Feasibility assessment of wireless series reactive compensation of long submarine AC cables

Author: **Gaspard Lugrin**, Research Scientist, SINTEF Energy Research

Presenting: **Andrzej Holdyk**, Research Scientist, SINTEF Energy Research

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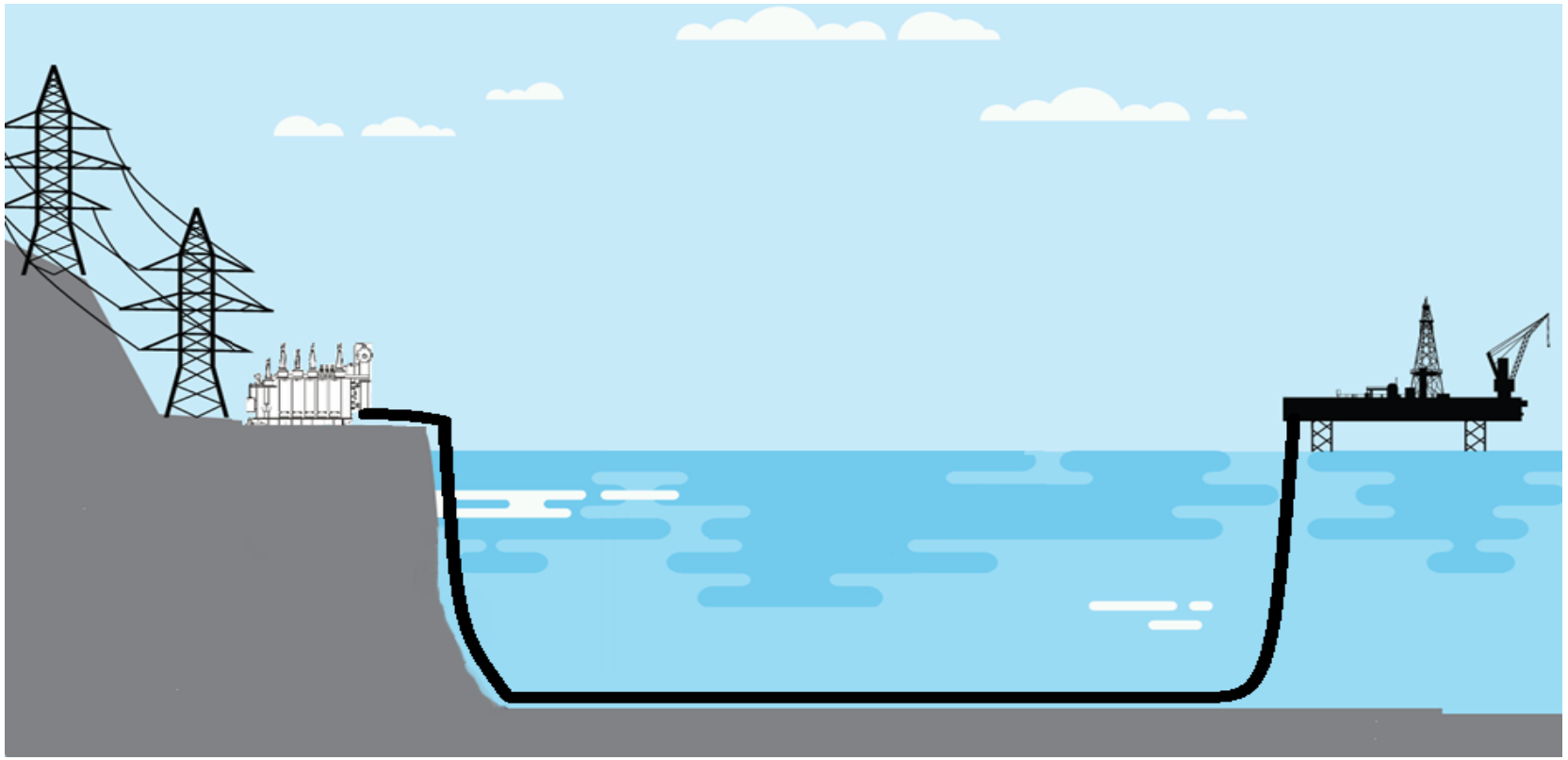
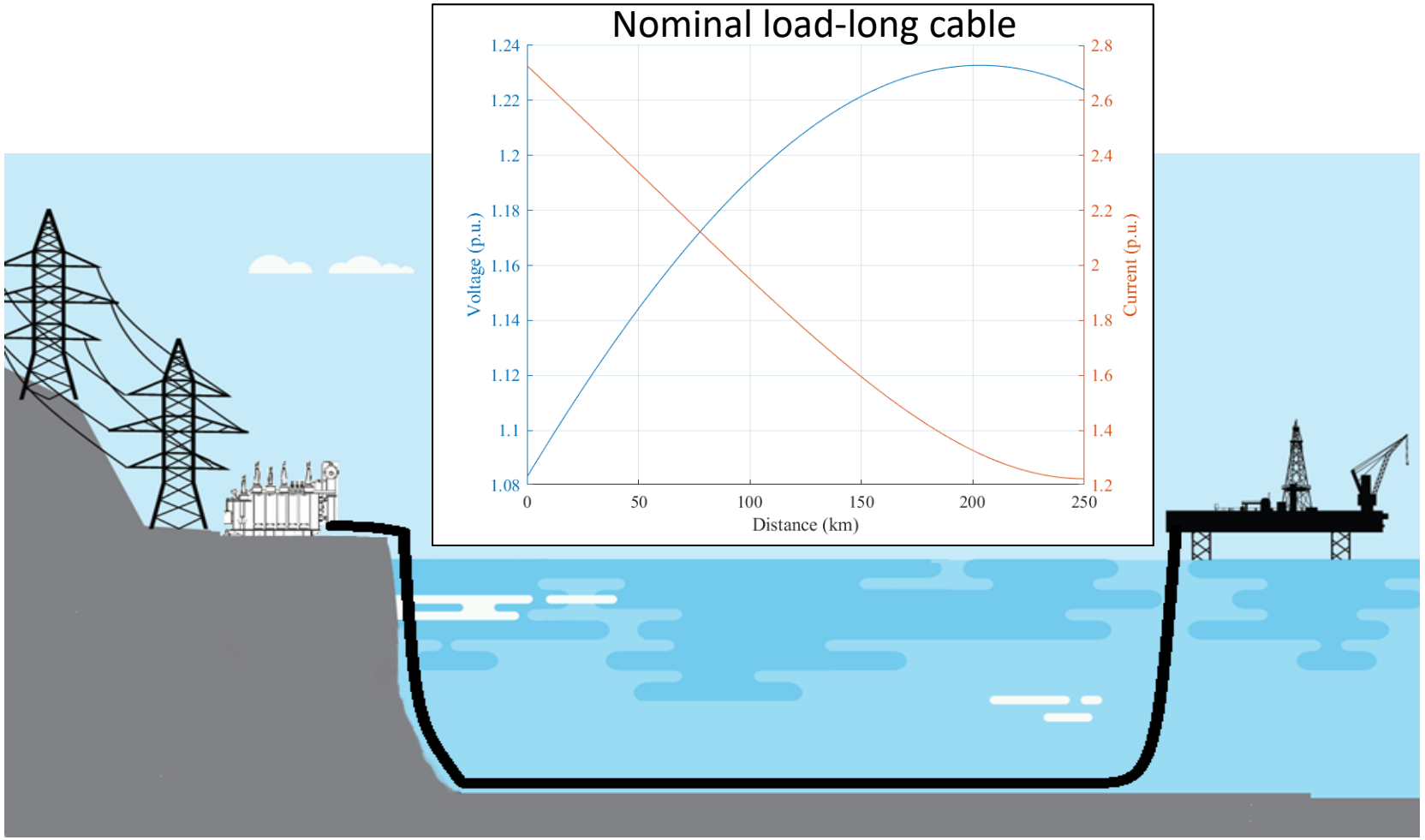
Background

