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Review of WEC-Sim development & applications

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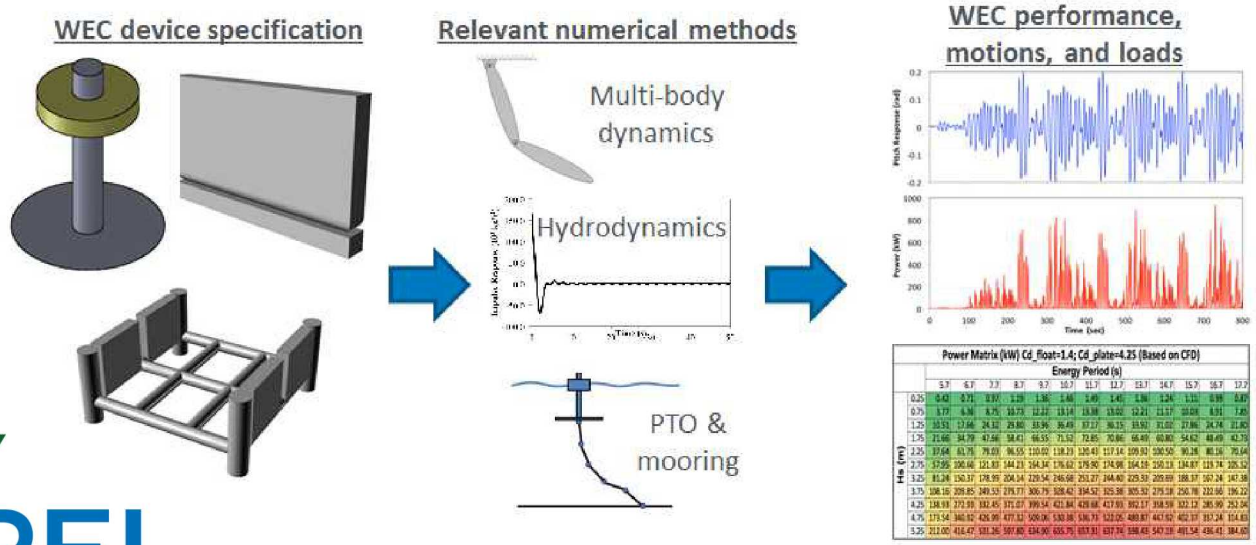
1. WEC-Sim overview
2. Novel device modelling
3. Experimental validation
4. Development of additional WEC-Sim capabilities
5. Control modelling
6. PTO modelling
7. Summary

Example cases

WEC-Sim code overview

- Open-source code for simulating WECs
- Used in conjunction with a BEM code (to provide linear frequency-domain hydrodynamic coefficients)
- Developed in MATLAB/Simulink



