CAPACITY CEILINGS IN EU FISHERIES: OBSTACLE OR OPPORTUNITY FOR THE DECARBONISATION PROCESS?

Report prepared by Sara Hornborg and Friederike Ziegler, RISE Research Institutes of Sweden, on behalf of ClientEarth

EXECUTIVE SUMMARY

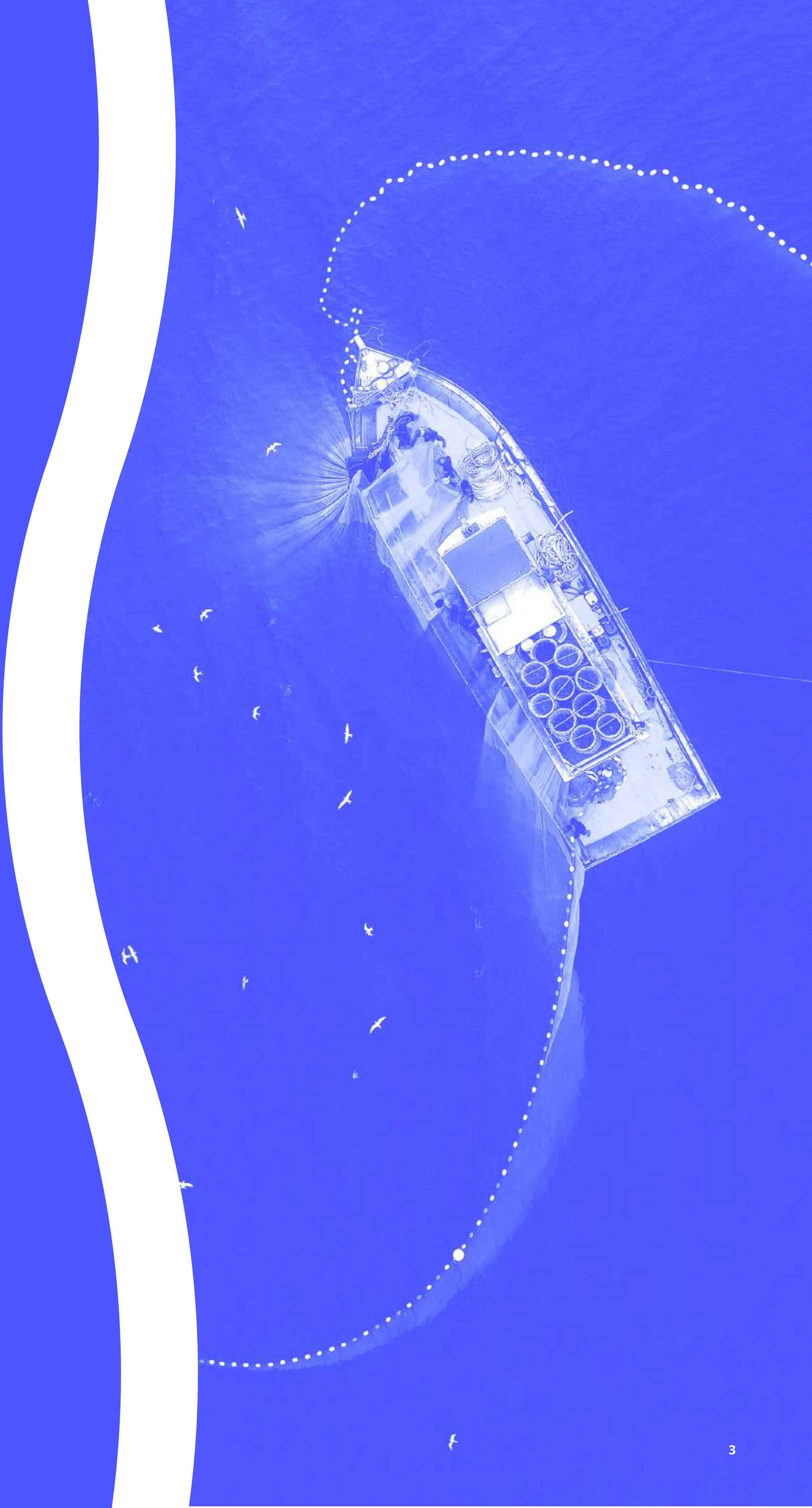
The need to transform our society in order to curb climate change has become increasingly urgent. In the case of EU fisheries, to achieve an energy transition means addressing both key knowledge gaps and potential hindrances. **The capacity ceilings set by the Common Fisheries Policy (CFP), with the intention to decrease overcapacity and halt overfishing in the form of a cap set on gross tonnage (GT) and total power (kW), are seen as a major obstacle by some parts of the EU fishing sector**. This is due to fishing vessels requiring larger energy storage volumes when using alternative energy sources than diesel, which affects both GT and kW. **This report investigates to which extent these ceilings prove to be a hindrance, with the overall aim to identify and investigate which steps of the decarbonisation process can be taken within the existing capacity ceilings of the EU**, and opportunities for hybrid- or full decarbonisation from the point of capacity ceilings and their purpose.

