30/08/2022

Matteo Baudino Bessone

STEP WIND

TU Delft

Delft University of Technology

CATAPULT

Offshore Renewable Energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 860737.

Trade-offs in manufacturing, installation logistics and O&M for floating wind farms

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- Introduction
- Case study 1 – manufacturing vs installation
- Case study 2 – spar buoy vs semi-submersible
- Conclusions

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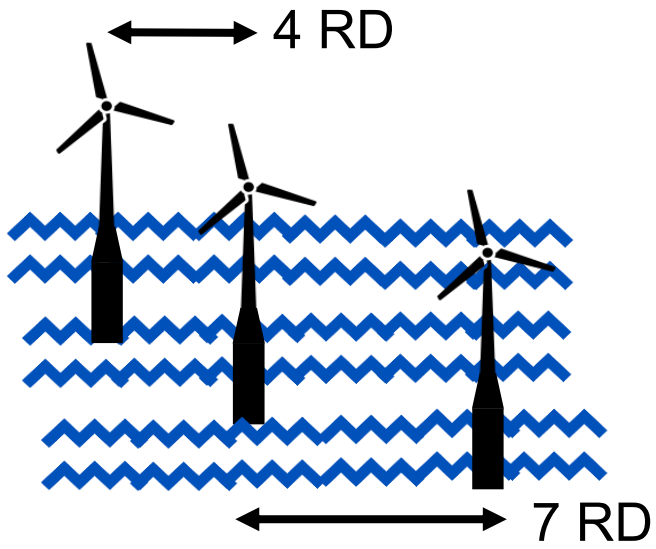
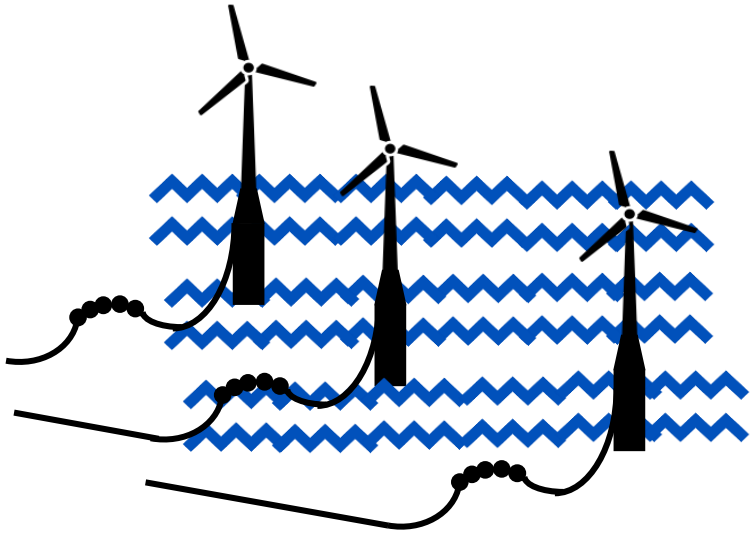
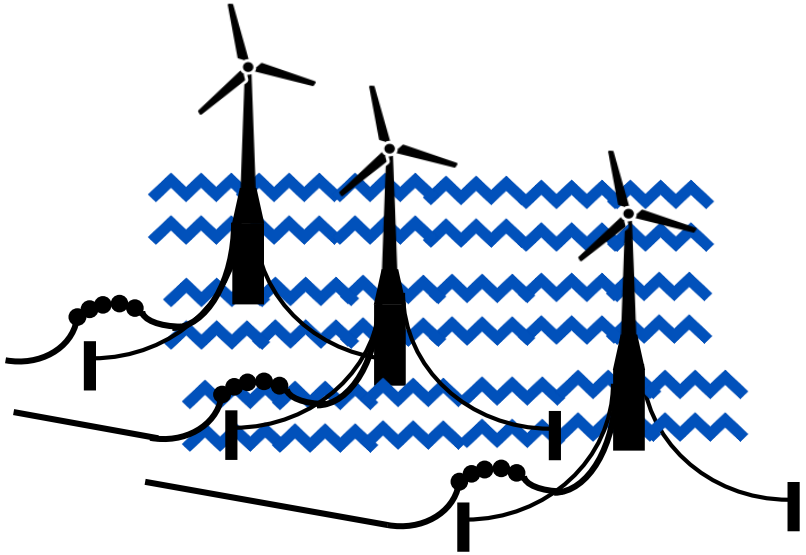
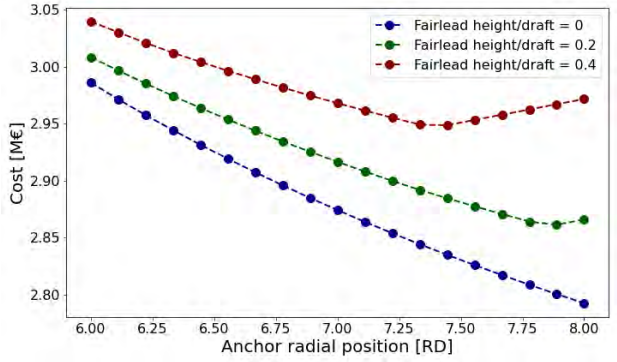
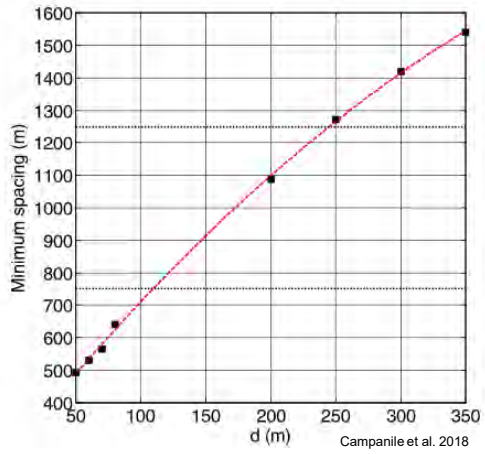
Trade-offs in layout design











Campanile et al. 2018

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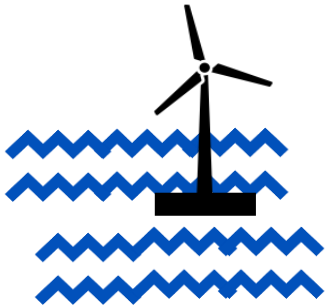
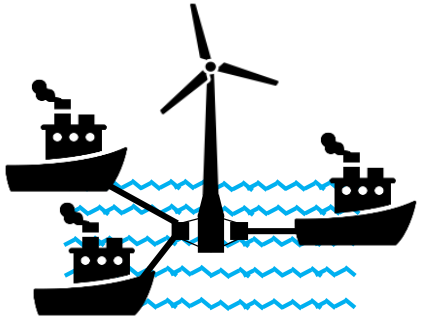
Trade-offs in life-cycle

