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Wind power project II

- Wind Farm Financing, Contracting & Construction
- Briefly about offshore wind

Aalto University,
Advanced Wind Power Technology

ESA HOLTTINEN, 14.10.2022

Content

Part I 7.10.2022

1. Wind resource estimation
2. Wind project development

Part II 14.10.2022

1. Project economy, financing and contracting
2. Building of a wind farm
3. Briefly about offshore wind

Main focus on the ONSHORE wind projects

Some Useful Abbreviations (1/2)

AEP	Annual Energy Production
BOP	Balance of Plant (= "Everything other than the actual wind turbines")
CAPEX	Capital Expense (the cost to develop, finance and construct the plant/project)
CDD	Commercial Due Diligence
CF	Capacity Factor
CFD	Computational Fluid Dynamics
COD	Commercial Operation Date
DEVEX	Development Expense (the cost to develop the plant/project prior to construction)
DFIG	Double-fed Induction Generator (a commonly used generator type in wind turbines)
EDD	Environmental Due Diligence
EIA	Environmental Impact Assessment
EPC	Engineering, Procurement and Construction
EYA	Energy Yield Asssessment (= study to estimate the AEP)
FID	Final Investment Desicion
FS	Feasibility Study
HSE	Health, Safety and Environment
LCOE	Levelized Cost of Energy
LiDAR	Light Detection and Ranging (a method to measure e.g. wind speed based on laser scanning technology)
LLC	Land Lease Contract (agreement on the rights to use the land area for construction and operating of the plant)

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Some Useful Abbreviations (2/2)

NTP	Notice to Proceed
O&M	Operation and Maintenance
OPEX	Operating expense (the cost to operate the plant/project after construction)
P50	AEP level that will be exceeded with 50% probability (likewise e.g. P75, P90, P95)
PMG	Permanent Magnet Generator (a commonly used generator type in wind turbines)
PPA	Power Purchase Agreement
PCC	Point of Common Coupling (point in the public transmission grid where the project is connecting to)
PFS	Pre-Feasibility Study
PPA	Power Purchase Agreement
SAA	Service and Availability Agreement
SCADA	Supervisory Control and Data Acquisition (remote monitoring and control system of the plant)
SCOD	Scheduled Commercial Operation Date
SoDAR	Sound Detection and Ranging (a method to measure e.g. wind speed based on sound scanning technology)
TA	Technical Advisor
TDD	Technical Due Diligence
TSA	Turbine Supply Agreement
WTG	Wind Turbine Generator (= "the actual wind turbine" consisting of rotor, nacelle and tower)

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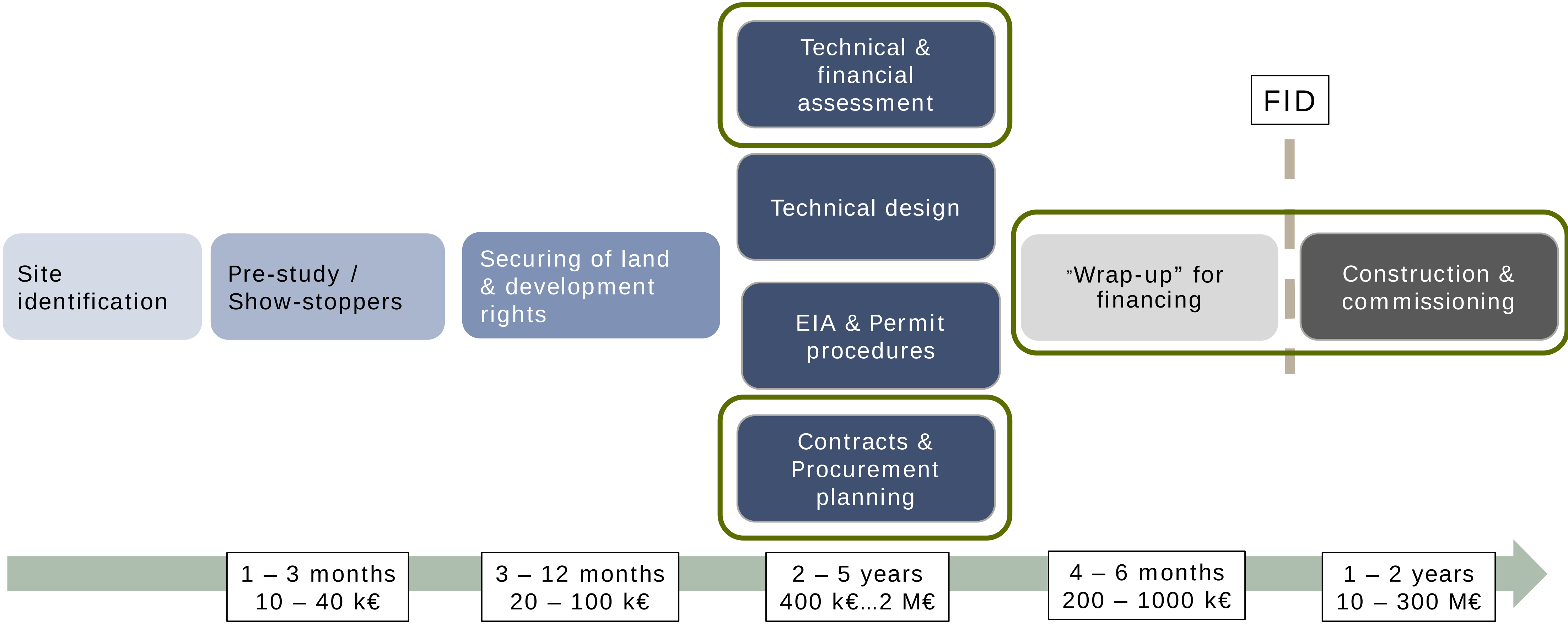
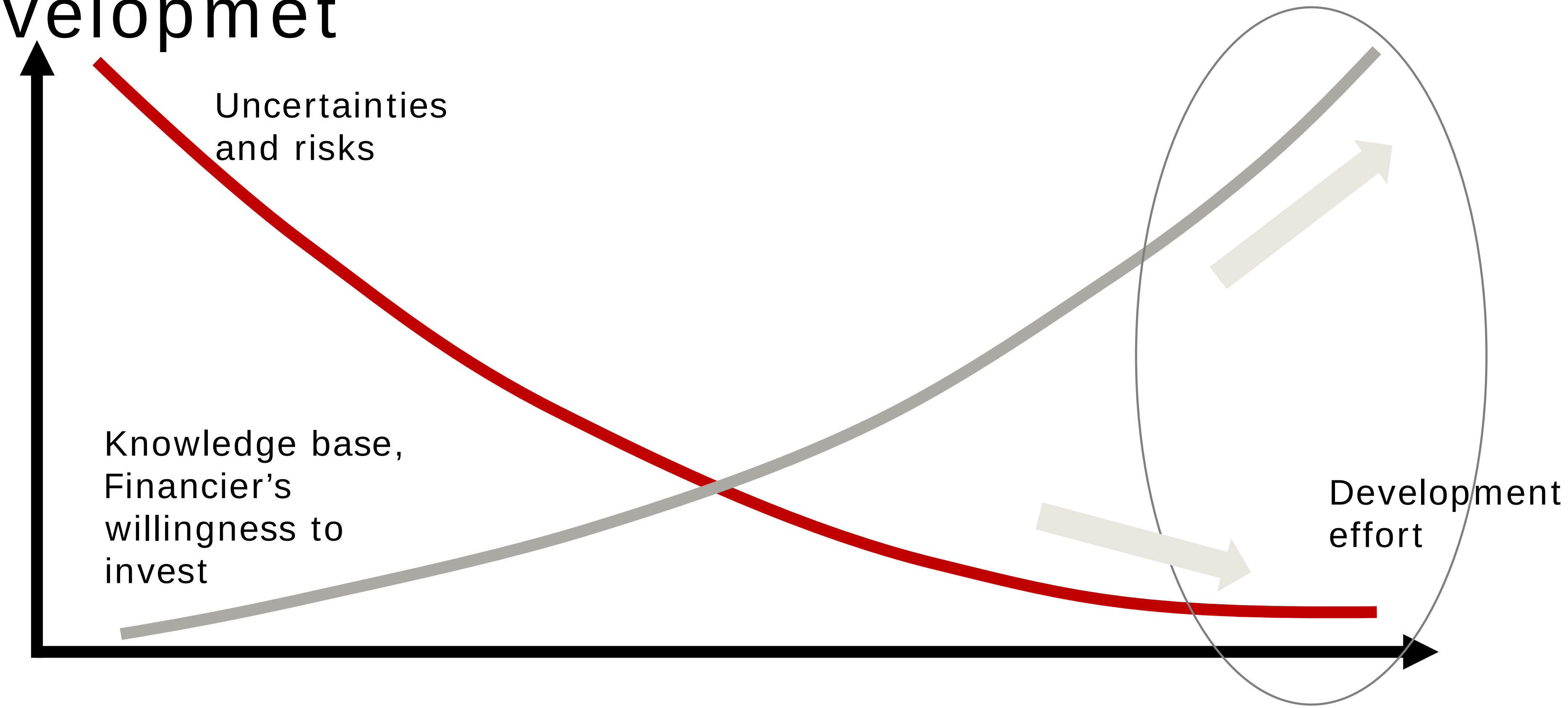
Topics for this time:



