Floating Wind *Solutions*

Influence of Floater Design Aspects on Serial Production, Logistics and Project Development

Dr. Denis Matha
Global Service Line Lead Floating Wind
RAMBOLL

Organized by QFWE Quest Offshore

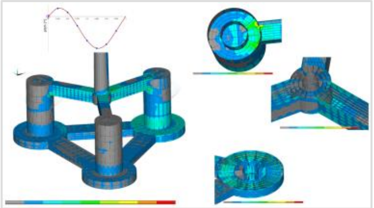
Speaker Introduction

Dr. Denis Matha - RAMBOLL
Global Service Line Lead Floating Wind

- 12 Year's working in Floating Wind
- Joined Ramboll in 2015
- Engineering Ph.D.
- Broad Expertise in various areas of Floating Wind, both technical and commercial

Figure by Ramboll

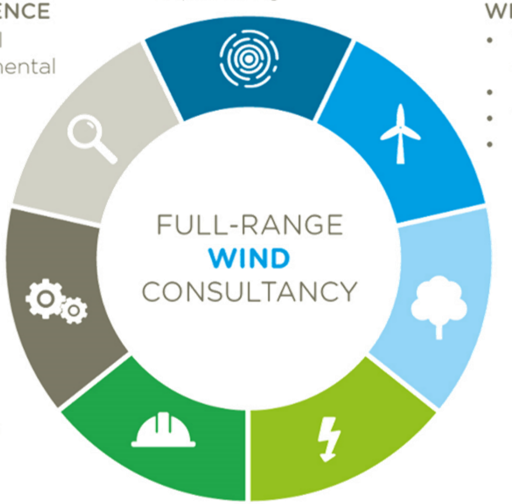
Ramboll In Brief



PROJECT DEVELOPMENT
- Layout & micro-siting
- Feasibility studies
- Project engineering
- Cost optimisation
- Procurement & contracting
- Permit management
- Owner's & Lender's Engineer
- Repowering

DUE DILIGENCE
- Technical
- Environmental

WIND & SITE
- Wind measurements (LIDAR & masts)
- Energy yield assessments
- WTG site compliance
- Power curve measurements



ASSET MANAGEMENT
- Technical operation management
- Performance optimisation
- Lifetime extension
- Nacelle based LIDAR
- Inspections
- Condition monitoring

ENVIRONMENTAL SERVICES
- Environmental and Social Impact Assessments
- Landscape impact
- Noise & shadow flicker impact
- Visualisation
- Icefall modelling
- Cultural heritage studies

CIVIL & STRUCTURAL DESIGN
- WTG foundation design
- Geotechnical investigations
- Tower design
- Road & hardstands

ELECTRICAL DESIGN
- System studies
- Grid connection concept
- LV, MV and HV grid design
- Substation design
- Smart grid solutions

Ramboll Group: 16,500 Employees

Leading intl. Consultancy in Offshore Wind

Ramboll combines ***independent*** *detailed* ***offshore knowledge*** *of Floater, Moorings, Cables with an in-depth* ***understanding of wind turbine*** *dynamics and* ***project development, logistics, T&I, O&M, ports design, financing, strategy and risk experience*** *from large offshore wind projects*

- **Since 2007, Ramboll has provided engineering consultancy services in more than 40 commercial and R&D projects in floating wind**
- **Ramboll is approaching the market as an independent one-stop engineering consultancy, not focussed on a single concept or technology**
- **Ramboll is not developing an own proprietary floating substructure design but has full design capabilities to support clients**
- **We have a dedicated floating wind team covering FOWT specialist topics (coupled analysis, mooring, dyn. cable) integrated with our over 300 offshore wind experts**

