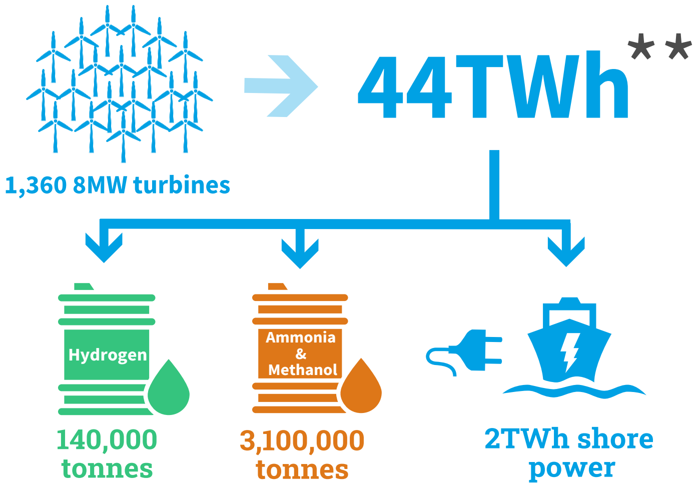
UK shipping needs a renewable fuel mandate

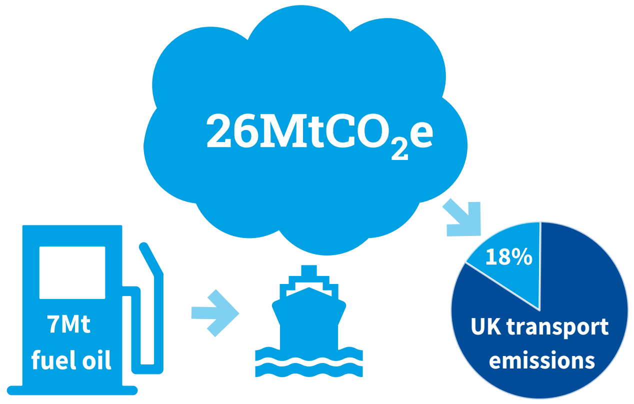
June 2023

T&E calculate that to stay within the UK carbon budgets in 2035* using a combination of zero-emission renewable e-fuels and direct electrification - the most cost-effective options - UK shipping will require **almost as much electricity as the UK's total wind generation in 2021**: **44 TWh** from **1,360** of the largest turbines. This could produce almost **3.25 million tonnes of hydrogen and hydrogen-based e-fuels** such as e-ammonia and e-methanol, as well as **2TWh shore power**.

* Using the Government's Carbon Budget Delivery Plan assumptions (March 2023)



** Total UK wind generation in 2021 was **49TWh**

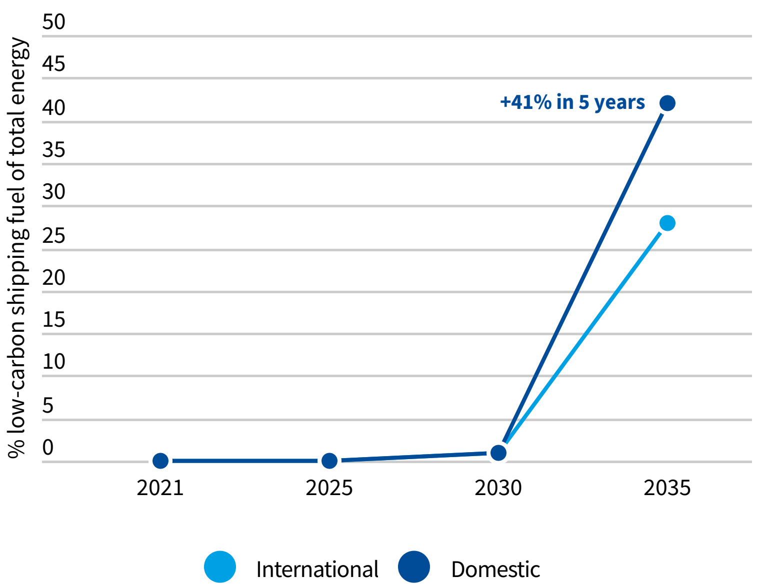


In 2021, UK shipping used over **7 million tonnes** of fossil marine fuel oils, producing more than **26 million tonnes of carbon dioxide equivalent** and accounting for **18%** of UK transport emissions.