Reminder: the Golden Rule of project developmet



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Cost structure of a wind farm

- Capital expenditure (CAPEX): Project development, construction, turbine purchase, grid connection, project management, financing cost…
  - Turbines typically from 2/3 to 3/4 of the total CAPEX, civil works and electrical works in the range of 10…15% each
  - In developed markets, total CAPEX currently in the range of 1.0…1.4 M€/MW, decreasing rapidly
  - NOTE: In emerging markets, the total CAPEX can still be close to 2 M€/MW
- Operating expenditure (OPEX): Wind farm management, maintenance and repairs, insurances, land lease, grid fees,…
  - OPEX typically around 10…15 €/MWh, also decreasing rapidly due to improving production and increasing turbine sizes
- Total LCOE (levelized cost of energy) = total CAPEX + OPEX for wind farms built with latest technology varies from <30 to ca. 50 €/MWh
  - One of the cheapest means of producing electricity (when new investments are compared)
  - Highly location-specific, however
- Early stage in any new market is always more expensive – it takes several years / 1…2 GW to create a functioning market with efficient supply chains, fully commercial financing terms etc.

Financing of a wind farm investment

- Project finance vs. Balance sheet finance

- Project finance: Each project has to be self-standing
- Equity finance:
  - A separate company (”SPV” = Special Purpose Vehicle) established for each project, owners provide equity for the project company
  - Equity share typically 20%...30% of the total CAPEX
- Debt finance:
  - Wind turbines and other assets and rights owned by project company are used as loan security
  - Other assets owned by equity investors are not used as securities for bank loans
  - The bank will take over the assets if project company is unable to pay back loans
- ”Due Diligence”
  - Production estimates and other studies + existing permits and contracts are critically reviewed by the banks (”Due Diligence”), and the SPV will pay for the review!
    - If banks foresee risks and uncertainties in the project, the share of debt will be lower, payback time shorter and interest margin higher -> higher financing cost, lower profit for equity investors
    - Project development needs to be highly professional to make the project ”bankable”
- Upsides of project finance:
  - The project is self-standing; (shares of) project company are easy to sell, and investors’ other assets are not affected in case of problems in one project
  - Works for investors of varying sizes, no ”broad shoulders” required

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Financing of a wind farm investment

- Project finance vs. Balance sheet finance

- Balance sheet finance
- Equity finance:
  - Typically no separate companies (SPVs) for individual projects
  - Owners provide equity directly for the project (usually less equity is required compared to project finance)
- Debt finance:
  - Other assets owned by investors are used as securities for bank loans
  - Wind turbines and other assets and rights owned by the project may or may not be used as (additional) loan security
- ”Due Diligence”
  - Production estimates and other studies + existing permits and contracts not as critically reviewed by the banks
    - The banks will basically always get their money back (unless the equity investors go bankrupt)
    - The equity investors manage their risks by investing in a number of projects
- Downsides of balance sheet finance:
  - The project is not self-standing; the project is not easy to sell, investors’ other assets are affected in case of problems in one project
  - This financing option only works for companies with big balance sheet

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Making a project "bankable"

- Debt/equity ratio, DSCR and ROE

- Debt/equity ratio:
  - Share of debt finance vs. share of equity finance of the total CAPEX
  - Equity provider aims in maximizing the share of debt

- DSCR (Debt Service Coverage Ratio)
  - The project's total (average) annual net income divided by the total (average) annual loan repayment & interest
  - If DSCR = 1, there's no margin to cover lower-than-average revenue (e.g. due to a bad wind year) or higher-than-average costs (e.g. due to high repair cost)
  - Banks typically require DSCR of minimum 1.3 to make sure they will get their money back.
  - DSCR therefore sets the upper limit for share of debt finance

- ROE = Return on Equity
  - Measure of financial performance calculated by dividing (annual) net profit by total amount of equity
  - The higher the debt/equity ratio, the higher the ROE (from the same profit)
  - ROE expectation varies depending on e.g. the risk appetite of investors and maturity of the market (uncertain investment => higher ROE expectation)
  - Balance sheet investors can often accept lower ROE than project finance investors
  - E.g. pension funds look for long term, low but secure ROE, whereas e.g. Venture Capital funds look for quick payback time but accept higher risk level

$$\text{DSCR} = \frac{\text{Net Operating Income}}{\text{Total Debt Service}}$$

where:

