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Installing Array Cables between Offshore Windturbines, from Land! FreeFloating over 40 km?

Willem Griffioen

VISION & PERFORMANCE

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- WaterPushPulling and FreeFloating from land
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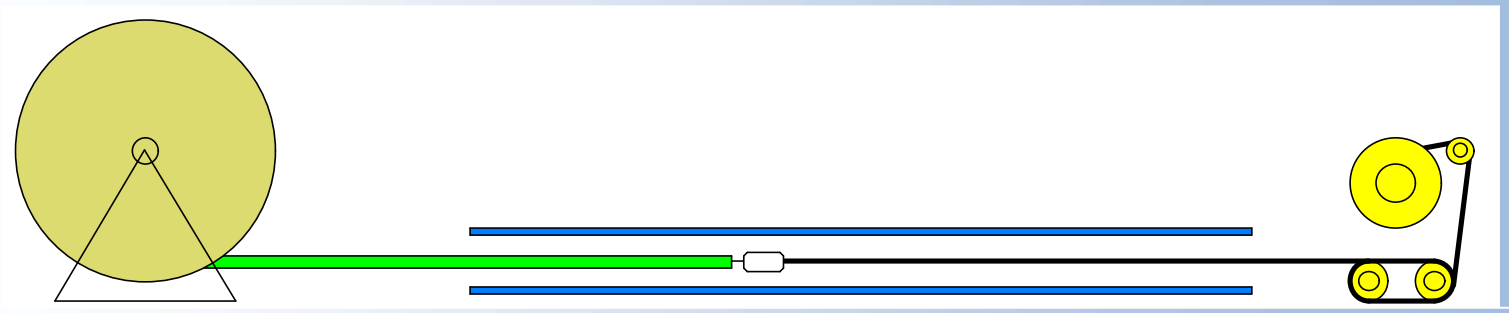
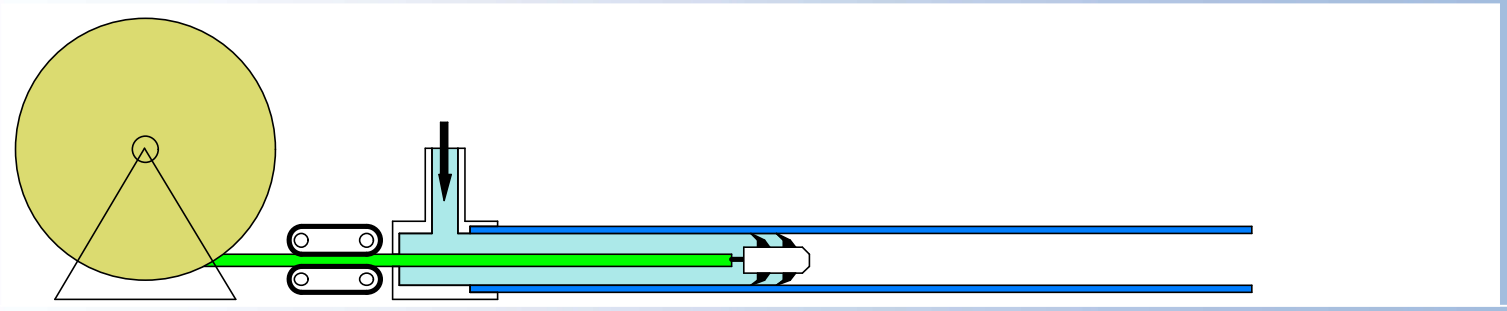
Introduction

- Techniques to install cables into pipes
  - Winch Pulling
    - Extra step of installing a winch line before pulling
    - Material and labour on both ends of pipe
    - High pulling and sidewall forces, lot of wear, limited length



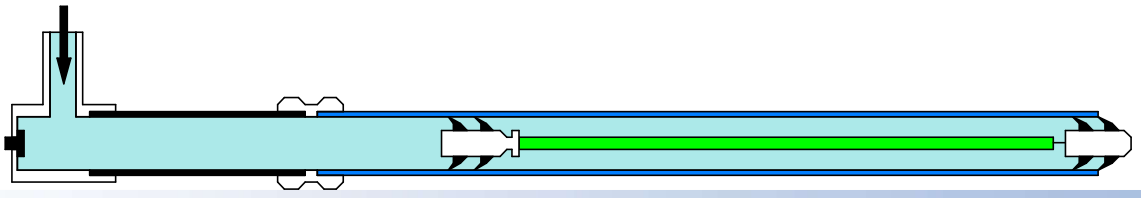
Introduction

- Techniques to install cables into pipes
  - Winch Pulling
    - Extra step of installing a winch line before pulling
    - Material and labour on both ends of pipe
    - High pulling and sidewall forces, lot of wear, limited length
  - WaterPushPulling
    - None of these drawbacks