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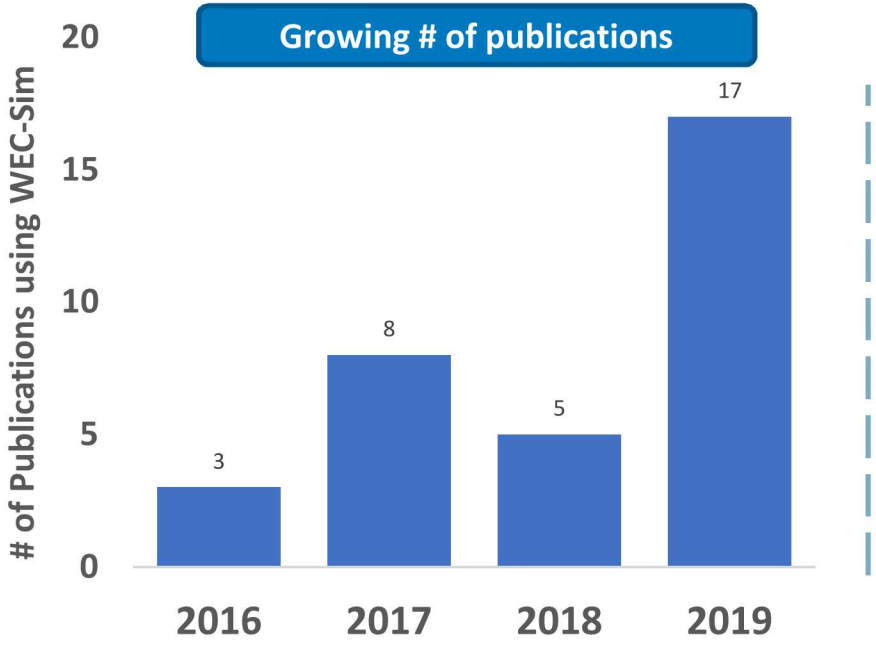
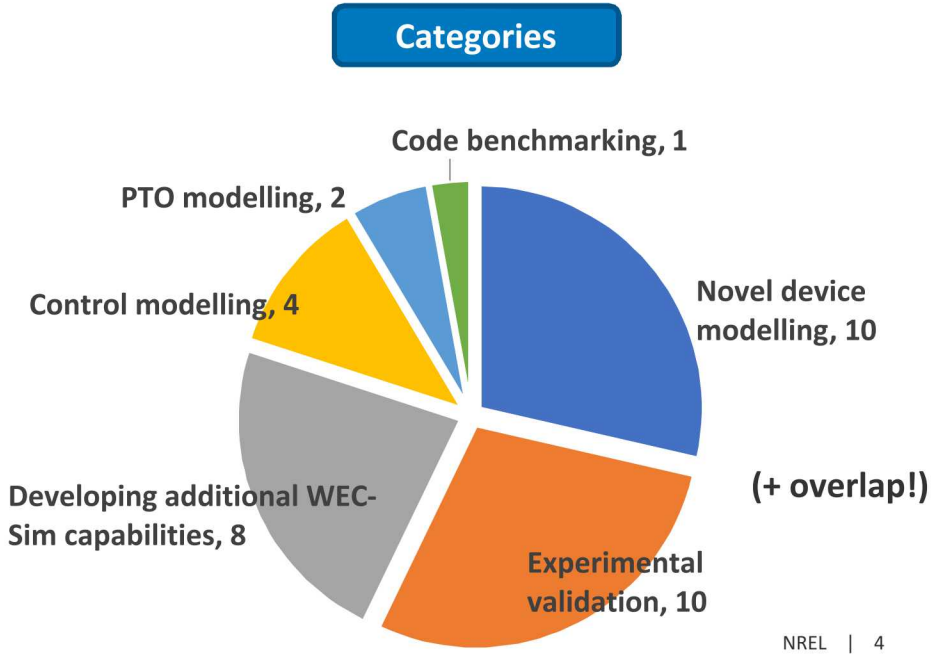
WEC-Sim usage overview

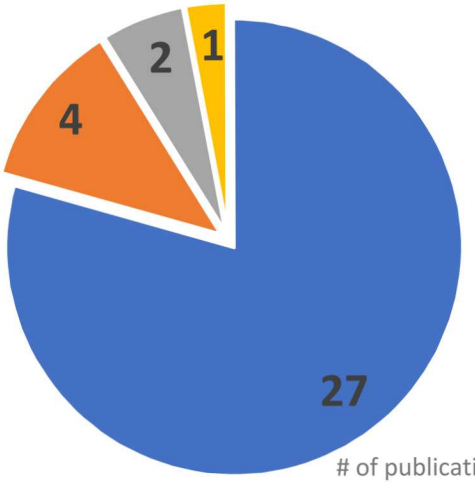
- 34 papers published 2016-2019 (~50 including NREL & SNL)
- From 10 different countries (EU nations, US & China)





