General information

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Project title	CABLE JIP 2
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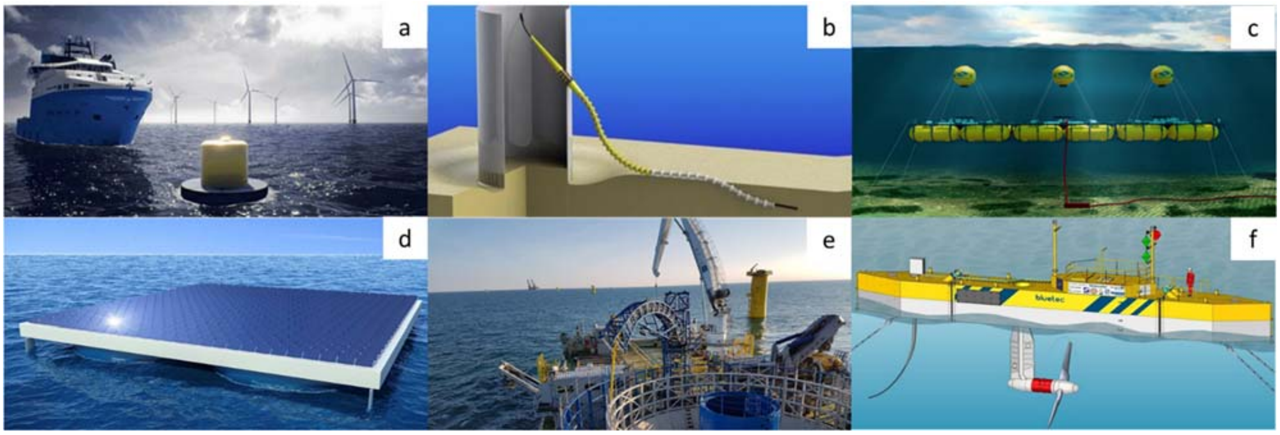
Potential Project partners	Twentsche Kabel Fabriek Bluewater <partner n>
GROW Program Line	*HER+*

1. Problem statement

CABLE JIP 2 is an industry R&D project for next generation inter-array electrical cables for the offshore renewable energy industry. Specifically, the project concerns the development of a next generation cable to achieve a technology readiness level of TRL 5-7. The project focusses on the electrical cable under a floating wind solution, which is assumed to be the most challenging case for dynamic cables offshore. It is believed that if the problem is solved for this severe case, it is also solved for most other applications, such as wave energy conversion (WEC), tidal energy conversion or floating solar and e-charging buoy. The investment cost of the project can be easily earned back on AEP, CAPEX and/or OPEX.



Examples of dynamic cables in offshore renewable industry: (a) e-charging buoy, (b) free hanging part of electrical cable for bottom-founded wind, (c) wave energy converter, (d) floating solar, (e) offshore installation of inter-array cable and (f) offshore floating tidal energy.

2. Objectives and results

The main objective of the project is to develop the required subsea inter-array cable technology for the rapidly developing offshore renewable industry. As evidenced by insurance claims and recent experience from offshore wind farms, there is still a lot to be gained for subsea electrical cable technology. Overall, there is a strong need to de-risk the subsea electrical cables and to bring down the levelized cost of energy (LCoE): The projects the project will deliver:

- A new generation subsea inter-array cable with improved fatigue properties. The new subsea inter-array cable will retain the attractive features of the present generation cable, including its competiveness compared to alternative solutions. The improvement of the new cable is obtained by corrugated aluminium sheathing, which will reduce the bending stiffness as well as the stress levels under cyclic loading. The modern design of thecable allow for rapid offshore installation and repair, without the complications of 'dirty tar' or other difficult to handle materials. The cable will be produced in long length up to several hundreds of kilometres for up to 66 kV application.
- The project will fill in the knowledge gaps for design life prediction for free spanning subsea electrical cables in exposed offshore dynamic application. Although the technology exists in principle (e.g. in Orcaflex or Shear7), the large uncertainties prevents the potential cost saving that can be achieved for the electrical cables. The main knowledge gaps that will be addressed in the project are: more accurate dynamic response calculations in the time domain, more accurate VIV predictions and industry qualified fatigue resistance tests for the electrical cable. The project aims at achieving TRL 5-7, which is substantially above current TRL 3-5.

3. State-of-the art

The end result of CABLE JIP 1 (2017-2019) can be considered as state-of-the-art for subsea inter-array cable technology for offshore renewable industry [1]. Several man year of work has been devoted in CABLE JIP 1 to bringing the required technology forward for the specific topic of free spanning subsea electrical cables in exposed offshore dynamic application. A review of recent EU and TKF-WoZ research project with more or less the same ambition is provided below. The research initiatives all recognize the need to fill in the knowledge gaps and although it is not yet completely clear what the other project will achieve, it can be stated that CABLE JIP was successful in producing a fully comprehensive design life prediction methodology. Fully comprehensive means that all relevant design aspects are taken into account in the prediction. However, understanding the complexity of the matter, CABLE JIP 1 still qualifies the end result of the project as TRL 3-5. It is expected that the other projects will reach TRL 3-5 at the most.

1] Wilde, J. d., Nat, C. v., Pots, L., Vries, L. d., & Liu, Q. (2021, accepted). *CABLE JIP: A Research Project to Assess the Feasibility of a Semi-Static Electrical Subsea Cable for the Power Take-off from a TLP-type Floating Offshore Wind Turbine*, OTC-31209-MS, Houson, Texas, USA.

