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POLICY ANALYSIS ARTICLE

Tack to the future: is wind propulsion an ecomodernist or degrowth way to decarbonise maritime cargo transport?

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ABSTRACT

This article explores the political economy of the re-uptake of wind propulsion for maritime cargo transport so as to shift this sector onto a decarbonization pathway. It focuses primarily on how wind propulsion technologies, both old and new, aim to close the 'emissions gap' between projected emissions and the target to reduce them, as set by the International Maritime Organization in 2018. In doing so, it questions whether and how wind propulsion technologies could help attain 'absolute decoupling' of GHG emissions from industry growth, resulting from growing demand for shipping. It concludes that wind propulsion can help decarbonize the industry. But there is lack of certainty regarding the possibility to (a) deploy zero-emission technology at scale and (b) the extent to which reducing demand for shipping activity may suffice to attain full decarbonization. This article argues that a combination of both technological innovation and reduced demand is crucial to developing a decarbonization pathway for the shipping industry to meet Paris Agreement commitments at scale and in time.

Key policy insights:

- Wind propulsion can contribute to a decarbonization pathway for the shipping industry
- This technology can be pursued from both 'ecomodernist' and 'degrowth' perspectives
- It is unlikely that either technological innovation or reduced demand alone will bring down shipping emissions to net-zero quickly enough, thus a combination of both may need to be considered to meet emissions reductions targets

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1. Introduction

The IPCC reports with 'high confidence' that 'reducing global transport greenhouse gas (GHG) emissions will be challenging since the continuing growth in passenger and freight activity could outweigh all mitigation measures unless transport emissions can be strongly decoupled from GDP growth' (Sims et al., 2014, p. 603). They stress that emissions need to be reduced to net-zero by 2050 to have a chance at limiting global warming to 1.5°C.

Maritime cargo transport is a significant polluter, contributing 1.06 gigatonne, or 2.89%, of global anthropogenic emissions, which amounted to 36.57 GT of CO_2 in 2018 (IMO, 2020). In the same year, the International Maritime Organization (IMO) set the first-ever sector-wide emissions reduction target, which commits to – at least – halving its GHG emissions by the year 2050 compared to 2008 levels, while aiming to phase them out entirely. This target marks a significant step forward, as the shipping industry has long avoided taking action on climate change (Bows-Larkin et al., 2014; Heine & Figueres, 2018). However, significant questions remain about how the shipping industry will meet this goal (Bullock et al., 2020; De Beukelaer, 2020b; Garcia

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et al., 2020; Sharmina et al., 2021), while bearing in mind that this target would also need strengthening to be compatible with Paris Agreement commitments.

According to Climate Action Tracker, the shipping industry's 2030 and 2050 commitments are 'critically insufficient' and 'highly insufficient', respectively. This means that current targets would see warming in excess of 4°C based on 2030 commitments and up to 4°C based on 2050 commitments, if all other sectors would have the same level of ambition (Climate Action Tracker, 2020). This is why several countries, including Denmark, Norway, and the United States, are pushing for a 'zero-emission shipping mission', through which they call for industry to lead a transition that exceeds the regulatory ambitions of the IMO (Bondareff & Salese, 2021; Global Maritime Forum, 2021).

Shipping emissions need to come down by at least 85% by 2050 on a 2008 baseline, ideally down to net-zero, to avoid excessive global warming of more than 2°C (Sharmina et al., 2021; Traut et al., 2018; Walsh et al., 2019). The August 2021 IPCC report warns that net-zero by 2050 may be too late: 'unless there are immediate, rapid and large-scale reductions in greenhouse gas emissions, limiting warming to close to 1.5°C or even 2°C will be beyond reach' (IPCC, 2021), thus jeopardizing Paris Agreement targets.

A Forbes article (Degnarain, 2020) argues wind propulsion could play a significant role in decarbonizing the shipping industry, if only regulatory and political leadership would support this shift. The International Windship Association (IWSA) is a UK-based organization that joins a range of companies, researchers, shipowners, and naval architects to support the commercialization of wind propulsion technologies that will reduce ships' carbon emissions. The solutions they present have one thing in common: they harness the wind for the propulsion of contemporary cargo ships. What sets them apart is that they come in two major categories: wind-assisted propulsion, which reduces fuel use of vessels that rely primarily on a main engine, and primary wind-propulsion, which relies on an auxiliary engine only in exceptional circumstances. The available technologies sit somewhere on the spectrum between the two.