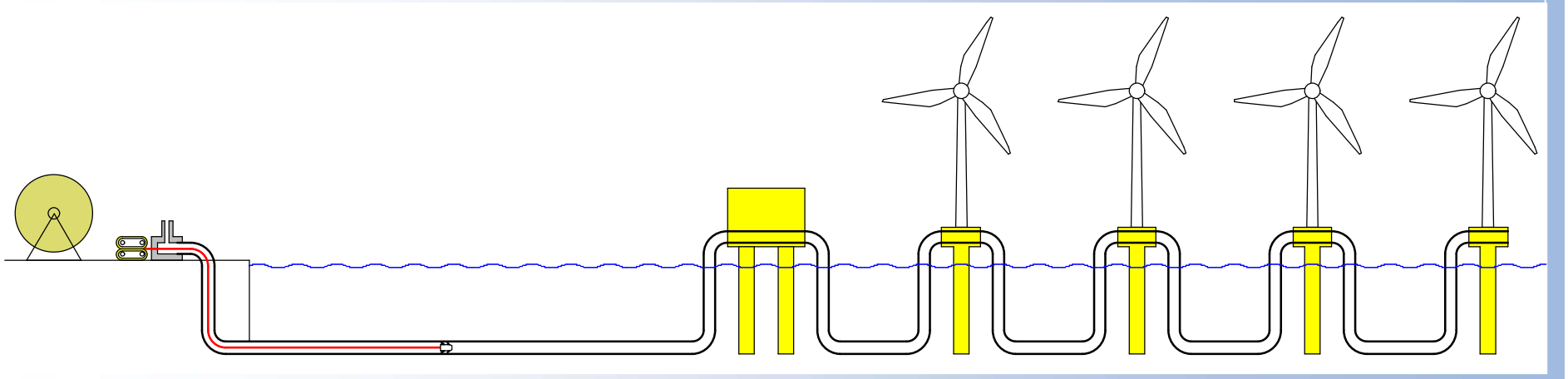
Introduction

- Techniques to install cables into pipes
  - Bonus advantage for WaterPushPulling:
    - Once installed with this technique the cable can be transported further through coupled pipes by the sole action of water, like “tube post”
  - Called FreeFloating



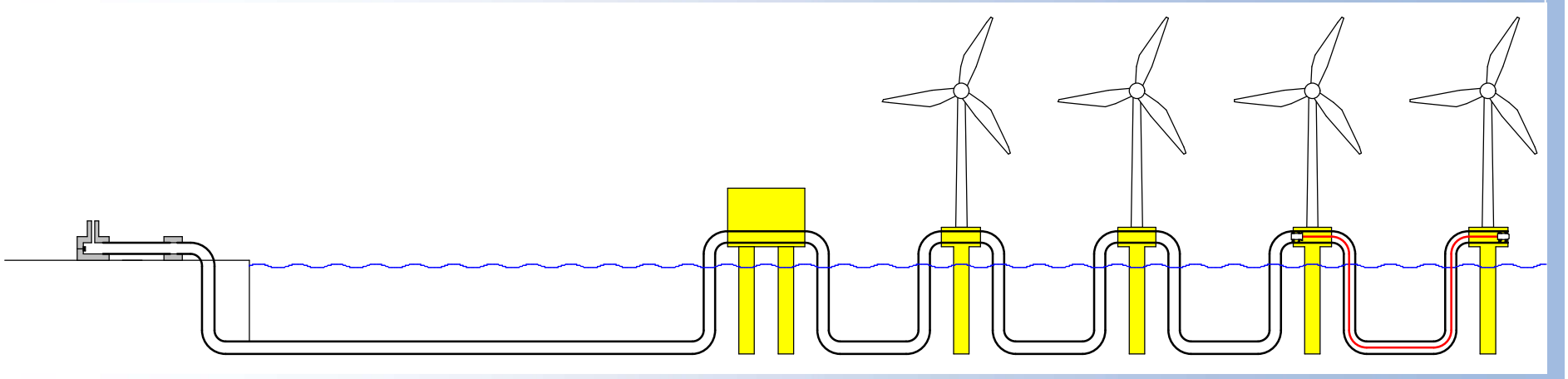
WaterPushPulling and FreeFloating from land

