



# WEC-Sim Training Course

Online Training Materials

*PRESENTED BY*

Kelley Ruehl, Sandia



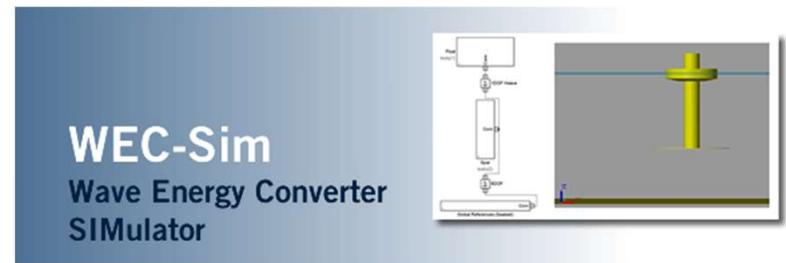


# WEC-Sim Overview

## What is WEC-Sim?

### WEC-Sim (Wave Energy Converter Simulator)

- Simulates wave energy converter dynamics in operational waves
- Time-domain rigid body equation of motion solver based on Cummins' formulation
- Open source software developed in MATLAB/SIMULINK
  - Available at <https://github.com/WEC-Sim/WEC-Sim>
- Joint NREL/Sandia project funded by the US Department of Energy
- First Release: v1.0 in June 2014
- Current Release: v5.0.1 in Sept 2022





## Apache 2.0

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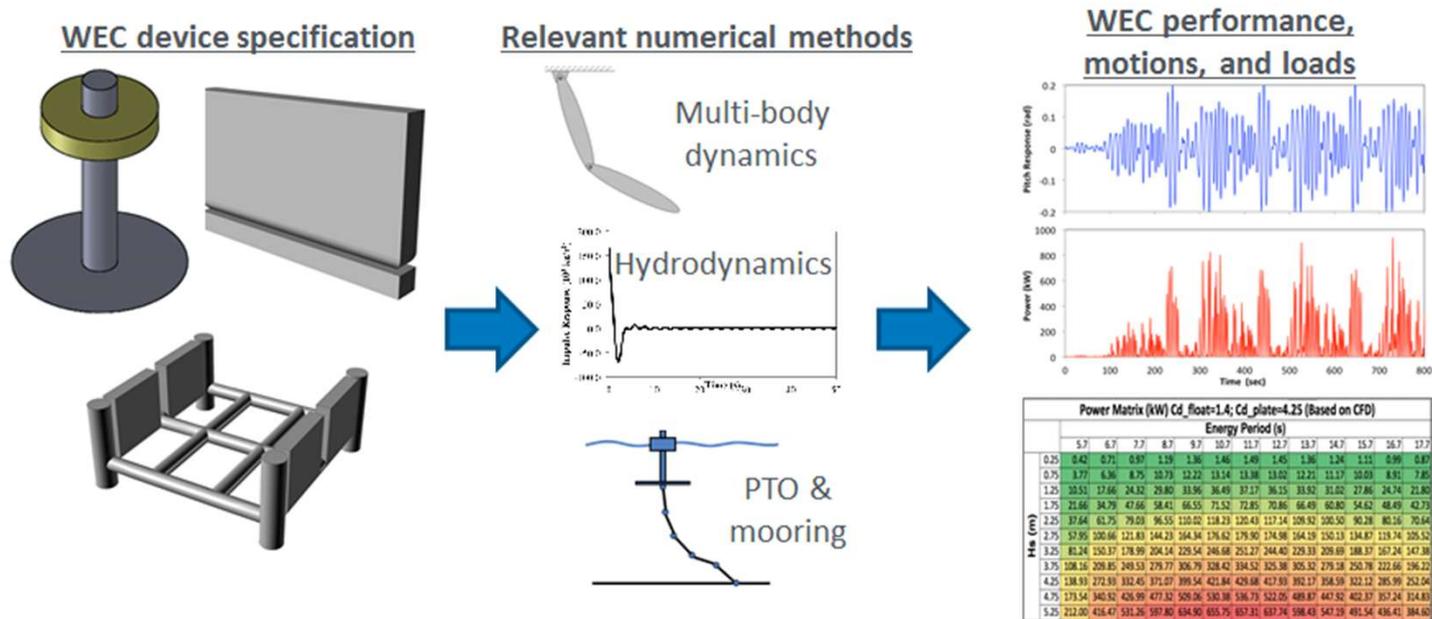
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## Why use WEC-Sim?