WEC-Sim usage overview

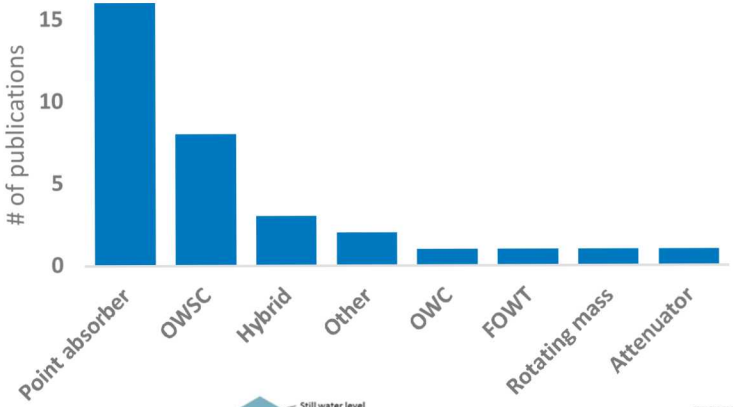
Papers from academia & industry

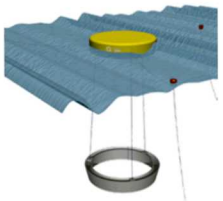


# of publications, categorized by lead author's affiliation

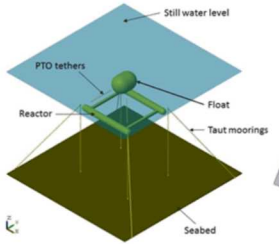
co-author affiliations create overlap

Used to model a broad range of devices

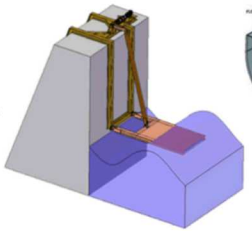




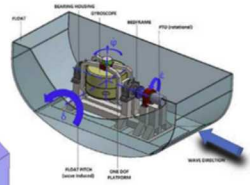
Triton



WaveSub



ALETTONE



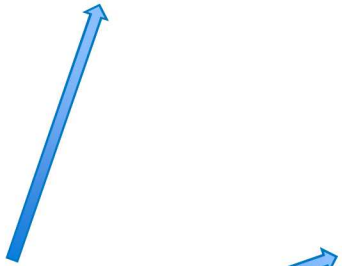
ISWEC

Selected papers

- Novel device modelling
- Experimental validation
- Development of additional WEC-Sim capabilities
- Control modelling
- PTO modelling

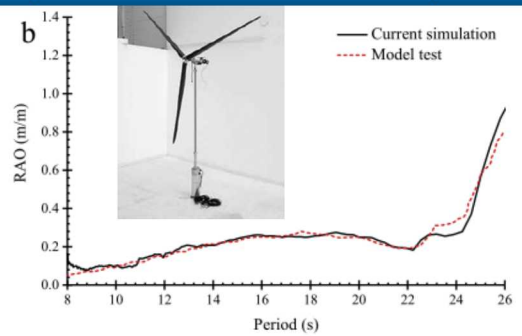
Novel device modelling

- Li et al (2019) – An integrated (tidal, wave & wind) renewable energy device



"WindSloke" is coupled with WEC-Sim to calculate the unsteady thrust forces on the turbines.

Experimental validation of spar & WT



Assessment of the concept

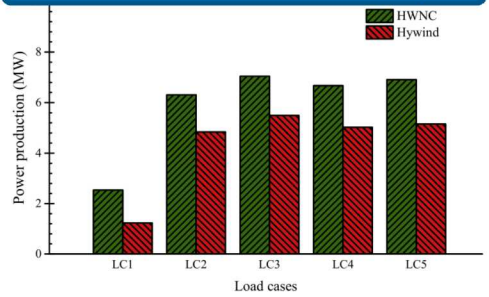


Fig. 10. Mean value of overall power production.

Greater power production
WT power output potentially more stable

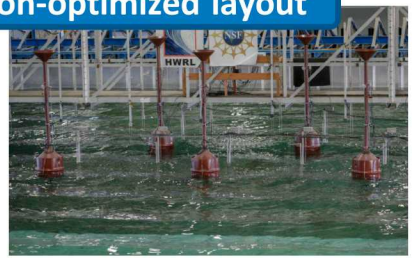
Future work: include wave-current couplings and wind turbulence

Li, L., Yuan, Z. M., Gao, Y., Zhang, X., & Tezdogan, T. (2019). Investigation on long-term extreme response of an integrated offshore renewable energy device with a modified environmental contour method. Renewable Energy, 132, 33–42.

Experimental validation

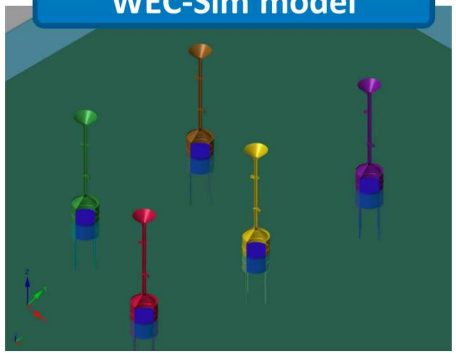
- **Bosma et al (2019) – Physical and numerical modeling of fixed OWC array**