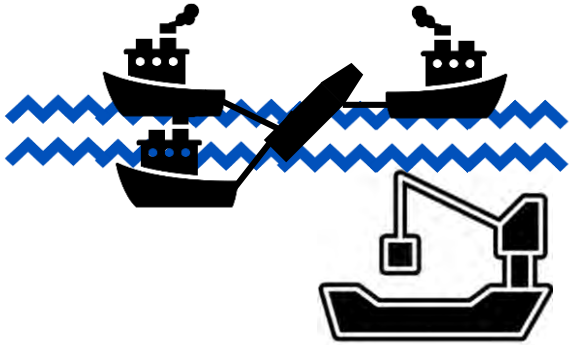
Minimise mass of the structure, cheaper materials, simple geometry



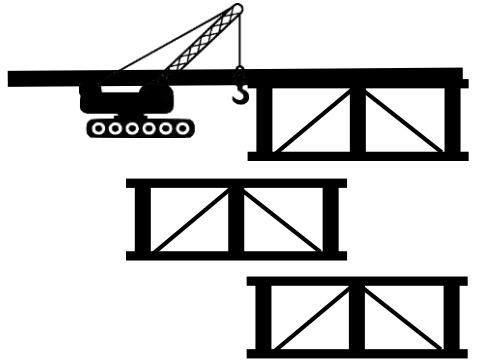
Cheap but instable structure



Deep draft



Large footprint, Complex assembly



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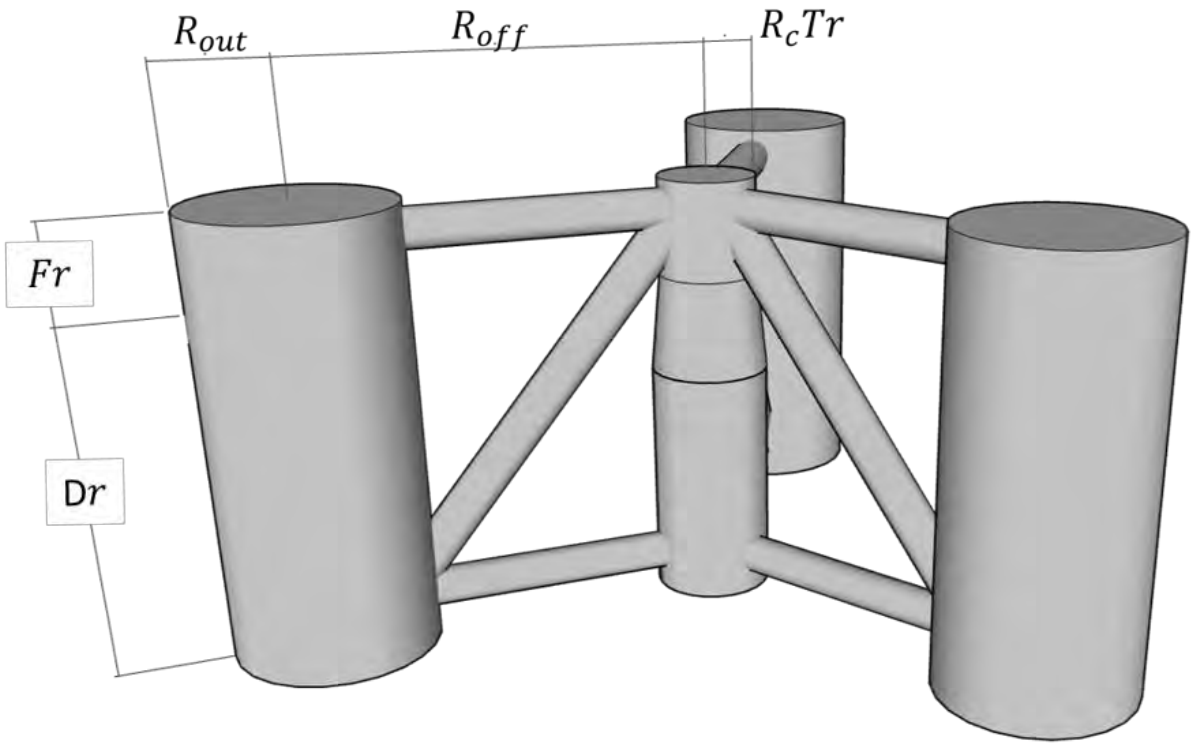
Substructure sizing model



- Sizing based on hydrostatic stability
- Steel structure with fixed concrete ballast
- Supports NREL 5MW turbine
- Minimum draft and freeboard constrained
- Cross bracings' diameter based on pinned-pinned critical bucking load

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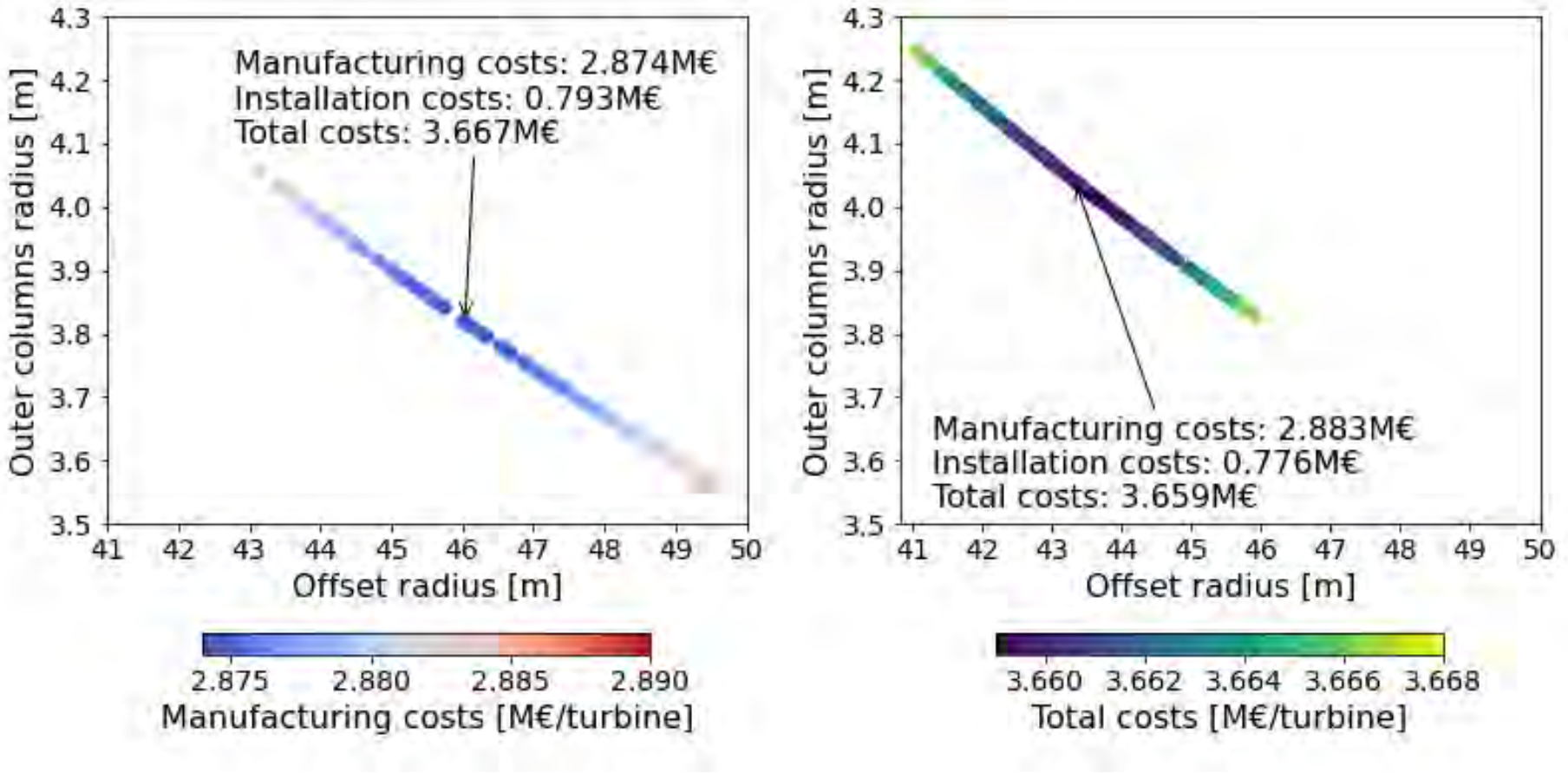
Manufacturing vs. installation