- WEC-Sim has the ability to model the dynamics of devices that are comprised of rigid bodies, power-take-off (PTO) systems, and mooring systems.



# Why use WEC-Sim?



CPU time/  
Simulation  
Time

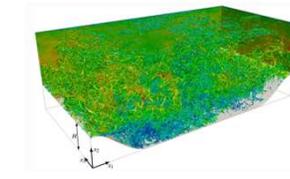
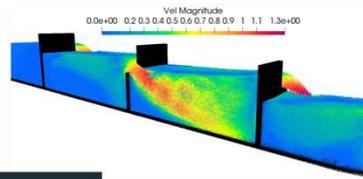
10<sup>10</sup>  
10<sup>8</sup>  
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10<sup>-2</sup>  
10<sup>-4</sup>

Real Time →



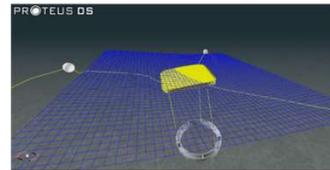
Low Fidelity

High Fidelity



English, A., Domínguez, J.M., Vacondio, R. et al. (2022)  
**LES SPH** (SPH-FLOW, SPHYSICS,  
...)

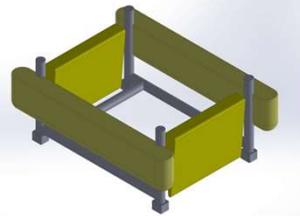
**RANSe** based approaches  
(STARCCM+, FLUENT, ISIS-  
CFD, ICARE-SWENSE,  
OPENFOAM...)



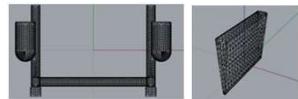
Krank, B., Kronbichler, M. & Wall, W.A (2018)

**Non-linear** potential flow based  
approaches (LAMP3-4, AEGIR)

<https://dsaocean.com/tag/oscilla-power/>



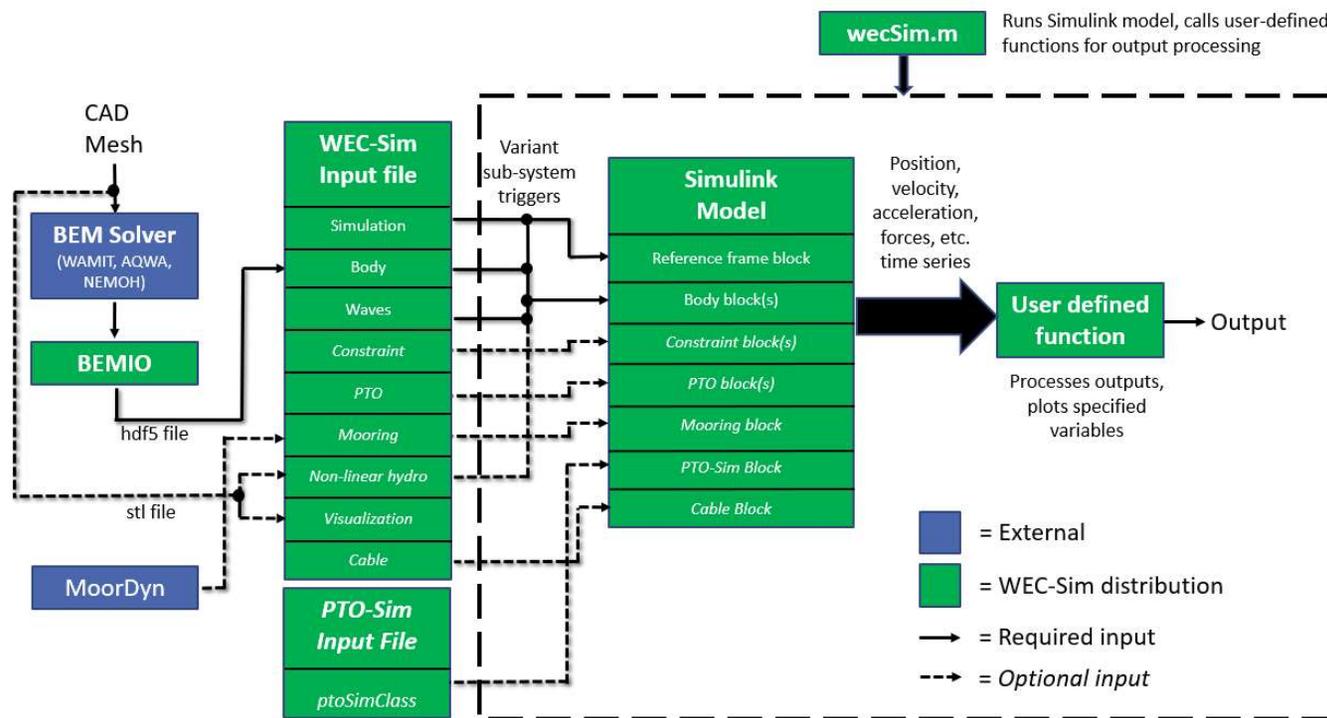
**Linear time domain**  
potential flow theory based  
BEM Codes & approaches  
based on **Morison** equations  
(LAMP1-2, Orcaflex,  
Deeplines, **WEC-SIM**,  
InWave, Proteus3D, ...)