- Start WaterPushPulling
- Continue until entire cable is inside pipe



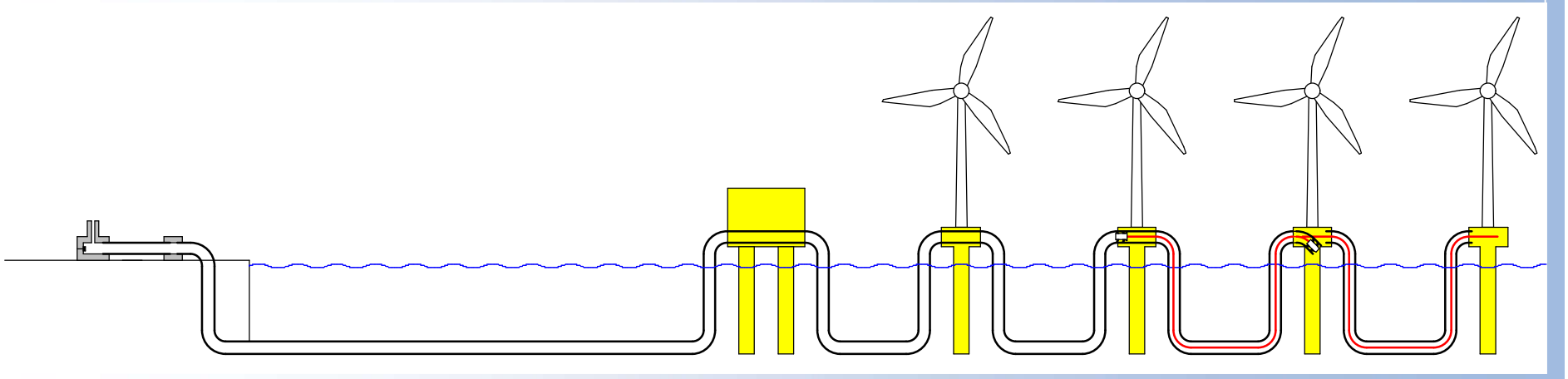
WaterPushPulling and FreeFloating from land

- Change to FreeFloating
- Continue FreeFloating
- Until final destination reached



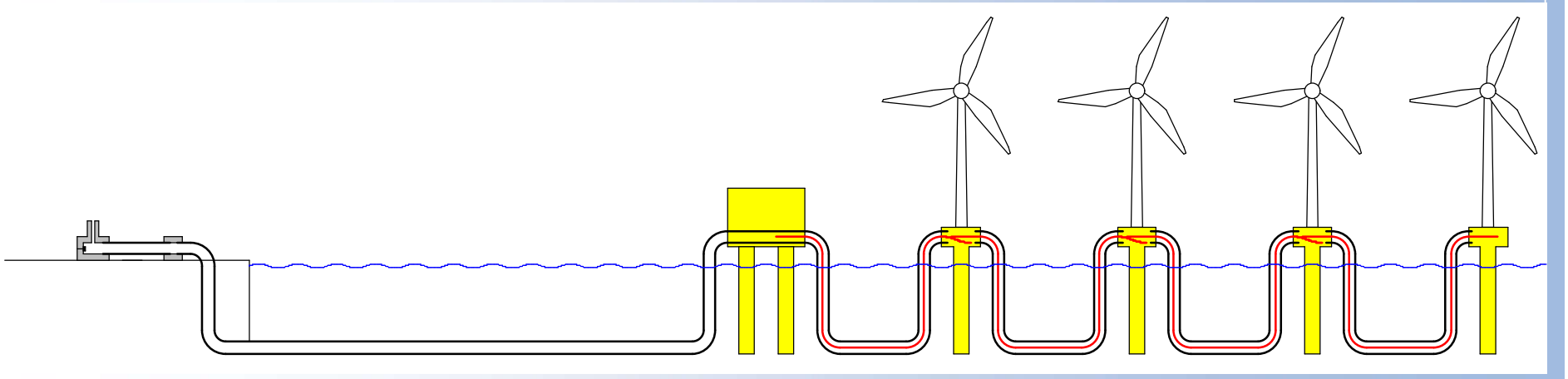
WaterPushPulling and FreeFloating from land

- Remove pigs and start new WaterPushPulling
- Continue FreeFloating
- Until final destination reached

