Transition pathways to zero emissions shipping: Wind and H2 with the MATISSE-SHIP model

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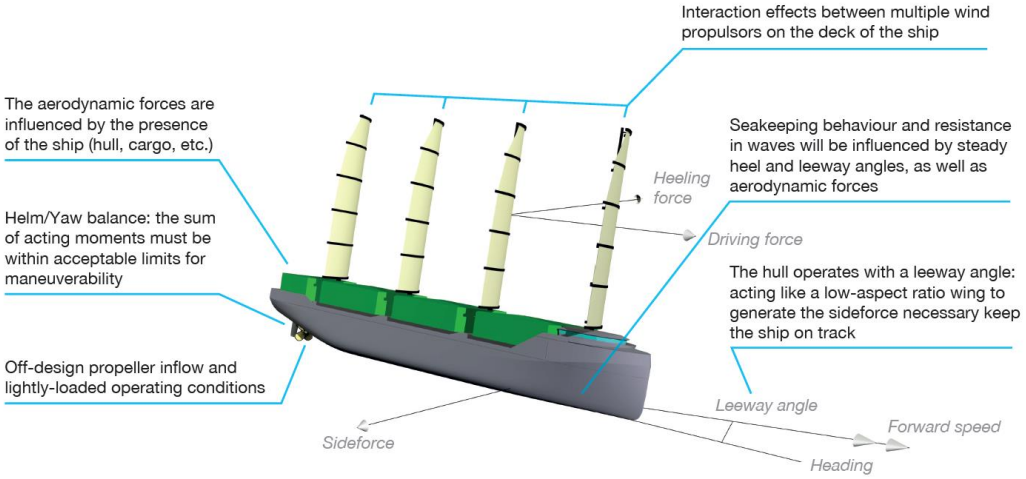

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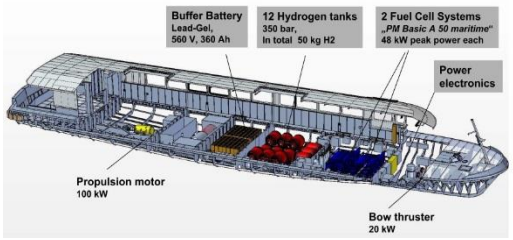
H2 fuel cells in shipping



World's first fuel-cell ship "FCS ALSTERWASSER" proves its reliability (Maritime Propulsion, 2012)

Energy Observer, Wired.com 2018

"Ballard PEM (proton exchange membrane) fuel cells are modular. They can be used in various combinations in parallel to provide the power and redundancy needed by a vessel, from 100kW to 1MW or more."

blog.ballard.com/fuel-cells-marine-vessels, 2019

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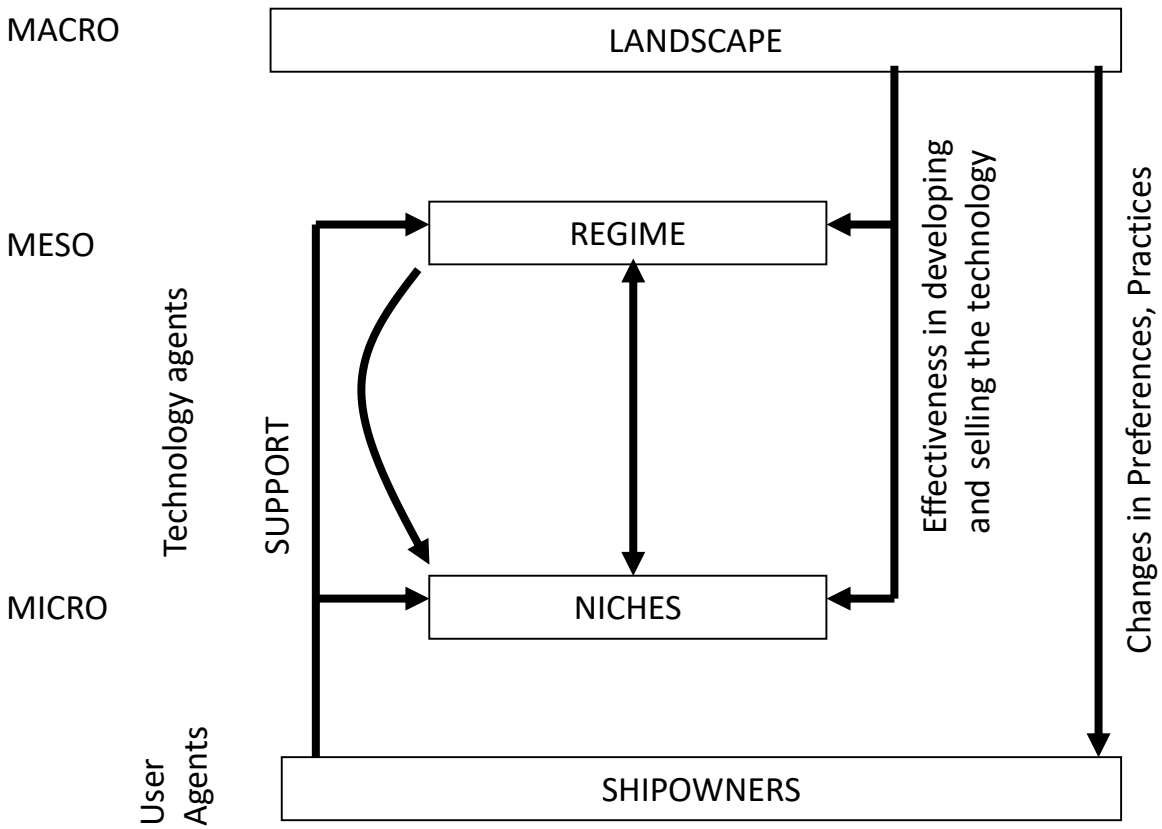
Structure of the MATISSE-SHIP model