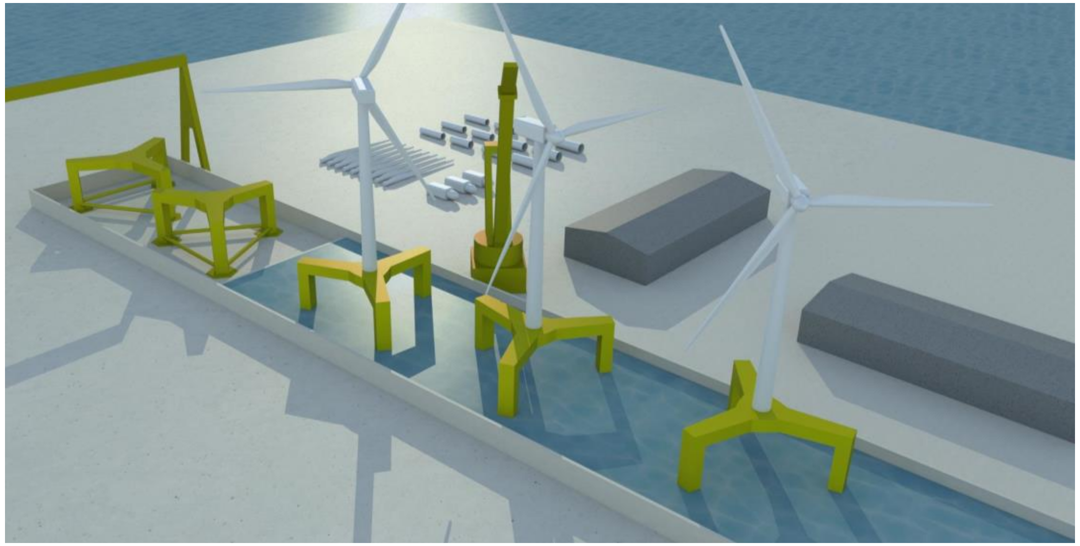
Introduction

Efficient Serial Production is key for future commercial large scale floating wind farms:

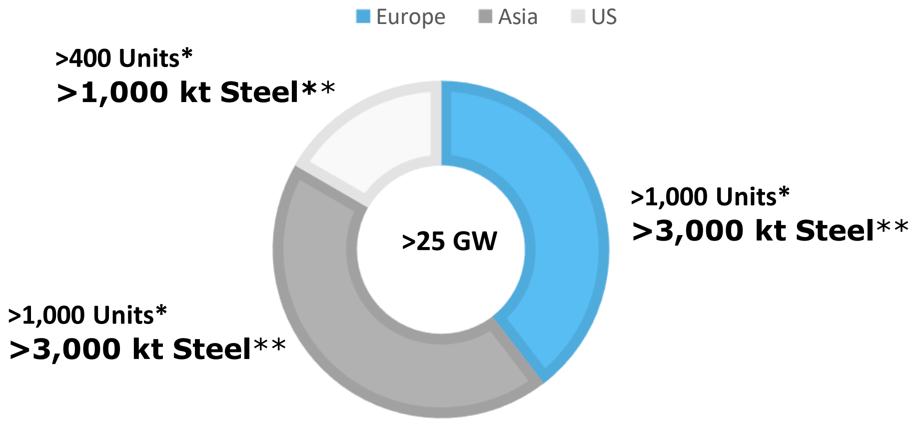
- Time / Throughput:
  - Min. 1 Floater every 2 weeks, Target <1 week
  - Monopile Benchmark: Up to 4-5 per week
- Impact on Cost & Project Schedule:
  - Production Speed / Level of Automation
  - Complexity of Fabrication
  - Required infrastructure and Logistics
  - Quality Control

Key influencing Factors:

- **Floater Design** Focus of this Presentation
- Available Infrastructure, Port & Fabrication Facilities
- Supply Chain



EXPECTED GROWTH IN FOW WORLDWIDE BY 2035



*Estimate; **Structural steel mass for floaters only, assuming all commissioned systems use a steel floater.

