MECMate

WES Quick Connection Systems Stage 2 Public Report

Nova Innovation Ltd

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1 Project Introduction – MECMate

Nova Innovation's MECMate (Marine Energy Converter Mate) subsea connector is a robust and cost-effective hybrid (electrical and communications) wet-mate quick connection solution, specifically designed for marine energy converters by one of the world's leading marine energy companies.

The system utilises a single pin, multi-pass electrical connection transferring both high power and high bandwidth communications; a design that offers significant advantages over traditional solutions:

- Market leading generous misalignment tolerances
- Mechanical robustness for enhanced survivability
- Improved reliability through minimal sealed surfaces with multiple redundant seals
- Self-capping for maximum protection when unmated
- Quick, simple connection and disconnection
- Specifically designed to be cost-effective for the marine renewable energy market.

MECMate builds on Nova's field-proven, dry-mate subsea electrical connector, the NovaCAN, which is successfully installed and has proven itself through years of trouble-free operation on three tidal turbines in Nova's Shetland Tidal Array.

The product is designed to meet the demanding requirements of early MEC prototype testing, where operational loads are uncertain and multiple connection and disconnection operations will be required. As the industry matures, MECMate's highly scalable architecture will allow the product to evolve to meet the needs of commercial devices at MW and array scales.

The MECMate project was one of four successful bids in the WES Stage 2 Quick Connect System (QCS) call.

The MECMate team is led by Nova Innovation (Nova), with partners Wave Venture. Nova Innovation is a world-leading tidal energy company with unrivalled experience of successful MEC design, build and operation, including the design and real-world offshore operation of subsea electrical connectors. Within the Nova Innovation team there are also many years of Wave Energy Converter (WEC) development experience. Wave Venture brings knowledge of the latest developments in WEC technology, close links to the WEC developer community and strong analytical capabilities for offshore operations.

Products currently available for hybrid wet-mate connection are designed for oil and gas (O&G) applications rather than the needs of the wave energy sector. For example, available solutions:

- fit multiple, off-shelf connector contact pins (designed for O&G applications) into a stab-plate requiring a bespoke actuation and alignment system
- require separate connectors for power and communications
- are designed for mate/de-mate cycles and operations suited to O&G applications, including the use of costly and condition-sensitive local actuation by diver or Remote Operated Vehicle (ROV)
- assume operation in much more benign met-ocean conditions than those typical at marine energy sites.

The proposed MECMate solution is a single *hybrid electrical & communications* connector suitable for use alongside any mechanical quick connect system, or as a standalone connector. The vision is to deliver a WEC technology-agnostic, step-change product that provides a robust, reliable, and cost-effective solution for electrical connection of marine energy devices, with broadband communication capability, at low voltage (LV) or medium voltage (MV), kW or MW scale. The work conducted in this Stage 2 project has taken this vision a huge step closer to reality.

2 Description of Project Technology

Key MECMate connector features

- A single, robust 'jack' style pin with multiple passes.
- Hybrid: LV/MV power plus broadband communications.
- Passive wet-mate connection requiring no secondary actuation.
- Very robust design featuring proven NovaCAN 'back-end' cable termination and breakout.
- Self-capping when unmated.
- Designed from the ground up for the marine energy market.

Benefits of MECMate implementation

- The single central pin connector removes one axis of alignment, allowing for a much-increased overall misalignment tolerance, facilitating easy integration through a significantly lower alignment feature requirement than a multi-pin solution. This brings benefits to any WEC combined (electrical, comms and mechanical) mooring connection system or standalone MECMate connection.
- Hybrid connector, providing suitable ratings for power (LV or MV, kW to MW) and broadband communications in a single package designed specifically for marine energy applications.
- Passive connection simplifies marine operations and actuation requirements over existing solutions, reducing equipment cost, time, and health and safety risks.
- More robust design than existing multipin connectors, for use in a broad range of deployment conditions. Built on Nova's existing, field proven, MEC-specific dry-mate connection technology (NovaCAN – see figure below).
- Self-capping of unmated subsea connections has been identified in previous WES studies as a critical feature to avoid marine biofouling and connector failure. Biofouling is a particular issue in the highly energetic, nutritious, and well-lit waters in which marine energy resources are concentrated. Self-capping also avoids the need for extremely expensive external capping or cleaning operations normally carried out by divers or work-class ROVs.
- MEC applications have specific requirements in terms of power transmission (kW to MW), DNO grid compliance (voltage and fault levels) and high bandwidth, long-distance communications. The cost and scale of the MECMate product are aligned with WEC developer needs, offering a step-change improvement on currently available products.