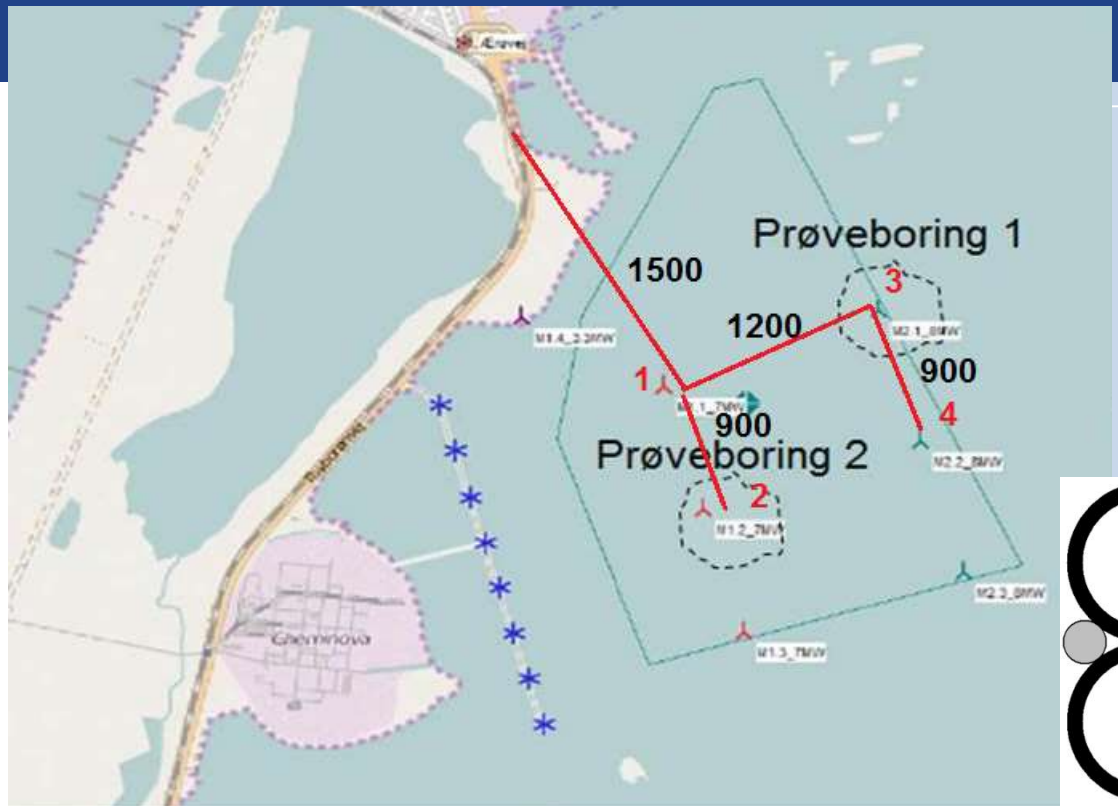


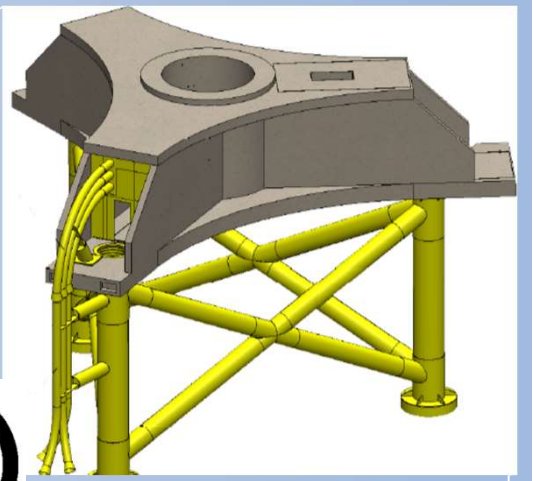
WaterPushPulling and FreeFloating from land

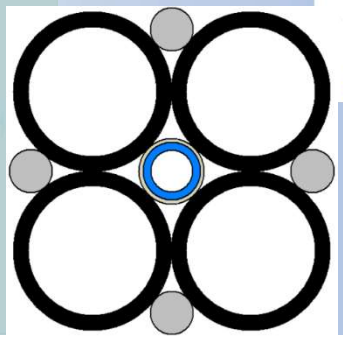
- Install rest of the cables
- All array cables installed

