NOVEL METHODOLOGY FOR THE HOLISTIC ASSESSMENT OF WAVE ENERGY DESIGN OPTIONS

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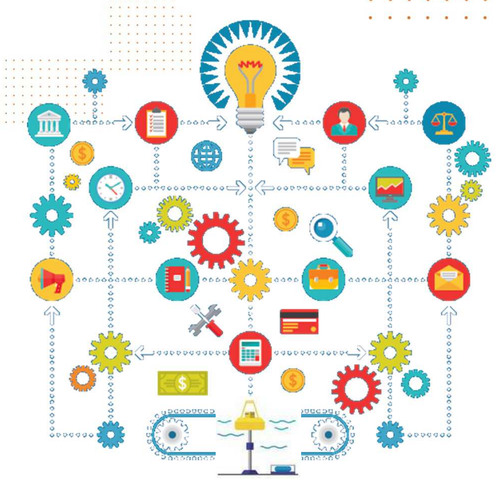
ABSTRACT

Despite significant efforts in last decades Wave Energy technologies have not reached commercial maturity yet [1]. Wave Energy is not competitive with other renewable energy sources due to its poor performance, reliability levels and high costs. Conventional methodologies focused on Technology Readiness Levels (TRL) have proved insufficient to guarantee Wave Energy technologies meet their technical and economic goals.

Systems Engineering methods [2] have been successfully applied in other industrial sectors (e.g. automotive, aerospace) to develop innovative products meeting very diverse and demanding customer requirements. This approach is particularly useful during the first stages of technology development. Likewise, multicriteria analysis [3] has been applied to inform the decision-making process in early design phases of complex engineering problems, particularly when alternative solutions can be heterogeneous.

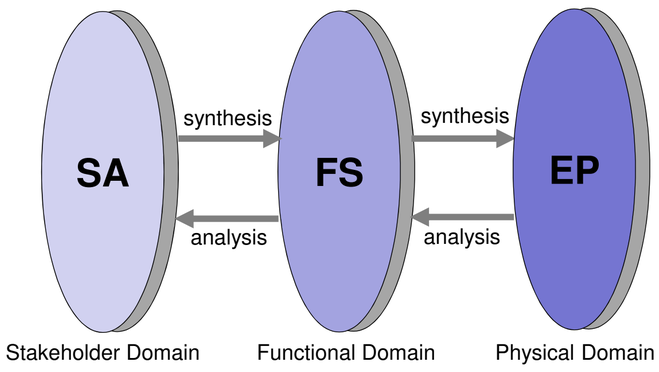
This poster presents a novel methodology for the holistic assessment of wave energy design options based on sound systems engineering and multicriteria analysis principles.



DESIGN METHODOLOGY

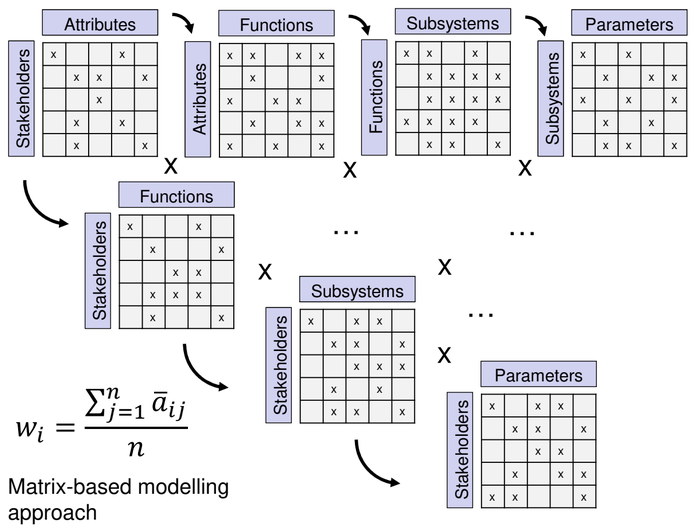
REQUIREMENTS FULLY TRACED THROUGH THREE DOMAINS OF THE DESIGN WORLD

- **Stakeholder Domain**, defined by the Stakeholder Attributes (SA) the customer and associated stakeholders would like to see in their system.
- **Functional Domain**, where requirements are transformed in a comprehensive Functional Specification (FS).
- **Physical Domain**, in which the Engineering Parameters (EP) emerge.