9% smaller footprint but cost reduction not very significant

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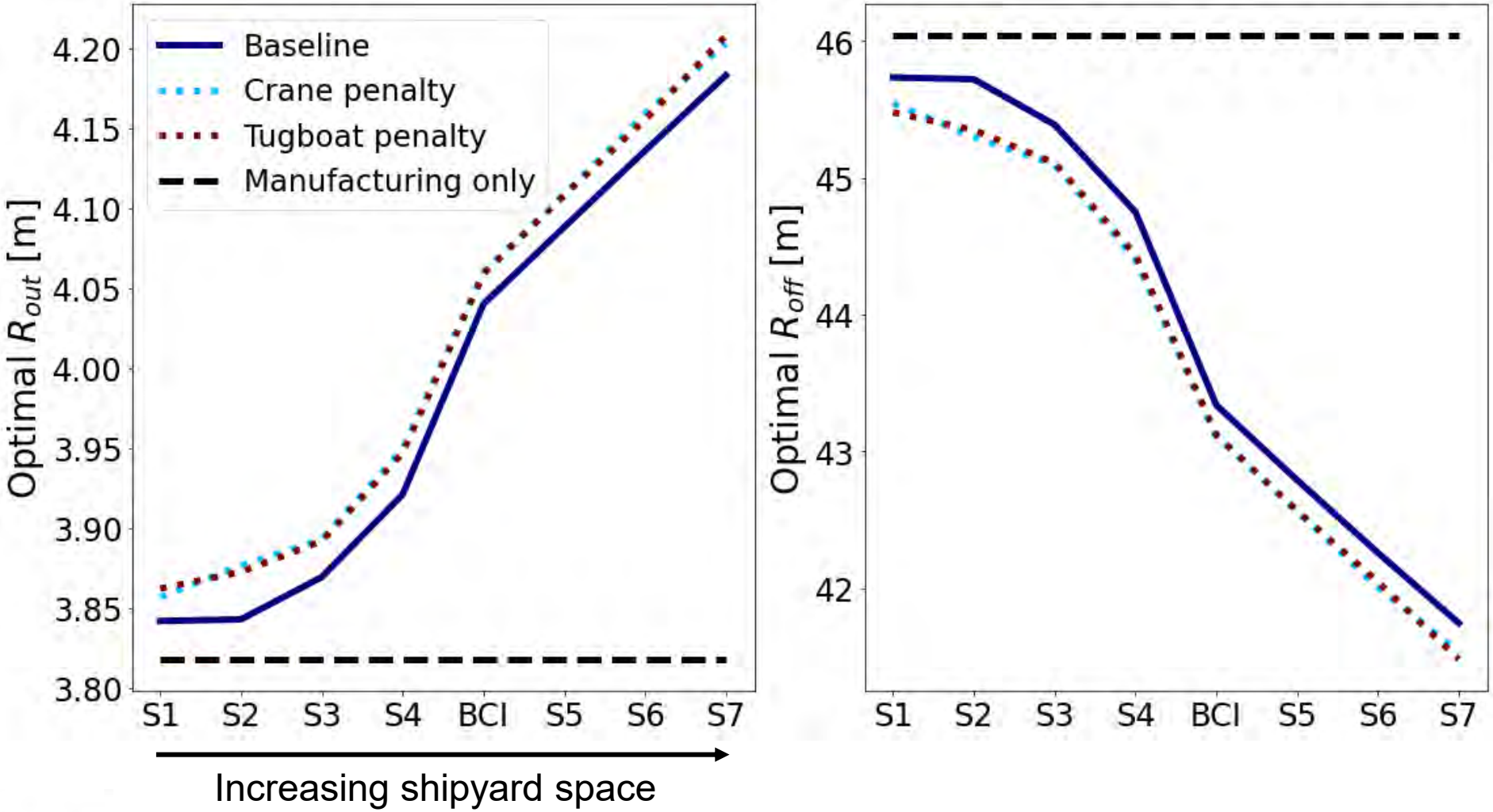
Sensitivity analysis