Net Operating Income = Revenue − COE

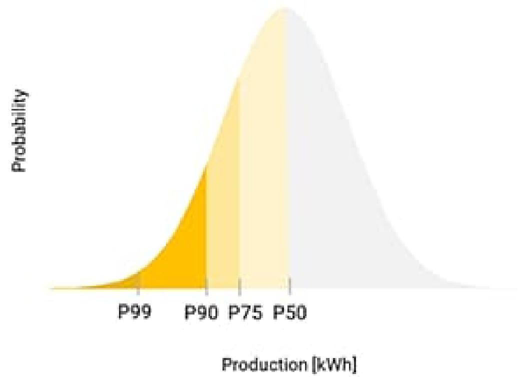
COE = Certain operating expenses

Total Debt Service = Current debt obligations

$$\text{ROE} = \frac{\text{Net Income}}{\text{Shareholder's Equity}}$$

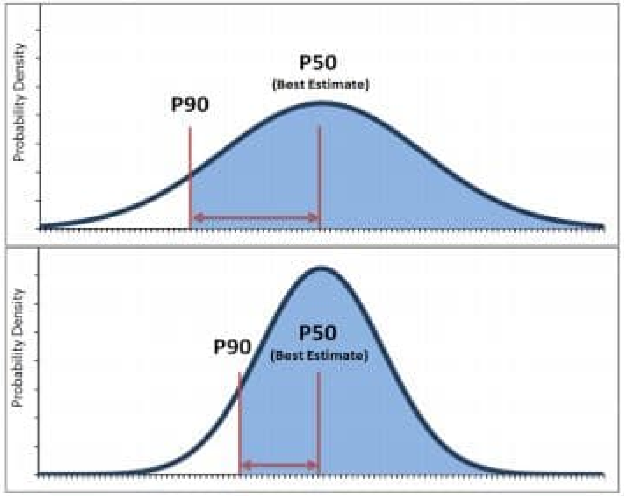
Reminder: Energy Yield Assessment (EYA)

- Combining of wind speed statistics, terrain and topography data, turbine location coordinates, and the wind turbine characteristics
  - Utilizing verified software tools (WasP, WindPro, Numerola CFD tool, etc.)
  - Result: estimated gross production (MWh/a) for each turbine location on an ”average wind year”
- From estimated gross production to estimated net production:
  - Taking into account the various losses (wake losses from other turbines, electrical losses, unavailability losses,…)
  - And uncertainties!
- Probability of exceeding a certain production level:
  - Production estimate is not a single MWh-figure, it’s a probability distribution!
  - P50 – ”50% chance that the production is at least this much”
  - P90 – ”90% chance that the production is at least this much”



Reminder: Energy Yield Assessment (EYA)

- If there are lots of uncertainties in your measurements (due to bad location, poor quality equipment, gaps in data, bad documentation, short measurement period…) or in the data handling and modelling…
  - …There will be a huge difference between P50 and P90
  - And the financiers are typically more concernced of P75 and P90 than of P50 !



Two identical sites with identical P50 production estimate…

- One with "bad EYA"
- Another with "good EYA"

… have very different P90 values…

One gets financed, while the other perhaps not!

A lower P90 & P75 will mean a lower DSCR, leading to a lower debt/equity ratio...and a lower ROE!

Identical projects in terms of average wind speed and cost structure may result in very different profitability depending just on the quality of their wind assessment!

- Conclusion: No matter how windy the location is, the wind resource still needs to be properly verified!

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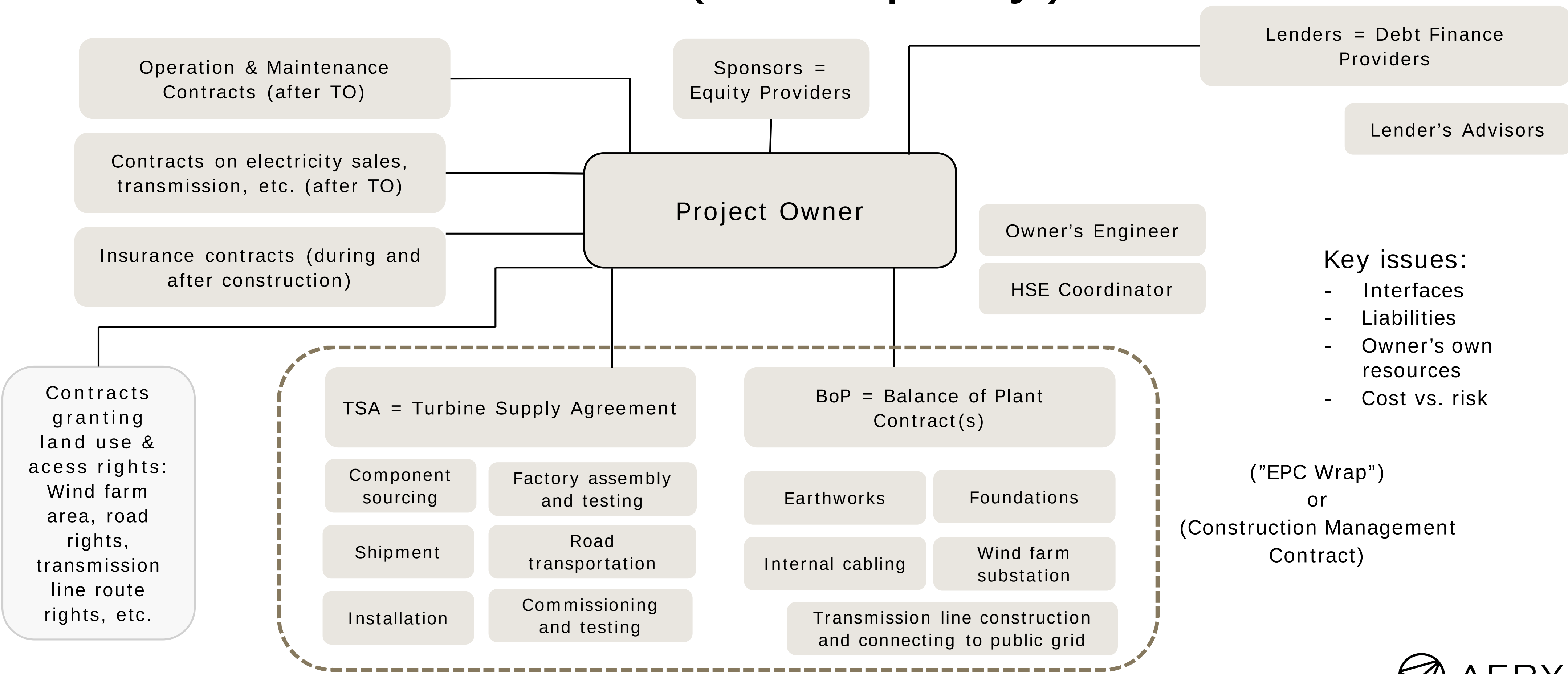
Reminder: What is needed to reach the Financial Close

— Technical planning:
  – Detailed wind resource assessment based on high quality measurement data and for the chosen wind turbine type
  – Detailed engineering design for civil and electrical works incl. soil investigations for the chosen wind turbine type

— Permitting:
  – Acquiring final building permits for the chosen turbine type and detailed siting plan (based on the detailed engineering design)
  – Acquiring environmental permits & other permits & licenses (if required)

— Contracting:
  – Turbine acquisition contract ready to be signed
  – Construction and grid connection contracts ready to be signed
  – Financing contracts: Equity & debt finance, sales and transmission of electricity, balancing of production / hedging of market price risks, etc. ready to be signed
  – Service and management contracts for the operation of wind farm ready to be signed
  – Insurance contracts for construction and operation ready to be signed

Contract structure (exemplary)



Key issues:
- Interfaces
- Liabilities
- Owner's own resources
- Cost vs. risk

Contracting a project

- How to structure it?

