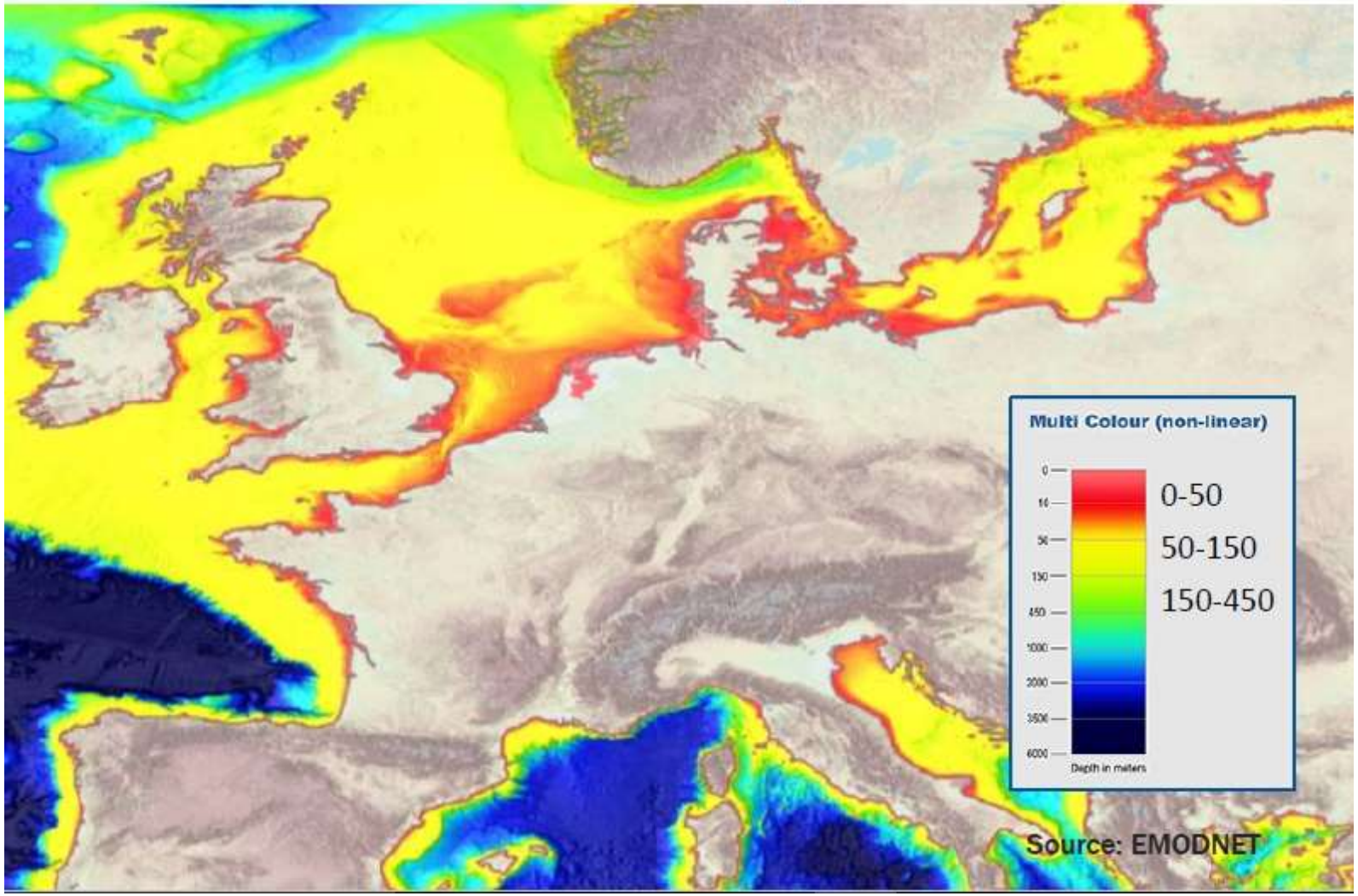
Bathymetry



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The first offshore wind farm

Project: Vindeby Offshore Wind Farm

Country: Denmark

Developer: Small local developers

Year online: 1991

Turbine Type: Bonus 450 kW

Total capacity: 5 MW

Water Depth: 2-4 m

Distance to shore: 1.5 km

Export cable: 10kV AC

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A typical project developed 10 years ago