- Long AC subsea cable
  - Connects offshore installation with shore
- Main applications:
  - Offshore Wind Power Plants (OWPPs)
  - Oil and gas platforms



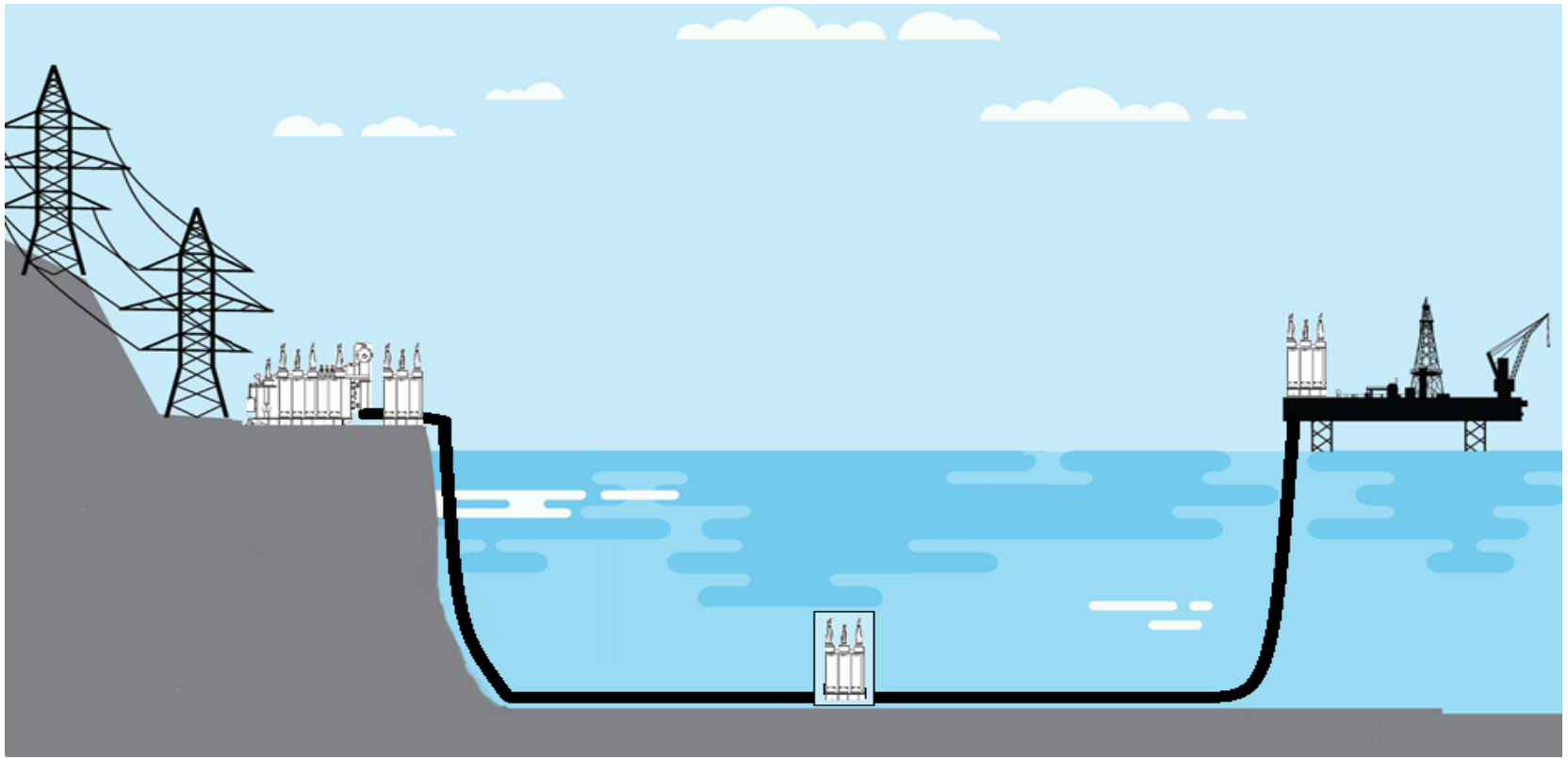
Long AC subsea cable

- Submarine cables have large capacitance
- Always generate reactive power
- Capacitive current is added to the load current
- Long distances require compensation