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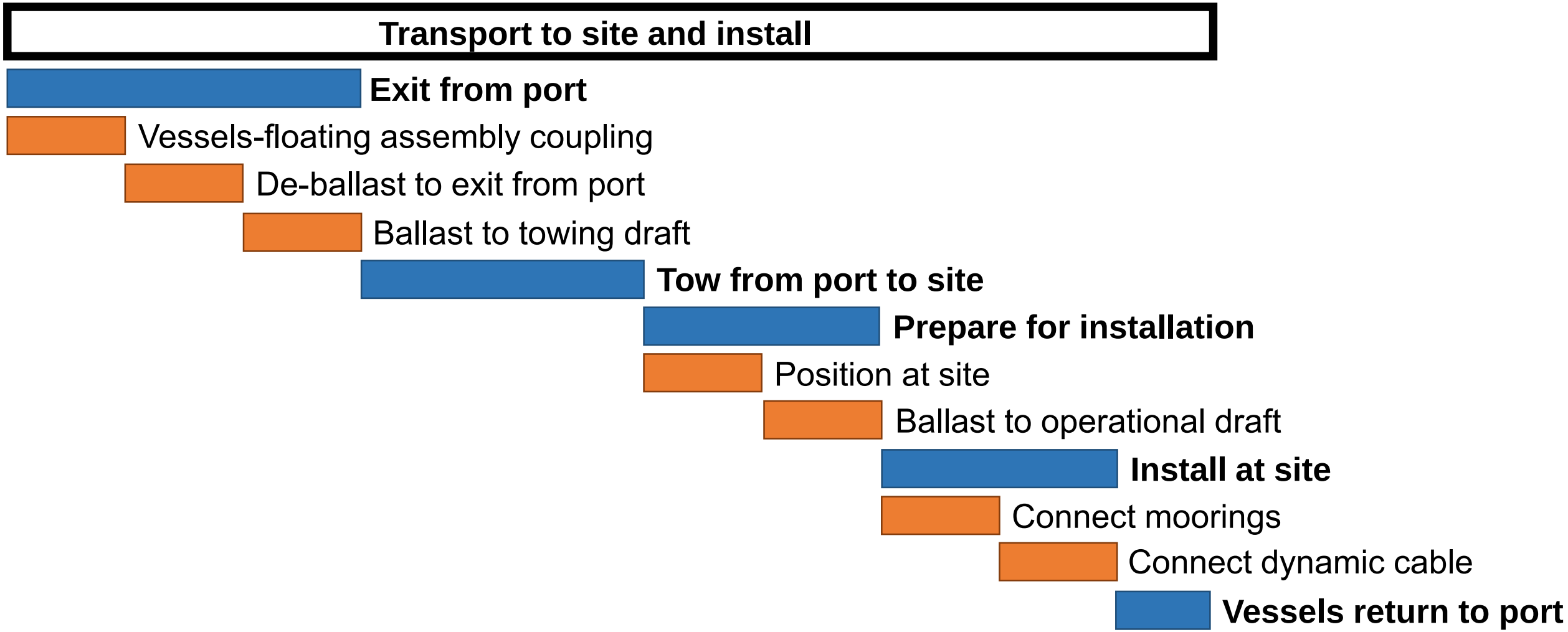
Critical sequences



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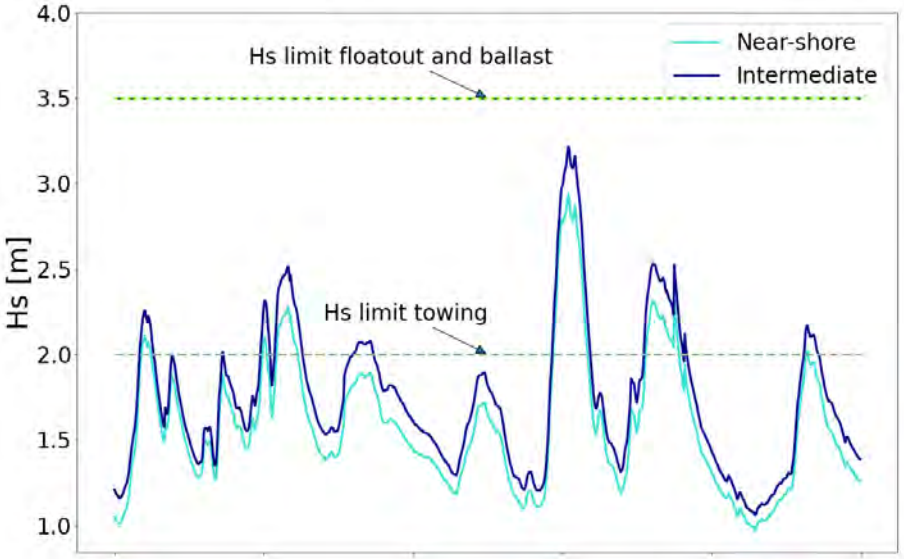
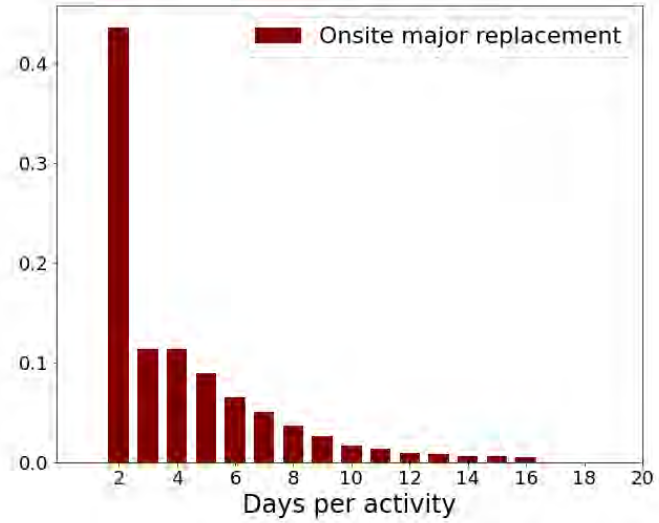
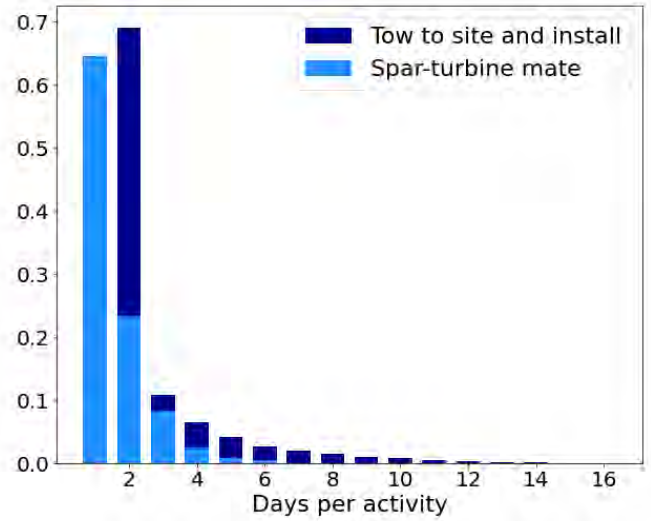
Weather delay