Project: Belwind

Country: Belgium

Developer: Evelop

Year online: 2010

Turbine Type: 3-5MW

Total capacity: 150-500 MW

Water Depth: 15-30+ m

Distance to shore: 30-50 km

Export cable: 150kV AC

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A current typical project

Project: North Sea Offshore Wind Farm

Country: UK/Germany/Holland/Belgium/France

Developer: Large Utility

Year online: 2017-2022

Turbine Type: 6-10MW

Total capacity: 500+ MW

Water Depth: 30-50 m

Distance to shore: 50-100+km

Export cable: 220kV AC/ 400kV HVDC

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A future typical project

Project: North Sea/Atlantic/Asian Offshore Wind Farm

Country: UK/Germany/Holland/France/China/Taiwan/Japan

Developer: Large Utility

Year online: 2022-2030

Turbine Type: 10-20MW

Total capacity: 1GW+

Water Depth: 30-200 m

Distance to shore: 30-100+km

Export cable: 400kV AC/ 1000kV HVDC

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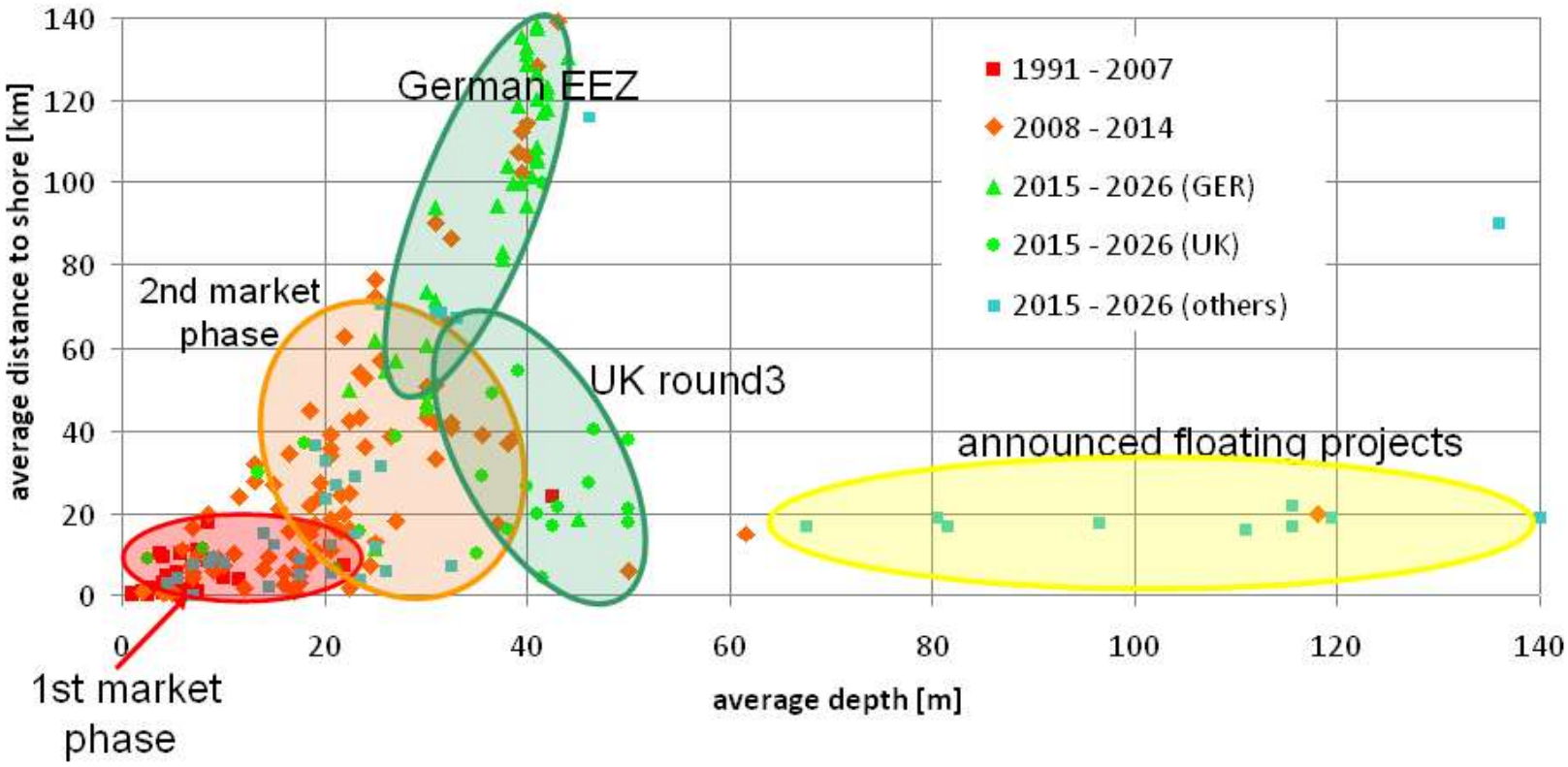
Offshore developments