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Technology/Operations niches

- Biofuels: which are sustainable, how much?
- Wind
- Wind assistance (windassist)
- Hydrogen Fuel cells
- (Batteries as auxiliary power source)
- Liquid Natural Gas including dual and triple fuel engines (LNGDF)
- Low flashpoint Liquid fuels e.g. Methanol, ammonia, dimethyl ether (LfL)
- Synthetic fuels (so-called power-to-liquid PtL)

- Slow steaming as a practice rather than a technology

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Practices

- GHG intensity - CO2 emissions/tonne km or passenger km;
- fuel cost Euro/tonne;
- operational speed (adoption of slow steaming);
- local air emissions /tonne km or passenger km (NOx, SOx, particles);
- capital cost/MW;
- perceived technological and operational change (reduced operational speed and weather optimised routing, even if this involves extended transit times compared to diesel propulsion at the operational speeds of 2012;
- requirement for new bunker infrastructure.

Markets/Trades

- cruise/ferry
- ferry LNG
- bulk (tanker and dry bulk)
- bulk-wind
- container
- psv/service
- psv/service LNG

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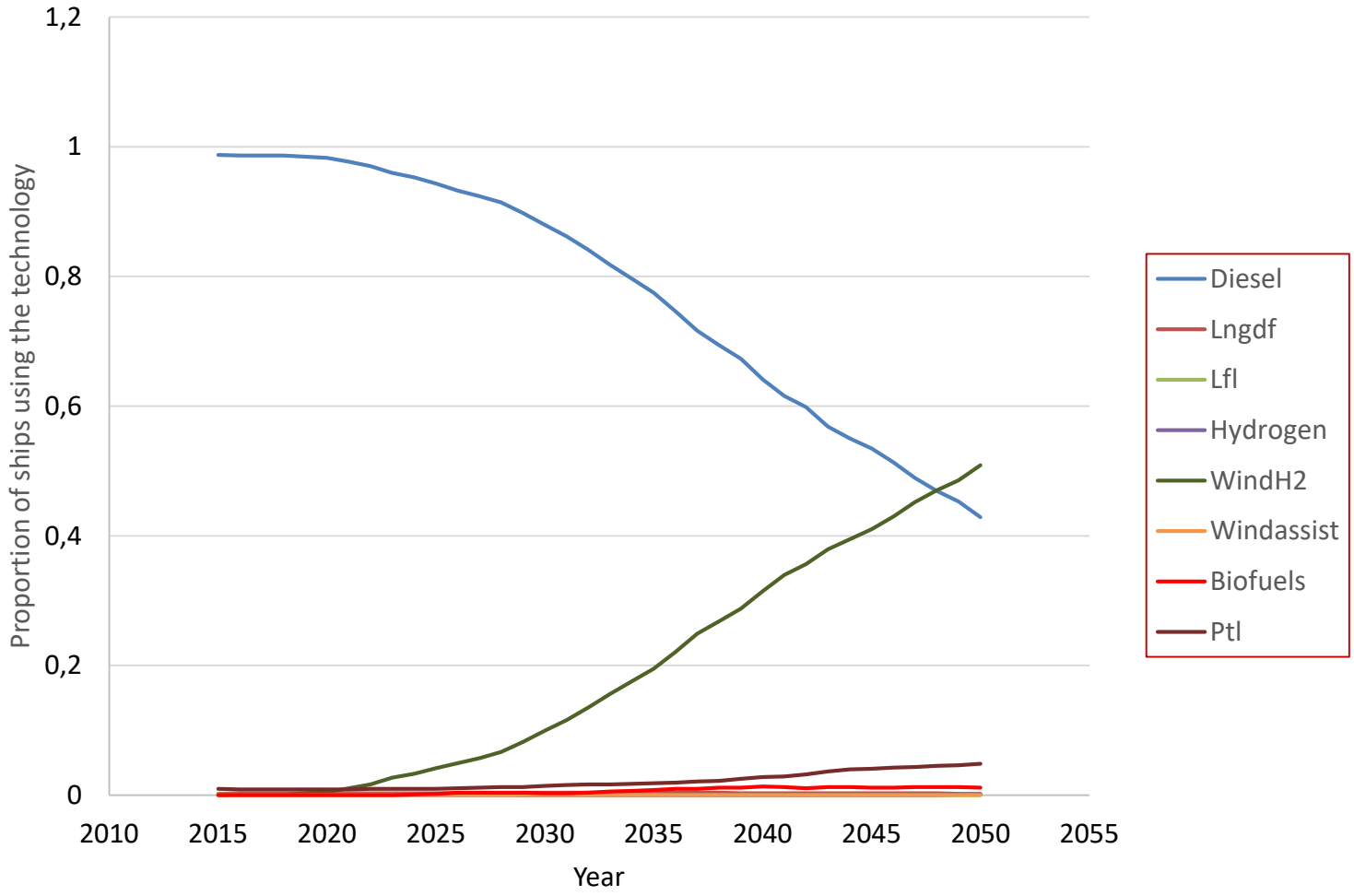
Wind combined with H2 by 2050