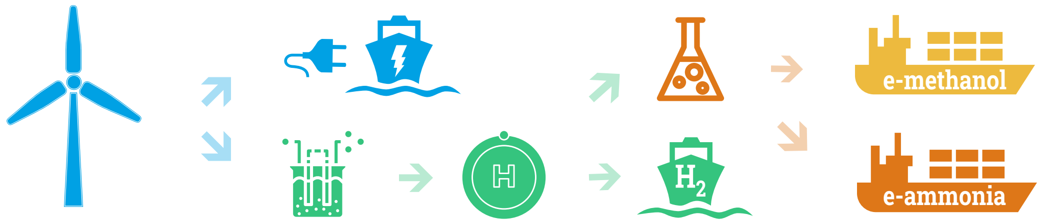
Net Zero requires these emissions to be eliminated by 2050, and significant reductions are required by 2030 and 2040 for the UK to remain compliant with the carbon budgets.

The Carbon Budget Delivery Plan (CBDP) assumes that **1% of all UK shipping fuels used in 2030** must be low-carbon, **increasing in 2035** to **28%** for UK international shipping and **42%** for UK domestic shipping.

Assumed uptake of low-carbon fuels



Zero-emission shipping fuels will be required to achieve these pathways. T&E analysis shows the least-cost, scalable technology options to be based on **renewable electricity.**

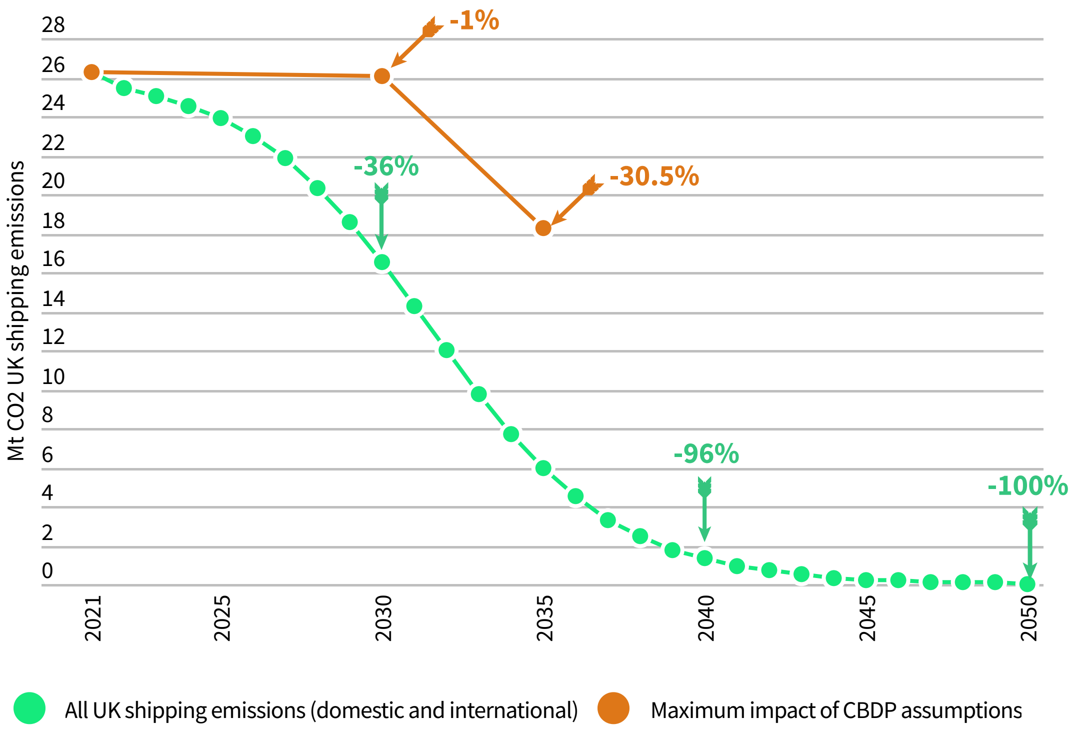


This includes **directly** for battery electric charging and power requirements at berth, and **indirectly** though **e-hydrogen** and **e-hydrogen-based e-fuels** such as **e-ammonia** and **e-methanol** for propulsion.