**Linear frequency domain**  
potential flow theory based  
BEM Codes (WAMIT,  
NEMOH, Capytaine...)

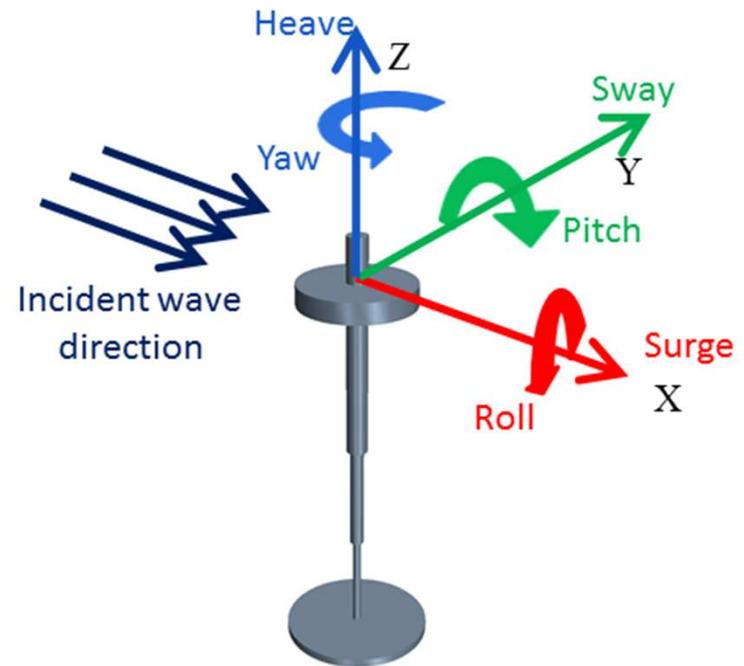
## Why use WEC-Sim?

- WEC-Sim has the ability to model the dynamics of devices that are comprised of rigid bodies, power-take-off (PTO) systems, and mooring systems.
- WEC-Sim uses hydrodynamic coefficients derived from frequency-domain boundary element (BEM) simulations to model the relevant hydrodynamics.