Shipping has relied on sails as a zero-emission technology for thousands of years before the invention of the steam engine (Fagan, 2014; Paine, 2015; Smil, 2017). But the industry has changed significantly in scale, speed, and safety in the last two hundred years, allowing for the development of global just-in-time supply chains. While carbon emissions soared, the trade winds on the world's oceans have continued unabated, as there continues to be 'a good alignment between the windier sea areas and the areas where there is significant shipping activity' (Rehmatulla et al., 2017, p. 218).

The challenge to implement these solutions is not technological but operational (Mander, 2017; Wind Assisted Ship Propulsion, 2020). This raises the question of why these promising technologies that could quickly reduce, and potentially eliminate, the carbon emissions from vessel propulsion see a slow uptake. This article explores the potential of wind propulsion options, from both ecomodernist and degrowth perspectives. Technologically, the propulsion-related emissions from shipping may be curbed, but will this suffice to curb catastrophic climate change? Can the global economy and its 'derived demand' for shipping continue to grow?

The remainder of this article is organized as follows. The article begins by setting out its methodology. Then, it presents findings, in section three, by explaining why the shipping industry is lagging behind in its decarbonization commitments. In section four, it offers results on the potential of green growth and degrowth in relation to wind propulsion, followed in section five by a discussion that weighs up these perspectives. Finally, it offers a conclusion, arguing that a combination of technological innovation and reduced demand is crucial to developing a decarbonization pathway for the shipping industry to meet Paris Agreement commitments at scale and in time.

2. Methodology

This article takes an empirically informed political economy approach to the regulatory futures of the shipping industry. It does so to explore how two extremes in environmental thinking, ecomodernism and degrowth, could influence decisions concerning the regulation, investment, and deployment of various wind-assisted and wind-propelled technologies. The political economy approach is vital to connect the question of how to reduce shipping emissions to zero while also exploring the role maritime transport plays in the growth of material consumption worldwide.

This research builds on three key sources of data. First, it explores the existing regulations through a review and analysis of IMO decisions. Second, it critically engages with industry reports and initiatives to understand both their plans, actions, and intentions. Third, it derives insight from extensive ethnographic fieldwork, including a five-month voyage aboard a sailing cargo vessel (February – July 2020) and twenty-three semi-structured interviews with stakeholders in the revival of sailing cargo vessels, including representatives of shipping companies, industry organizations, and campaigners (June 2019 – March 2021; Table 1). By triangulating the methods and data these different methods yield, this article develops a critical appraisal of the challenges ahead to decarbonize the shipping industry using wind propulsion.

3. Shipping is lagging behind in its decarbonisation commitments

Before the IMO's 2018 emissions reduction target, there was no mechanism to curb international shipping emissions as a whole, despite this being an IMO responsibility since the 1997 Kyoto Protocol (Martinez Romera, 2018; Oberthür, 2003; Walsh et al., 2019). The Kyoto Protocol set clear emission reduction targets on a 1990 baseline for Annex I (highly industrialized) countries and charged the IMO with shipping regulation, but did not set any specific targets (Martinez Romera, 2018). It took the IMO until 2013 to adopt regulatory tools such as mandatory design requirements for new vessels (EEDI) and mandatory ship energy efficiency plans for large vessels (SEEMP).

The IPCC (2018) estimates that there is a 'remaining carbon budget of 580 $GtCO_2$ for a 50% probability of limiting warming to 1.5°C' and a '420 $GtCO_2$ [budget] for a 66% probability' of meeting that goal. The most recent research suggests that the remaining carbon budget is around 440 $GtCO_2$, though this sits in a range where 230 $GtCO_2$ gives a 67% chance of not exceeding the 1.5°C target, whereas 670 $GtCO_2$ gives a 33% chance of not exceeding it (Matthews et al., 2021).

At current emissions levels of around 42 $GtCO_2$ per year (42, ±2 as per IPCC, 2018), the remaining carbon budget will be depleted in less than six years, if we are to have a 67% chance at curbing global warming to less than 1.5°C. To have a 33% change of meeting this target, the budget will stretch to just under sixteen years. This means that net-zero emissions targets are central to meeting Paris Agreement commitments (van Soest et al., 2021). For shipping, this means urgent action is needed to reduce emissions as quickly as possible through operational measures, while pursuing all the technological and economic means possible to bring emissions down to zero soon after.