Average duration per critical sequence for costing

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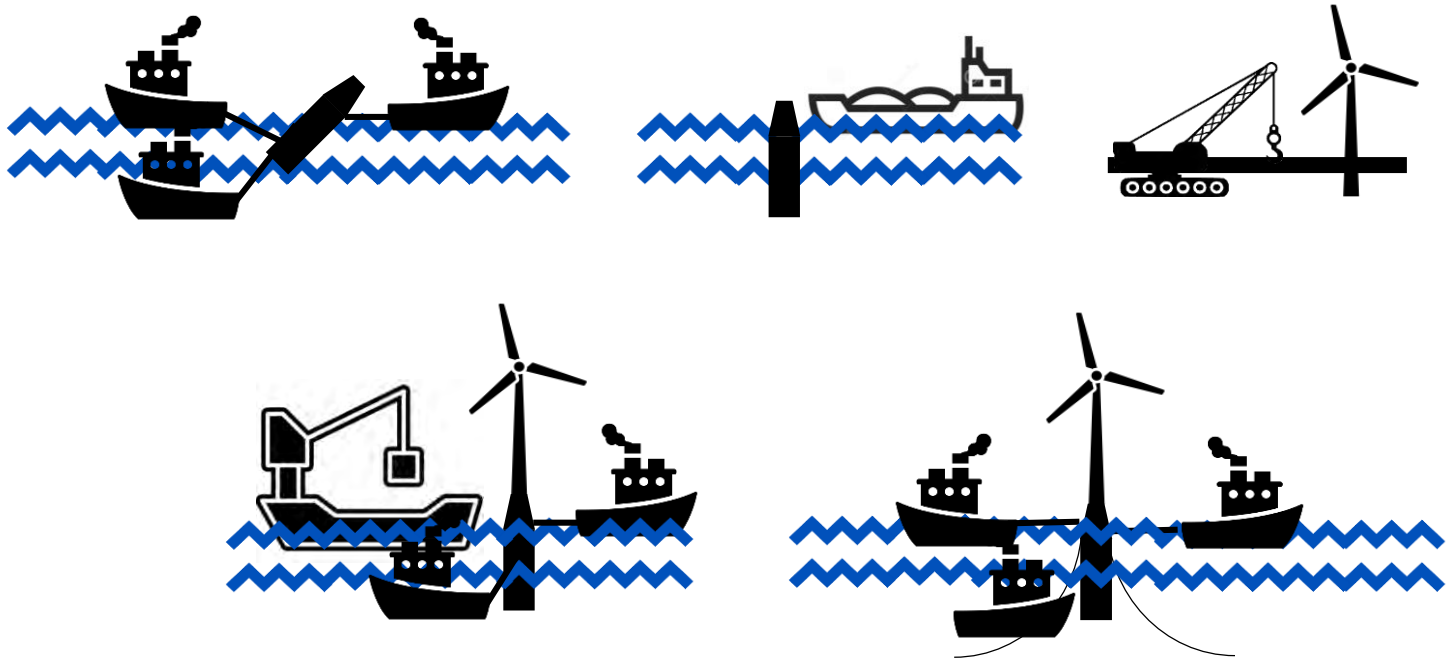
Installation

Semi-submersible quayside turbine assembly

Spar buoy turbine mating single lift



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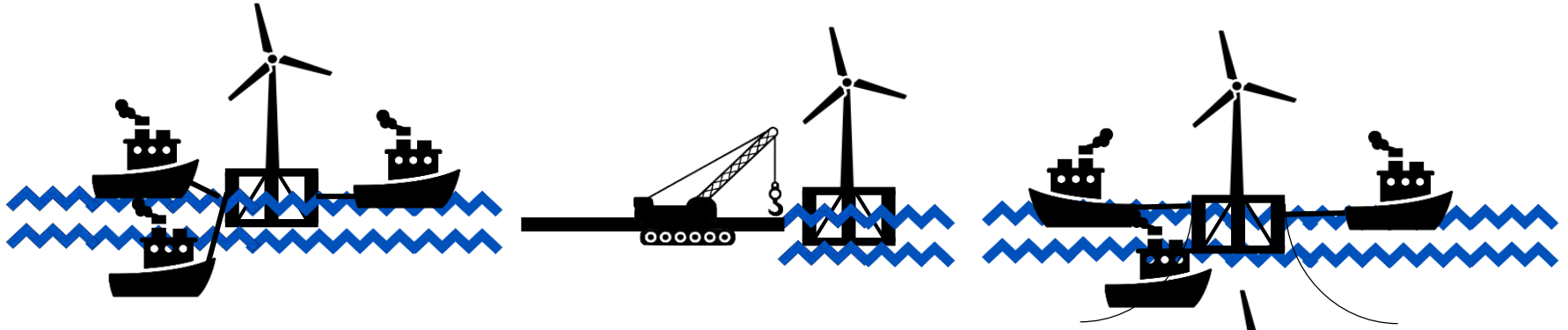
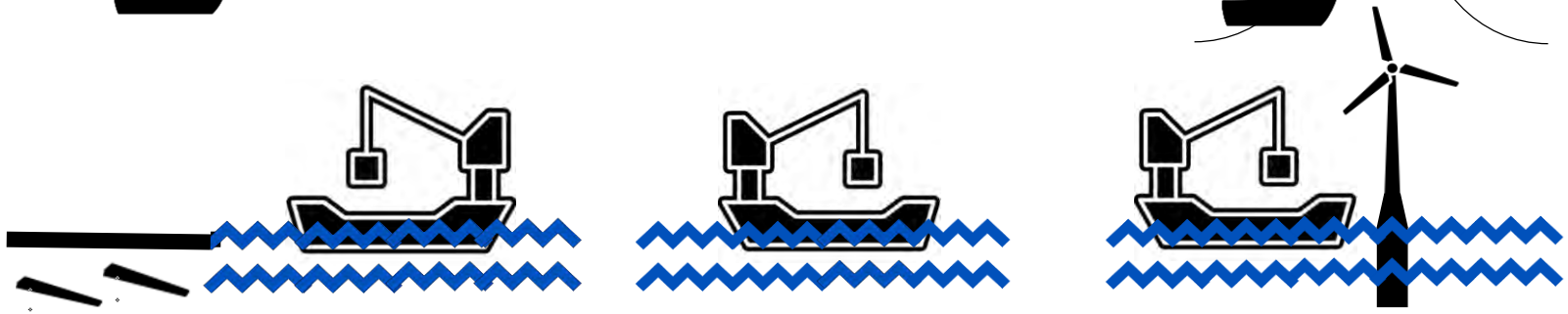
Major components replacement

