Marine Energy Modeling for Power Flow Studies
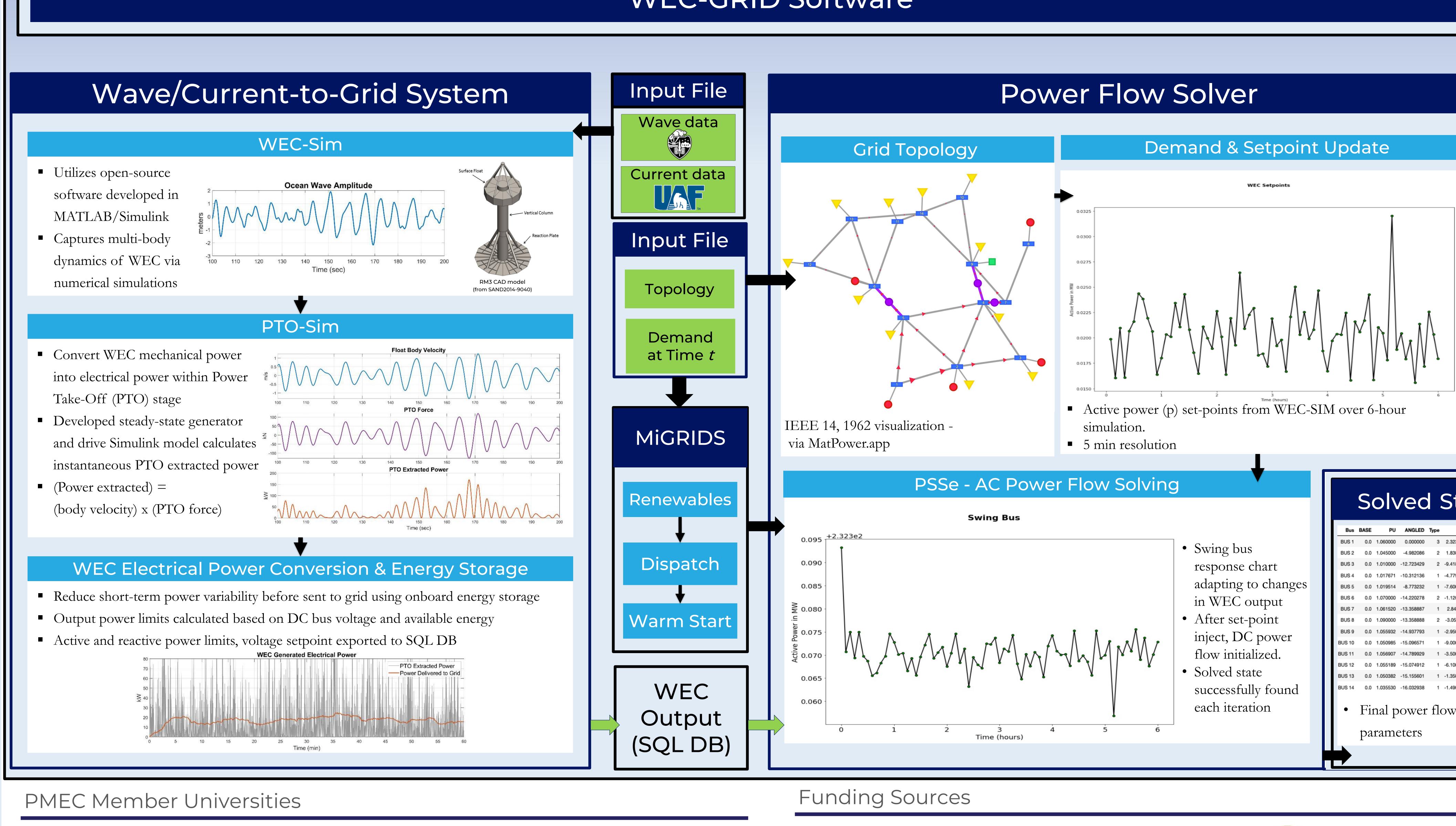
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WEC-GRID Software

Wave/Current-to-Grid System

WEC-Sim

- Utilizes open-source software developed in MATLAB/Simulink
- Captures multi-body dynamics of WEC via numerical simulations

Ocean Wave Amplitude

Surface Float
Vertical Column
Reaction Plate

RM3 CAD model
(from SAND2014-9040)

PTO-Sim

- Convert WEC mechanical power into electrical power within Power Take-Off (PTO) stage
- Developed steady-state generator and drive Simulink model calculates instantaneous PTO extracted power
- (Power extracted) = (body velocity) x (PTO force)

Float Body Velocity

PTO Force

PTO Extracted Power

WEC Electrical Power Conversion & Energy Storage

- Reduce short-term power variability before sent to grid using onboard energy storage
- Output power limits calculated based on DC bus voltage and available energy
- Active and reactive power limits, voltage setpoint exported to SQL DB

WEC Generated Electrical Power

PTO Extracted Power
Power Delivered to Grid

Input File

Wave data

Current data

Input File

Topology

Demand at Time t

MiGRIDS

Renewables

Dispatch

Warm Start

WEC Output (SQL DB)

Power Flow Solver

Grid Topology

IEEE 14, 1962 visualization - via MatPower.app

Demand & Setpoint Update

WEC Setpoints

- Active power (p) set-points from WEC-SIM over 6-hour simulation.
- 5 min resolution

PSSe - AC Power Flow Solving

Swing Bus

- Swing bus response chart adapting to changes in WEC output
- After set-point inject, DC power flow initialized.
- Solved state successfully found each iteration

Solved State

Bus	BASE	PU	ANGLED	Type	P	Q
BUS 1	0.0	1.060000	0.000000	3	2.323729e+02	-1.654552e+01
BUS 2	0.0	1.045000	-4.982086	2	1.830001e+01	3.085251e+01
BUS 3	0.0	1.010000	-12.723429	2	-9.418206e+01	6.067843e+00
BUS 4	0.0	1.017671	-10.312136	1	-4.779999e+01	3.900000e+00
BUS 5	0.0	1.019514	-8.773232	1	-7.600002e+00	-1.600001e+00
BUS 6	0.0	1.070000	-14.220278	2	-1.120000e+01	5.230852e+00
BUS 7	0.0	1.061520	-13.368887	1	2.842171e-14	9.536743e-07
BUS 8	0.0	1.090000	-13.368888	2	-3.053113e-14	1.762336e+01
BUS 9	0.0	1.055932	-14.937793	1	-2.950000e+01	4.584854e+00
BUS 10	0.0	1.050985	-15.096571	1	-9.000000e+00	-5.800000e+00
BUS 11	0.0	1.056907	-14.789929	1	-3.500000e+00	-1.800000e+00
BUS 12	0.0	1.055189	-15.074912	1	-6.100000e+00	-1.600000e+00
BUS 13	0.0	1.050382	-15.155601	1	-1.350000e+01	-5.800000e+00
BUS 14	0.0	1.035530	-16.032938	1	-1.490000e+01	-5.000000e+00

- Final power flow solution parameters

PMEC Member Universities

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Oregon State University

UNIVERSITY of WASHINGTON

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