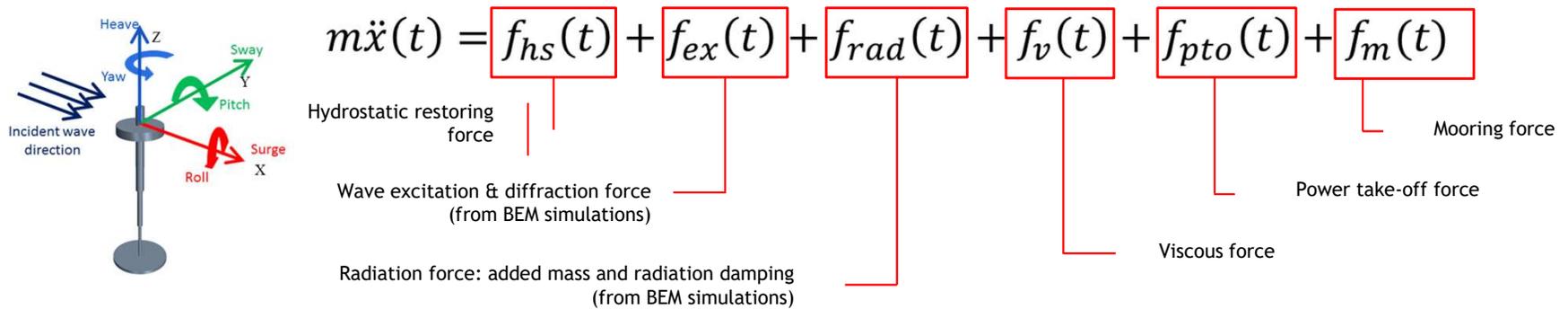
## Why use WEC-Sim?

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- WEC-Sim uses hydrodynamic coefficients derived from frequency-domain boundary element (BEM) simulations
- Time-domain simulations are performed by solving the governing WEC equations of motion in 6 degrees-of-freedom.



## WEC-Sim Theory

- Dynamics simulated by solving time-domain equation of motion (Cummins, 1962)



- Use radiation and diffraction method and calculate the hydrodynamic forces from frequency-domain Boundary Element Method (BEM)

$$f_{rad}(t) = -A_\infty \ddot{X} - \int_0^t K(t-\tau) \dot{X}(\tau) d\tau$$

$$f_{ex}(t) = \Re \left[ R_f F_X(\omega_r) e^{i(\omega_r t + \phi)} \int_0^\infty \sqrt{2S(\omega_r)} d\omega_r \right]$$

$$= \int_{-\infty}^\infty \eta(\tau) f_e(t-\tau) d\tau$$

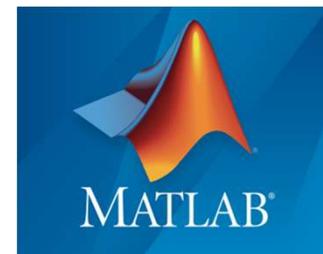
## WEC-Sim Software Requirements

CAD (Computer-aided design), e.g. Rhinoceros, SolidWorks, ANSYS, etc.

BEM (Boundary Element Method), e.g. WAMIT, Capytaine, NEMOH, AQWA

WEC-Sim (Wave Energy Converter Simulator)

- <http://wec-sim.github.io/WEC-Sim/>
- Requires MATLAB, Simulink, Simscape, and Simscape Multibody
- Includes BEMIO (Boundary Element Method Input/Output)