- Project Owner’s internal resources and capabilities:
  - Big, resourceful and skillful Project Owners can manage complex structures and accept higher risk exposure
  - Smaller players look for simple structures, with more risk shouldered to contractors
  - Split structure results in lower total CAPEX, because the owner takes bigger share of risks
  - Single Point EPC is the lowest-risk solution but has the highest total price

- Financing structure:
  - Project Finance may require a simple contract structure to reduce the risk exposure of the SPV
  - Balance Sheet financiers can accept higher risk exposure and are more eager to keep the CAPEX level low

- Market maturity:
  - New, emerging markets: lack of local experienced subcontractors with good track record and understanding of special requirements for wind projects
  - Big, international EPC contractor required to shoulder the risk and take overall responsibility
  - Experienced Turbine Suppliers can act as EPC contractors in emerging markets (if the market is perceived as promising!)
  - When the market becomes more mature, the contract structures tend to become more complex, as the investors start trusting the local contractors and get more experience with local special circumstances
  - Turn-key, single point EPC contracts are rare in mature markets, whereas they are more a rule than an exception in first projects in a new market

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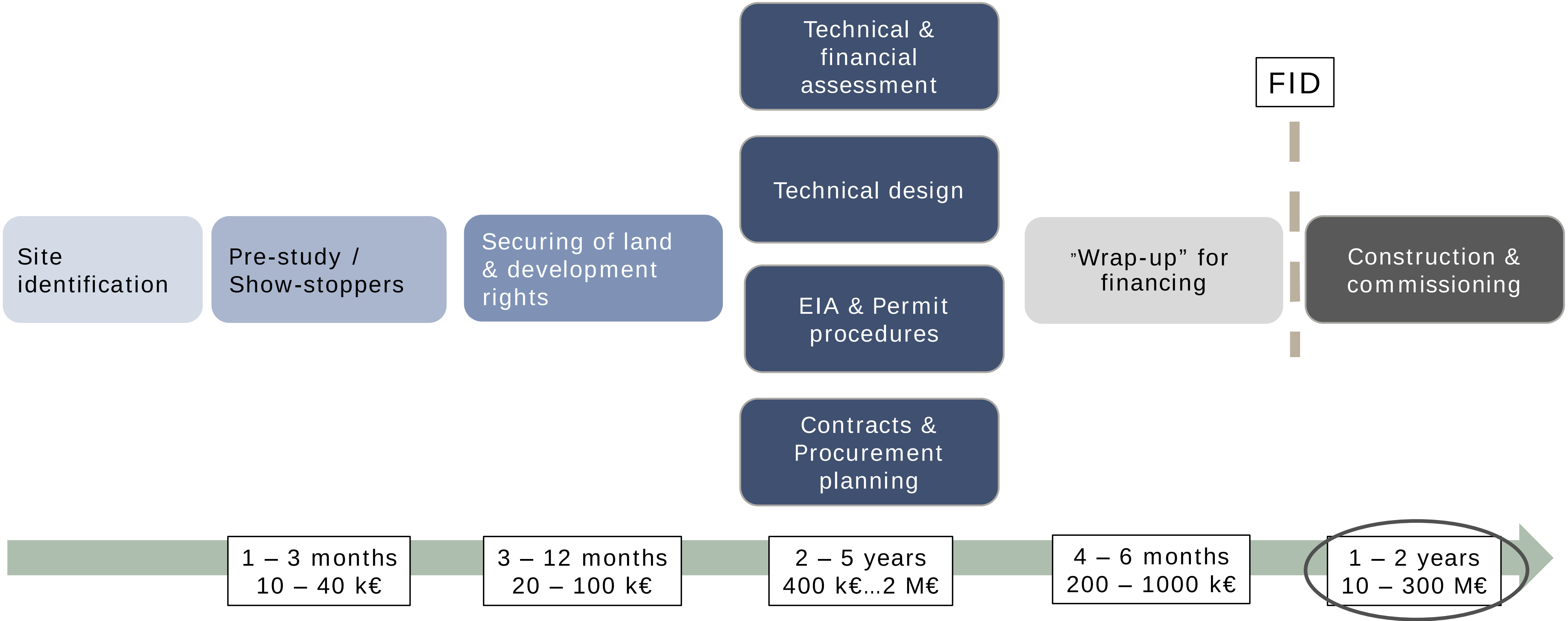
Point of No Return: Final Investment Decision



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BUILDING OF A WIND FARM

Constructing a wind farm

- Roads and assembly areas
- Foundations
- Cabling
- Substation and HV line
- Turbine installation
- Commmissioning

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BUILDING OF A WIND FARM

...And outside of the wind farm

- Accessibility via public roads

<u>Transportation study</u> should be done well ahead prior to start of construction!

Roads and assembly areas

Authority requirements:
Junction to public road…

Info sign at the entrance of construction site…

Road construction

- Bearing capacity
- Curve bending radius
- Maximum slope, bumps
- Free space on both sides
- Blasting through bedrock may be needed to fulfill the requirements above
- Weather resistance!
- Drainage / ditches!

Assembly areas

- Bearing capacity
- Max inclination / uniformity
- Space requirements for manouvering of cranes, trucks, large components
- Weather resistance
- Drainage / ditches

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BUILDING OF A WIND FARM

Foundations

- Pit excavation
- Blasting of bedrock
- Piling for soft soils
- Levelling and compacting
- Pouring of blinding layer
- (Earthquake resistance in some regions)

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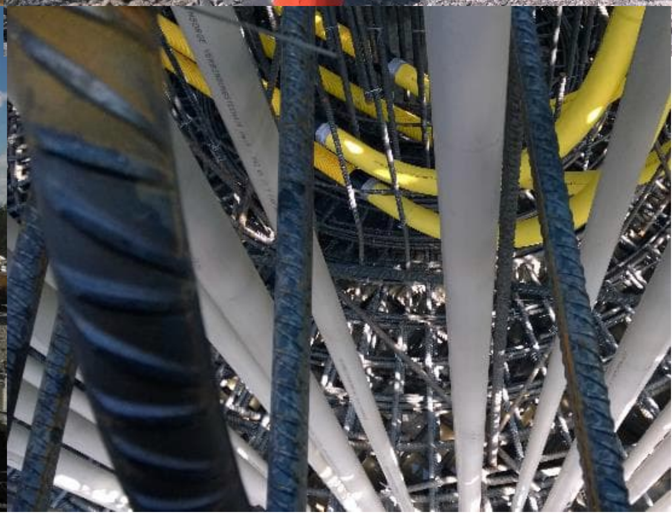
BUILDING OF A WIND FARM

Foundations



- Anchor cage
- Steel reinforcement
- Moulding
- Earthing
- Start of casting

BUILDING OF A WIND FARM

Foundations

Continous, uniform casting
”on one go”, sometimes
through the night
(bring your own sausages...)