The Carbon Budget Delivery Plan assumptions will not be enough...

The government has not yet published an emissions reduction pathway for UK shipping. But it has endorsed the **Science Based Targets initiative (SBTi)** at the **International Maritime Organization (IMO)**, an emissions reduction pathway compatible with the climate goal of the Paris Agreement. SBTi requires emissions cuts of **36% by 2030** and **96% by 2040**. When applied to UK shipping, emissions need to decline as shown here. The maximum reductions possible from the CBDP assumptions are also shown.

How UK shipping emissions must reduce to zero (and impact of CBDP assumptions)



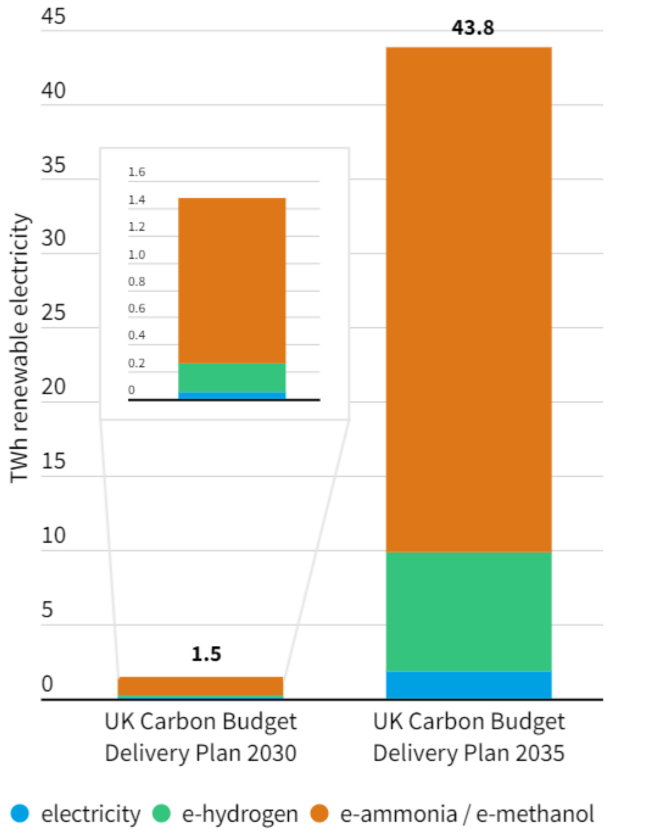
T&E recommends the use of fuel mandates to drive the uptake of the fuels considered here. Mandates are effective instruments already in use by the UK government. Here, we show the energy requirements of implementing the CBDP assumptions with a combination of **direct electrification** and **green e-fuels**, using **100% renewable electricity**.

Total electricity required

	TWh	Turbines
Carbon Budget Delivery Plan 2030	1.5	46
Carbon Budget Delivery Plan 2035	43.8	1359

= 50 x 8MW turbines

Electrical energy* required to meet mandates



* Includes electricity required for electrolysis, carbon or nitrogen capture and for e-fuel synthesis

In 2021, UK shipping used almost 7 million tonnes (Mt) of fossil marine fuel oil, producing 26.3 Mt of carbon dioxide equivalent (CO_2e) and accounting for over 18% of UK transport emissions.[1]

The UK government is currently considering policies to decarbonise the UK shipping sector, for publication in the Clean Maritime Plan later in 2023. But at the time of writing, the Government has not published or committed to a decarbonisation pathway for UK shipping, or a policy framework to achieve it. This is a glaring policy gap.

There are however some signs that the Government is aware of the problem and the need for ambitious policy solutions. At the level of the International Maritime Organization (IMO), the UK has endorsed a goal-based maritime emissions reduction pathway called the Science Based Targets initiative (SBTi).[2] SBTi is compatible with the climate objective of the Paris Agreement and requires emissions reductions of 36% on a 2020 baseline by 2030, and 96% by 2040. SBTi is intended to guide IMO, national and company-level emissions reduction pathways. It is therefore an appropriate trajectory for UK shipping.

In addition, the Government's Carbon Budget Delivery Plan (CBDP, published March 2023) sets out assumptions for the quantity of low-carbon shipping fuels needed for compliance with the carbon budgets: 1% of all shipping fuel in 2030, increasing to 28% and 42% in 2035, for UK international and domestic shipping, respectively.