MAPPING PROCESS VIA WEIGHTING (w_i) AND RELATIONSHIP MATRICES (a_{ij})

Combination of well-established tools: Analytical Hierarchical Process (AHP), Quality Function Deployment (QFD), Design Structure Matrix (DSM)

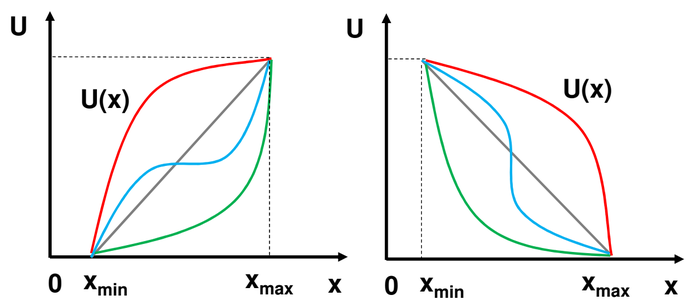


$$w_i = \frac{\sum_{j=1}^{n} \bar{a}_{ij}}{n}$$

Matrix-based modelling approach

ANALYSIS OF ALTERNATIVES FACILITATED BY THE USE OF UTILITY FUNCTIONS

To overcome subjectivity, the fundamental relationships between the physical design parameters and the actual value offered to stakeholders are modelled.

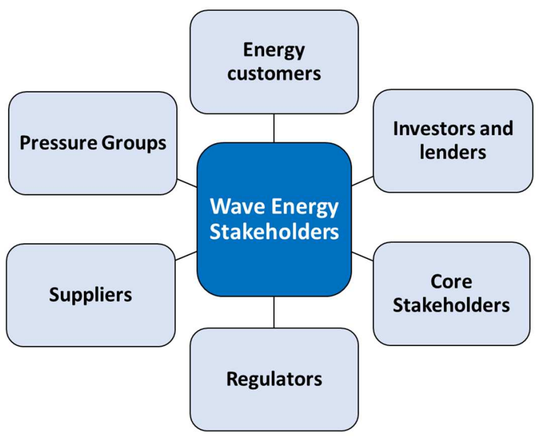


Five parameters (B, k, xmin, c, p) can produce different shapes when modified: S-shape, concave, convex, and linear curves

$$U(x) = B\left[1 - e^{-k\left(\frac{|x-x_{min}|}{c}\right)^{p}}\right]$$

APPLICATION TO WAVE ENERGY

MAIN STAKEHOLDERS GROUPS

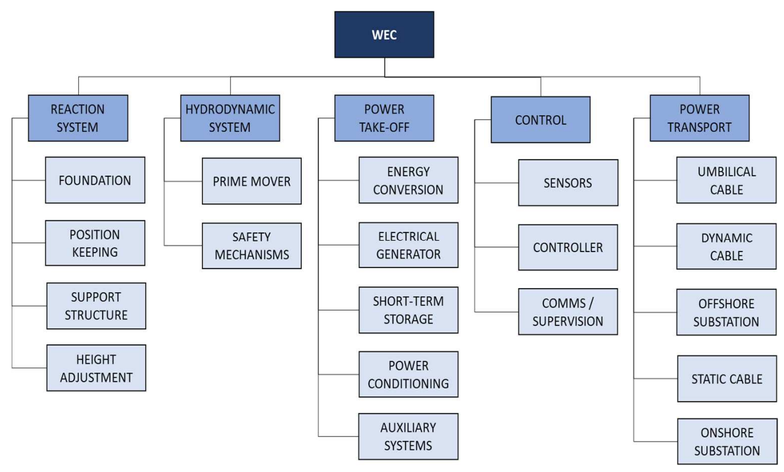


STAKEHOLDERS ATTRIBUTES

- **Benefits (B)**, certain attributes supporting the objective: *Clean energy production; Reliability; Controllability; Affordability; Lifetime; Replicability*
- **Opportunities (O)**, uncertain attributes supporting the objective: *Economic growth and job creation; Climate change mitigation; Public health; Energy independence*
- **Costs (C)**, certain attributes rejecting that objective: *Production; Deployment, Servicing; End-of-Life*
- **Risks (R)**, uncertain attributes rejecting the objective: *Survivability; Financial risks; Acceptability; Regulation*

MAIN FUNCTIONS & SUBSYSTEMS TAXONOMY

- Maintain position with respect to seabed
- Capture useful energy from waves
- Transform energy into electricity
- Connect wave farm with onshore grid
- Control safe wave farm operation
- Withstand harsh ocean environment



FUTURE WORK

- Finalise stakeholder, functional and physical domain analysis.
- Model fundamental relationships between the physical design parameters and the actual value.
- Identify wave energy design alternatives with greatest potential.

REFERENCES

[1] D. Magagna et al. “JRC Ocean Energy Status Report - 2016 Edition”. ISBN 978-92-79-65940-9, European Union 2016.
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[3] C. Zopounidis & P. M. Pardalos. “Handbook of Multicriteria Analysis”. ISBN 978-3-540-92827-0. Springer-Verlag Berlin Heidelberg 2010.

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