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Foundations

- Sample tests / quality control
- Controlled heat transfer
- Several weeks' drying time
- Backfill with rock material
- Levelling and compacting prior to turbine installation
- Inspections and documentation prior to casting and backfill!

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Internal cabling

- Mostly along the internal roads
- Sometimes shortcuts necessary to avoid high costs
- Spacing between cables to avoid overheating
- Heat transfer control by applying specific filling materials
- Protection against mechanical damage
- Inspection and documentation prior to covering!

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Foundations and cabling - Interfaces

- Cable conduits through foundations
- Earthing rings around foundations
- Measuring of conductivity and resistance

BUILDING OF A WIND FARM

Overheadline and substation

- Basically standard solutions can be applied, not that many ”wind-specific” issues to be considered
- Interfaces and timing!

BUILDING OF A WIND FARM

Turbine installation

- Lifting of tower sections
- Cleaning, repair of scratches
- Grouting and bolt tightening

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Turbine installation

- Lifting of nacelle and drive train
- Rotor assembly and lifting
- Weather constraints!

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Turbine installation

- Internal fittings: lift & ladders, lights, connections,…
- Final inspections prior to test runs

Testing, Commissioning & Taking Over

- Going through checklists
- Checking of alarms
- Walkdowns & punch lists
- Continuous test runs (usually 120 to 240 hours per turbine)
- Signing of Taking Over documents

Things to consider in construction planning

- Weather statistics & extreme weather events
  - Heavy rain, flooding
  - High wind speeds
  - Extreme temperatures (high / low)
  - Snowfall, icing, thunder & lightning,…
- Different construction stages have very different weather requirements / limitations
  - But in many cases, there are parallel stages of construction ongoing at different parts of the project site
- Several contractors working on site at the same time (e.g. turbine supplier, civil contractor, electrical contractor)
  - All trying to find excuses for their own delays, accusing the weather and/or pointing fingers at each other...
  - Managing site activities: keep records (on weather, on ongoing activities of each contractor,…)
  - BUT: don't interfere in issues that are part of contractors' liability!
- HSE management
  - Occupational safety matters
  - COVID-19 was an "interesting" learning experience...

How to succeed in project development, financing and construction?

- Invest in right things at the right time
- Make sure the interplay between technical, environmental and contractual work functions at all times; planning a project is an iterative process
- Do your homework properly; no shortcuts, no loose ends
  - Shortcuts in environmental studies or communication may cost you years in court!
  - Poor quality of wind measurements and assesments may kill the project profitablity
  - Due Diligence and Financial Closing are ”the ultimate acid test” for your project
- Site management, supervision and documentation during construction!
  - Managing of weather risks & other unpleasant surprises – Plan B (and C!)
  - Smooth running of parallel & overlapping activities in different parts of site by different companies – coordination and interface management!
- Report to your financiers and external stakeholders openly and without delay

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Content

BRIEFLY ABOUT OFFSHORE WIND

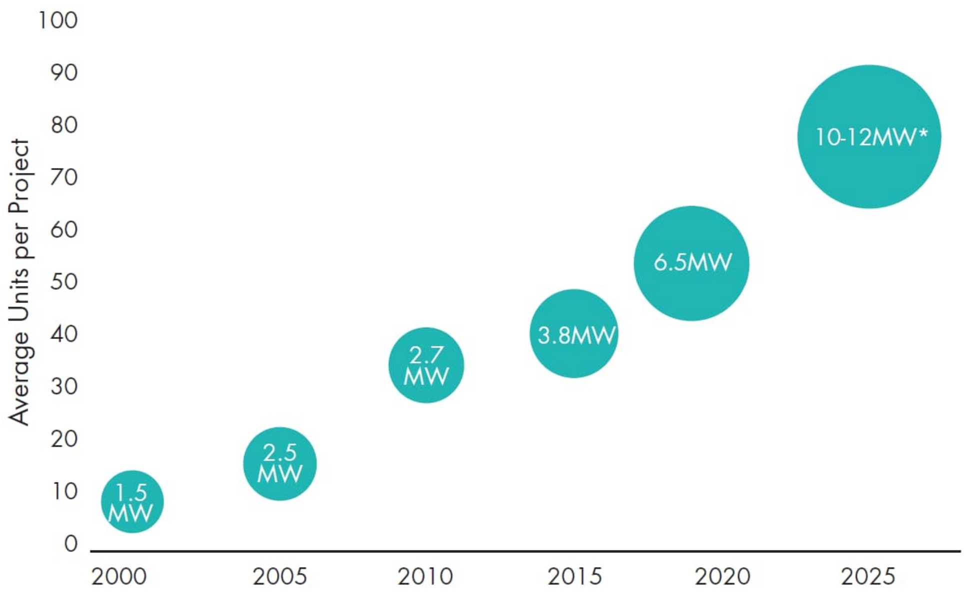
- How is offshore wind different from onshore
- Specific issues for offshore wind
- Specific competence required for offshore project development
- Offshore players vs. onshore players

How is offshore wind different from onshore

- Challenging conditions for construction and operation
    - Much higher CAPEX and OPEX level per MW
    - Therefore, huge project size required to achieve economy of scale
    - Maximizing of turbine size also helps to reduce both CAPEX and OPEX per MW

- Projects planned to be constructed by ~2025:
    - Up to ~15 MW turbine size
    - (~3 to ~6 MW in onshore projects)
    - Typical project size ~1GW or more
    - (30 to 600 MW in onshore projects)

Evolution of Offshore wind turbine and project size



* Expected average turbine size in markets outside China where average size is likely to be 7-8 MW
Source: GWEC Market Intelligence, June 2020