Introduction

Serial Fabrication

Efficient, industrialised serial production is a key factor to enable commercial large scale floating wind farms

Key aspects:

- Fabrication Strategy (global vs. local)
- Fabrication/Yard Facilities (capability & availability)
- Floater type, material & general arrangement
- Standardisation and modularisation
- Storage/Area/Draft requirements
- Throughput
- Supply Chain

Logistics, T&I

Logistics and T&I strategies adopted to floating-specific constraints are key for optimizing schedule and cost.

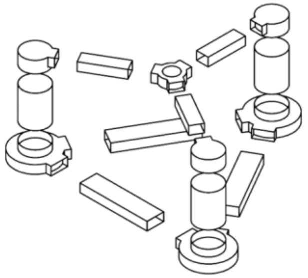
Key aspects:

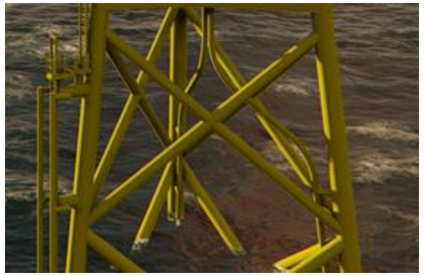
- Logistics Strategy (global hubs vs. local / storage & buffer req.)
- Installation Strategy (WTG quayside vs. offshore)
- Floater type, modularity and assembly process
- Project location
- Ports and infrastructure constraints
- Vessel cost and availability
- Supply Chain

Floater Design Impact on Fabrication

Floater designs can follow a variety of different fabrication approaches:

1. Applying offshore O&G / Shipbuilding principles and adapting them regarding serial production (designs with larger volume blocks)
2. Designs aiming to exploit existing fixed-bottom (Jacket) offshore wind fabrication and logistics principles (smaller, slender components)
3. Application of civil engineering principles and adapting them regarding serial production (concrete designs)
4. Hybrid approaches drawing on all above, respectively applying individual principles





Figures by Ramboll

Large-volume Steel structures
Assembled from blocks around 100-350 tons. Assembled structures will have outer dimensions of 75-100m for 15MW class. Mainly stiffened plates.

Concrete structures (in-situ)
In-situ slipformed or casted in place, using mobile batching plants. Single block or few large blocks. Steel armouring & post-tensioning. Integrated steel interfaces.

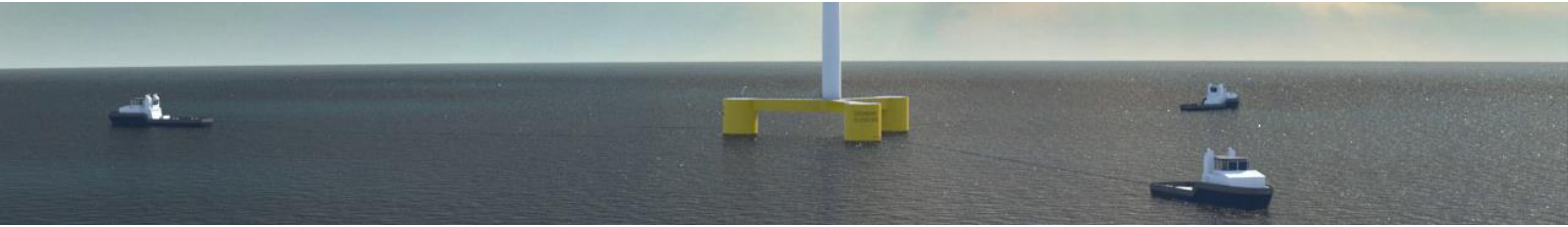
Slender Steel structures
Assembled from slender (tubular) elements; "Jacket-type" structures. Different types of joints possible (welded, pins/bolts, grouted, etc.). Mainly unstiffened tubulars.

Concrete structures (modular)
Prefabricated concrete modules. Assembled at central assembly area. quayside; different types of joints. Integrated steel interfaces.