Source: Fraunhofer IWES, 2011

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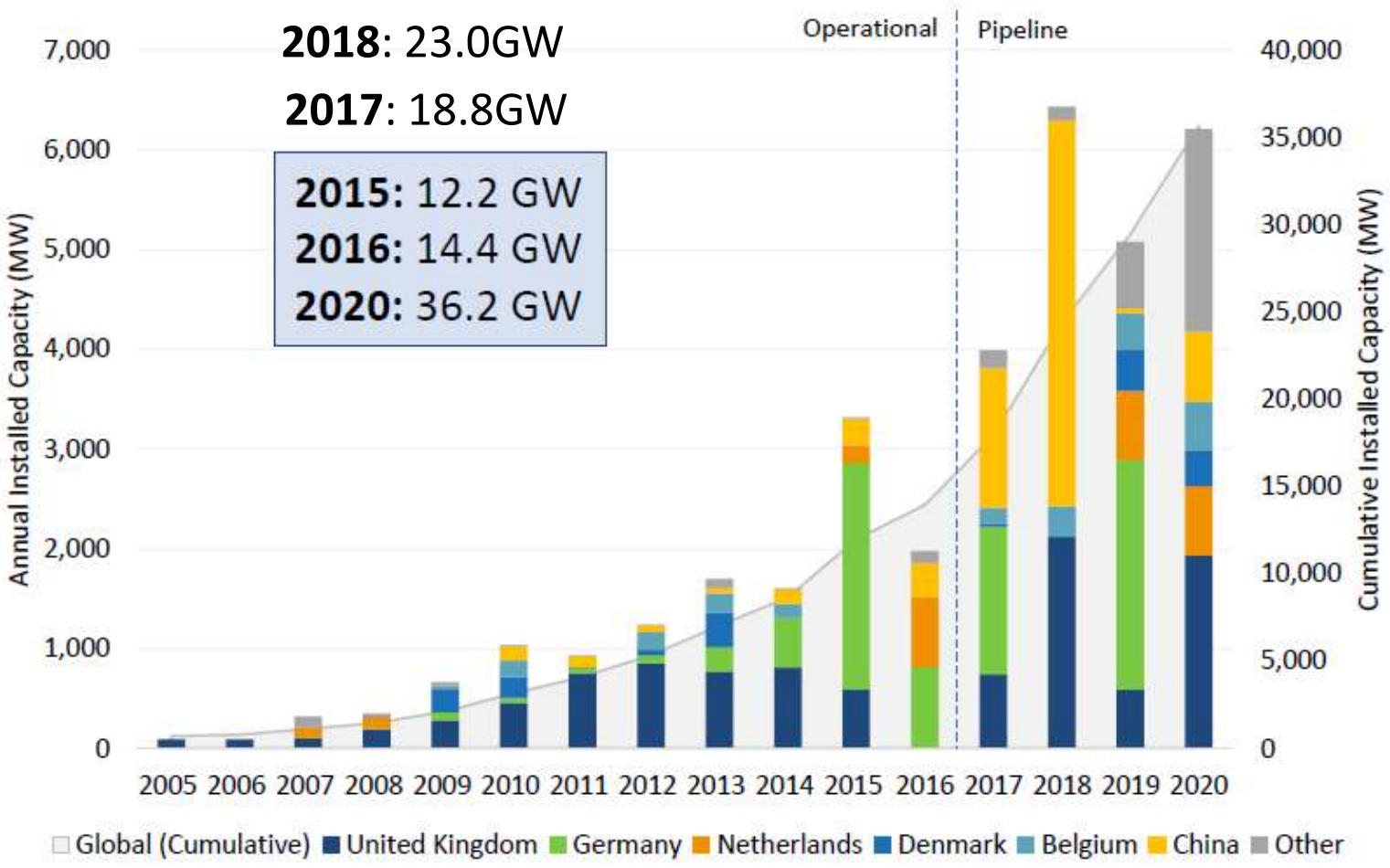
Status 2018