In 2014, the Third IMO GHG Study projected shipping sector emissions to grow by 50% to 250%, under different business-as-usual scenarios (IMO, 2014). In 2020, the IMO's Fourth IMO GHG Study revised these projections. The IMO now assumes that emissions in 2050 will amount to 90-130% of 2008 levels (IMO, 2020). While this is significantly less than the projections calculated in 2014, it remains well above its own emissions reduction target of 50%.

The precise targets are not the only challenge. The IMO lacks a clear implementation pathway, as the way it has translated its 2018 targets into operational measures will not see emissions drop (Apuzzo & Hurtes, 2021; Bannon, 2020, 2021; Rutherford et al., 2020). Moreover, the IMO has no mandate to enforce these regulations; its 'conventions' serve as guidelines for member states, who are left to translate them into domestic frameworks

Table 1. Subjects interviewed.

Organization / Company	Name	Role
Fairtransport	Andreas Lackner	Co-Founder
EcoClipper	Jorne Langelaan	Founder
Timbercoast	Cornelius Bockermann	Founder
SV Avontuur	anonymous	Fourteen Crew
Sail Cargo Inc.	Danielle Doggett	Co-Founder
International Windship Association	Gavin Allwright	Secretary General
Hawila Project	Rob Weir	Co-Founder
	Romed Bucher	Co-Founder
Wallenius Wilhelmsen	Roger Strevens	VP, Global Sustainability
Wind Ship Project	Ron de Vos	Founder and Ship Designer

and enforcement mechanisms. The power to set rules for ships resides with the countries they operate between ('port states') and the countries they are registered in ('flag states'). As international shipping emissions occur *between* countries, they do not currently count towards national carbon budgets of either 'port states' or 'flag states', making it difficult to convince, let alone coerce, countries to take action. Furthermore, the deliberate opacity of the organization makes it difficult to discern how decisions are made and whose interests they serve (Apuzzo & Hurtes, 2021; Prehn, 2021; Transparency International, 2018).

Today, industry stakeholders publicly recognize the importance of tackling shipping emissions. Still, very few make the necessary commitments, investments, and concessions, meaning that 'proposed candidate measures risk becoming broad ambitions with little action' (Garcia et al., 2020, p. 2). This tension became all the more apparent when the IMO, at the 75th session of its Marine Environment Protection Committee in November 2020, translated its overall emissions reduction target set in 2018 into guidelines that will see aggregate emissions increase into the 2020s (Bannon, 2020; Ocean Conservancy, 2020; Rutherford et al., 2020). Though Bullock et al. (2020, p. 14) argue that despite significant levels of 'committed' emissions (locked into the existing fleet), 'a combination of policies on low-carbon ships from 2030, combined with speed and operational measures from the early 2020s, could keep shipping within a Paris-compatible carbon budget', this would require more ambition than current IMO targets. Greater ambition could either lower ships' carbon intensity more significantly and rapidly or lower demand for shipping. The following section explores how current wind propulsion initiatives could contribute to either option.

4. Decarbonizing shipping: wind-powered pathways

The shipping industry can reduce its emissions to zero by either reducing its carbon intensity to zero or by reducing demand to zero. As the first option is not likely in the short term and the second option would cripple the global economy, a middle ground needs to be found. Wind propulsion offers the potential to contribute to the partial decarbonization of propulsion (Wind Assisted Ship Propulsion, 2020). This is a necessary consideration, as 'zero' or 'low' carbon fuels may externalize upstream emissions, meaning that their lifecycle emissions remain well above 'zero' (Lloyd's Register & UMAS, 2017; Sustainable Shipping Initiative, 2021). As long as new fuels and wind propulsion cannot deliver zero emission propulsion, reducing demand for shipping should also be considered. The remaining carbon budget is so limited that business-as-usual until the deployment of new technologies is not an option.

The IWSA focuses on the decarbonization of propulsion and remains agnostic on the scale and political economy of the industry (G. Allwright, personal communication, 21 June 2019). Their neutral stance on what and how much ships carry pits the organization against the 'sail cargo' movement.