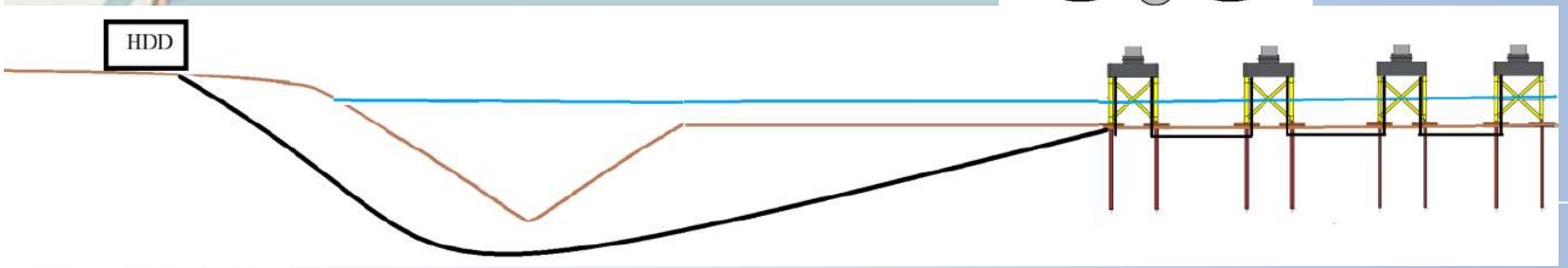


First offshore project, Nissum Bredning (DK)