Fabrication facility requirements

- Requirements highly concept and material dependent
- Overall Dimensions and masses
- Depends if only blocks are fabricated, or the floater assembly shall also be performed at same location
- Handle steel plate thicknesses around 15-30mm
- Min. 20-30 15MW Class Floaters per year throughput (~70,000 - 110,000 tons/year)
- Steel: Cutting, blasting, flat and curved panel fabrication, plate rolling and profile bending, jigs, welding, block fabrication, coating, sufficient workshop dimensions
- Concrete: Batching plant, formworks, areas with sufficient ground bearing capacity, launching capabilitites
- Dry and wet storage areas, areas for block assembly
- Internal transport, cranes, offloading/float-out capabilities

Floater Design Impact on Logistics and T&I



Dimensions and Masses

Implications on fabrication facilities, port, storage/buffer strategy (area, draft, crane, ground bearing, etc.).

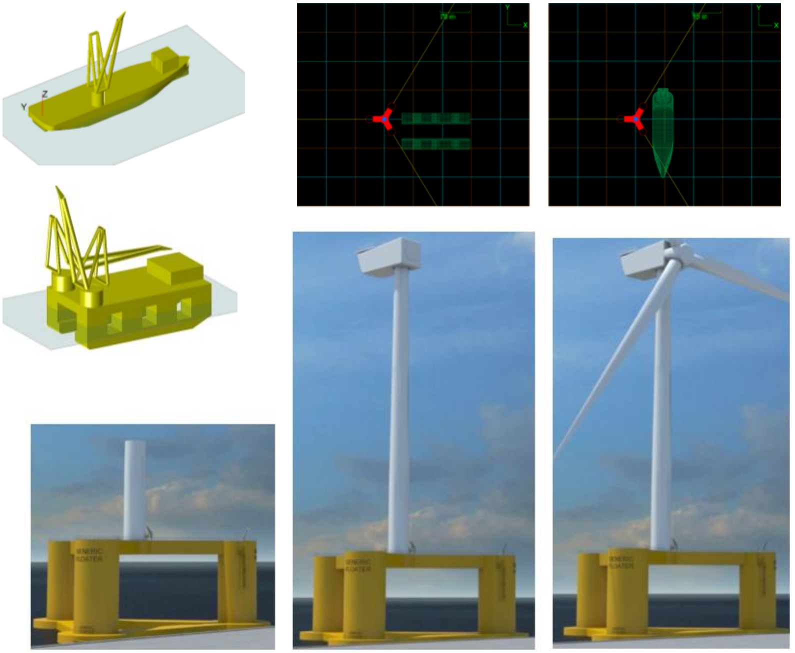
Draft & Stability during launching, WTG Integration and Towing

The draft and stability of the floater in different loading conditions and the installation process govern the quayside and on-site procedures and vessels / cranes / infrastructure required, as well as harbour basin and navigation channel depth requirements.

For 15 MW+, draft is expected to be become a key requirement (typically <10 m)

WTG-Floater Integration quayside vs. offshore

Depending on vessel availability, capacity, floater stability and weather conditions, it will have a major impact on the logistics strategy (local staging/marshalling port required)



EXAMPLE: Sequential Production (Steel Floater)