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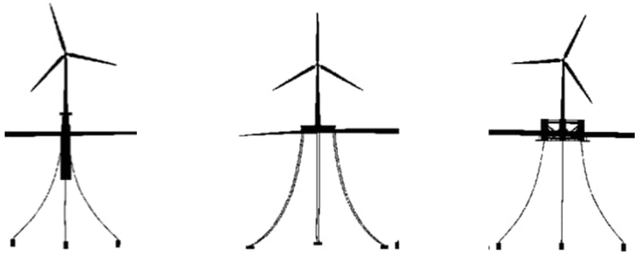
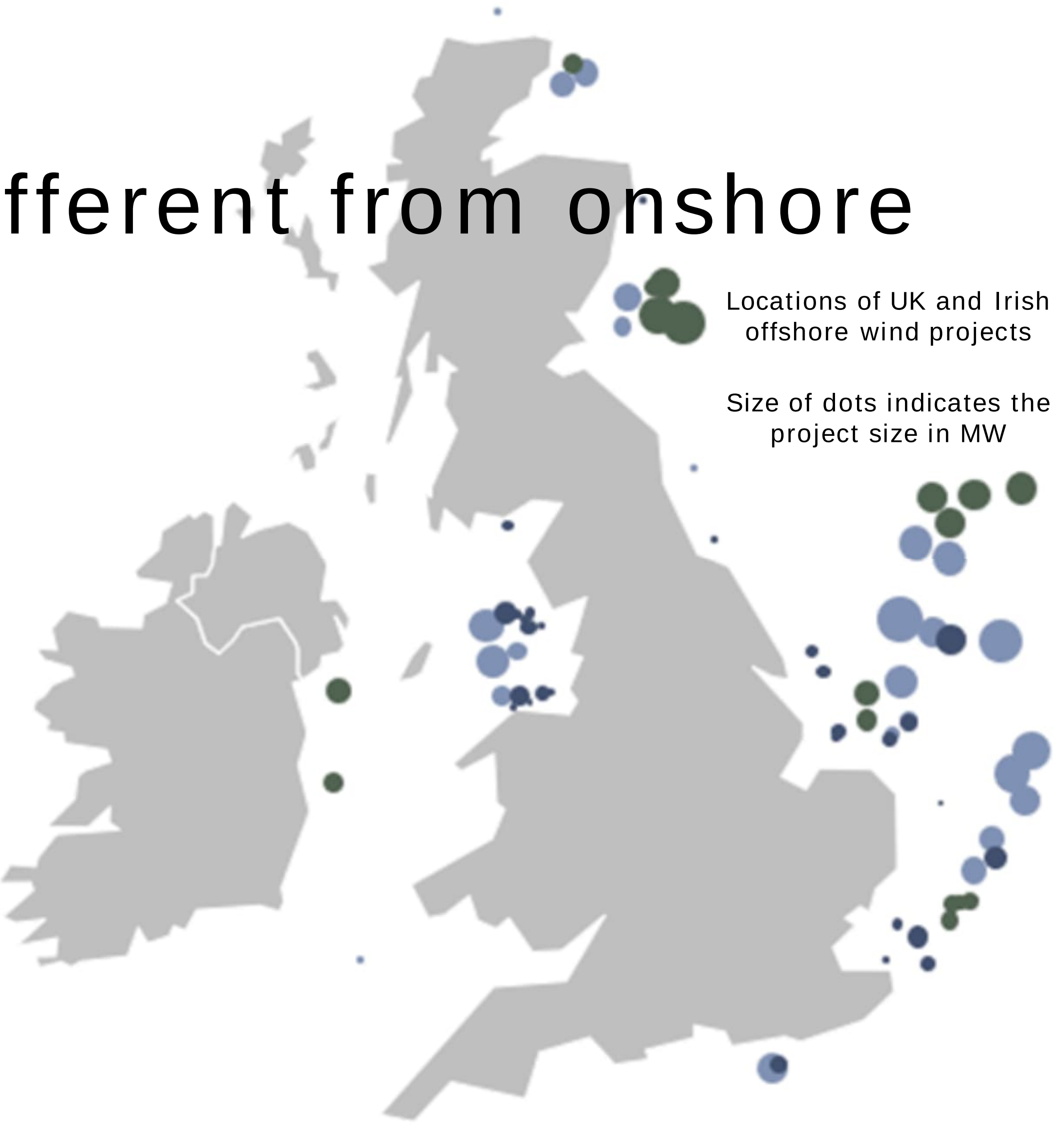
How is offshore wind different from onshore

- Site locations typically 10...150 km from coastline
- Water depth typically 15...45 m for bottom-fixed (”traditional” offshore wind technology
- Floating offshore wind: water depth 50...1000 m



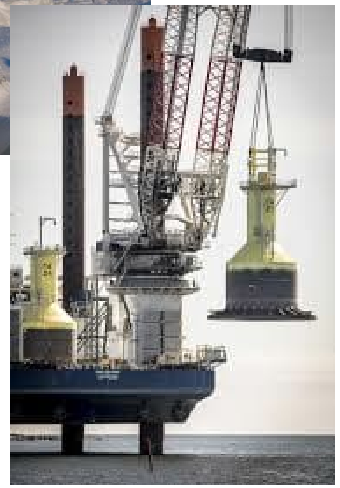


Locations of UK and Irish offshore wind projects

Size of dots indicates the project size in MW

Specific issues for offshore wind

- Underwater geotechnics
- Marine conditions:
  - Waves, sea currents, corroding environment,…
  - Wind-wave interaction & load combinations
  - Ice-infested waters at northern latitudes
- Offshore logistics (construction & maintenance):
  - Handling of big loads at unstable conditions
  - Weather windows; accessibility / waiting times
  - Long distances
  - Complex construction sequence and supply chains
  - Special HSEQ requirements
- Grid connection (and grid impacts) of huge projects
  - Sea cables
  - High voltage levels (HVDC or HVAC) and power levels
  - Offshore substation: design, construction, maintenance
  - Project size vs. design criteria for power systems ("N-1")
- Special environmental considerations:
  - Impacts on fish & fishing, marine traffic, seabed & benthos, birdlife, sea mammals, underwater noise during construction,…



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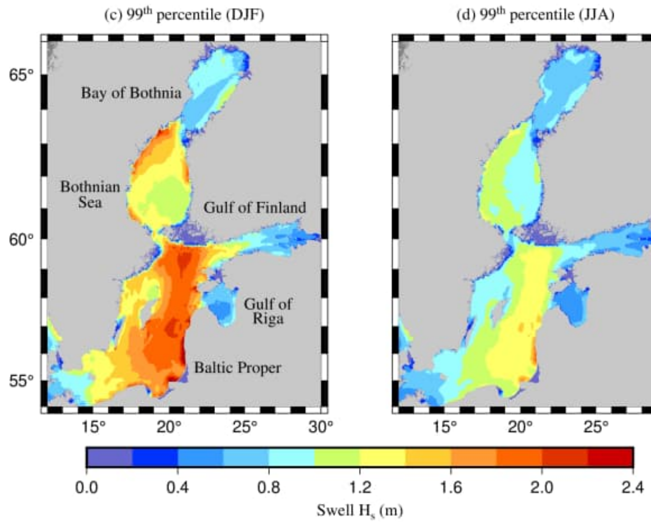
Specific competence required

- Site assessment:
  - Geotechnical investigations
  - Metocean studies
  - Offshore wind measurement
  - Marine flora & fauna
  - Etc.