Non-optimized layout

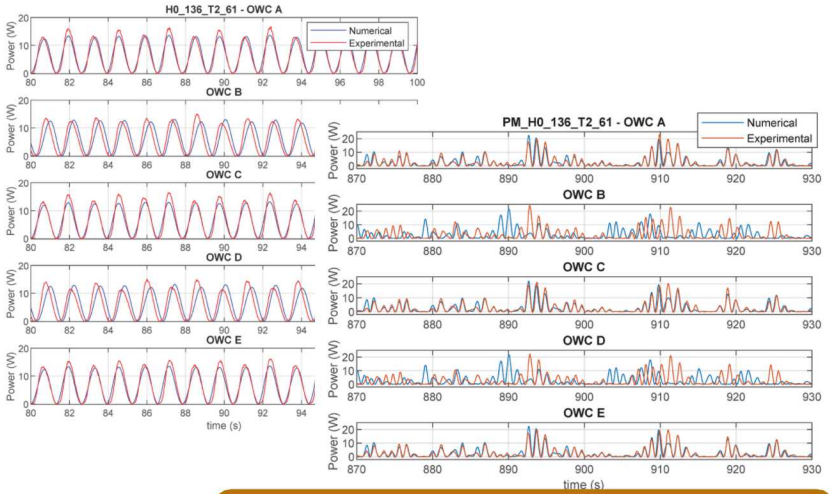


Optimized layout

WEC-Sim model



Numerical/experimental comparisons



Average power increase of up to 12% between non-optimized and optimized layouts

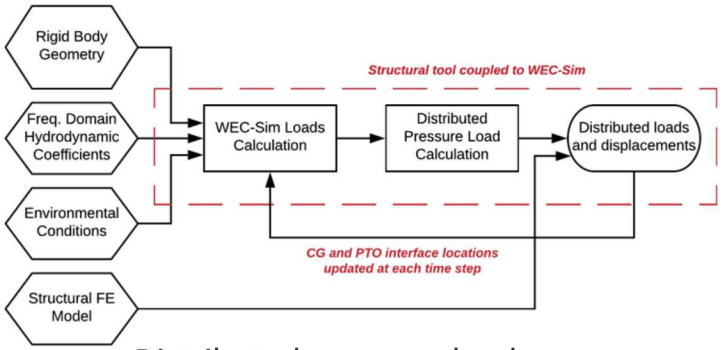
Bosma, B., Brekken, T., Lomonaco, P., Dupont, B., Sharp, C., & Batten, B. (2019). Array modeling and testing of fixed OWC type Wave Energy Converters. *Proceedings of the 13th European Wave and Tidal Energy Conference*, 1–7. Naples, Italy.

Development of additional WEC-Sim capabilities

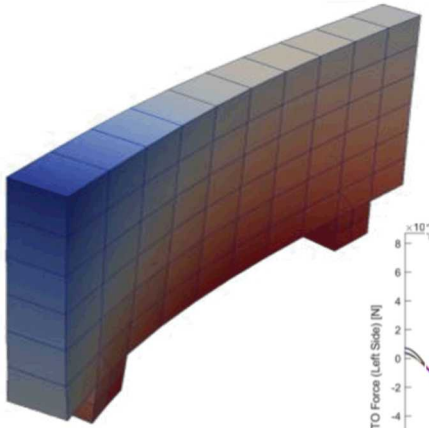
- **Scriven et al. (2019) – Non-rigid body structural dynamics in WEC-Sim**

(in addition to generalized modes approach already included in WEC-Sim)

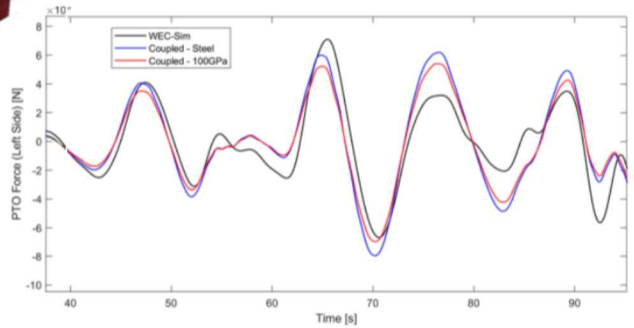
FE solver Code_Aster coupled to WEC-Sim:



Distributed pressure loads are derived from WEC-Sim and applied to the FE model at each time step



(displacement of the flap)



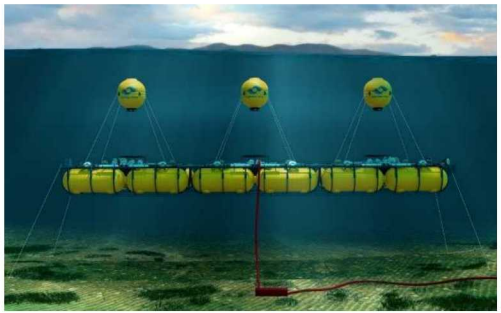
Peak PTO loads vary by up to 10% when structural dynamics are considered in the analysis.

Scriven, J., Laporte-Weywada, P., & Cruz, J. (2019). Introducing non-rigid body structural dynamics to WEC-Sim. *Proceedings of the 13th European Wave and Tidal Energy Conference*, 1–9. Naples, Italy.