This sail cargo movement consists of a handful of traditional sailing ships transporting goods under sail (Cutcher, 2020; De Beukelaer, 2018, 2020a). These companies operate tiny vessels (carrying less than a hundred tonnes of cargo) that use sails as their primary – and often sole – means of propulsion. Much like the IWSA, they aim to show that wind propulsion is a feasible and viable alternative to fossil fuels. Unlike the IWSA, these companies challenge the political economy of both the shipping industry and the underlying consumption-driven world economy. For them, wind propulsion is a means to raise awareness about the scale of the shipping industry and its carbon emissions while arguing for a smaller and slower global economy (see below).

The tension between their respective approaches, particularly in their normative views of the future: green growth and degrowth, prompts an assessment of what these pathways would mean for wind propulsion.

4.1. Green growth: wind as magic bullet?

From an 'ecomodernist' perspective, 'green growth' will result in necessary emissions reduction through innovation. Wind propulsion, or assistance with propulsion, is an important technology that can rapidly and significantly reduce carbon emissions from shipping. The International Windship Association (2021) argues in an open letter to the shipping industry that it could deliver a 20-30% reduction in emissions across the global fleet if widely deployed. They support their claim by a wide range of independent academic studies, which put the

degree of fuel and emissions savings between 0.4-60%, though most are 5-30% (Wind Assisted Ship Propulsion, 2020). The technological advances in recreational sailing and aerospace engineering make it possible to utilize various innovative designs that can marginally reduce fuel use and carbon emissions. These solutions come in two main categories.[1]

First are existing and emerging technologies that *assist* the propulsion of ships, such as kites, Flettner rotors, and rigid sails. These wind technologies aim to *reduce* fuel use, while ships rely primarily on hydrocarbon-driven engines (Traut et al., 2014).

Second are those that use the wind as a primary means of propulsion, including the Neoline and the Oceanbird. Neoline currently builds two 136-meter-long ro-ro vessels, each for 478 cars, for service on trans-Atlantic routes by 2022 (Berry, 2021; Hakirevic, 2020). The Swedish shipping company Wallenius Wilhelmsen are developing a 200-meter-long car carrier, Oceanbird, which will have retractable rigid sails that can extend up to 105 meters above the waterline (Sea Wanderer, 2020).

Both of these kinds of solutions can be seen as 'magic bullet' options, as they employ technological innovation to decarbonize the shipping industry without considering whether or not its current scale and expected growth are sustainable beyond carbon emissions. In doing so, these fully automated wind-propelled vessels cater to the demands of major shipping companies and cargo owners by offering a zero-emission propulsion solution without challenging the industry's political economy. While some solutions are ready for deployment, others – including Wallenius' – require further development and rigorous testing before economic and operational viability can be confirmed.

4.2. Degrowth: slowing down and shrinking?

From a degrowth perspective, the issue of shipping emissions extends well beyond propulsion. It is, in essence, an issue that requires a *cultural shift* to lower levels of consumption and more localized production. The current shipping industry, sail cargo company owners argue, is too big. They argue the industry ships goods across huge distances too cheaply and too easily. These activists believe that we ship far too much, as low relative emissions (in CO_2/tkm) add up to huge aggregate emissions across the industry. This allows – and even enables – excessive consumption, which they argue drives the climate crisis.

This is the argument Cornelius Bockermann, owner and captain of the Avontuur, makes (C. Bockermann, personal communication, 18 October 2019): 'Do we really need to just improve what we've already got?' he asked when I first met him. 'We've got a very efficient shipping industry with modern ships and we can make these ships clean by a different kind of propulsion, like sails, but do we really want to do this, or should we rather take a few steps back and reduce everything? Go back to natural materials. Go back to a lot less transport. Of course, a lot less consumption. A post-growth economy'. Andreas Lackner of the Tres Hombres makes a similar argument, claiming it is simply 'too easy to stow five or twenty thousand containers and chase them across five thousand miles of ocean' (A. Lackner, personal communication, 19 October 2019). His co-founder Jorne Langelaan, who now runs *EcoClipper*, argues that meeting emissions reduction targets requires having 'radically less transport', putting the mark at roughly 10% of current volumes (J. Langelaan, personal communication, 19 October 2019).