The notion that capacity ceilings are a hindrance for decarbonisation of EU fisheries may be dismissed as shown by the analysis of the data hereinafter, given a combination of factors: **i)** there is room for increase in GT and kW at Member State levels relative to the ceilings set; **ii)** the extra GT that would be needed is likely marginal; **iii)** actions towards decarbonisation may align with the purpose of the ceilings and broader CFP legislation; and **iv)** focus on nominal capacity to decrease overcapacity and overfishing is flawed as used today – there are better alternatives to achieve their purpose. Based on our analysis, today, most Member States have capacity available to increase GT and kW at national level – ten Member States have ≥25% capacity left before they hit the ceiling for GT. At fleet level, overfishing still occurs despite a decade of capacity ceilings. There is also a vessel size component – fleets with larger vessels utilise their boats more, but are also to a higher degree dependent on, and impact, overfished species/stocks.

All scenarios that lead towards decarbonisation require optimisation of energy efficiency.

A starting point would be to install energy monitoring devices that will allow fishers to identify fuel consumption patterns and improve their energy efficiency, and to reduce their fuel consumption and emissions. At fleet level, many adjustments can be made to improve fuel use efficiency by at least around 30% without conflicting capacity ceilings, and even be aligned with action plans for fleets where overfishing occurs. In combination with hybrid solutions such as fossil fuel and sustainable biofuel or a combination of fossil fuel and electric engine, theoretically, a total 79% reduction in greenhouse gas emissions may be achieved. Full decarbonisation requires major investments to support a transition, with different opportunities and challenges depending on fleet and targeting pattern. Larger vessels, especially those operating in distant waters and/or using demersal trawls, will require substantial change in storage capacity when utilising alternative energy that is less-energy dense compared to diesel – e.g., twice the volume is required for methanol. Nevertheless, it appears that the relative change in GT is small. Further technological analysis is however needed for improved understanding of full implications for different vessels and fishing operations.

Overall, effective transition towards decarbonisation of EU fisheries would need support by EU regulatory instruments related to fisheries. **Overfishing occurs within all case study fleets, suggesting that the purpose of capacity ceilings is not being fulfilled**. This calls for further actions to reduce overcapacity which can also align with progressing the energy transition of EU fisheries. Actions include moving towards less impactful fishing practices (e.g., change in gear type), decommissioning of fuel-inefficient vessels to decrease capacity and fishing effort – all actions with the potential to also reduce current overfishing, which has been identified as an important component to fuel use efficiency – i.e., win-win actions for both climate and elimination of overfishing.



CONTENT

6 ______ 1 BACKGROUND
6 ______ 1.1 A GREEN TRANSITION OF EU FISHERIES
7 ______ 1.2 THE EU CAPACITY CEILINGS
8 ______ 1.3 AIM OF THE STUDY
9 ______ 2 METHOD
9 ______ 2.1 CAPACITY CEILINGS AND CURRENT BALANCE
9 ______ 2.2 SCENARIOS
11 ______ 3 FLEET CAPACITY AVAILABILITY
13 ______ 4 SCENARIOS
13 ______ 4.1 BASELINES FOR THE YEAR 2021
13 ______ 4.1.1 SPAIN – DEMERSAL TRAWLER FLEET
14 ______ 4.1.2 FRANCE – DISTANT WATER PURSE SEINE
14 ______ 4.1.3 ITALY – SMALL VESSELS UNDER 12 M
14 ______ 4.1.4 THE NETHERLANDS – PELAGIC FREEZER TRAWLERS
14 ______ 4.1.5 PORTUGAL – LONGLINERS
16 ______ 4.2 SCENARIO 1
18 ______ 4.3 SCENARIO 2
20 ______ 4.4 SCENARIO 3
25 ______ 5 CONCLUSIONS AND RECOMMENDATIONS
26 ______ 6 ANNEX 1
27 ______ 7 ENDNOTES

1 BACKGROUND

1.1 A GREEN TRANSITION OF EU FISHERIES

The need to transform our society in order to curb climate change is increasingly urgent[1]. The European Union (EU) aims to achieve net-zero emissions by 2050, legally binding through the European Climate Law[2]. Intermediate targets include reduction of greenhouse gas (GHG) emissions by at least 55% by 2030 compared to 1990; all sectors must play their part in achieving these targets. A recent communication by the EU commission, 'Securing our future'[3], concluded that immediate investments are needed for deployment of zero and low carbon technologies to achieve the highest reductions. In this endeavour, a shift from operational costs (fossil fuel purchase) to capital costs are foreseen, and there are several barriers to overcome – technological, knowledge and skill, and financial.