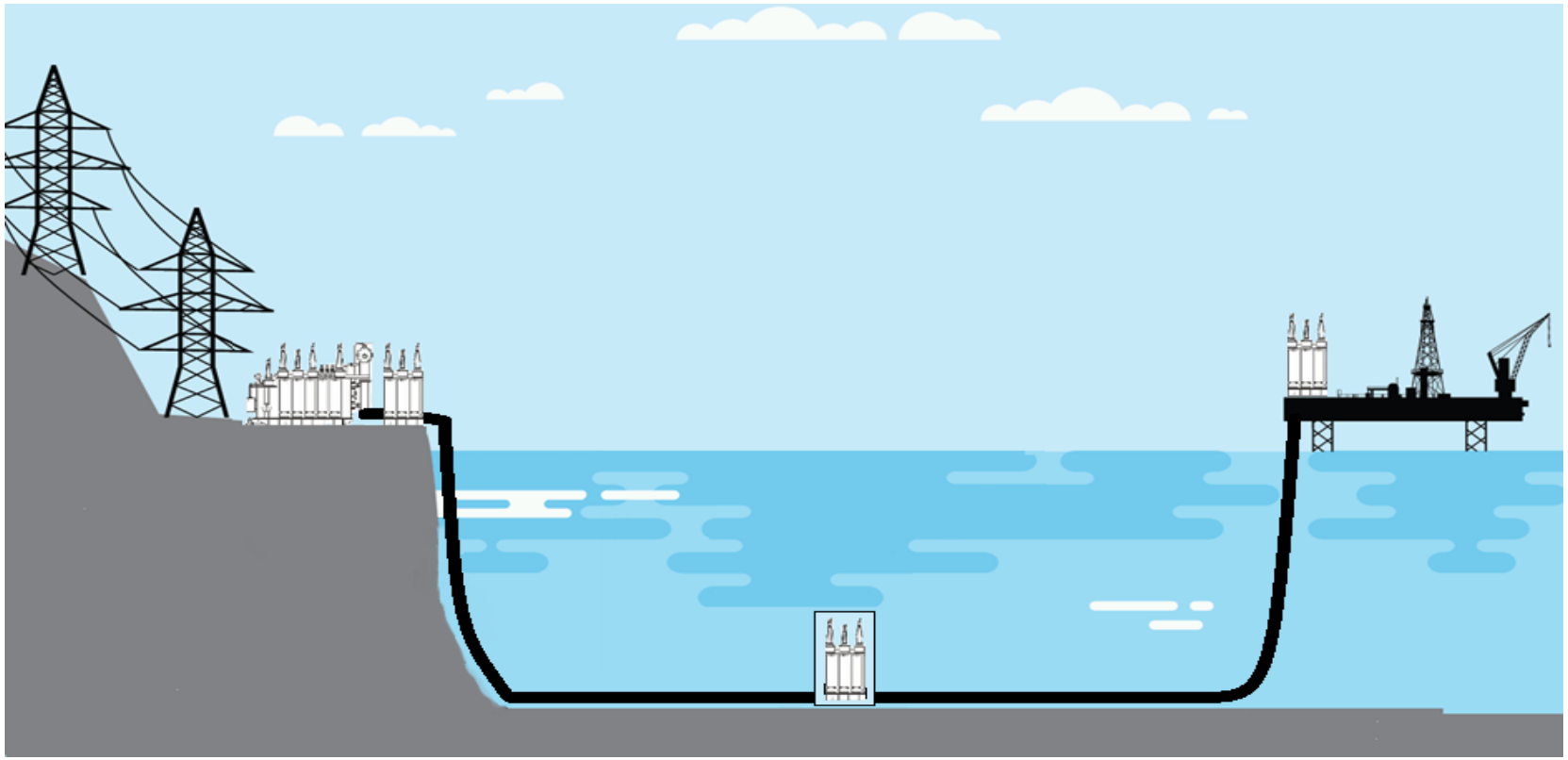
Compensation of long AC subsea cables

- Compensation usually done using shunt reactors
- Due to costs, reactors are usually placed at:
  - Substation
  - Platform, near the load
  - Additional platform in the middle
- Could also be placed at the sea bottom