Source: IEA RTD, March 2017

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Floating

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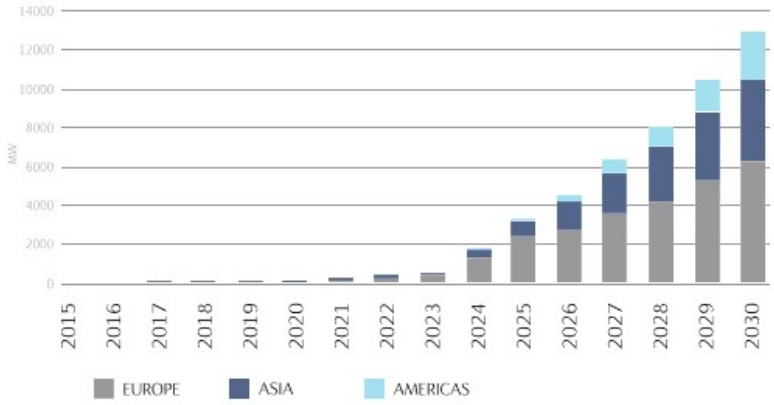
Floating

Project Name	Capacity	Country
Hywind Scotland	30 MW	Scotland
WindFloat Atlantic	30 MW	Portugal
Kincardine	48 MW	Scotland
Dounreay Tri	30 MW	Scotland
French Demonstrators	4 x 25 MW	France
Fukushima Forward III	100 MW	Japan



Source: Hywind, 2017

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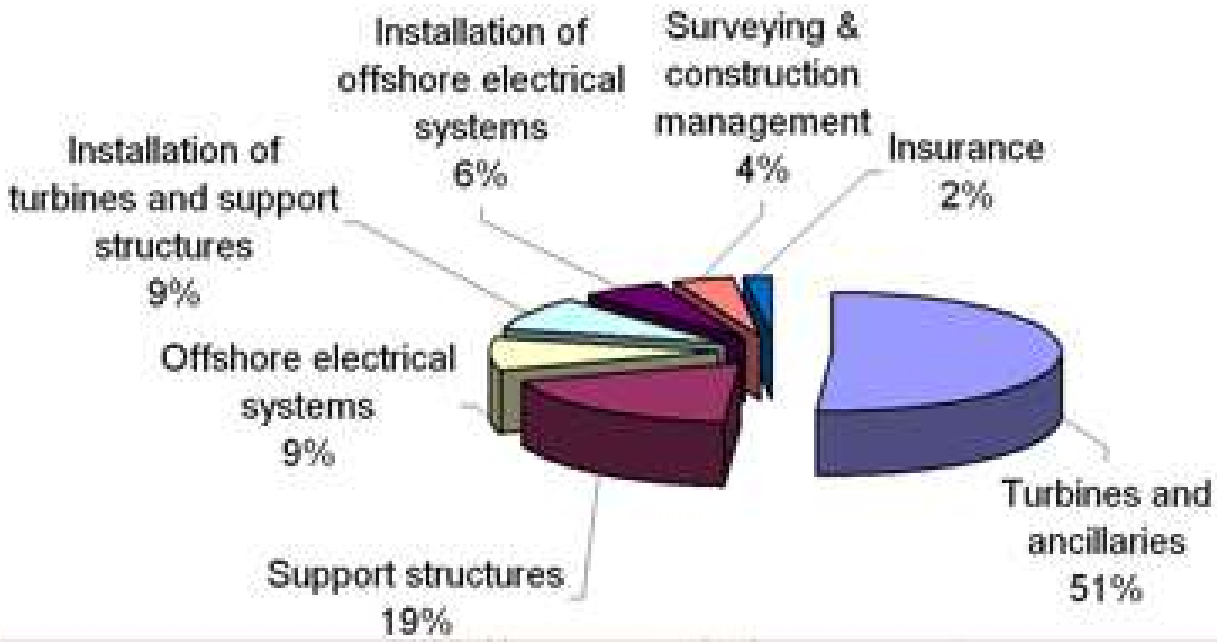
Offshore wind costs