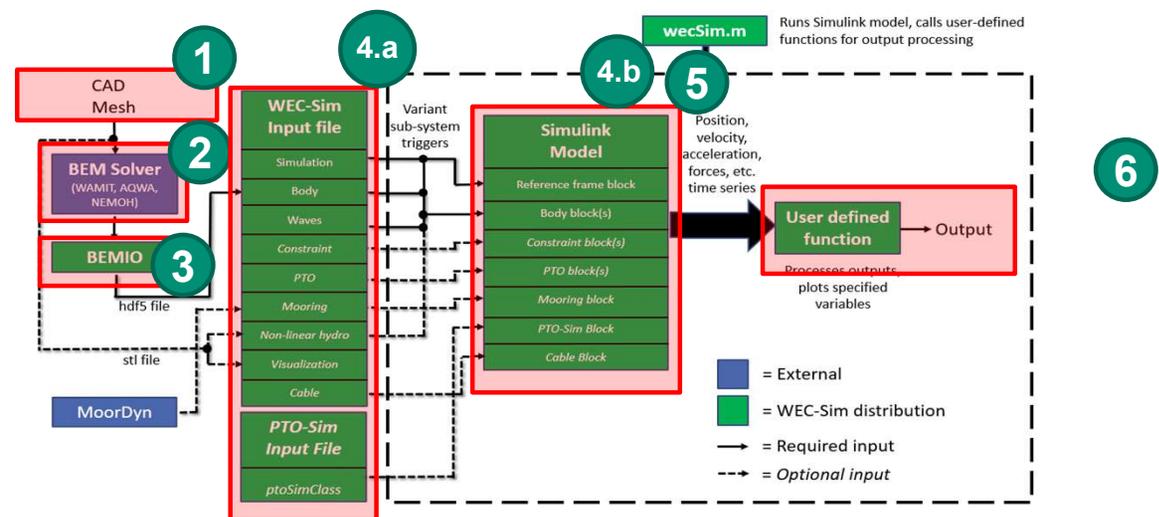


Required Toolbox	Oldest Compatible Version
MATLAB	Version 9.9 (R2020b)
Simulink	Version 10.2 (R2020b)
Simscape	Version 5.0 (R2020b)
Simscape Multibody	Version 7.2 (R2020b)

# WEC-Sim Overview

## General steps to simulate a floating device using WEC-Sim

1. Generate device CAD geometry and mesh
2. Calculate hydrodynamic coefficients using a BEM code such as WAMIT, NEMOH, Capytaine, etc.
3. Run BEMIO to generate .h5 file
- 4.a Write WEC-Sim Input file
- 4.b Build the Simulink model
5. Run cases
6. Analyze WEC-Sim output