NovaCAN: operational MEC dry-mate connector variant with typical biofouling following several months of subsea deployment

3 Scope of Work, and Project Achievements

3.1 Work Package 1: Design Definition

The requirements of the design were clearly specified and fully documented. The conditions and layouts in which the connector system operates were defined, including environmental conditions, load case definitions and the functional requirements of the connector. The test design for Stage 3 of the WES Quick Connection System call was also considered.

Achievements and Lessons Learned

- A thorough requirements specification was developed combining existing offshore and MEC standards as well as in-house experience. The result is a connector specification that is optimised for the marine energy environment and a step-change improvement on products currently available on the market.
- Test plans were developed, and suitable facilities identified to accelerate progress of the design through the technology development pathway to commercial roll-out.

3.2 Work Package 2: Concept Development Studies

Each key area of technical challenge for MECMate has several potential solutions for implementation, so focused development of these areas was carried out as early as possible to de-risk the project. The following aspects were considered:

- Dynamic sensitivity analysis to assess compatibility of solutions specific to the dynamic loading of the cable, also informing the limits for dynamic cable loads.
- Assessment of different options for data communication across the connector.
- The form that the physical contacts would take and their arrangement within the connector to make the most cost-effective, robust and manufacturable connector system possible.

Achievements and Lessons Learned

- Each identified focus area was de-risked by development of the concept, providing increased confidence that requirements and targets would be met, resulting in a robust and stress-tested conceptual design.
- Focusing on load definition early in the project ensured an efficient design process.

3.3 Work Package 3: Concept Design Development

System design work and associated detail was further developed, including the following:

- Sizing and spacing for insulators and conductors, including consideration of conductor sizing, clearance and creepage distances, and minimisation of the possibility of partial discharge.
- Material selection for insulators and conductors including contact plating.
- Design of active system components for data communication, physical sealing from sea water, guidance of the central connector parts, and oil management including pressure compensation.
- Design of passive system components for areas such as physical plug and socket sheaths, structural consideration, manufacturing integration, alignment and compliance, and connector termination.
- Operation and maintenance considerations including operation instructions, servicing and replacement of parts, and condition monitoring.

Achievements and Lessons Learned

- Concept development was successfully completed, identifying and analysing preferred solutions for each novel area of design.
- Priorities for simulation and testing were set, and test procedures and designs developed to put the MECMate design through its paces.

3.4 Work Package 4: Subsystem Simulation and Testing

Simulation and physical testing of subsystems were used to identify hidden risks in the design, and to ensure system reliability and survivability under all test cases. Areas of work included environmental testing, communication system tests, and mechanical tests such as exploring the impact of misalignment tolerance.

Achievements and Lessons Learned

- Early-stage benchtop testing once again proved its worth, reinforcing the view that low-cost, physical testing is a very efficient tool in early-stage design.

- Focused testing on communication and sealing systems provided extremely valuable performance data, and successfully demonstrated the feasibility of the proposed communication system.

3.5 Work Package 5 Survivability Analysis, PDR and Test Case Simulation

The project team verified that the proposed system met the design specification, including surviving the extreme design limit states. A design package was created, and a Preliminary Design Review (PDR) undertaken. Operational modelling was undertaken to demonstrate improved costs, expanded operational windows, and improved safety. The design was evaluated against three test cases representing a broad range of MEC devices.