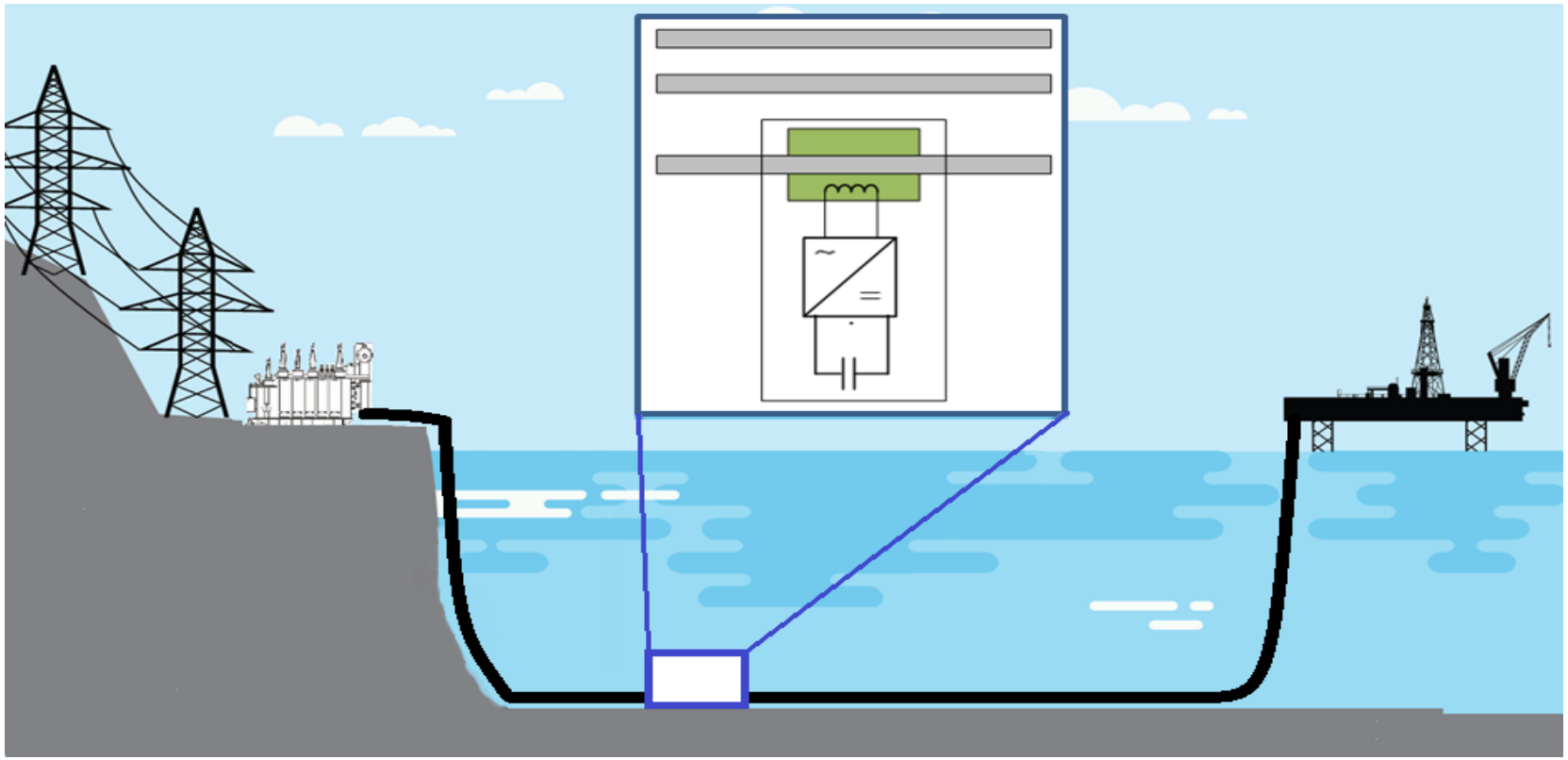
Compensation placed at the sea bottom

- Shunt reactors must be encapsulated
- Cable must be split and connected to the structure
  - HV wet-mate connectors
- Might be difficult to disconnect from the system in case of failure



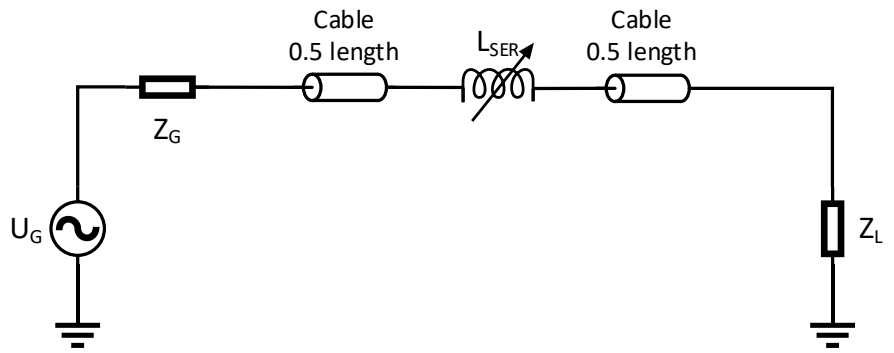
Initial idea: wireless compensation with magnetic coupling

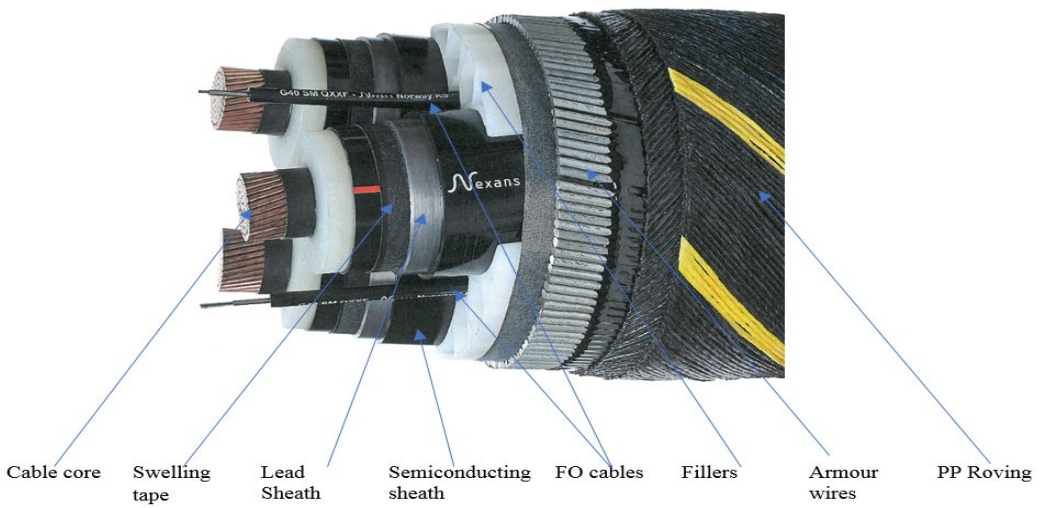
- Magnetic coupler:
  - Iron core
  - Primary circuit: cable
  - Secondary circuit:
    - Coil
    - Pressure tolerant power electronics converter
    - Storage device
- Clamped around a cable
  - No need for splitting the cable
  - No need for connectors
  - No problems in case of failure