WS — Pre-assembly 17 blocks/great-blocks

WS IX — Coating 17 blocks/great-blocks

D1 — Final assembly 1 pontoon

D2 — Final assembly 4 columns

D3 — Final assembly 4 deck/corners

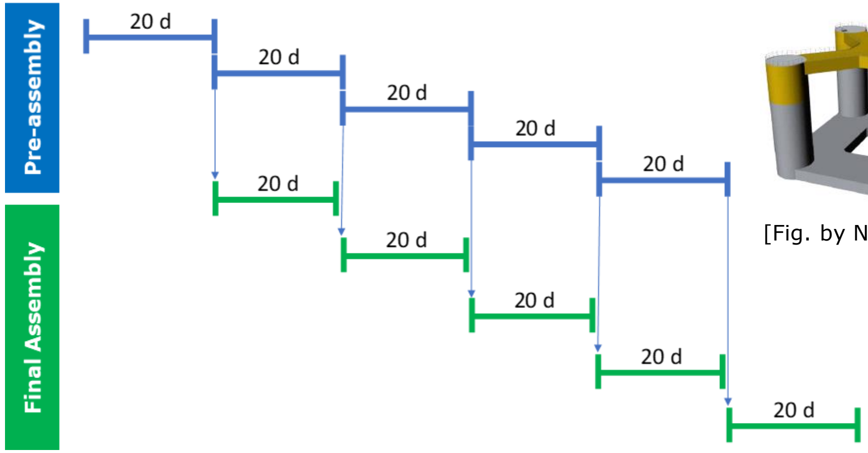
D4 — Final assembly 1 center cross

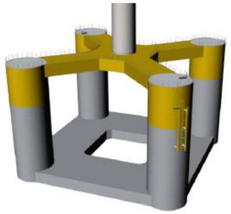
D5 — Floating 1 structure

D6 — Ballasting Installation 1 RNA

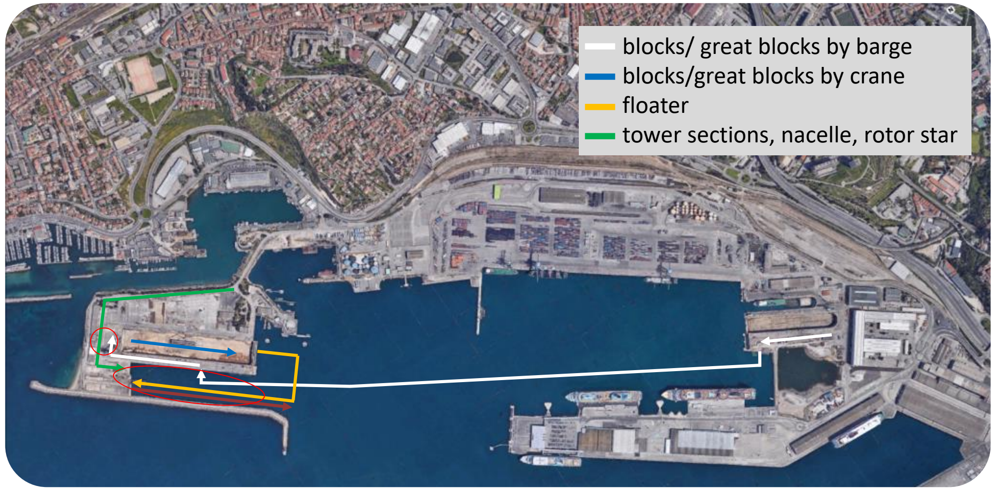
Example:
Chantier Naval de Marseille, FRANCE

- **Repair shipyard** with dry docks
- **Limited capacity** for storage **Upgrade** of facilities required
- **Serial** production 1 unit at a time
- Pre-fabrication and assembly/coating separated
- **Output of floaters**: 1.5 units/month
- **Steel throughput**: 5700 t/month