For the fisheries sector, fishery management may be added as a potential barrier, but also as an opportunity. As highlighted and explored both in a communication by the European Commission[4] and a recent report prepared for the European Parliament[5], **strategies to reduce current fuel consumption and progressing towards full decarbonisation are both needed.**

Many short-term mitigation opportunities exist for improving energy efficiency, many of which go hand-in-hand with improving economic conditions for fisheries. Furthermore, yet another report prepared for the European Commission[6] found that many energy-saving technologies already exist; it is mainly a matter of implementation. The largest opportunities for reducing fuel use are however arguably dependent on fishery management[5], such as effective elimination of overcapacity, rebuilding stocks and use of energy-efficient fishing gears – measures that have short term economic and social implications but, in the longer term, will be more economically beneficial for the fishers remaining in the system. Full decarbonisation comes with considerable initial costs through economic investments required both on land and on vessels to be able to convert to alternative energy sources and require training of crew. To this end, effective transition towards decarbonisation of EU fisheries would need support by EU regulatory instruments related to fisheries while also considering general barriers[3].

For initiating the process of energy transition of EU fisheries, some key knowledge gaps and potential obstacles exist. **One obstacle is the current fossil fuel subsidies that provide reversed economic incentives for fuel saving and uptake of alternative energy sources by the industry which most likely negatively affects fuel efficiency**[7]. A report by Our Fish[8] estimated that this tax exemption each year amounts from €759 million to over €1.5 billion for the EU fishing fleets – money which could be spent on funding the energy transition instead. In terms of knowledge gaps, tailored solutions will be important, acknowledging the heterogeneity of the EU fishing sector[5]. Questions that need to be addressed by decision-makers, fishers and other stakeholders such as shipbuilders are what characterises best available technology – including technology under development – for the various fleets. Here it is important to consider both the short- and long-term perspective, and the tension between the changes that must be made to fishing vessels to store larger volumes of less energy-dense fuels compared to fishing restrictions set to reduce overcapacity and risks for overfishing, e.g., fishing capacity ceilings in the form of a cap set on gross tonnage (GT) and kW in Annex II in the Common Fisheries Policy (CFP) basic regulation[9].

Even if barriers may exist, **there are also many opportunities that support the energy transition**, such as effective implementation of the policy objectives of the CFP. For example, **Article 17 on allocation of fishing opportunities could be used to favour energy efficiency**. Furthermore, **achieving effective elimination of overcapacity (Article 22) would also favour energy efficiency**. However, the Fisheries Secretariat[10] identified several hinders in reducing overcapacity today through, e.g., weakness in indicators to measure true fishing capacity. Still, the capacity ceilings set in Annex II in the CFP that are related to Article 22 are repeatedly highlighted as a major obstacle for initiating the energy transition. This is due to the cap set on total GT and kW which may not be exceeded while fishing vessels will require larger storage volumes when using less energy-dense fuels than diesel. Thus, capacity ceilings are the focus of this report, i.e., to which extent these hinder or delay the decarbonisation process of EU fisheries, or if ambitions to reduce overfishing and initiate the decarbonisation process could be initiated. This is regardless of whether both these ambitions can be aligned under the current capacity ceilings– i.e., not increasing fishing capacity or even enabling effective reduction of existing overcapacity while also allowing for improved energy efficiency and even decarbonisation.

1.2 THE EU CAPACITY CEILINGS

The purpose of the capacity ceilings is to decrease overcapacity and halt overfishing – identified as major problems in the Green Paper from 2009[11]. Besides the ceilings set in 2014 (Annex II of the CFP), Article 22 of the CFP sets out mechanisms related to 'adjustment and management of fishing capacity', where Member States are to identify and continuously decrease overcapacity by adjusting their fishing fleets to their fishing opportunities, and annually report on the balance (Fleet capacity reports[12]). If overcapacity is identified, the Member State should prepare and submit an action plan to concretely adjust the identified imbalance.

The Scientific, Technical and Economic Committee for Fisheries (STECF) annually prepares a summary report on the balance capacity of EU fleets[13]. A set of indicators (biological, technical and economic) has been developed for the purpose (Annex 1 Table 1). The biological indicators intend to assess whether vessels are relying on overfished stocks or are involved in causing a high biological risk to a depleted stock. Economic indicators should indicate if the fleets are economically sustainable both in the long term (which may allow capital investments) and in the short term (if they are able to cover their costs). Technological indicators should reflect how intensively the vessels of a fleet segment are used, where low utilisation of vessels indicate imbalance.

