DataWave: An Open WEC Data Architecture for Supervisory Control & Smart Data Analytics

WES Control Systems Stage 1 Public Report

MarynSol

This project has been supported by Wave Energy Scotland.

1 Project Introduction

1.1 Overview

An **Open Data Architecture (ODA) is a key enabling technology**. Wave Energy Converters (WECs), like many industrial systems, are a complex collection of electro-mechanical sub-systems, each requiring data-based control functions to optimise their activity. Supervisory Control is essential to permit operators and automated software tools to monitor, analyse, and control not only the individual subsystems, but optimise across the whole device in a system-wide approach.

These software tools all require data exchange (formats, interfaces and protocols) to sub-system components, but also increasingly to other devices (e.g. WEC array; external sensors), and external information sources (such as: weather and met-ocean information; grid management). It is very unlikely that all these components will be supplied by the same manufacturer, hence typically operate with many different propriety interfaces and very few open standards. This is where data standardisation would be fitting.

Data standardisation is the process of ensuring that all data is in one consistent format, giving confidence in the completeness and integrity of the data. The ability to use consistently formatted data in crucial for wave energy development due to the potentially large amount of data from multiple WECs. Use of a standard is cost effective as it ensures that vendors of SCADA systems and advanced analytical tool are only working with one set of data regardless of who manufactured the WEC.

Many different pieces of technology and software are built on standards. The success of many of these things would not have been possible without the use of standards. Such an example is the internet: the internet, as it is commonly used for browsing websites and messaging people around the world, is all built on standards. These standards consist of architectures, data formats and protocols, and enable easy integration, use and consumption of data in this format, allowing any company, group or individual to interact with information with ease.

In similar areas, such as the wind and hydroelectric energy sectors, standard data architectures have already been developed (IEC 61400-25 and IEC 61850-7-410 respectively). These standards have enabled these devices to have a common data format for communication externally between devices and internally between subsystems leading to better scalability, connectivity, and interoperability. Similarly, a standard for life-cycle data for process plants, primarily those in the oil and gas industry, has been developed (ISO 15926) to facilitate communication between all parties involved, regardless of platform.

As part of the ODA development, a partner workshop was hosted to capture knowledge, expectations, and desired features of any introduced ODA from device developers. The conclusion of the workshop was that introduction of a similar data standard to existing IEC standards for wind and hydroelectric would be welcome and desirable. Introduction of such a standard as part of the ODA would bring many benefits to development, quality assurance, testing and operation.

1.2 Project Team

The Stage 1 DataWave team consists of MarynSol, Wave Venture, CorPower Ocean, Mocean Energy and PolyGen.

The MarynSol team brings years of knowledge and experience from the autonomous underwater vehicle domain in working with both big data and standardisation of data from multiple sources for use in automated processing and analysis.

Wave Venture bring specialist knowledge of wave energy consultancy and software development to feed into the controls system requirements and design, provide advanced WEC body simulation as well as providing objective Levelized Cost of Energy (LCoE) modelling.

The expertise of CorPower Ocean, Mocean Energy and PolyGen, as WEC developers, will play an important role in requirements gathering and specification of an ODA as well as the needs for advanced analytical tools in WEC development and operations. As WEC developers at different stages of development, they will be providing key technical requirements and their experience of developing WECs for input into the controls system requirements and design.

2 Description of Project Technology

The aim of the DataWave project is to produce an ODA suited for WECs that will enable a common format and communication between a WEC, optionally its subsystems, and on-board and off-board tools, which, versus implementation of another proprietary format, will give adopters a measurable competitive advantage, cost savings on development and operation of WEC systems, and the capability for collaboration to improve WEC energy generation and survivability.

Initial requirements and specification for the desired ODA have been created with input from WEC device developers, gathered from a hosted Supervisory Control & Analytic Tools Requirements Workshop.

Given the requirements, it is clear that a standard would benefit Wave Energy Devices to provide and support scalability, connectivity, and interoperability between different devices and internally between subsystems and components.

The ODA for WECs will be developed using similar principles and design decisions as Wind Energy standard IEC 61400-25. It will be developed to provide a common and uniform basis for the monitoring and control of wave energy converters. It will define details for communication formats and mechanism for information exchange in a manufacturer independent environment.

Due to the varying designs and complexity of WEC devices, the ODA will be designed to be flexible to suit any complexity of device. A hierarchical data structure would be best suited for this, allowing for descriptive identification labels that contain the core WEC information as well as common sub-system information such as PTO subsystem, hydrodynamic subsystem, reaction subsystem. The information may be simple data and configuration values or more complex readings and information. All common WEC infrastructure will be designated a particular tag within the ODA to maintain standardisation across the industry. Extensions will be allowed, following a defined convention, to allow for custom system designs.