In making this argument, they implicitly contest the industry's claim to be a mere 'handmaiden' to trade. In their view, the shipping industry does not play a subservient role in responding to demand in global trade. Instead, regulatory loopholes like flags of convenience (DeSombre, 2006), the absence of taxes on 'international' bunker fuels (Martinez Romera, 2016), and the strong resistance to environmental regulation (Transparency International, 2018) make shipping so cheap that globalized supply chains become easier. They argue, in sum, that it is because shipping is so cheap and easy that demand for cargo transport has grown so much since the 1950s. This, sail cargo companies claim, more so than the means of propulsion, is the main issue with shipping emissions. And merely eliminating the carbon emissions caused by burning hydrocarbons may turn shipping into a zero-emission industry. Still, it does not resolve the fact that cheap shipping makes global supply chains possible as much as shipping relies on global supply chains to remain viable.

The Avontuur, like the Neoline and Oceanbird vessels, is propelled almost entirely emission-free. The Tres Hombres's shipboard operations are entirely emission-free, as the vessel does not even have an engine. The

difference between the traditionally rigged vessels, like the Avontuur and the Tres Hombres, and the newly designed modern rigs, like the Neoline and Oceanbird vessels, is twofold. First, the former currently operate as commercial cargo vessels, whereas the latter do not yet exist. Second, while the latter ships serve to ship goods, the former are in large part activist initiatives that, as the direct quotes at the start of this section illustrate, take issue not just with shipping's carbon emissions, but also with the enormous scale of commerce and consumption it enables.

Timbercoast and Fairtransport are commercial companies that pursue direct climate action through commercial wind-propelled cargo transport. Their mission is similar to Patagonia's, the American outdoor clothing retailer, by urging people to rethink their consumption levels and limiting their purchases to fewer but ethically sourced and produced goods (Hepburn, 2013). Both Patagonia and Timbercoast might see their revenues increase as consumers shift their habits to more ethical alternatives. Without additional policy and regulation, these individual consumer choices may do little more than fuel the sense of 'ecopiety' of consumers rather than driving societal change (Taylor, 2019). For these reasons, one could easily dismiss these small sail cargo initiatives as romantic nostalgia without any sense for pragmatism. They are, after all, symbolic projects that cannot compete with the shipping industry on scale or speed.

Sail cargo companies realize that their traditional sailing cargo ships cannot operate at the scale and the speed of the conventional fossil fuel fleet, nor of a future emission-free fleet. But it also revealed that this is not their objective, which is reducing the scale of the shipping industry while slowing it. They argue that scaling and slowing down transport would bring down total transport tonne/kilometre. This reduction of transport activity, they claim, is necessary to meet the emission reductions targets needed to avert global warming beyond 2°C, as per the Paris Agreement. Some scientists signal that beyond slow steaming and operational measures, reduced demand for shipping is the primary option for immediate emissions reductions (Sharmina et al., 2021; Traut et al., 2018). They do not argue for 'degrowth' by using that exact phrase, but do call to consider decreased demand for shipping.

5. Discussion: green growth or degrowth?

Can the global economy and its 'derived demand' for shipping continue to grow? A rapid shift to a zero-emission global economy is crucial to avoid global warming beyond 2°C (Traut et al., 2018; Walsh et al., 2019). The underlying question is whether the planet can sustain perpetual economic growth, considering that decoupling growth from its material footprint is even more challenging than decoupling growth from carbon emissions (European Environment Agency, 2021).

On the one hand, proponents of 'ecomodernism' argue it can, by claiming that 'green growth' through technological innovation could help us 'decouple' economic growth from resource use (Asafu-Adjaye et al., 2015; Symons, 2019). This approach should allow us to bring our emissions to net-zero while perpetuating GDP growth.

The shipping industry pursues a green growth agenda by pursuing different options to reduce fuel use and thereby GHG emissions in four categories: improving energy efficiency, using renewable energy, using fuels with lower carbon intensity, and using post-emission technologies (e.g. conversion or capture and storage), or a combination of them (Newell et al., 2017, p. 251).

Many of the solutions they propose have yet to be tested, approved for commercial use, and deployed at scale – and in some cases, the necessary innovations have yet to be discovered. Thus, averting the worst kind of climate change relies on the uncertain outcomes of further – and rapid – technological innovation and its widespread deployment.