Feasibility studies

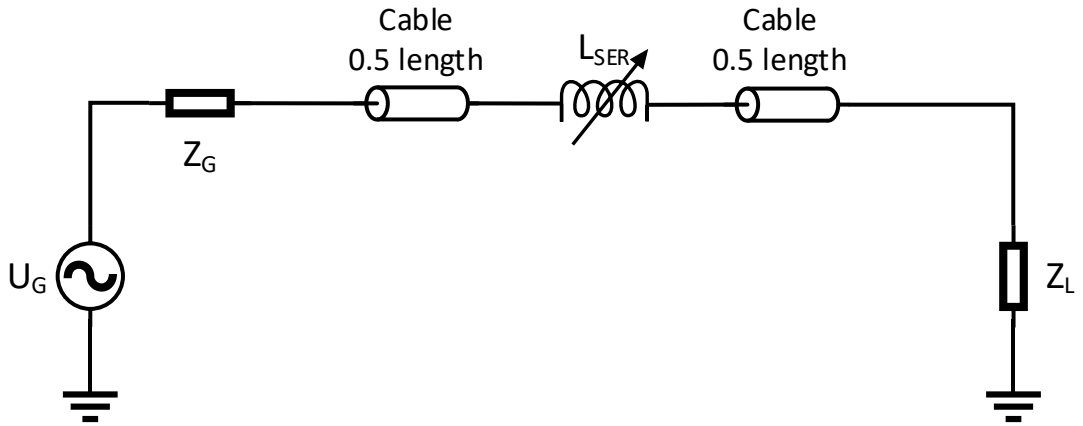
- Feasibility studies looked into:
  - Load flow
    - Can we dynamically compensate the cable?
    - Is the entire system stable?
    - Do we still need shunt compensation?
  - Cable design and possibilities of connection
  - Coupler
    - Main characteristics and estimation of weight of couplers





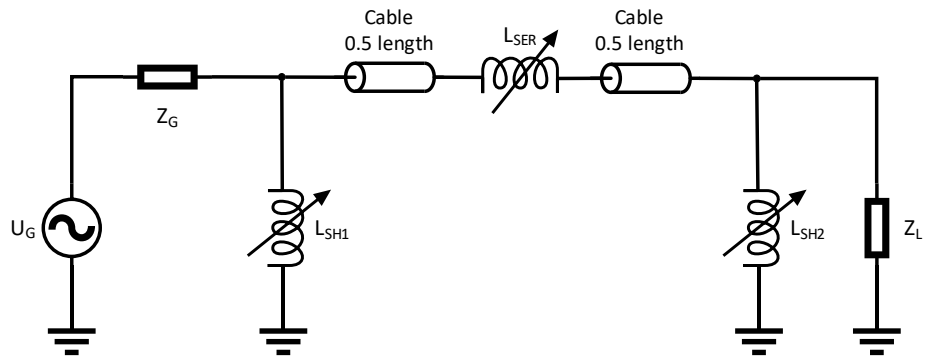
Results: Load flow analysis

- Initial idea: series inductive compensation only:
  - At low transmitted power, full compensation requires arbitrary high voltage and causes a transmission angle larger than 90°; small partial compensation worsens the voltage at load.
  - For cables longer than a given value (depending on system parameters), full compensation causes transmission angle larger than 90°.