Utilisation and implementation of this ODA will allow low-level controllers and SCADA systems to communicate with other WECs and subsystems from multiple vendors. Standardisation of SCADA applications and other actors on the system are excluded from this standard but with a common standard to reference for data formats and communication, any vendor could produce software which is automatically compatible with other software working from the same standard. This enables competition, which promotes innovation and in turn reduces costs to end clients as they no longer have to commission bespoke software at high prices.

As such, end clients are no longer locked in to using one vendor's software. If a client sees another tool built on the standard which introduces new or improved features or functionality, they can acquire that software as-is or with minimal changes.

Using this ODA will enable interoperability to promote features such as data sharing, trending, scheduling, remote device and network management which in terms of a WEC can mean production of tools to provide functions such as Diagnostic Processes, Alarm Systems, Decision Support and Operator Situational Awareness.

Adopting the ODA at the subsystem level would mean all subsystem intercommunication being standardised. This results in easier maintenance and installation as all systems and subsystems communicate in a common way.

The ODA will standardise the core WEC information, the transport format and communication stacks, which builds a basis to which future procurement specifications and contracts could easily refer.

3 Scope of Work

The project goal is to develop an open WEC data architecture as part of the WES call for Control Systems for Wave Energy Converters. Stage 1 of the project sets out to assess the feasibility of such an open standard being created as part of an Open Data Architecture (ODA) and what would be involved in creating the ODA as well as showing some of the possible analytical tools, and their benefits, that could be built on this ODA.

It is not the goal of the project to replace existing supervisory control systems but instead to enrich existing subsystems by providing a common communication format between all WECs to improve scalability, connectivity, and interoperability.

The DataWave project may consist of the production of a new Open Data Architecture for Wave Energy Converters as well as integration with existing, and production of, various analytical tools to provide functions such as Diagnostic Processes, Alarm Systems, Decision Support and Operator Situational Awareness.

The approach is to consider adopting existing Open Data Architectures and standards from the Marine Data and industrial IoT (Internet of Things) community, extending them to include Wave Energy Converter concepts as necessary. Adoption of an ODA would, in turn, offer the Wave Energy community rapid access to the quickly growing library of tools for data analytics, such as machine learning and advanced statistical techniques.

4 Project Achievements

This project has successfully achieved creating a concise set of requirements and an outline of specifications for an Open Data Architecture (ODA) that would benefit the whole wave energy community. The requirement for further development and the required steps are clear to take the ODA to commercial readiness.

Key achievements during Stage 1:
- Gathering of requirements and proposed specifications were welcomed by project partners.
- Adoption of an approach used in other energy generation sectors based on similar IEC standards which can be used as templates for development.
- Implementing a basic version of the ODA facilitated integration of analytics software to simulation outputs.
- Advanced data analytics using the ODA show the potential for tools based on a standard.

Could have been better if:

- Further refinement of the developed Sea State Predictor would allow for more accurate predictions at the extremes of inputted data. This will be addressed along with the development of other analytical tools in future stages.

5 Recommendations for Further Work

The base requirements and specification for the Open Data Architecture have been defined. With these, an ODA can be developed. This future development of the ODA will involve creation and documentation of a full reference standard as well as integration with testing environments and real WECs.

Key activities for future development include:

- Continue to work with device developers to build a description of common WEC device components to be defined by the standard and ensure that rules to extend allow for all WEC types.
- Assess existing open standards for external sensors and data sources for viability for inclusion in ODA.
- Develop the ODA for WECs in conjunction with device developers.
- Create a software reference library and set of examples for implementation of the standardised format.
- Develop a suite of tools/integrate with existing tools based on the standard.
- Implementation of standard with a WEC simulator for testing and validation.
- Implementation of standard on payload of real WEC (can be run in tandem with existing communication and data format for testing if applicable).
- Integration of ODA into existing SCADA system.
- Create conformance testing guidelines for ODA.
- Release final ODA in open-source format.

6 Communications and Publicity Activity

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7 Useful References and Additional Data

[1] IEC 61400-25: Communications for monitoring and control of wind power plants.

[2] Schwarz, Karlheinz, and Im Eichbaeumle. "IEC 61850, IEC 61400-25 and IEC 61970: Information models and information exchange for electric power systems." *Proceedings of the Distributech* (2004): 1-5.

All referenced material is publically available.