CAPEX: EUR 3million/MW

OPEX: EUR 100k/MW



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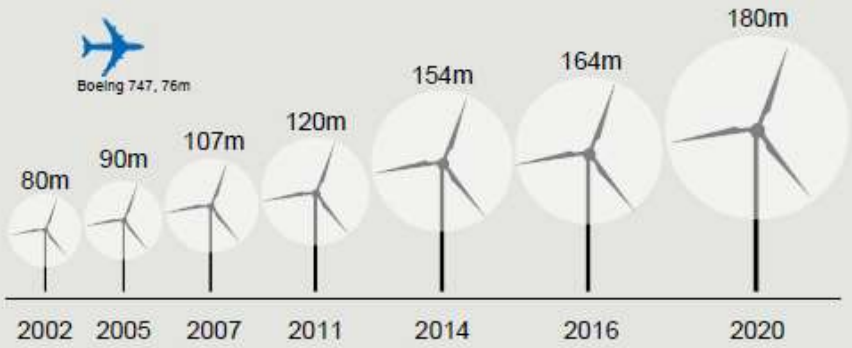
Offshore Wind costs are decreasing

Multiple levers to drive down cost in offshore wind

		Development	Impact
Scale	▪ Turbines and rotor size	6-8 MW → +10 MW	▪ Fewer positions
	▪ Sites	200-300 MW → +1 GW	▪ Greater overhead leverage ▪ Scale effects
	▪ Vessel size	2-4 wind turbines → 8 wind turbines	▪ Less transit time ▪ Higher utilisation
	▪ Cable capacity	300 MW → 400 MW	▪ Fewer substations ▪ Fewer cables
Innovation	▪ Foundation design	Monopile → Suction bucket jackets	▪ Greater water depth and heavier loads possible ▪ Faster installation time
	▪ Electrical	AC → 2nd generation HVDC[1]	▪ Longer distance to shore ▪ Less grid loss
Industrialisation	▪ Supply base	Single supply → Multiple global suppliers and purpose built factories	▪ Broader and more robust supply base ▪ Low-cost country sourcing ▪ Efficient production

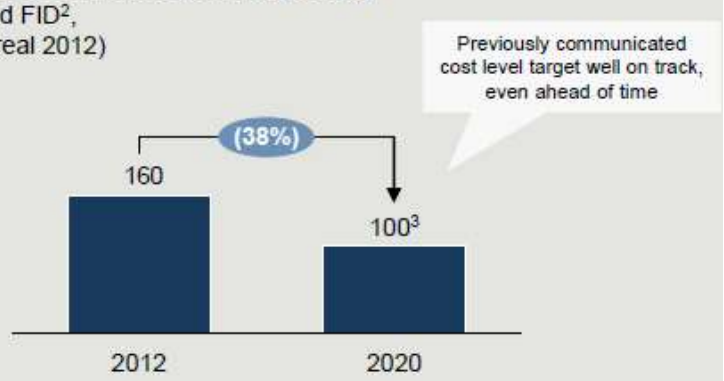
Rapid technological development

Wind turbine rotor diameter, year of commissioning



Significant cost reduction trajectory

Offshore wind FID[2], EUR/MWh (real 2012)



Source: DONG (Orsted), 2016

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Offshore Wind LCOE

- Weighted average global LCOE for 2017 commissioned projects:

  EUR 120/MWh

- Weighted average global LCOE for projects to be commissioned in 2020 and beyond:

  EUR 50-83/MWh

Source: IRENA, 2018

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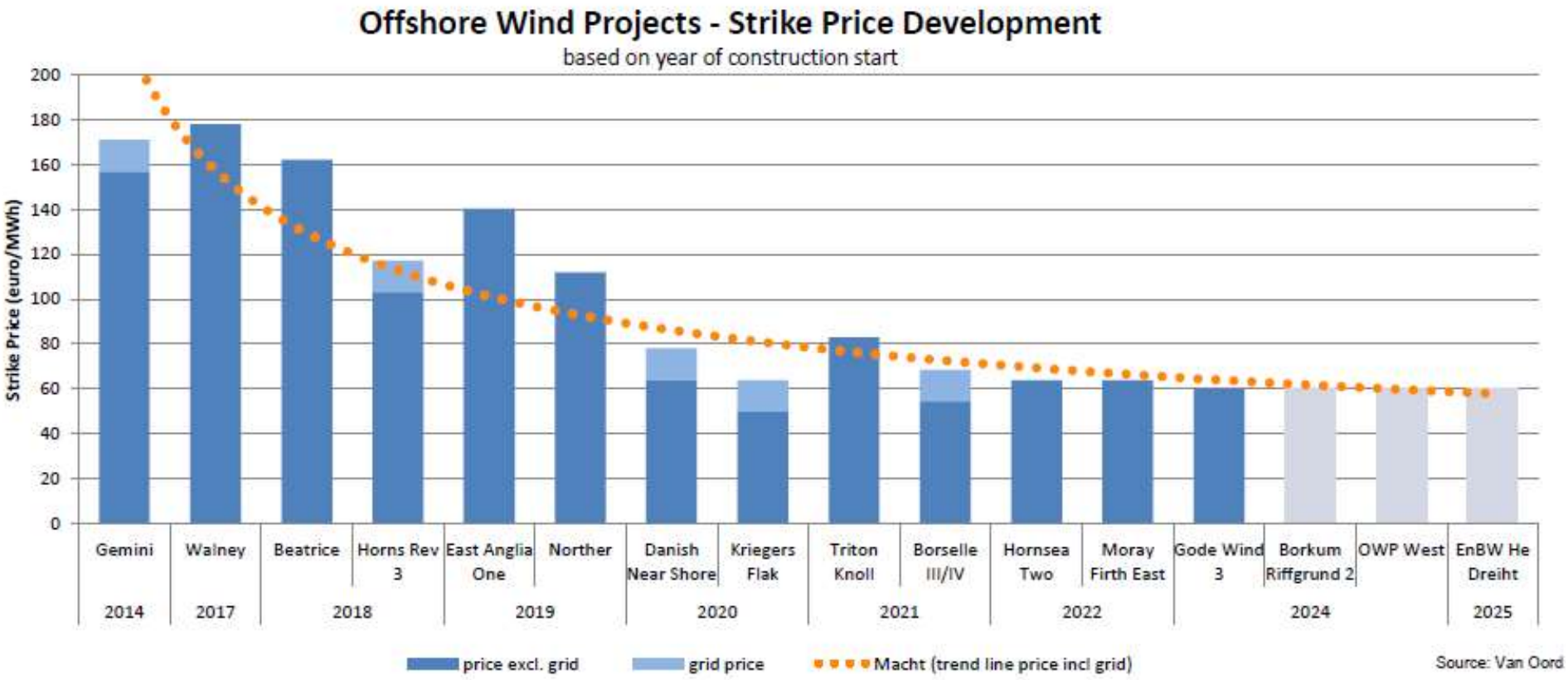
Offshore Wind costs are decreasing



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What about Greece?

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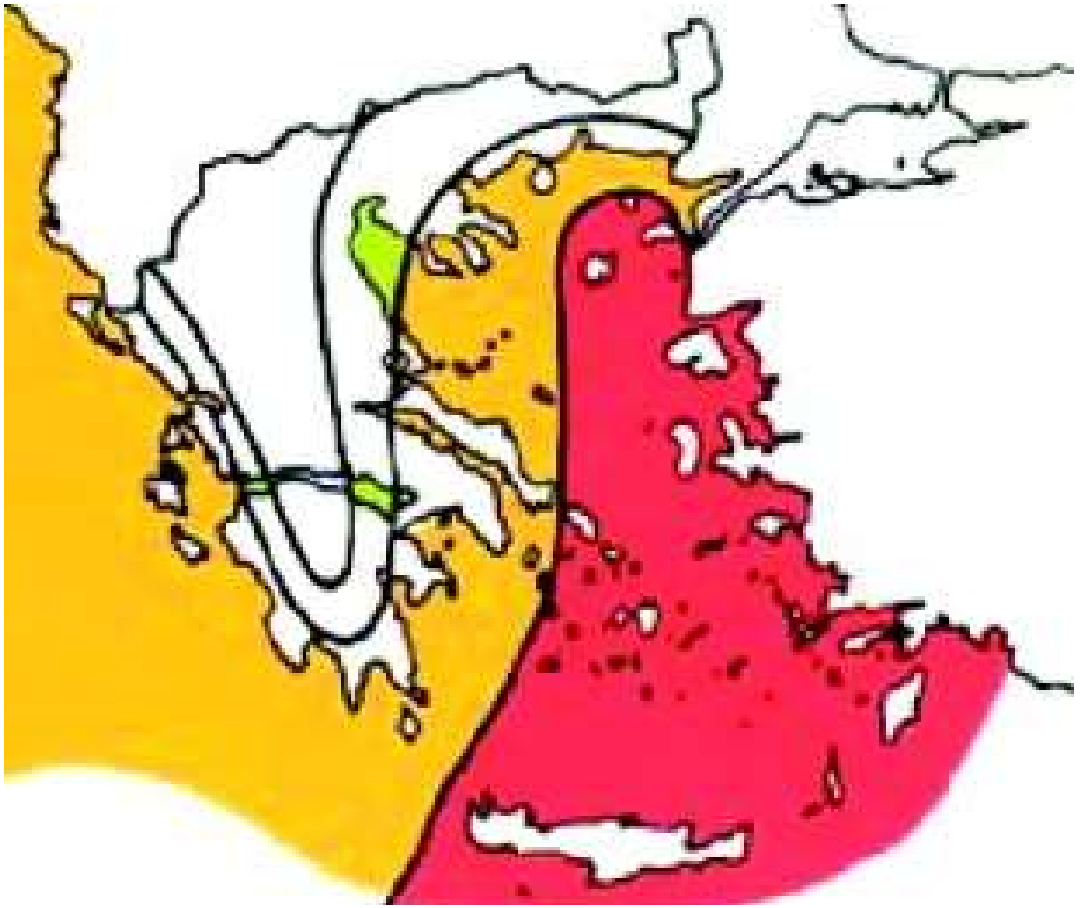
Wind Resource