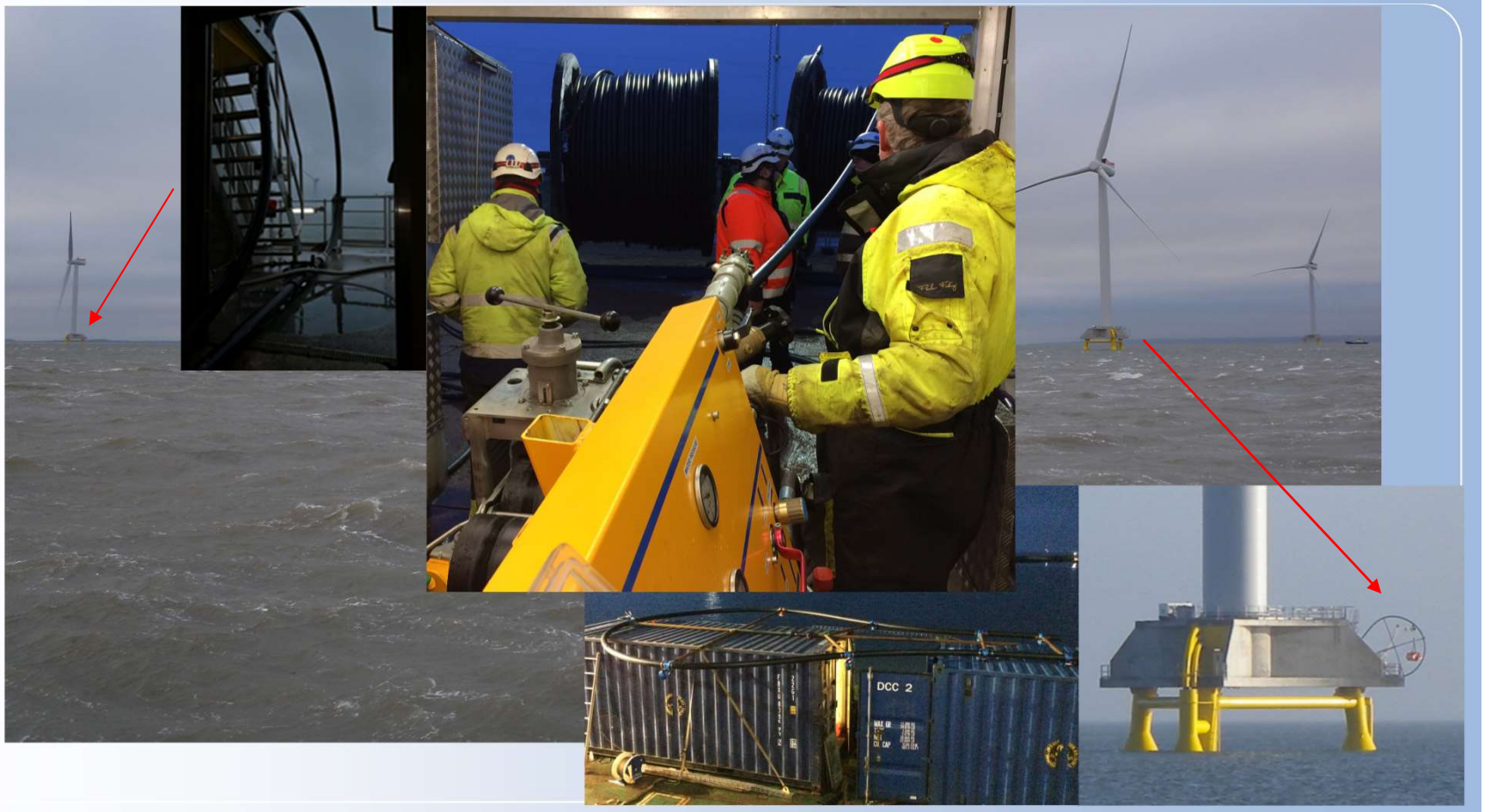




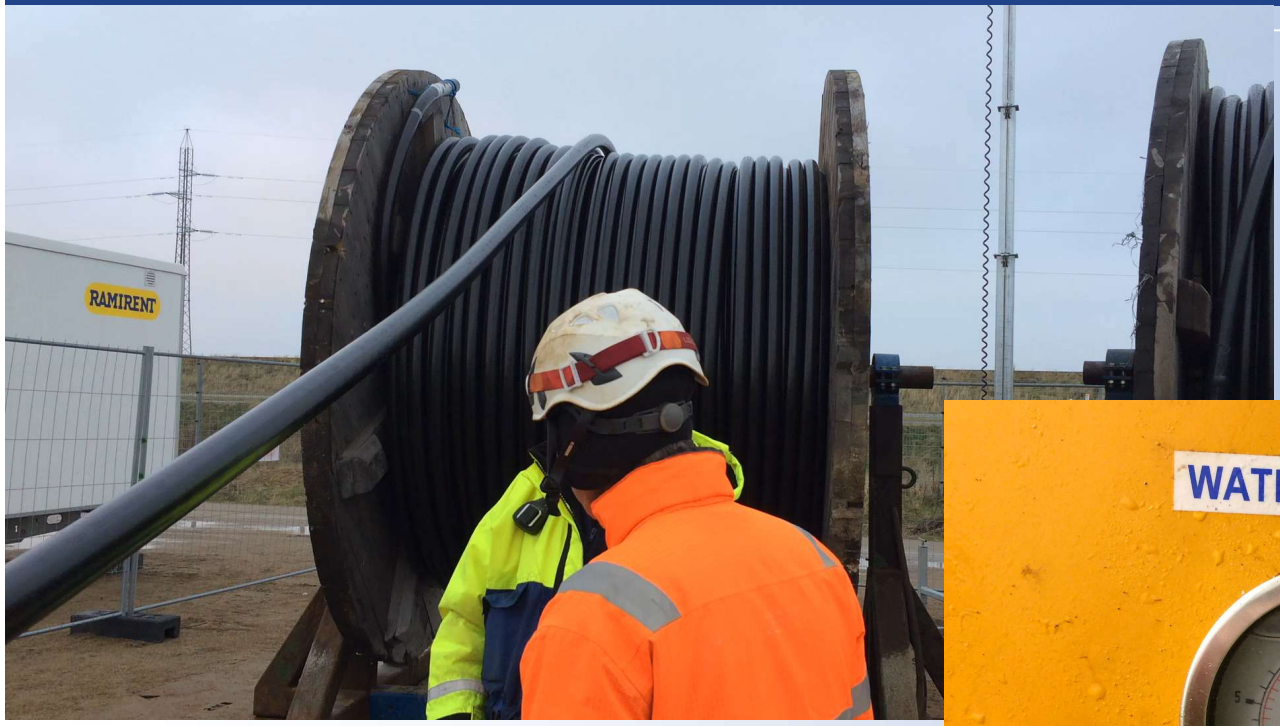
First offshore project, Nissum Bredning (DK)

- 4 “nearshore” wind turbines, each 7 MW
  - Connection from land via HDD drill
  - Export and array cables the same
  - Duct bundle 4 × 110/90 mm, with steel ballast
  - Cables 72 kV, 68.1 mm, 4.6 kg/m, longest 1300 m
  - WaterPushPulling from land (export cables) and from sea (array cables)
  - FreeFloating from land (array cables)
  - Cable speed of 28 m/min reached!
  - Installed even with Beaufort windforce 8!