T&E's recommended decarbonisation technologies are a combination of shore power and battery-electrification, and zero-emission renewable fuels of non-biological origin (RFNBOs) including e-hydrogen, e-ammonia and e-methanol[3]. All technologies require 100% renewable electricity. T&E does not support the use of biofuels or biomass in shipping, because as advised by the Climate Change Committee, biofuel in maritime applications is a non-optimal use of bioenergy even in the short-term, and will simply delay the introduction of zero-emission fuels and technologies.

As shown here, T&E has modelled quantities of renewable electricity and RFNBOs needed to fulfil the CBDP assumptions, and compared the resulting abatement potential to the SBTi trajectory (see Annex A for methodology). We calculate that the maximum emissions abatement potential from the CBDP low-carbon fuel uptake scenarios is 1% in 2030, increasing to 30.5%[4] in 2035. In contrast, the SBTi pathway requires 36% abatement in 2030, increasing to 77% in 2035.

It can be seen therefore that the CBDP assumptions, ambitious as they are compared to the present, fall far short of the abatement required to adhere to the SBTi pathway.

Normal market conditions, even with carbon pricing under current proposals to include a small percentage of UK shipping in the UK Emissions Trading Scheme, will simply not precipitate the technological transition required. This is because there are no sustainable, scalable, drop-in replacements for traditional fossil marine fuels, and no market either for zero-emission alternative fuels and energy, or the vessels to use them.

Therefore, just as the Government has already implemented for development fuels under the Renewable Transport Fuel Obligation, and is currently consulting on for sustainable aviation fuels, a mandate for zero-emission marine fuels is required. Additional abatement above what could be theoretically delivered by the CBDP assumptions as currently configured is also needed to meet the SBTi trajectory. Further consideration should therefore be given to emissions targets as well as mandates for energy efficiency technologies (to maximise their use by 2025 as envisioned in the Clean Maritime Plan[5]) and speed reduction.

However, as this is beyond the scope of this analysis we include these as policy recommendations only, consistent with our response to the Course to Zero consultation[6].

Further information

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Annex A
Methodology

Using the UK's 2021 shipping emissions inventory as described here, T&E has calculated the UK shipping sector's current energy requirement based on an average fuel emissions factor of 75.34 gCO_2/MJ[7]. From this we have determined quantities of RFNBO e-hydrogen, e-ammonia, e-methanol and electricity necessary to replace percentages of current fossil fuel use with zero-emission alternatives according to the amount specified in both Carbon Budget Delivery Plan scenarios, as shown below. We have also determined the quantity of renewable electricity necessary to produce these e-fuels using efficiencies from Concawe's 2022 assessment of European e-fuel production[8] for water electrolysis, the Haber-Bosch and methanol synthesis processes.

All estimates of energy requirements include the entirety of the production process, including supplying heat to the reaction and any necessary liquefaction or pressurisation. We have illustrated quantities of fuels in tonnes for the headline scenario and also the overall electricity requirement for both scenarios, including the number of wind turbines[9] necessary for each.

We have adapted the CBDP scenarios set out below to illustrate how much renewable electricity would be required to replace current use of fossil fuels with the selected zero-emission alternative technologies at the percentages given. The CBDP definition of low carbon fuels is broader than the fuels and technologies included in this analysis. However, as the technologies selected for this analysis represent the least-cost options to achieve zero-emission shipping, we have limited the analysis to these technologies only.

Scenario	UK target
UK Carbon Budget Delivery Plan 2030	1% domestic and international shipping using low-carbon fuels [10] [11]
UK Carbon Budget Delivery Plan 2035	42% domestic and 28% international shipping using low-carbon fuels

We estimate the following allocation of fuel and energy use [12] for both scenarios:

Emissions source	**Abatement technology assumed**
At-berth domestic and international vessels	Shore power

Domestic ferries	Battery-electric
International ferries	Liquefied e-hydrogen internal combustion
Other domestic vessels	Liquefied e-hydrogen internal combustion
Other international vessels	E-ammonia / e-methanol internal combustion