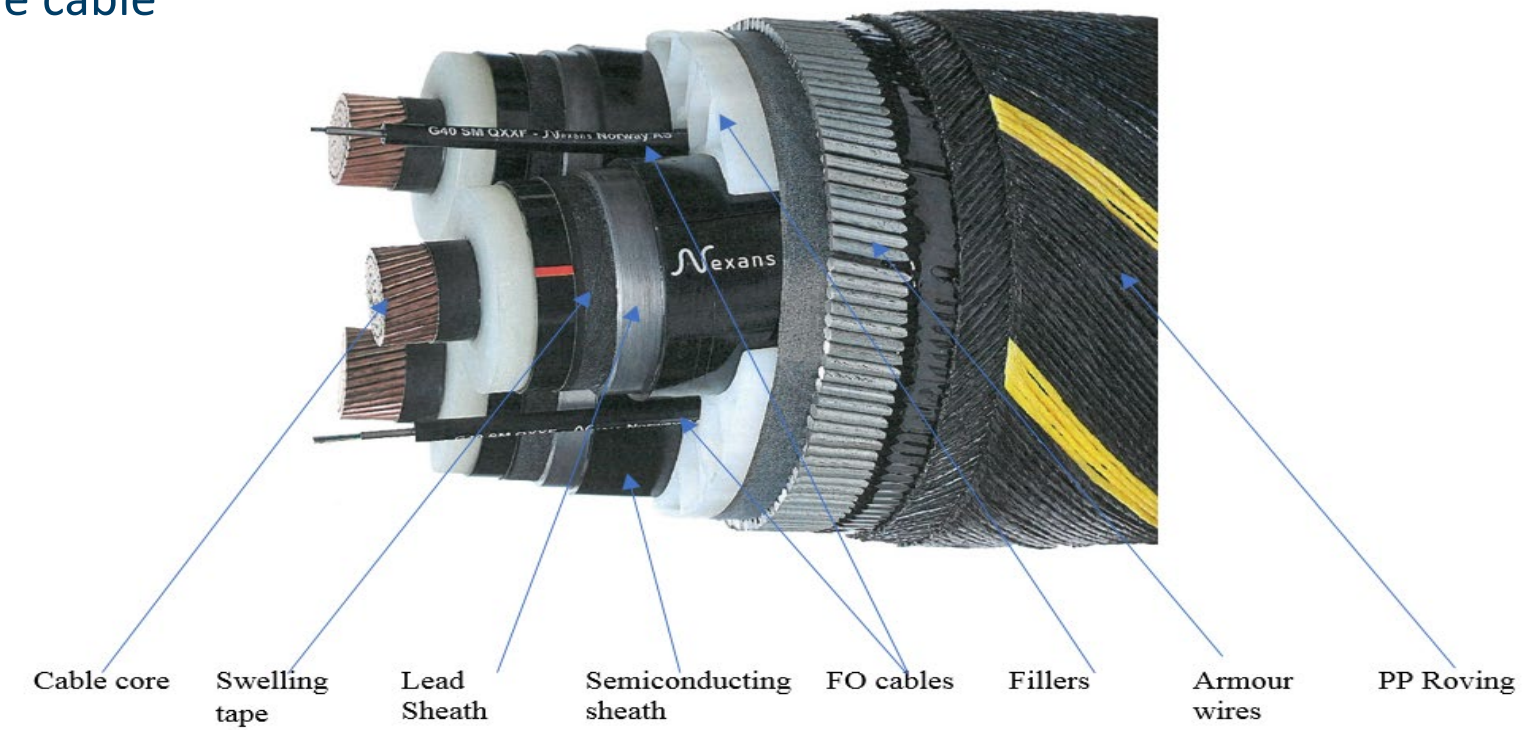
Results: Load flow analysis

- Proposed method: combination of shunt and series inductive compensation
  - Increase of power transfer capability or operative cable length in comparison with a case where no compensation is present along the cable
  - Requires variable shunt inductances
  - The total installed reactive power for full compensation is larger with the proposed method than with shunt inductive compensation only.
  - Transient behaviour should be checked