First offshore project, Nissum Bredning (DK)



First offshore project, Nissum Bredning (DK)



WaterPushPulling

FreeFloating

First offshore project, Nissum Bredning (DK)

- Advantages Cable in Pipe for Offshore
  - Standard onshore cables on standard drums
  - Wider range of cable suppliers, cost reduction
  - Reduction in AC-losses (no steel armouring)
  - Pipe and cable can be installed with low cost vessels
  - Cable can also even be installed from shore
  - Trenching of pipe and cable less critical and can be done independent of other operations
  - Less (no) risk for cable damage during installation
  - Pipe damage easy to repair
  - Cable easily replaced when damaged in future

Limits and opportunities, speed and time

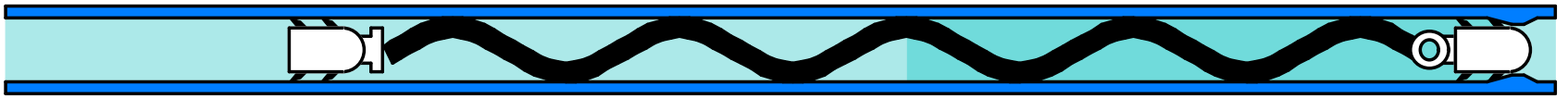
- **Water hammer**
  - Joukowski: $p=\rho c v$ → 60 m/min gives 15 bar
  - Much less because of pipe expansion
- **Cable speed**
  - Sudden stop → inertia, calculation analogously water hammer

$$F_c = \sqrt{\frac{m_c}{\frac{1}{k_c} + \frac{c_b \left(D_d - D_c\right)^2}{4\pi^2 B}}} \cdot v_c$$

  - Nissum Bredning cable 60 m/min → F_c = 12.9 kN

Limits and opportunities, speed and time

- **Cable and pig (!) hit obstacle**
  - **“Buckle wave” and water hammer wave start**
  - **Waves travel backwards until rear cable end**
    - **During wave travelling max force and pressure (at wave part)**
    - **Buckle force and pressure (pig) force do not add**
    - **Buckle wave travels faster than (~ 2x) pressure wave (1500 m/s)**



More info: W. Griffioen, C. Gutberlet, A. Uhl, G. Laurent, S. Grobety, “Projects with Remote Installation (“Tube Post”) of Energy Cables in Ducts”, Proc Jicable, Versailles, 23-27 June (2019) paper A3.2

Limits and opportunities, speed and time

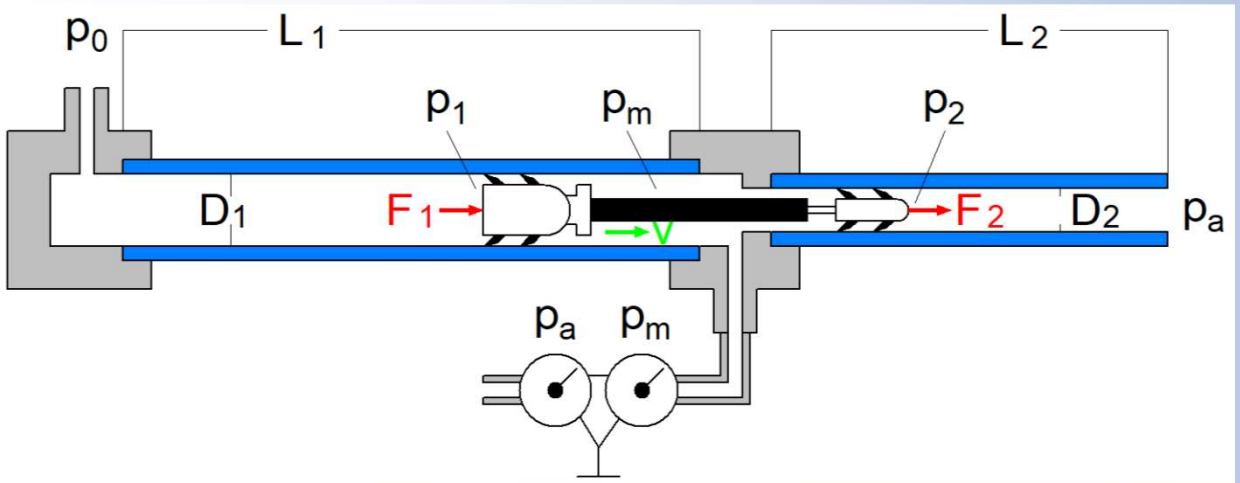
- Max water speed through long pipe (Blasius)

$$v = 2.9 \frac{D_d^{5/7}}{\mu^{1/7} \rho^{3/7}} \left(\frac{p}{L} \right)^{4/7}$$