All the project strands were brought together at this stage, allowing the team to demonstrate the concept's performance against three main test cases representing submersed wave, floating wave, and tidal energy devices, considering both focused areas of performance and holistic benefits.

Achievements and Lessons Learned

- **Expected cost reductions of 50%** compared to traditional power and fibre-optic wet-mate connection systems, bringing wet-mate technology CAPEX into line with deck-mateable connector costs.
- **Maximising the operation window** for MEC technology Operation and Maintenance is essential for a successful industry. Operational modelling provided vital understanding of the knock-on impact of offshore operations on energy yield and cost, and thereby on levelised cost of energy (LCOE) and the commercial viability of the MEC project.
- MECMate increases operational condition limits by ruggedisation of the connector and designing-out diver or ROV intervention, leading to a **reduction in installation costs of up to 82%**.
- Analysis of the potential lifetime impact of MECMate on the cost of offshore operations and device availability found that it was capable of **reducing the LCOE of MEC technology by 32%.**

3.6 Work Package 6: Commercialisation Strategy

Market research and engagement was used to pinpoint commercial opportunities for the MECMate product. An IPR assessment was carried out to confirm freedom to operate and to identify potentially patentable innovations. A commercial and technical development strategy was developed to take the technology from the R&D phase to the commercial market.

Achievements and Lessons Learned

- Focusing on commercialisation from the outset ensured that the MECMate product was developed to address client needs. Market research informed the design requirements, and the development strategy was used as a benchmark to review design decisions throughout the project.
- The most direct impact of the Covid crisis on this project was to change the nature of contact with potential customers and suppliers. Remote meetings proved effective and efficient in providing insight into stakeholder requirements.
- Market research reinforced the finding that MECMate is a highly relevant product for wave and tidal energy markets. This work confirmed that there is a compelling need and an appetite for a wet-mate solution, and that the MECMate design meets the identified market demand.

3.7 Work Package 7: Project Management

Efficient administrative execution of the project was delivered through tight coordination and oversight of technical plans, risks, financial and legal aspects, communication, and reporting according to WES requirements.

Achievements and Lessons Learned

- The Covid crisis and necessary workarounds resulted in significant changes in day-to-day activities. Changing regulations were monitored closely to ensure work progressed smoothly, leading to minimal project impacts.
- The project was managed on-time and on-budget, with regular updates provided to WES.

4 Recommendations for Further Work

The technology and commercial development path for MECMate highlights the following key next steps:

- **Technology demonstration**: conduct full-scale submerged testing and real-world MECMate deployment and recovery demonstration to verify that system performance meets expectations. This step is essential to de-risking future development stages, showcasing the technology, and gaining the confidence of potential clients, investors and technology development partners.
- **Commercial demonstration**: secure MEC developer clients, technology development partners and investment to demonstrate MECMate in long-term, continuous operation in a real-world marine energy project, including multiple deployment and recovery operations.

5 Summary

This Stage 2 project confirmed and sharpened the project team's understanding of market demand for the MECMate product. The key target market remains wave and tidal energy, which has the potential to become a £140m market for subsea connectors in the medium term as the sector matures. We have confirmed the market need for a cost-effective, reliable, hybrid wet-mate connector, confirmed freedom to operate, and identified potential patentable features of the technology.

MECmate has been designed from the outset to be device agnostic and easily scalable. It therefore has broad applicability to many low or medium voltage marine energy devices deployed in a wide range of water depths. We have outlined a technology and commercial development pathway for the product, and we have identified early clients and commercial partners to assist in this journey. The key next step is to de-risk the technology through testing a full-scale prototype connector in a real-world environment.

Test Case simulation undertaken in this project highlights the potential commercial impact of MECMate:

- **Expected cost reductions of 50%** compared to traditional power and fibre-optic wet-mate connection systems, bringing wet-mate technology CAPEX into line with deck-mateable connector costs.
- MECMate can increase operational condition limits by ruggedisation of the connector and designing out diver or ROV intervention, leading to a **reduction in installation costs of up to 82%** and **levelised cost of energy reductions of up to 32%.**