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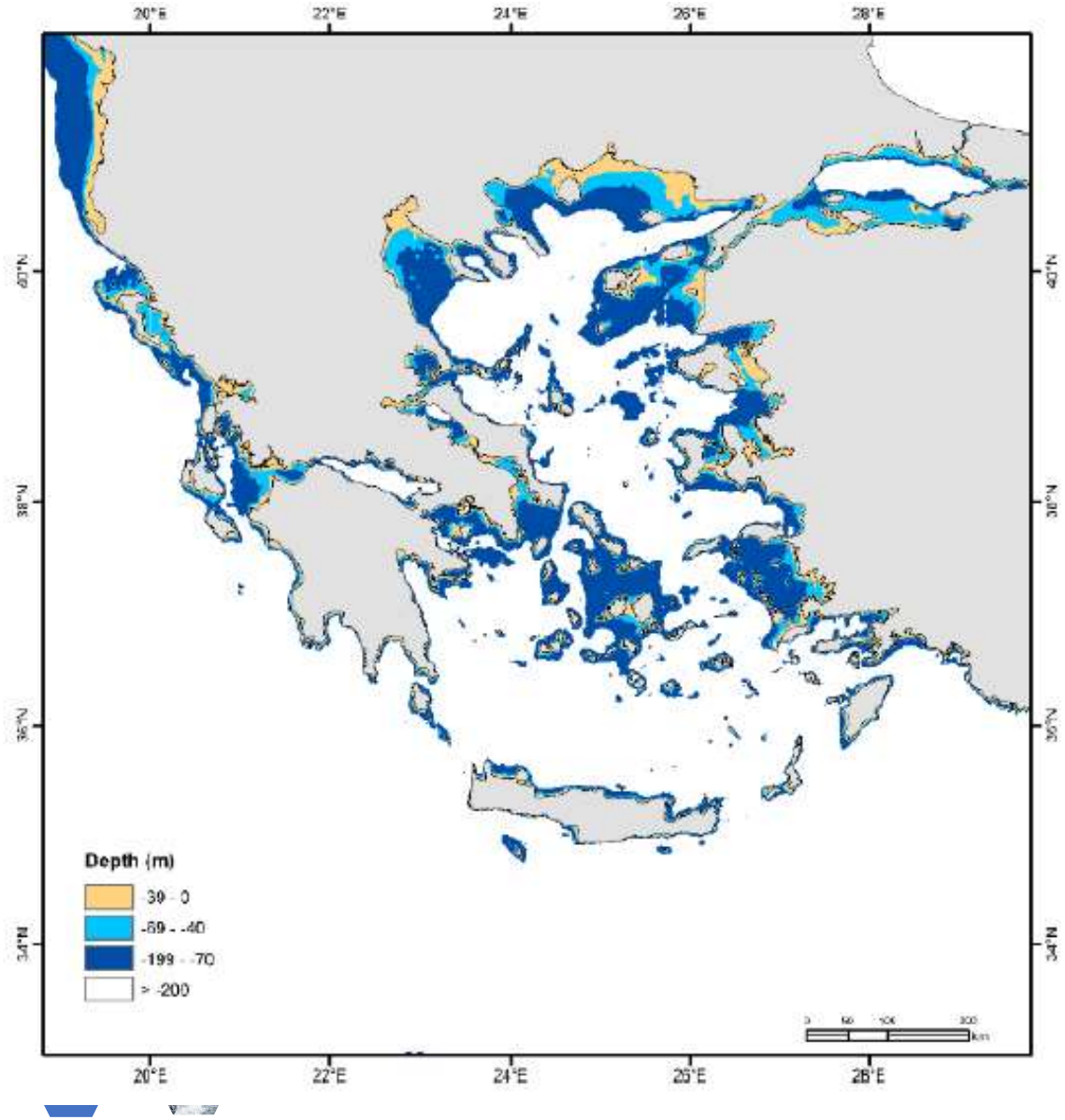
Bathymetry