On the other hand, 'degrowth' is now increasingly hailed as a necessary way forward to curbing climate change. Keyßer and Lenzen (2021) argue that while 'degrowth would not be an easy solution, … it would substantially minimize many key risks for feasibility and sustainability compared with established, technology-driven pathways'. They conclude that degrowth 'should be as widely and thoroughly considered and debated as are comparably risky technology-driven pathways' (Keyßer & Lenzen, 2021, p. 11). Furthermore, de Blas et al. argue that decarbonizing the transport sector within the growth paradigm is all but impossible (de Blas et al., 2020). It is unclear what level of consumption or energy use is appropriate or acceptable in a

degrowth future. Ecomodernists criticize degrowth proponents for focusing on reducing excessive consumption of the wealthiest, rather than the energy poverty and dignity of the poorest (Symons, 2019).

Vaclav Smil (2019, p. 499) argues that ecomodernist 'techno-optimism' and degrowth 'catastrophism' 'coexist within the mainstream of modern scientific research'. He concludes that ecomodernists (or 'techno-optimists' or 'techno-utopians') are misguided in their beliefs, but have economists on their side. Economists – and by extension, the shipping industry and its regulators – 'maintain a monopoly on supplying their physically impossible narratives of continuing growth that guide decisions made by national governments and companies' (Smil, 2019, p. 507). Smil stresses that living a prosperous life within planetary boundaries is feasible (see also Gaffney & Rockström, 2021; Raworth, 2017), but would require 'fundamentally restructured provisioning systems' (Smil, 2019, p. 507), which have 'so far been insignificant and largely ineffective compared to the ubiquity and the scale of the required temporary remedies and eventual long-lasting solutions' (Smil, 2019, p. 508). In short, he suggests that while reducing the consumption levels of the richest would not necessarily hamper their well-being, the full array of technologies needed to live well with less – beyond shipping alone – does not quite exist. Others warn against discounting the potential negative side-effects of ecomodernist innovations, including 'techno-authoritarianism' (Albert, 2020, p. 253).

6. Conclusion

The future of the shipping industry depends on IMO regulations that are meant to curb GHG emissions. However, the targets set by the IMO are not sufficiently ambitious to push the industry to move to net-zero GHG emissions quickly enough, as current regulations will allow emissions to increase through the 2020s (Bannon, 2020, 2021; Rutherford et al., 2020).

Much will also rely on the kind of future policymakers can envisage. Currently, that future imagined by the IMO is one in which the rapid adoption of zero-emission technologies and fuels will close the 'emissions gap' between the current projections and reduction targets. 'Green growth' driven by innovation is what the IMO expects to decarbonize the industry.

It may still be possible to reduce shipping emissions to a level compatible with the Paris Agreement. However, it is unclear how this will happen if both the deployment of existing technologies and further innovation (Rehmatulla et al., 2017) as well as slow steaming (Mander, 2017) remain tenuous, given the lack of economic incentives (carbon price) and political pressure (regulation) to do so.

Indeed, curbing emissions fast and hard enough to bring the sector in line with the Paris Agreement requires the deployment of low-carbon ships by 2030 and an immediate shift to slow steaming and other operational measures in the 2020s (Bullock et al., 2020). Focusing on either 'green growth' or 'degrowth' alone will likely not suffice when it comes to shipping decarbonization.

First, wind propulsion technologies could indeed help decarbonize the shipping industry, but they will need to be used as part of a portfolio of options suitable for the hugely varied ship types in operation. The shipping industry's adoption of wind propulsion technologies would also need to operate in conjunction with operational measures such as slow steaming and the rapid deployment of zero-emission fuels.

Second, given the lack of meaningful regulation of the industry in recent decades, it is uncertain whether the industry can continue to grow. Annual growth in demand currently exceeds annual fuel efficiencies, so aggregate emissions continue to rise (IMO, 2020). This suggests that further growth will rapidly deplete the remaining carbon budget. As long as the industry does not generate net-zero GHG emissions, growth is incompatible with its environmental obligations. Until that time, a shift in propulsion technology should probably be paired with a controlled contraction of the industry.

While reduced demand and wind propulsion do not currently receive sufficient attention within mainstream debate in policy arenas such as the IMO, it would be helpful to consider and pursue both options simultaneously as part of a broader portfolio of options, including – most urgently – widespread adoption of slow steaming. Focusing on either technological fixes or planned degrowth alone, risks warming well in excess of 2°C. Therefore, all possible solutions must be pursued.

Note

1. See the report, *New Wind Propulsion Technology A Literature Review of Recent Adoptions* (Wind Assisted Ship Propulsion, 2020) for a detailed discussion of the different propulsion options and their fuel saving potential.

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