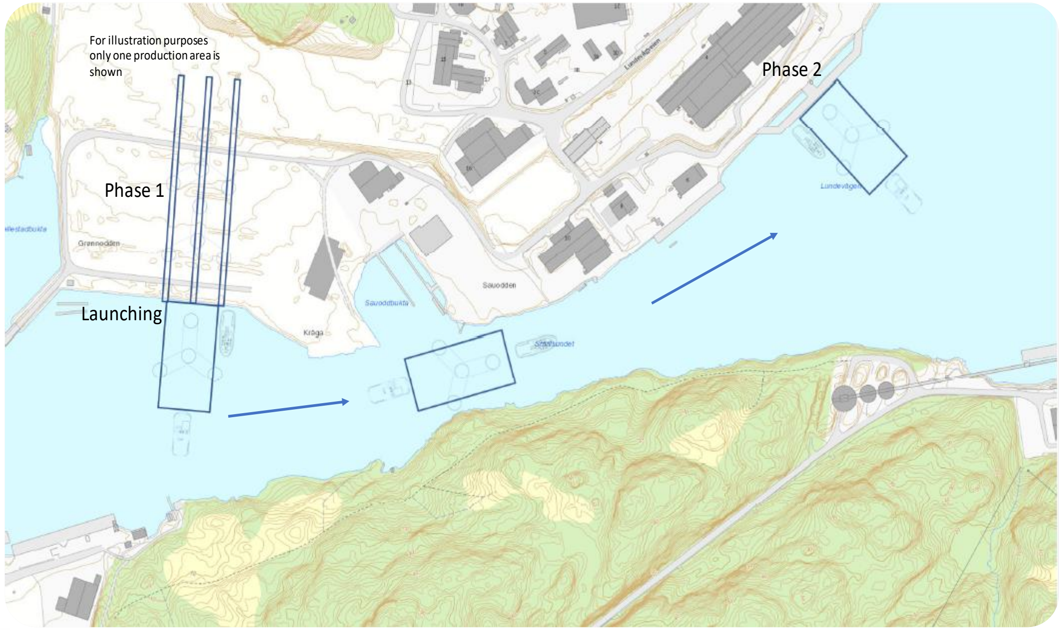
[Fig. by NAUTILUS]

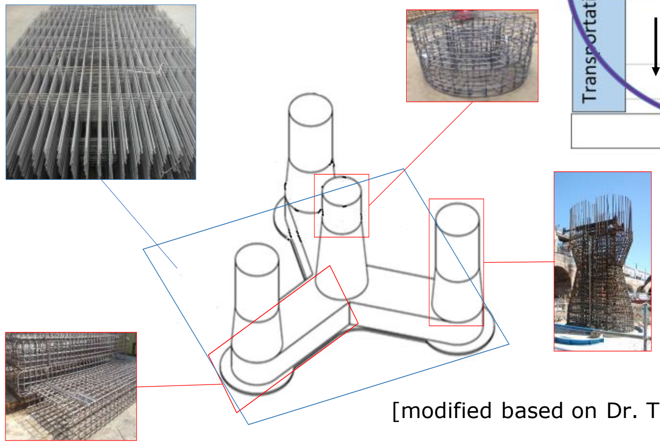


EXAMPLE: Parallel Production (Concrete Floater)