Remotely operated survey vessel


Jack-up drilling platform for geotechnical investigations


Floating LiDAR



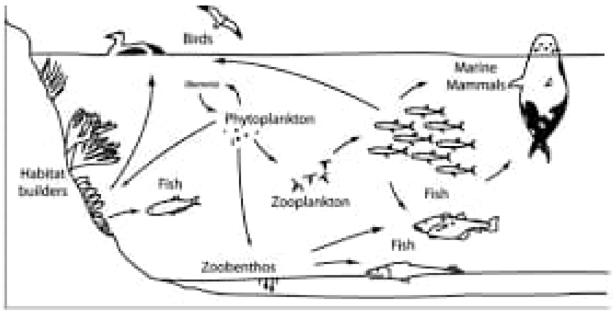
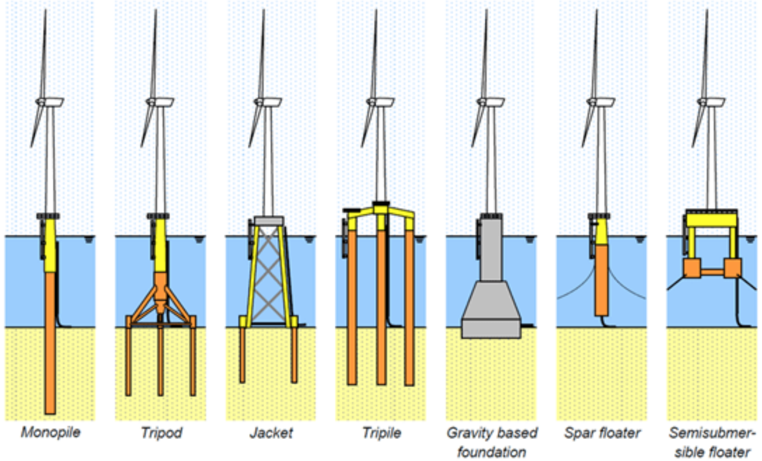


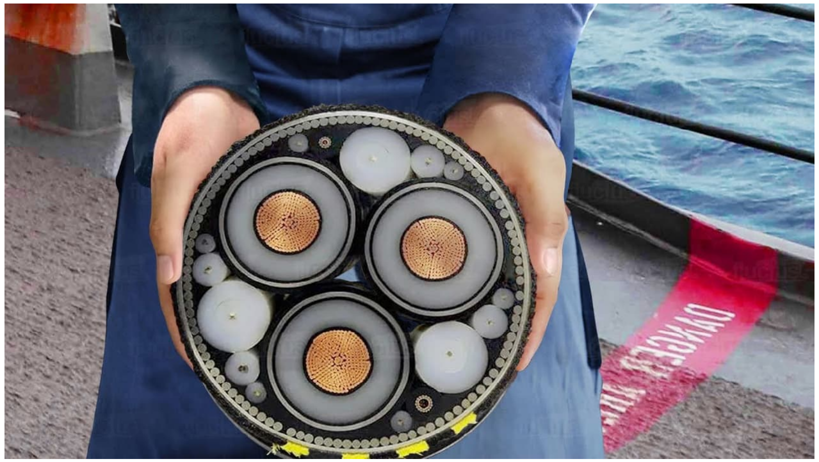
Figure 3. Food web illustration depicting the links among Baltic Sea communities (Hermanni Backer).

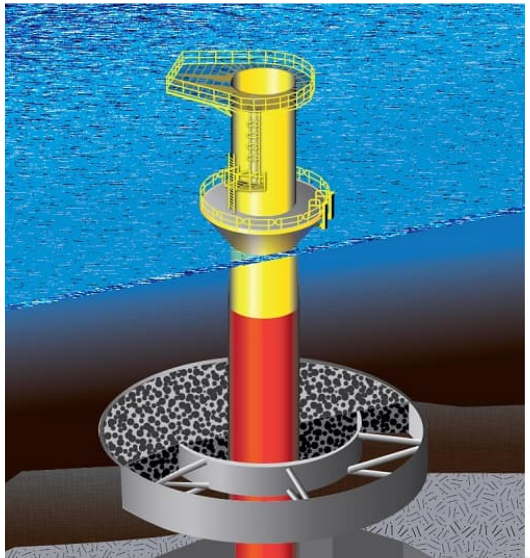

Marine biologist

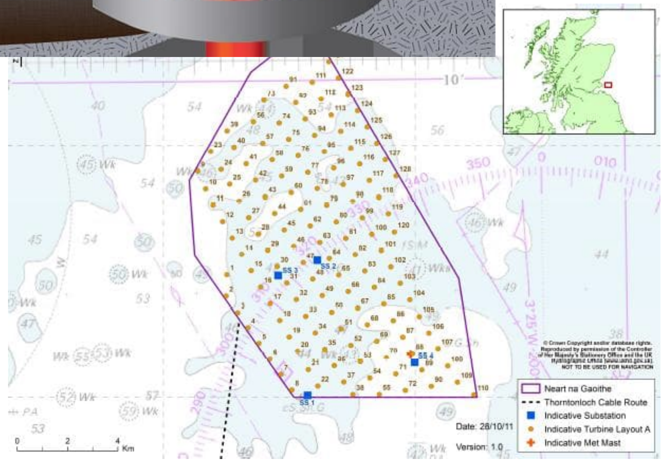
Specific competence required

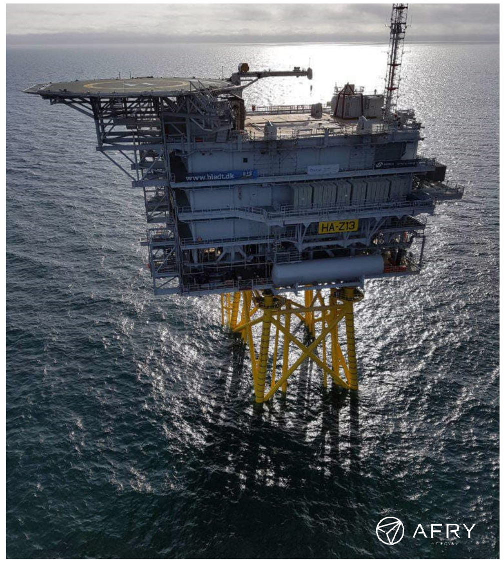


- Design & engineering:
  - Foundations
  - Cables
  - Substation
  - Layout design
  - Logistics planning
  - Etc.









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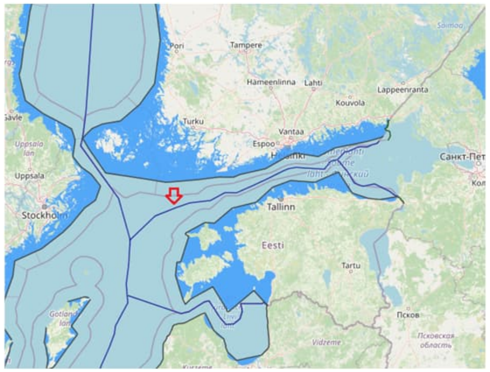
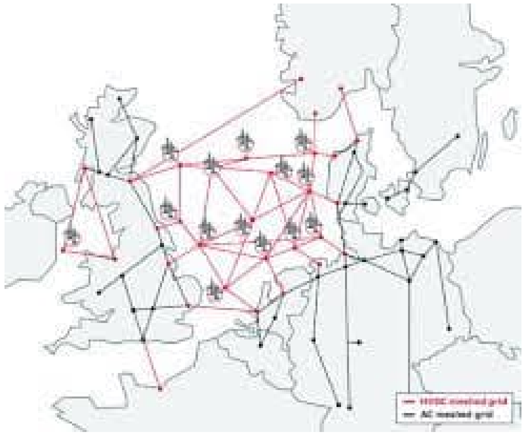
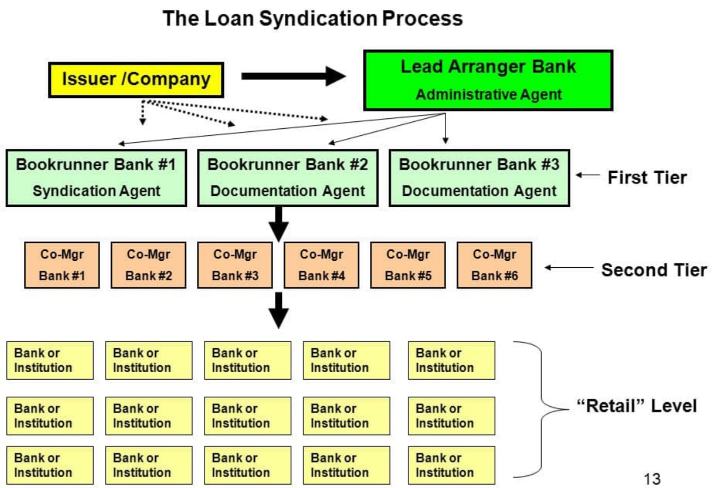
Specific competence required