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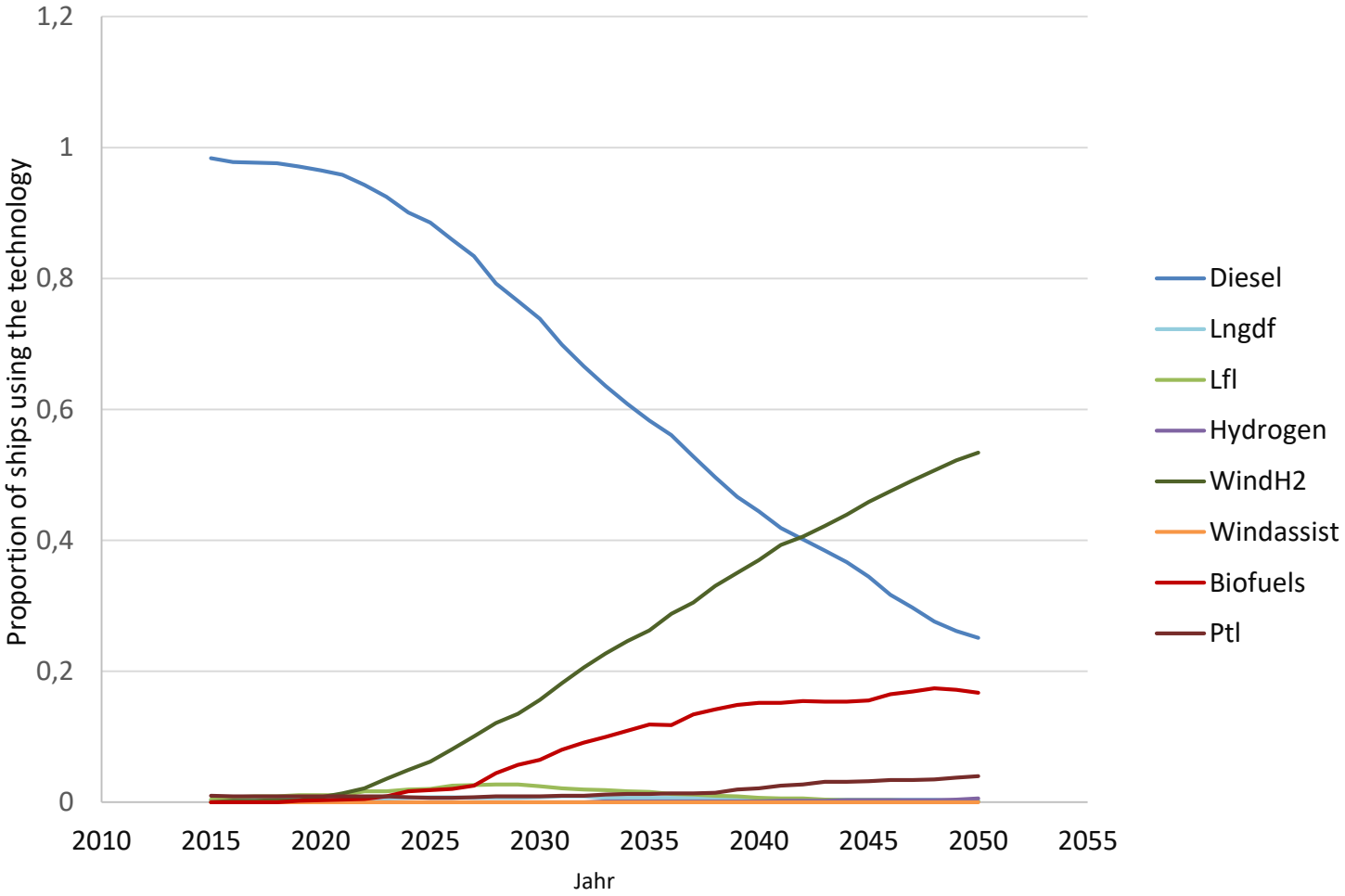
Wind combined with H2, biofuels by 2050



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