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# Reliability modeling in reliability-critical system development: case wave power

**Abstract:** Wave power is a potential technology for producing cost-efficient renewable energy. Reliability is one of the key issues to be considered in the design of wave energy converter (WEC) devices. To address the issue of reliability, we present a proposed design approach based on reliability block diagram (RBD) modeling. Based on experiences of utilizing the RBD approach, we provide some preliminary insights on the key characteristics of the RBD approach and its suitability to WEC design.

**Keywords:** reliability modeling, wave power, reliability block diagram

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## 1 Background

Wave power is a potential technology for producing cost-efficient renewable energy. For capturing and converting wave energy, various types of Wave Energy Converters (WECs) have been developed. One of the WEC types is an Oscillating Wave Surge Converter (OWSC) that extracts energy from wave surges and the movement of water within them. OWSC has a plate, flap or some other type of element that oscillates as a pendulum mounted on a pivoted joint in response to the movement of water in the waves. OWSCs are either completely submerged or partly above the water surface. In this paper, we focus on a proposed MegaRoller OWSC concept (Fig. 1).

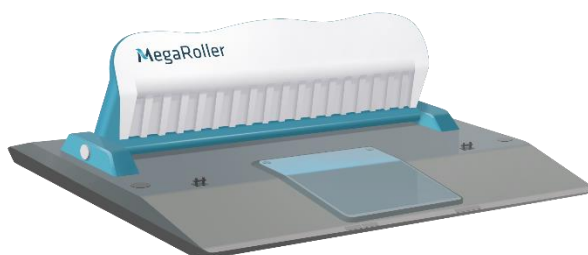


Fig 1. MegaRoller OWSC concept [1]

To achieve profitable electricity production, system dependability as a whole and especially reliability as one of its elements (see [2]) is a key issue to be considered in the design of OWSCs. Reliability is especially important because of challenges and high costs related to maintenance of such systems. In fact, it is likely that some maintenance activities of OWSC systems can be carried out only when the entire device is towed to the shore. Thus, OWSCs are typically designed for a long maintenance interval. Also, the facts that OWSCs operate in corrosive and in other ways harsh maritime environment and face substantial loads due to all possible occurring sea states, highlight the importance of reliability aspects in system design. The high degree of automation of OWSCs further emphasizes the importance of system reliability.

Reliability modeling is an approach that can be utilized to support the design of OWSCs, as well as other WEC types and other complex systems (including automation systems), to predict and improve their reliability performance. Various approaches for modeling have been proposed. The approach presented here focuses on the use of reliability block diagrams (RBDs) in modeling. RBDs describe the system as a set of interconnected blocks, representing the reliability characteristics of subsystems and individual components [3]. Each block is assigned with a probability distribution describing the block's reliability performance over time. Additional aspects, such as issues related to maintenance management, can also be incorporated in the reliability model.

## 2 Results & discussion

Based on experiences of applying the RBD approach in ongoing OWSC development activities, we can make some preliminary conclusions regarding the use of this approach in the context of wave power. The findings include:

- RBD modeling should be tightly interconnected with other analyses and R&D activities, starting from the early concept design phases. For example, FMECA analysis may provide guidance for focusing reliability modeling activities, and reliability modeling can provide input information e.g. for life-cycle cost

calculations.

- As with all modeling, the quality of results of RBD modeling is dependent on the quality of input data. The input reliability data can be a combination of experimental data, as well as data from other sources, such as component data sheets and industry guidelines.
- RBD modeling can be applied on various levels of detail: from component and subsystem level up to the level of a fleet of several devices.
- In addition to system reliability, the modeling tools can support in comparing system designs e.g. regarding maintenance-related activities.

We see the RBD modeling approach as a potential way to assess and help improve OWSC reliability. In the MegaRoller project, the methodology will be further developed and its interconnections with other analyses in the OWSC design will be studied in more detail.

## References

- [1] <https://www.sintef.no/MegaRoller>
- [2] IEC 60050-192:2015
- [3] Čepin M. (2011) Reliability Block Diagram. In: Assessment of Power System Reliability. Springer, London

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