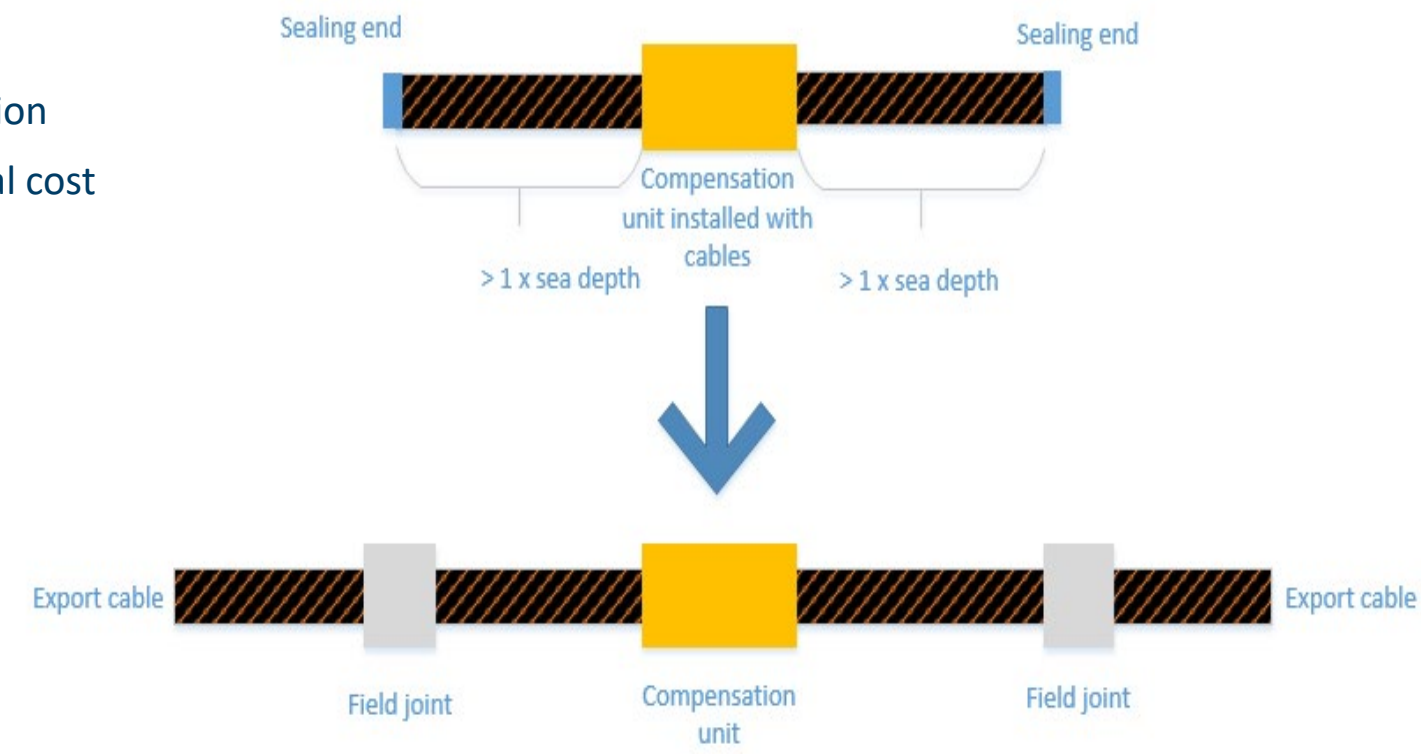
Limitations due to cable design

- Initial idea: coupling on a three-core cable
  - Cannot couple to a 3-phase cable directly
  - Armour, semiconductive layers, sheath



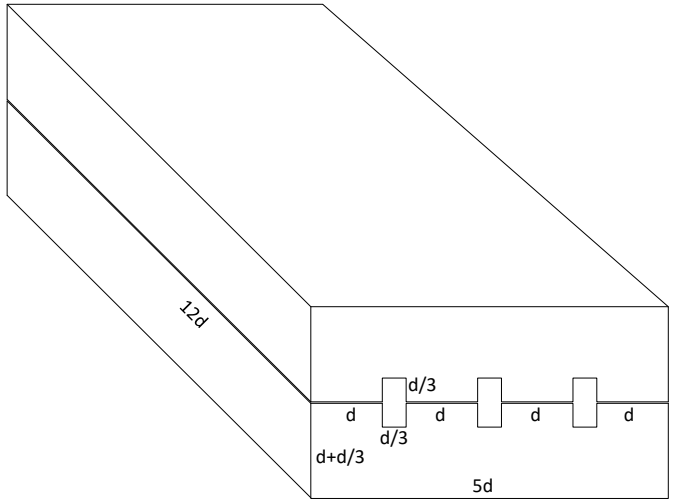
Limitations due to cable design

- Proposed method: compensation unit
  - Compensation unit pre-installed on a cable section
  - Subsea system: no need for a platform (potential cost reduction)
  - The method is not "non-intrusive"

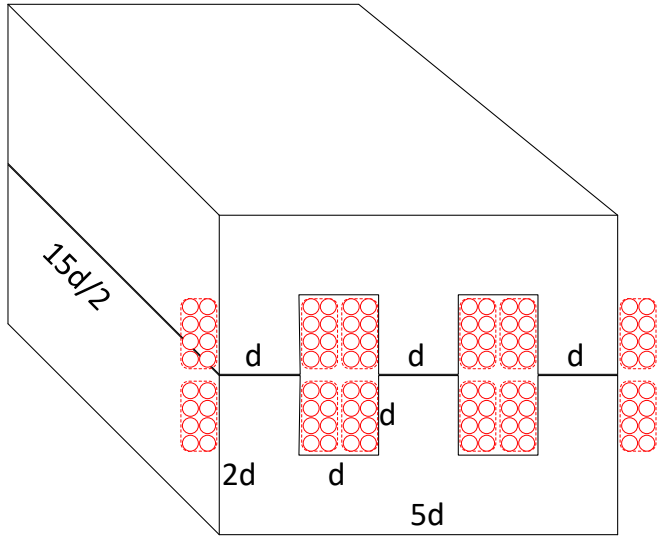


Coupler design

- Initial idea: single-turn secondary winding coupler
  - Very large size and weight



- Alternative: multiple-turn secondary winding
  - Weight is reduced in comparison with the single turn secondary winding
  - Would require to coil the cable
  - Not relevant if the compensation is pre-installed on the cable.



Conclusions

- Initial idea: non-intrusive inductive compensation
- Limitations in the practical feasibility of the initial idea
- Alternative solutions:
  - Combination of shunt and series inductive compensation
  - Use of a compensation unit pre-installed on the cable
- Advantages
  - Increase power transfer capability or operative cable length in comparison with a case where no compensation is present along the cable
  - Compensation comparable (but not as good) as shunt compensation alone
  - Subsea system: no need for a platform (potential cost reduction)

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