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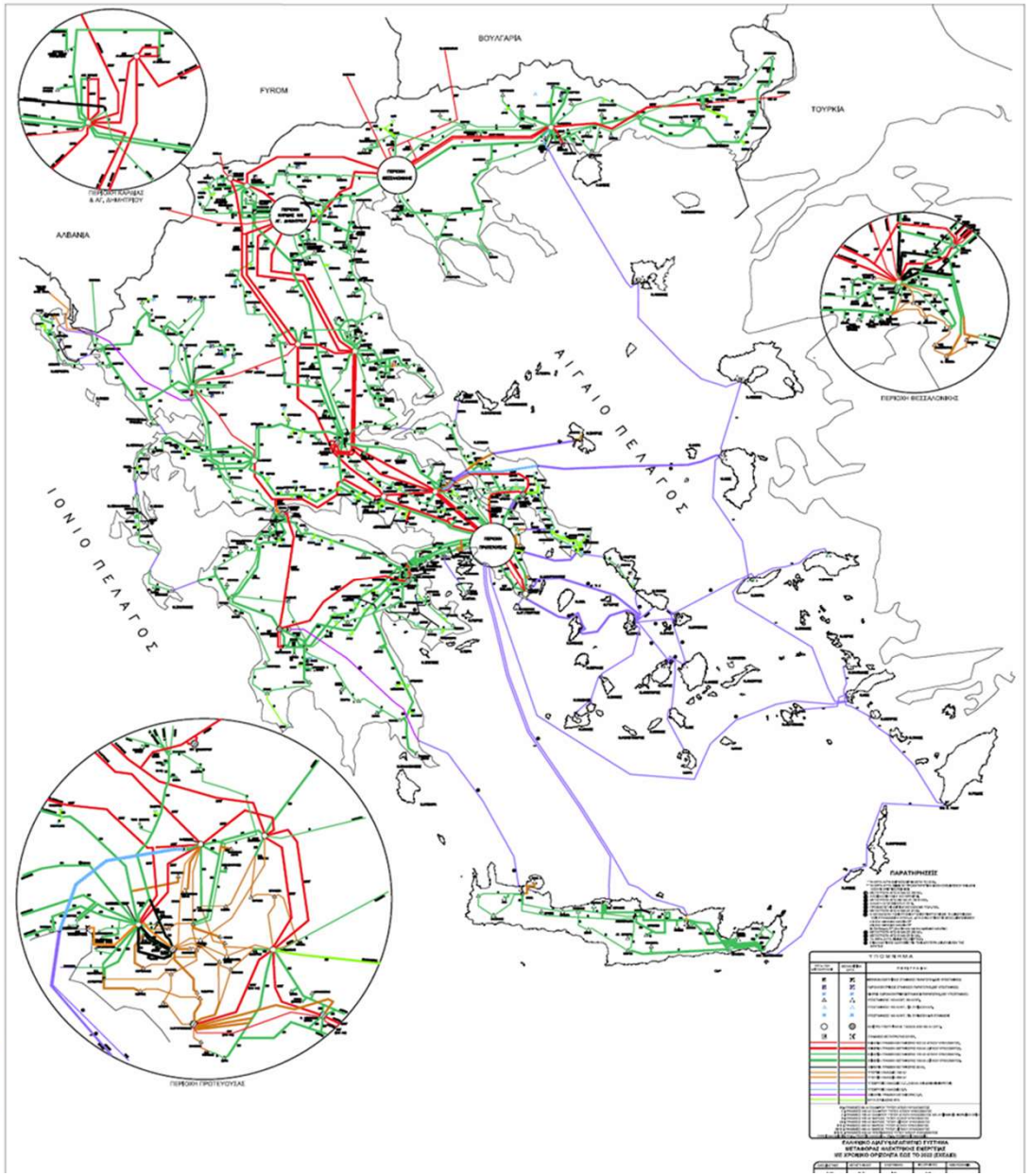
Grid connection



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40 years of wind experience in one picture

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