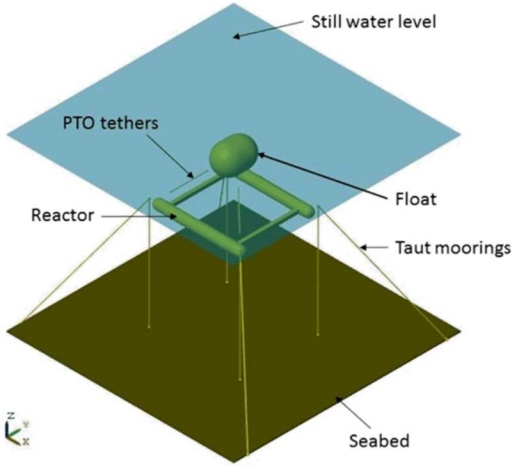
Control modelling

- **Hillis et al (2019) – Active control for the WaveSub WEC**

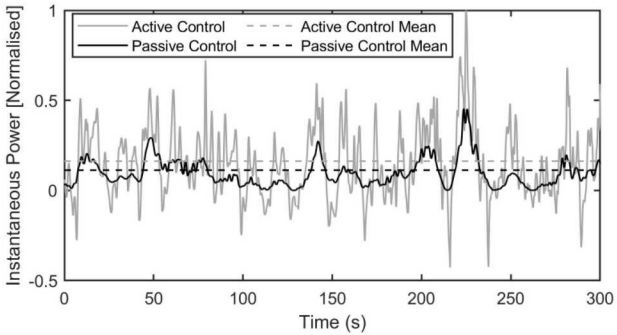
WaveSub



WEC-Sim model



Assessment of the controller



Mean power increases of between 13% and 86% seen for the active system (compared to passive control system) in irregular sea states.

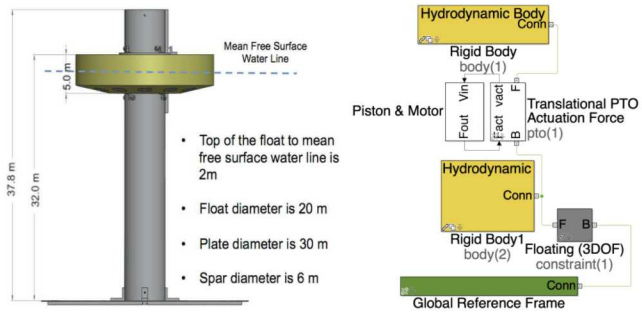
Future work: include methods of avoiding PTO tethers becoming slack and the imposition of a two-quadrant restriction on PTO operation

Hillis, A. J., Whitlam, C., Brask, A., Chapman, J., & Plummer, A. R. (2019). Power capture gains for the WaveSub submerged WEC using active control. *Proceedings of the 13th European Wave and Tidal Energy Conference*, 1–8. Naples, Italy.

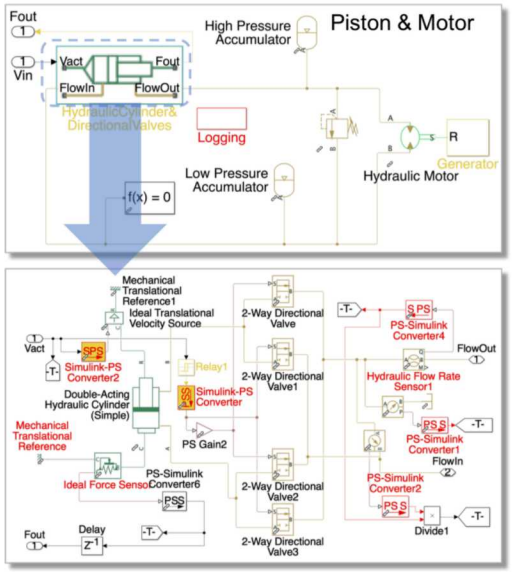
PTO/grid modelling

- **Yu et al (2018) – Hydraulic PTO modelling**

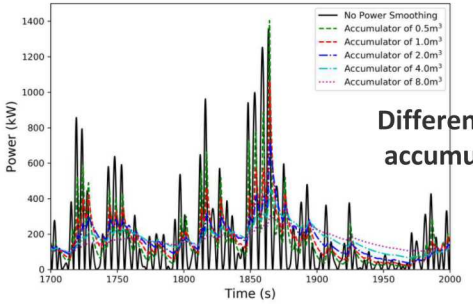
RM3 WEC-Sim model



Hydraulic PTO model in WEC-Sim



Analysis



Different hydraulic accumulator sizes

Yu, Y. H., Tom, N., & Jenne, D. (2018). Numerical analysis on hydraulic power take-off for wave energy converter and power smoothing methods. *Proceedings of the 37th International Conference on Offshore Mechanics and Arctic Engineering - OMAE 2018.*

Thank you
Q&A

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