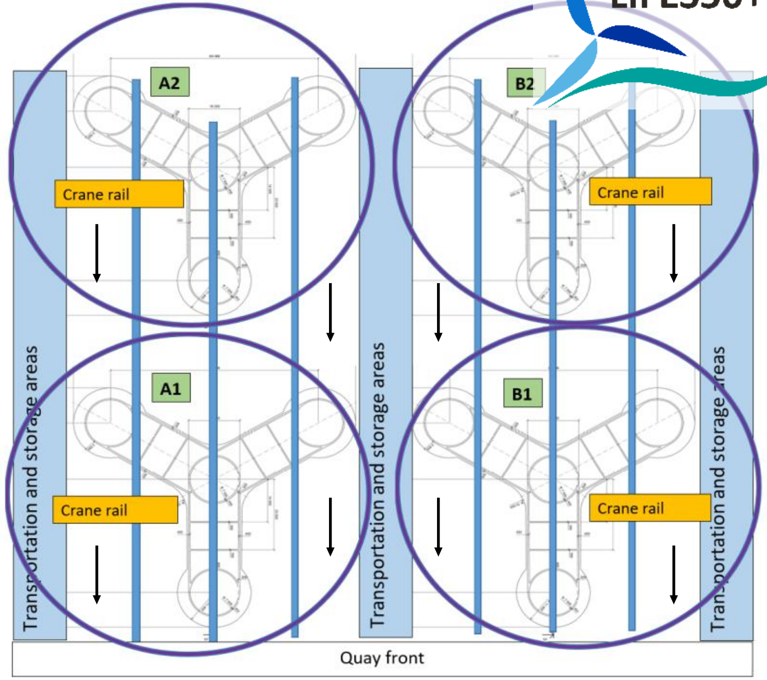
NORWAY: Lundevågen

- **Batch parallel production** (batch of 2 units at a time)
- Use of **pre-fabricated rebar units**
- **Phase 1 (onshore):** bottom slab, outer and circular walls, internal walls
- Launching using **standard barge and skidding beams**
- **Phase 2 (inshore):** top slab, roof corner tanks, mechanical outfitting





[modified based on Dr. Techn. Olav Olsen]



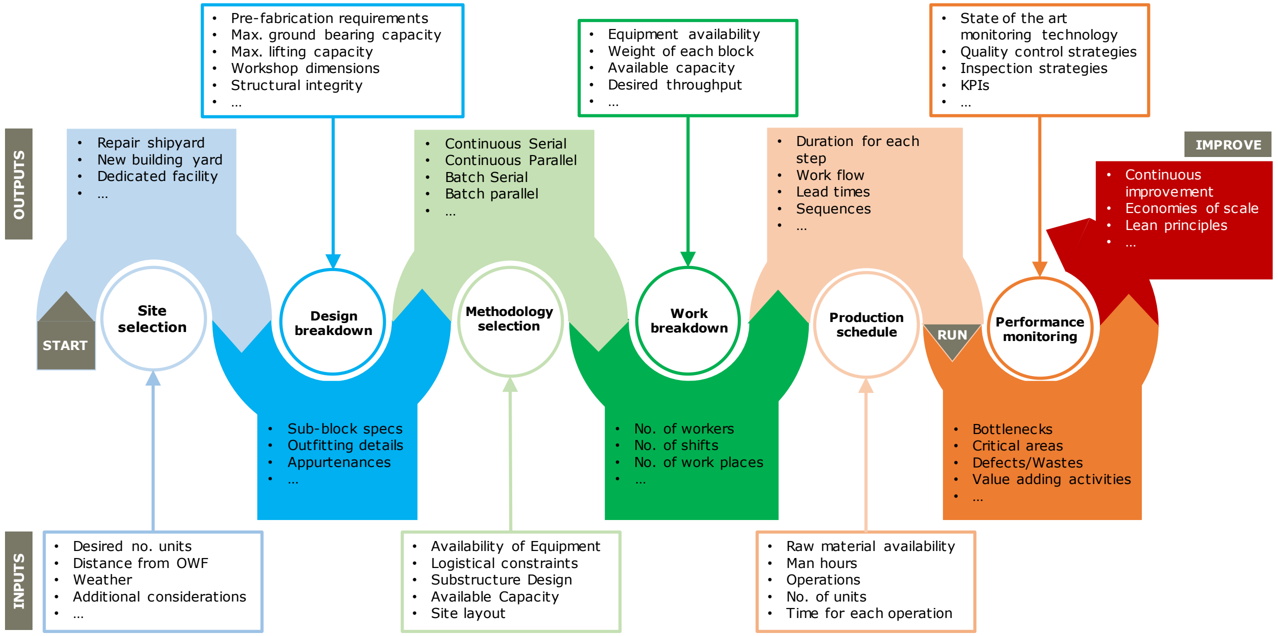
Summary

Selecting an optimized fabrication and logistics strategy in terms of cost and risk for a large scale floating wind project is highly project dependent.

Key influencing factors in early project phases:

- Size and Timeline of project
- Floater Concept and Material Selection
- Existing near-site ports, infrastructure and supply chain
- Local content, supply chain requirements and regulatory constraints
- Installation / WTG-floater integration process
- Fabrication and Logistics Strategy (local/global)

Selection of a floater concept and accompanying fabrication and logistics strategy considering project specific conditions and requirements is key.



Q&A

Bright ideas. Sustainable change.

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