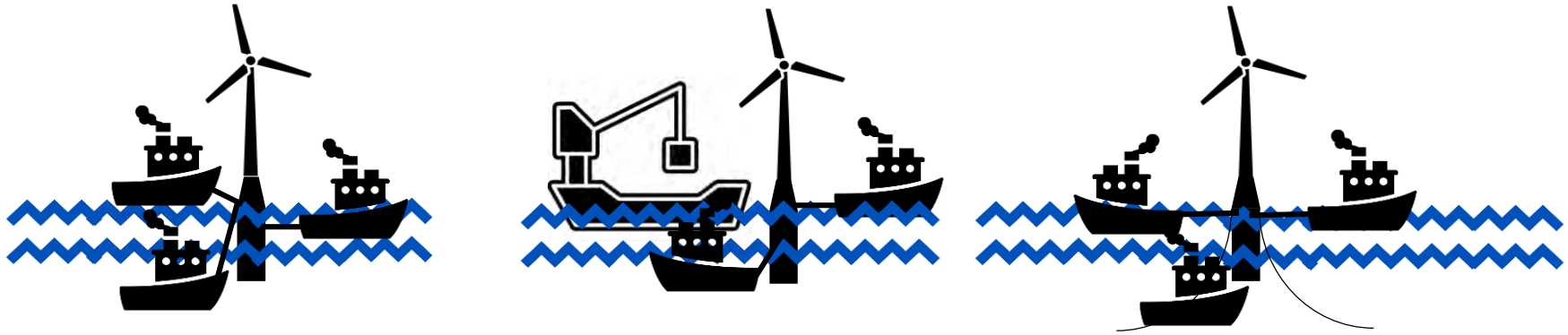
Semi-submersible, offsite



Spar buoy, onsite



Spar buoy, offsite



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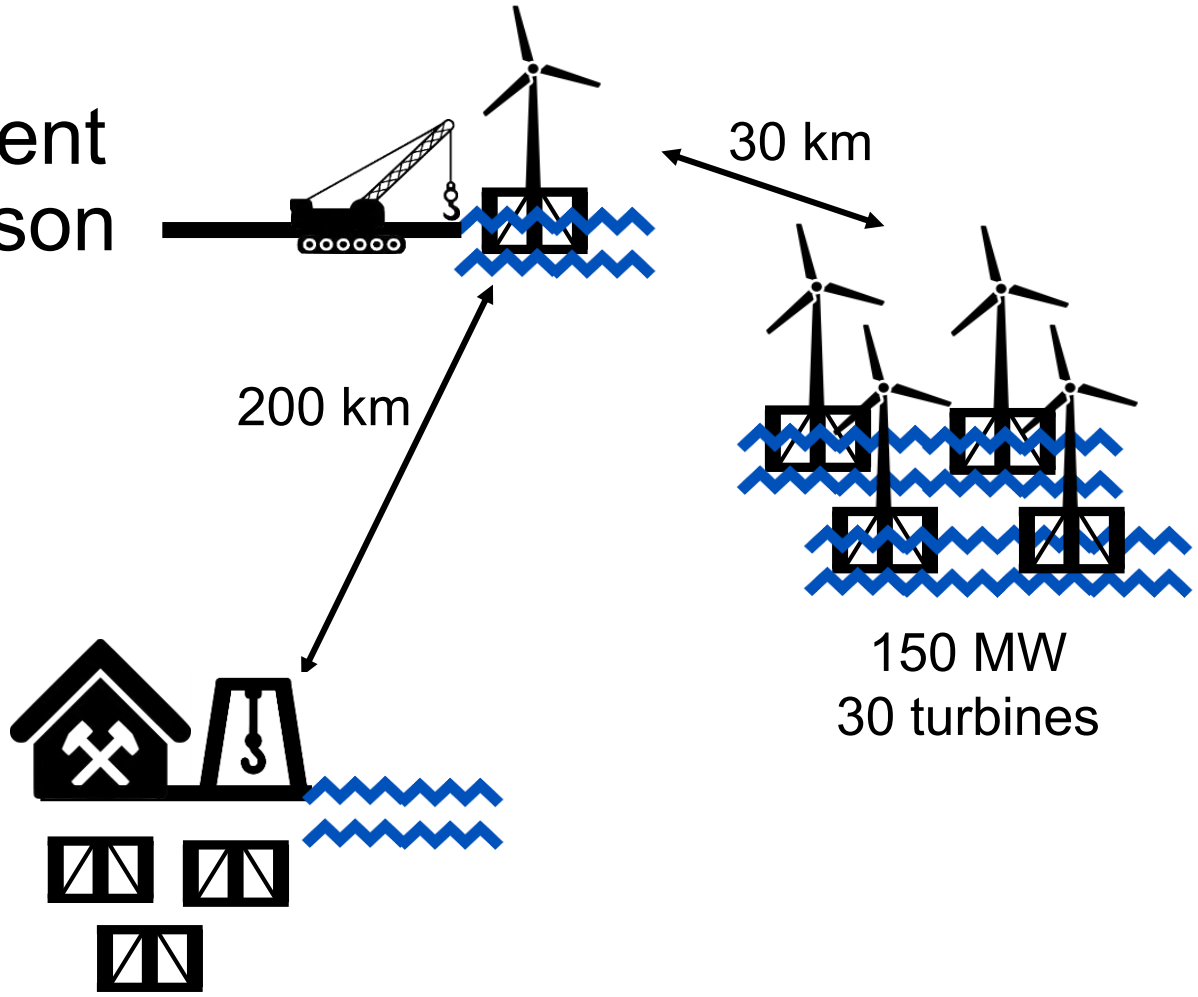
Case-study

- Major components replacement campaign over the good season
- 3 replacements/year
- Discount rate 8%
- Electricity price 100 €/MWh



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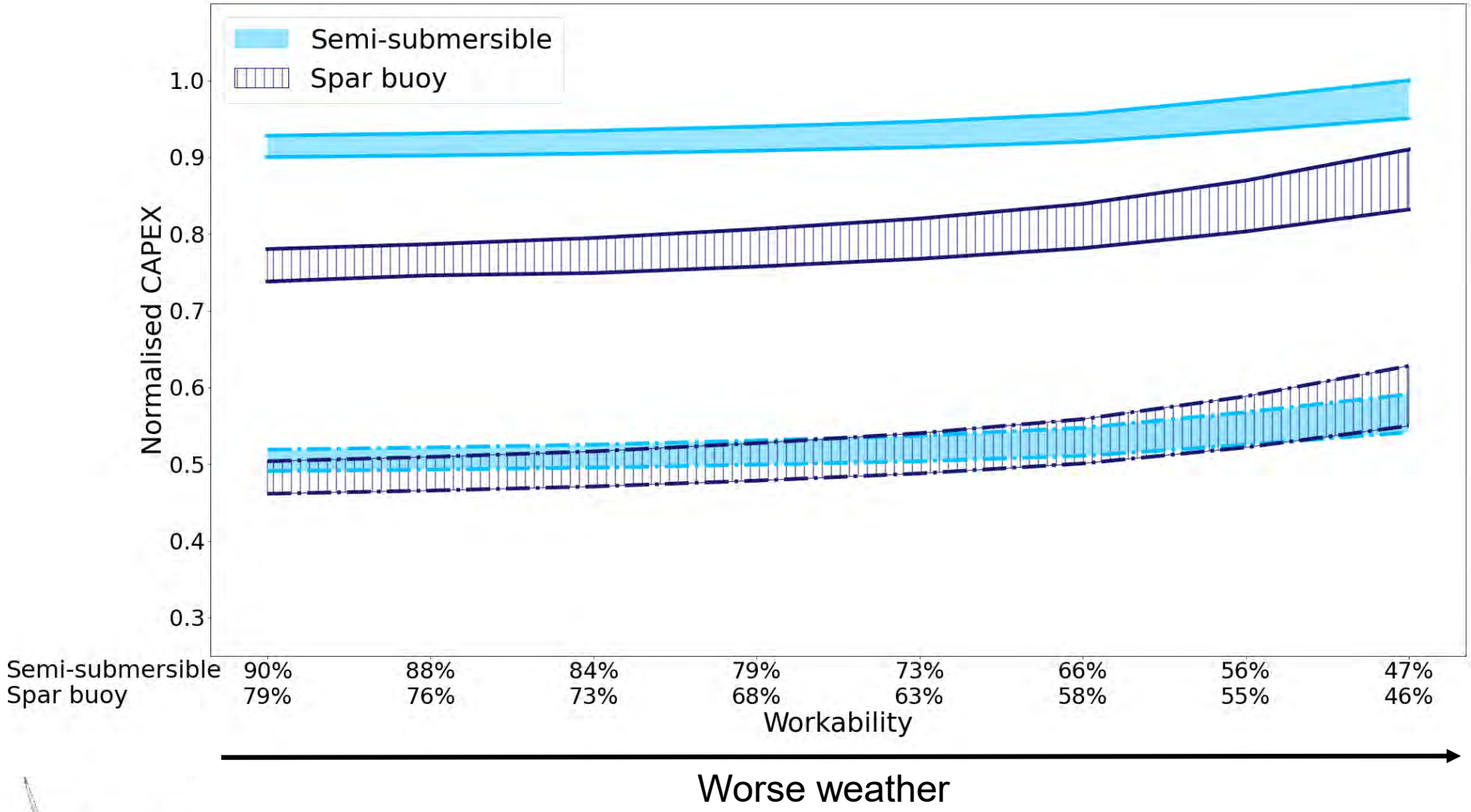
CAPEX