# GitHub Repositories

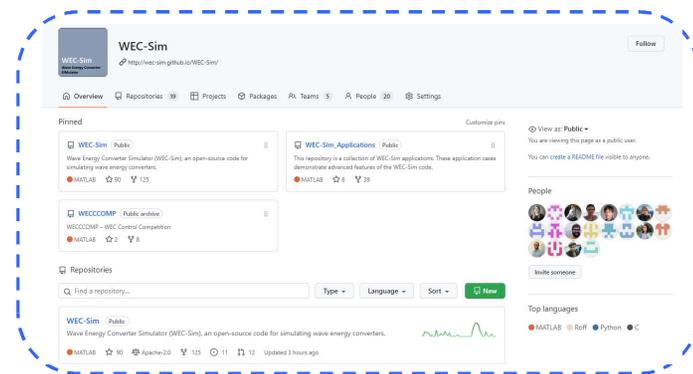
<https://github.com/WEC-Sim>



**WEC-Sim Source Code**



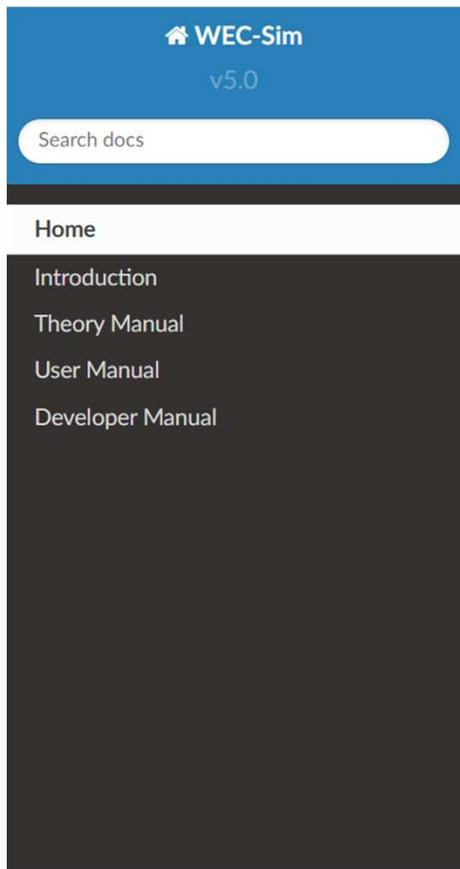
**Additional Applications**



**Repository Landing Page**

# Documentation

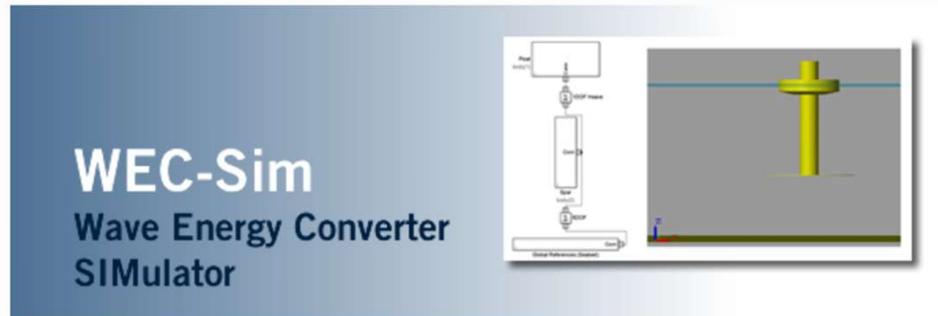
<http://wec-sim.github.io/WEC-Sim/>



The screenshot shows the top part of the WEC-Sim documentation website. At the top, there is a blue header with the text "WEC-Sim v5.0" and a search bar labeled "Search docs". Below the header is a dark grey navigation menu with the following items: "Home", "Introduction", "Theory Manual", "User Manual", and "Developer Manual".

» WEC-Sim (Wave Energy Converter SIMulator)

[View page source](#)



## WEC-Sim (Wave Energy Converter SIMulator)

WEC-Sim (Wave Energy Converter SIMulator) is an open-source software for simulating wave energy converters. The software is developed in MATLAB/SIMULINK using the multi-body dynamics solver Simscape Multibody. WEC-Sim has the ability to model devices that are comprised of bodies, joints, power take-off systems, and mooring systems. WEC-Sim can model both rigid bodies and flexible bodies with generalized body modes. Simulations are performed in the time-domain by solving the governing wave energy converter equations of motion in the 6 Cartesian degrees-of-freedom, plus any number of user-defined modes. The [WEC-Sim Applications repository](#)

# Online Forum

<https://github.com/WEC-Sim/WEC-Sim/issues>

WEC-Sim / WEC-Sim Public Edit Pins Watch 28 Fork 125 Star 90

<> Code **Issues 9** Pull requests 7 Discussions Actions Projects 3 Security Insights Settings

Filters  Labels 36 Milestones 0 New issue

<input type="checkbox"/>	<input type="radio"/> 9 Open <input checked="" type="checkbox"/> 587 Closed	Author	Label	Projects	Milestones	Assignee	Sort
<input type="checkbox"/>	<input checked="" type="radio"/> [Theory or Implementation] #873 opened 6 days ago by Aiswariak						3
<input type="checkbox"/>	<input checked="" type="radio"/> [Developer Issue] stopWecSim warnings #867 opened 13 days ago by jtgrasb		Library	MATLAB/Simulink	SCM		1
<input type="checkbox"/>	<input checked="" type="radio"/> [Theory or Implementation] Differences in AQWA and WEC-Sim conventions #865 opened 19 days ago by salhus		BEM/BEMIO	Documentation			
<input type="checkbox"/>	<input checked="" type="radio"/> [Theory or Implementation] Crane ship simulation Capytaine -> Wec-SIM #859 opened on Apr 28 by Dadidal		BEM/BEMIO	Body Class	Support		2
<input type="checkbox"/>	<input checked="" type="radio"/> [WEC-Sim Applications] Applying the Generator Damping to the Rotary Generator #849 opened on Apr 18 by wectechpol		PTO-Sim				3

# Thank you

For more information please visit the WEC-Sim website:

<http://wec-sim.github.io/WEC-Sim>

If you have questions on this presentation please reach out to any of the WEC-Sim Developers on GitHub:

<https://github.com/WEC-Sim/WEC-Sim>



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This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308.

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