- Non-technical project development:
  - New stakeholders: Fishermen, port operators and navigation authorities, marine spatial planning authorities,…
  - Acquiring development rights / securing of sites (Territorial waters / Exclusive Economic Zone)
  - Permit procedures
  - Grid connection and offtake arrangements
  - Cross-border / international processes (EEZ, international EIA, grid interconnectors,…)
  - Financial assessment and financing arrangements for huge investments!







Offshore players vs. onshore players

- Not a proper playing field for ”a man and a van” type project developers
  - Even the early stage ”pure project developers” need to have substantial internal resources and skills
- Some leading offshore wind developers:

Offshore players vs. onshore players

- Late stage developer / investor companies include
  - National & multinational energy companies
  - Oil & Gas companies
  - Large offshore contractors

Offshore players vs. onshore players

- ”Pure investors” include
  - International equity funds
  - Pension funds, etc.

- Shareholder structure usually more complex than in onshore projects
  - Typically 3 to 10 equity partners per project
  - May include the original developer(s) in minority role
  - Often a mix of one or more energy companies, ”pure investors”, and turbine supplier / marine contractor involved in the construction stage
- Shareholder structure often rearranged soon after construction, when one or more of original investors exit to invest in the next project(s)

Offshore players vs. onshore players

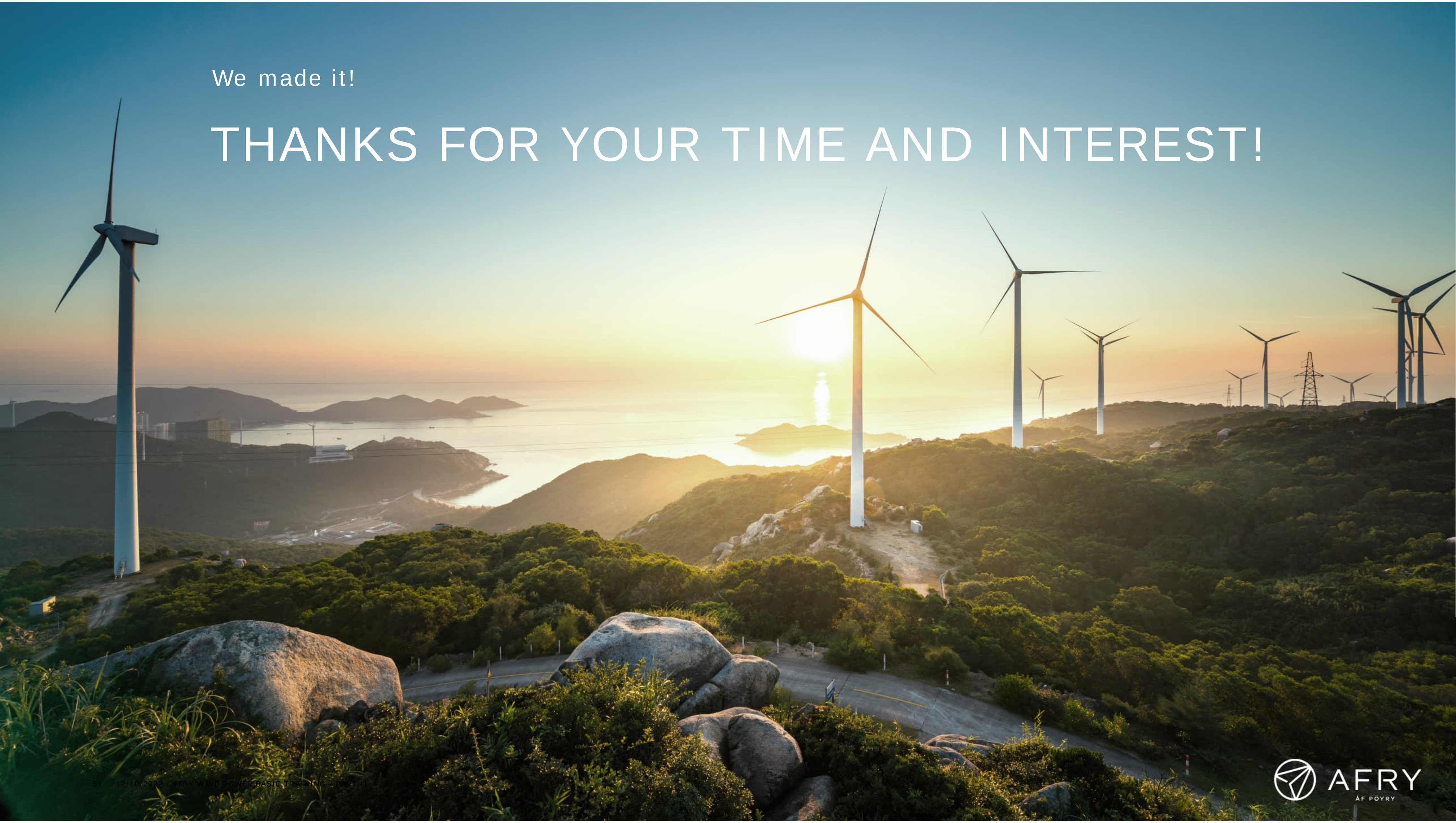
- Debt finance: typically syndicated loans from 10 to 20 banks per project!
  - Usually a mix of big international banks and local banks (with small shares)

Offshore players vs. onshore players

- Turbine suppliers
  - 3 big suppliers dominate the global market
- BoP contractors and marine operations providers
  - Large international contractors, mainly with offshore O&G, shipbuilding and/or port & coastal construction background

Conclusions on offshore vs. onshore wind

- Challenging physical & environmental conditions
- Big & complex projects, huge investments
- Broad set of special skills required
- Playing field for the big & strong
- Global business


We made it!
THANKS FOR YOUR TIME AND INTEREST!
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