Endnotes

1. Emissions calculated using 2021 AIS data and based on full geographical scope United Kingdom Monitoring, Reporting and Verification (UK MRV) regulations (which includes domestic and international) plus sub-5000 gross tonnage (GT) and other non-MRV commercial vessels. All inbound, outbound, intra-UK voyages and at-berth emissions from these vessels are included. Reflecting the Science-Based Targets initiative (SBTi) which the UK has endorsed at the International Maritime Organization, emissions are expressed as well-to-wake (WTW), carbon dioxide equivalent (CO2e). Conversion factors taken from FuelEUMaritime proposal. The UK government does not count emissions from UK international aviation and shipping bunkers towards the UK greenhouse gas emissions totals as reported to the UNFCCC. However, the methodology used for this briefing uses the full geographical scope of the UK MRV regulations and therefore includes both domestic and international emissions. For completeness, we also include the UK's share of international aviation emissions in the total. UK transport emissions calculated for 2021 as 109.5MtCO2e from government 2021 data tables, replacing 5.3Mt domestic shipping emissions with T&E's calculated 26.3Mt of domestic and international shipping emissions and including 13.3Mt UK international aviation emissions. Total 2021 UK transport emissions 143.8Mt CO2e. Fuel quantity back-calculated from emissions using an average emissions factor (75.34gCO2e/MJ, tank-to-wake) for all voyages reported under the European Union MRV regulations in 2020. This is a reasonable proxy for an average UK emissions factor in the absence of published UK MRV data.
2. The Science Based Targets initiative (SBTi) (IMO reference code *ISWG-GHG 14/2/9, 3 February 2023, Refining the levels of ambition in the Revised IMO Strategy on reduction of GHG emissions from ships (by Canada, United Kingdom and United States)*) was presented to the IMO in October 2022 and is aligned to the 1.5 degree temperature goal of the 2015 Paris Agreement (IMO reference code *ISWG-GHG 13/INF.2, 21 October 2022, Science-based target setting for the maritime transport sector*). The "S" curve depicted in this report accommodates a slower initial rate of abatement whilst zero-emission technologies are scaled up. The cumulative emissions are approximately the same as for a linear pathway. 2021 is used as the baseline year as it is the first year following the UK's exit from the European Union.
3. T&E modelling of the European shipping sector shows that the above e-fuels are likely to be the least-cost, zero-emission alternatives to conventional fossil marine fuels that are both scalable and sustainable. At present, sector interest is growing in e-methanol which, although more expensive than e-hydrogen or e-ammonia on a total cost of operation (TCO) basis, has certain advantages over other e-fuels including lower toxicity and relative ease of handling. We include all three fuel options in this analysis.
4. The 26.3Mt emissions inventory is split 82% / 18% international / domestic. Applying the CBDP low-carbon fuel uptake assumptions to those totals for combined UK domestic and international shipping as percentages of emissions abated gives a maximum abatement potential of 0.27Mt CO2e (1.0%) in 2030, rising to 8.03Mt CO2e (30.5%) in 2035.
5. Clean Maritime Plan, July 2019, page 6. Accessed at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/815664/clean-maritime-plan.pdf
6. Consultation Response to Plotting the Course to Zero, T&E, October 2022. Accessed at https://www.transportenvironment.org/wp-content/uploads/2022/09/Copy-of-Course-to-Zero-Consultation-Response-05.10.22.pdf
7. See footnote 1
8. E-Fuels: A technoeconomic assessment of European domestic production and imports towards 2050, accessed at https://www.concawe.eu/wp-content/uploads/Rpt_22-17.pdf
9. Assuming an average capacity of 8MW and capacity factor of 46%, consistent with the current best-performing UK offshore sites.
10. The Carbon Budget Delivery Plan (CBDP) defines low-carbon fuels as electricity, biofuels, solid biomass, hydrogen, ammonia and methanol. Accessed at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147369/carbon-budget-delivery-plan.pdf
11. The CBDP does not make explicit reference to shore power. However, T&E analysis shows 2021 UK port shipping emissions were 2Mt CO2 or around 10% of total UK shipping emissions. This is a significant

proportion of energy use that must be decarbonised. We have therefore included percentages of renewable shore power corresponding to each CBDP scenario.
12. We have not undertaken analysis of precise configuration of fuels and technologies across different vessel types. The above are estimates only.