High steel price 1200 €/t

Low steel price 600 €/t

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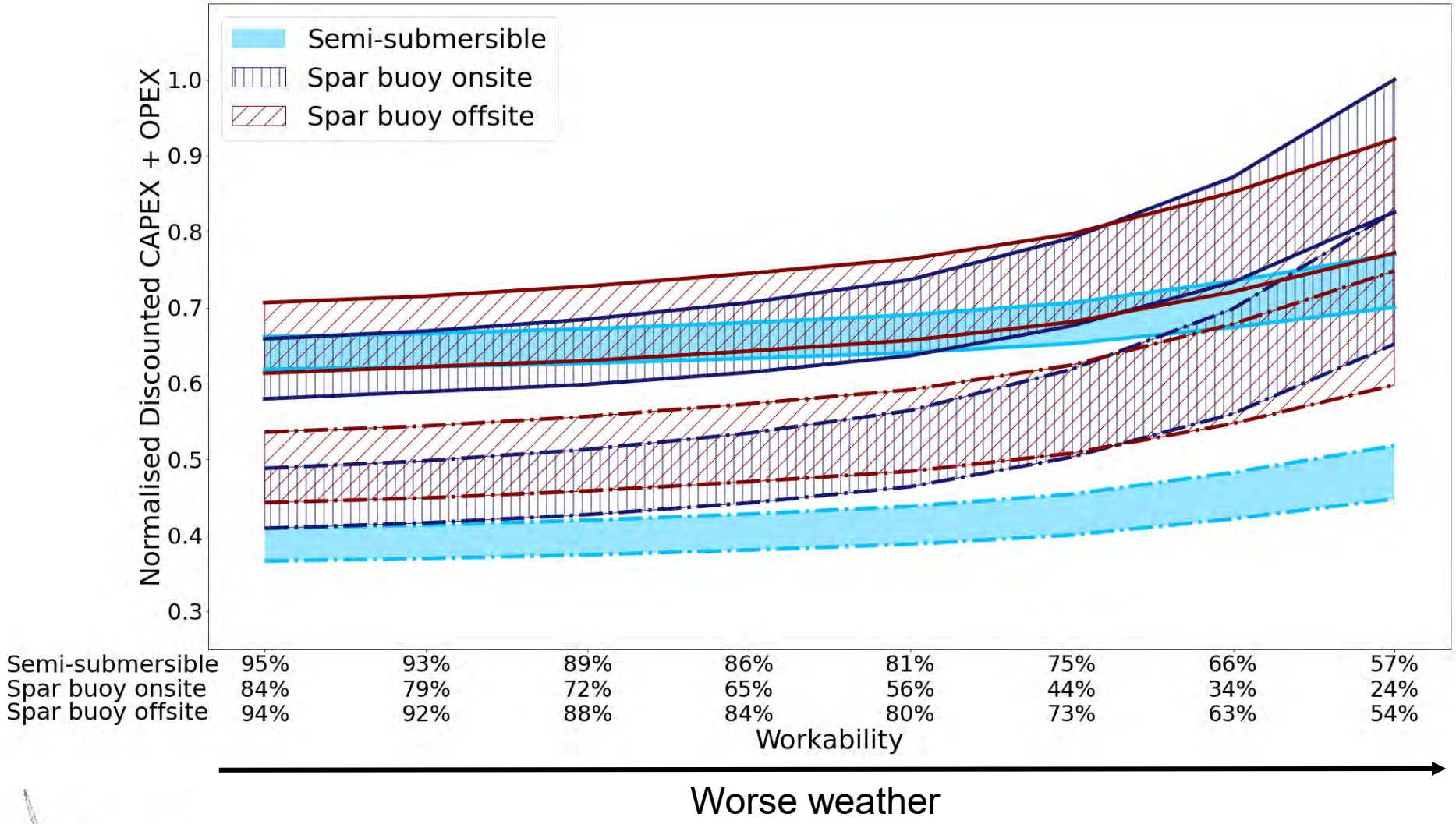
Discounted CAPEX + OPEX



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Conclusions

- Substructure sizing or concept selection has to take into account trade-offs with different phases of the lifecycle of the farm. External design drivers have a significant impact in determining the most cost-effective solution
- Where both spar and semi-submersible are feasible, high steel prices, low vessel rates and benign to moderate weather conditions favour the spar buoy over the semi-submersible
- There is no case where the combination of spar buoy and offsite major components replacement results in the most cost-effective solution

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Thank you!

Questions?