Review of recent EU and TKI-WoZ projects addressing subsea inter-array cable technology

Project	Lead	TRL	Year	Budget	Scheme
COREWIND	IREC	3-5	2019 2023	??	EU H2020
FLOTANT	PLOCAN	3-5	2019 2022	??	EU RES19
CALM JIP	DELTARES	3-5	2018 2020	1.5 MEuro + partners	TKI WoZ
CABLE JIP 1	MARIN	3-5	2017 2019	700 kEuro	TKI WoZ

4. Approach, activities and planning

The project will be structured as a normal joint industry project, such as executed in the framework of MARIN FPSO JIP week or MARIN Blueweek. The project is divided into 5 main work packages plus one additional work package for JIP management:

WP 1: Development of next generation cable (TKF)
WP 2: Design of cable system (Bluewater)
WP 3: Development of cable VIV tool (MARIN)
WP 4: Development of cable monitoring system (MARIN)
WP 5: Offshore site test of cable under a CALM buoy (contingency)
WP 6: Management & Coordination (MARIN)

The following main activities are executed in the project:

- TKF will develop a next generation cable, aiming at larger fatigue resistance and larger size cables for higher voltage and higher power. Specifically a cable will be developed with corrugated aluminium sheathing to reduce bending stiffness and obtain better fatigue resistance.
- TKF will perform fatigue tests for the full size OD 117 mm cable. This test will be executed under supervision of a qualified fatigue testing authority such as TNO or DNV-GL.
- Bluewater will work on the further development of the bend stiffener at the top of the cable and the support of the cable at the touch down area. Both aspect have large impact on the overall fatigue life of the free hanging cable. Other applications for the (dynamic) electrical cable will be studies as well, including a cable connected to a bottom-fixed wind turbine, e-charging CALM buoy and floating solar. Different types of floaters will be considered in the project, including TLP, spar and semi-submersible.
- Bluewater will further develop the fully coupled time domain ULS and FLS analysis to achieve TRL 5-7. Apart from the normal in-services life of the cable, also the fatigue accumulation during manufacturing, transport, installation and maintenance will be addressed in the project.
- The VIV of the cable is a specific research task for MARIN, aiming to achieve TRL 5-7. Different VIV prediction methods, such as frequency domain, time domain and CFD, will be tested and compared with each other. New VIV tow tests will be conducted by MARIN to better understand the effects of marine growth and VIV suppressing strakes.
- There is strong incentive in the offshore renewable industry to equip the subsea electrical cables with novel fibre optic measurement technique for cable monitoring and predictive maintenance. In CABLE JIP 1 (2017-209), experiments were already carried out with fibre optic distributed strain measurements based on Brillouin scattering. In CABLE JIP 2 the fibre optic strain measurements is further developed for to meet the required accuracy and sample rate.
- The project has plans for a test with a section of a full scale electrical cable hanging as dummy under an existing offshore structure such as a CALM buoy. The cable will be exposed to sever dynamic loading and open sea conditions for several months. The results of the open sea test will greatly help the understanding of actual aging, marine growth and fatigue accumulation.

5. Project partners

Partner	Website	Type	Role in project
MARIN	www.MARIN.nl	Research institute	Project coordinator. MARIN has a specific task in the project for VIV analysis of the electrical cable.
Twentsche Kabel Fabriek BV	www.tkf.nl	Large company	TKF is designer and manufacturer of electrical cables. TKF will develop next generation electrical cables for larger kWatt and next generation electrical cables for higher fatigue resistance using corrugated sheathing.
Bluewater Energy Services BV	www.bluewater.com	Large company	Bluewater is the designer of the catenary configuration of the electrical cable under a FOWT, including bend stiffener and anchor. Bluewater aims to execute an offshore site test with a full size electrical cable hanging as dummy under an offshore floating structure, such as a CALM buoy.

6. Business opportunities and economic impact

The cost of the project can be easily gained back, even when ‘only’ addressing a relatively small component such as a free hanging electrical cable. The Dutch ‘Klimaatakkoord’ envisages a CO_2 reduction of 49% and the 2030 target for the Dutch energy mix asks for at least 27% renewable sources. Offshore renewable energy plays an important role in the energy transition, especially offshore wind. The 2030 target for the energy production in the Netherlands is 40% from offshore wind farms. The world-wide potential is much bigger, with total Dutch energy demand being ‘only’ 0.36% of the world total. TKF and Bluewater initial ambitions are for projects in the Dutch North Sea sectors, but later also with outlook abroad in EU, USA, Asia and other places.

7. Budget

The total cost of the project is Euro 990,000.=. The project partners request a HER+ subsidy of Euro 740,000.00. The project partners are committed to provide the funding gap and have access to the means necessary to finance their own contribution in the project.

	Fundamenteel onderzoek	Industrieel onderzoek	Experimentele ontwikkeling	Total costs
Total project costs	€ 0	€ 990,000	€ 0	€ 990,000
Requested subsidy				€ 740,000
Own contribution				€ 250,000

8. Subsidy instrument

HER+: The project stimulates and accelerates the development of subsea electrical cables for the offshore renewable industry. The JIP will enhance the production of offshore wind energy and result in significant reduced costs of offshore wind energy production by 2030. The investment cost of the project can be easily earned back on AEP, CAPEX and/or OPEX.