- Example: HDPE pipe 160/130 mm, 40 km long:
  - Water speed of 40 m/min requires 12.4 bar
  - One cable takes 16.7 hours
  - SDR 11 pipe allows amply 20 bar water pressure (24 hours)
  - Rest available for FreeFloating
  - Larger pipes: higher speed and/or longer length possible (but stay below 60 m/min for safety)
  - In Nissum Bredning project 28 m/min was reached

Different duct diameters

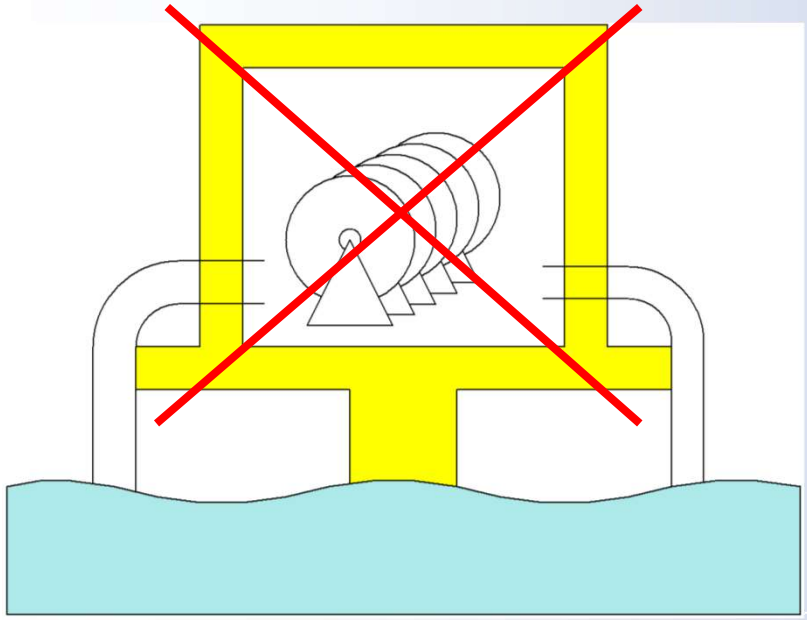
- Different duct diameters might exist
  - Smaller array pipes at edge of wind farm
  - Larger export pipe (migh be used for FreeFloating)
  - Need to change pigs at points of diameter change

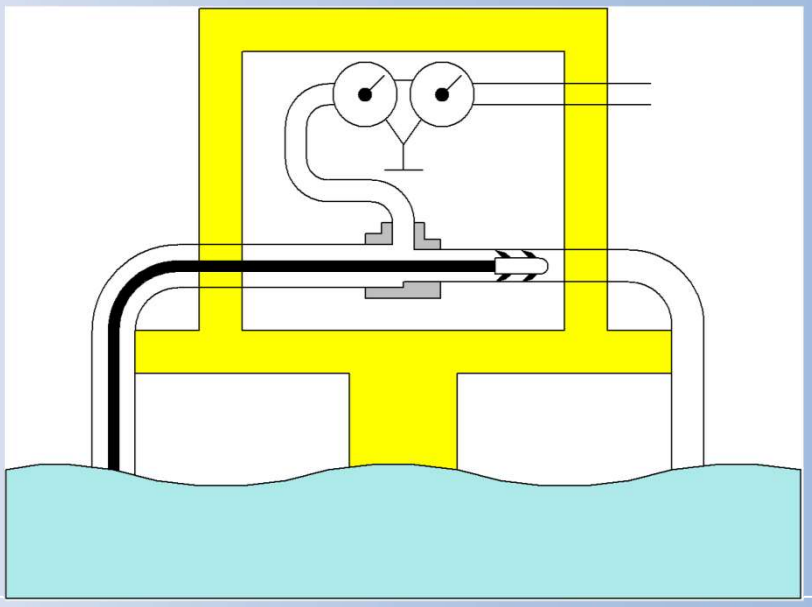


$$p_m = \frac{D_1^2 p_1 + D_2^2 p_2}{D_1^2 + D_2^2}$$

Limits and opportunities, speed and time

- No need to store (heavy) drums on platforms
  - And no vessels needed either for cable installation





Conclusions

- FreeFloating can be done from any suitable launch location to any desired destination, avoiding difficult to reach places
- Offshore wind farm: done from land to offshore turbines (also at bad weather, like Beaufort windforce 8)
- FreeFloating can be done safely at high speed and over long lengths
  (e.g. 40 km with 40 m/min in 160/130 mm pipes)
- Avoiding cable installation from vessels and storage of cable drums (on vessels or platforms)

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Thanks for your attention