M.BaudinoBessone@tudelft.nl

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Logistics assumptions

- Critical sequences are independent
- Towing vessels can remain at port or sheltered location after accomplishment activity
- HLV can remain at site, port or sheltered location after accomplishment activity
- +1 m Hs limit activity at port or sheltered location Vs. same activity at site

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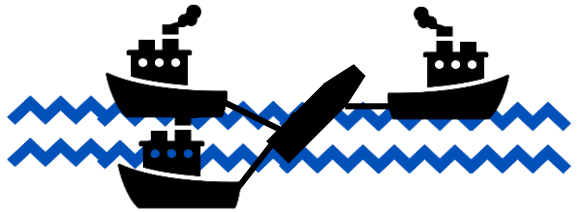
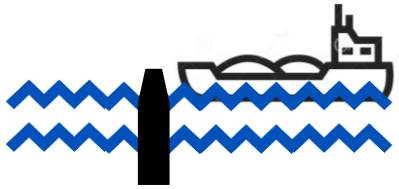
Case-study 2

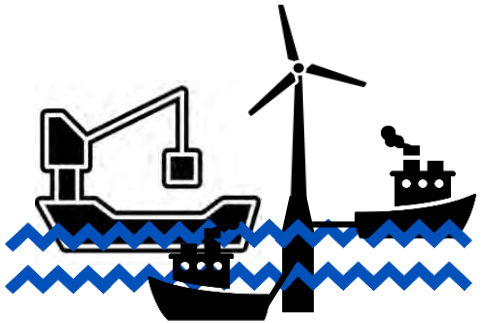


Transport from shipyard to sheltered location

Return to sheltered location



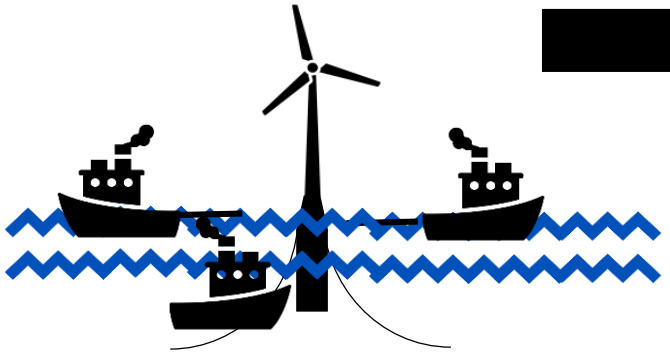
Ballast spar buoy



Onshore turbine assembly

Mate spar and turbine

Pre-commissioning



Transport to site and install

Commissioning

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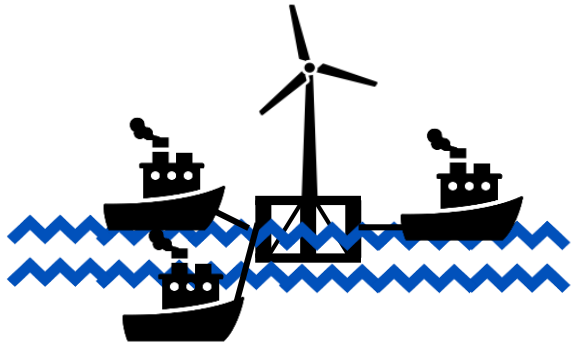
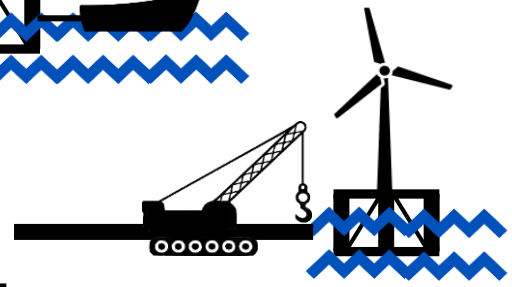
Case-study 2

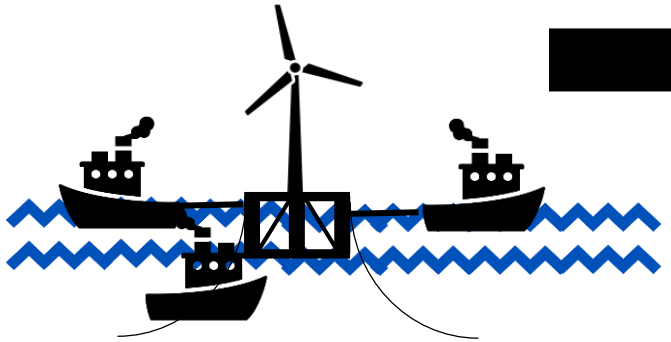
Transport from site to port



Major replacement



Transport to site and re-install



Re-commissioning

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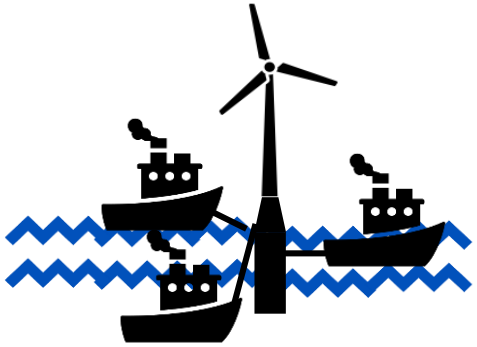
Case-study 2

Transport from site to sheltered location

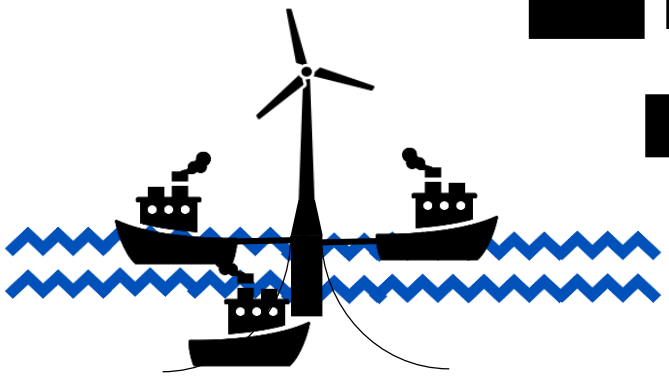


Load components on HLV

HLV transits to sheltered location

Major replacement

HLV transits to sheltered location



Transport to site and re-install

Re-commissioning

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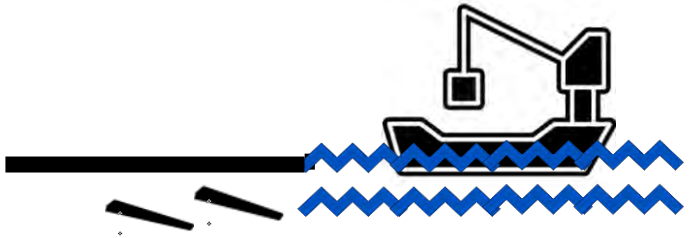
Case-study 2

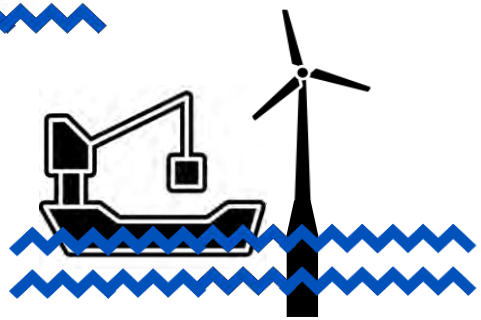
Rigging installation

Load components on HLV



Transit to site

Major replacement



Return to port

Re-commissioning

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