In practice, the current ambition of the CFP to reduce overcapacity and overfishing is however not sufficient, as several challenges remain for effective implementation[10]. Current evaluations of the degree of overcapacity are based on nominal capacity (kW and GT). However, the actual fishing capacity requires consideration of technological creep, i.e., improved efficiency of vessels to catch fish through e.g., innovations in gear design and methods to find the fish – estimated to, on average, increase catchability by 3.2% per year[14]. Furthermore, there are challenges in proper verification of the actual kW and GT installed – with often higher engine power installed than is registered[15]. To address overfishing, efficient management of fish stocks by ensuring reference points for fishing mortality and biomass are at sustainable levels, is more crucial to decrease risks for overfishing. Even if input (effort) or output (quota) controls are in place for different fisheries and stocks, it is still not enough to fully eliminate overfishing. These different control systems have also been suggested to influence fuel efficiency[5], and may thus also be worth scrutinising to identify overcapacity, overfishing and strategies for decarbonisation processes.

1.3 AIM OF THE STUDY

The objectives of this study are to i) provide an overview of the current capacity (kW and GT) in each Member state relative to the capacity ceilings set; ii) analyse tangible scenarios for a stepwise decarbonisation process for five case study fishing segments, including how/if these conflict the intention with capacity ceilings and current restrictions set. The overall aim is to identify and investigate which steps in a decarbonisation process can be taken within the existing capacity ceilings of the EU, and opportunities for hybrid- or full decarbonisation from the point of capacity ceilings and their purpose.

2 METHOD

2.1 CAPACITY CEILINGS AND CURRENT BALANCE

Capacity ceilings (kW and GT) at Member State level were extracted from Annex II in the CFP9 and current fishing capacity from Member State reports[12]. Furthermore, a set of Member States with large fisheries were further investigated – France, Italy, Spain, Portugal, and The Netherlands – countries with fleets that were studied in the recent report on fossil fuel subsidies by Our Fish[8]. For these Member States, the most recent Balance capacity indicators (STECF 22-1513) were extracted to identify percentage of fleets which were, when assessed, considered to be out of balance in the form of Species At Risk (SAR), Sustainable Harvest Indicator (SHI), and Vessel Utilization Ratio (VUR) per vessel size category (<12 m; 12-24 m; 24-40 m; >40 m). For more details on the indicators, see Annex 1 Table 1. Only active segments with at least one fishing vessel operating were included.

2.2 SCENARIOS

For five case studies (specific fleet segments for the same Member States that were investigated in further detail, see 2.1), it was explored how much decarbonisation can be achieved without reaching the current capacity ceilings at Member State level, or conflicting action plans identified for the fleet to reduce imbalance at fleet level found in Member State reports[12]. It was attempted to align the fleets studied here with those with CO_2 emissions and tax exemptions already assessed by Our Fish[8]:

- **SPANISH DEMERSAL TRAWLER FLEETS**
- **FRENCH PURSE SEINERS IN DISTANT WATERS (OVER 40 M)**
- **ITALIAN VESSELS UNDER 12 M**
- **DUTCH PELAGIC FLEET**
- **PORTUGUESE LONGLINERS (24-40 M)**

The fleets have different targeting patterns (gears, species, fishing areas) and structure (tonnage, length, kW), requiring different customised solutions in exploring measures that could be taken. They also currently benefit differently from fossil fuel subsidies as identified by Our Fish[8]. The scenarios also attempted to take into account options that would be the least harmful to the marine environment (bycatch and benthic impact). Based on these conditions, three scenarios were investigated (Table 1).

Table 1 Scenarios investigated for the five fleet segments.

Scenario	Description	Method
REDUCED FUEL CONSUMPTION	**Achieving ≥30% reduction in fuel consumption** (and thus emissions) without affecting capacity ceilings or compromising action plans.	Investigate potential of implementing measures to increase the fuel use efficiency (i.e., change in vessel, behaviour or gear).
HYBRID DECARBONISATION	**Achieving a ≥50% reduction of greenhouse gas emissions** from a combination of energy saving measures and hybrid solutions without affecting capacity ceilings.	Investigate potential energy efficiencies in combination with changes in energy carriers for onboard operations or use alternative energy sources with little or no change to GT or kW.
FULL DECARBONISATION	**Fully move away from fossil fuels** which may conflict capacity ceilings.	Investigate implications of changes in energy carriers that may affect GT and kW.

The most recent data on fuel consumption (year 2021) for these fleets was extracted at fleet segment level from STECF 23 07[16]. Quantitative estimates available on fuel use reduction potentials were extracted from literature, mainly from recent reports on decarbonisation opportunities for EU fishing fleets [5,17]. Experts in alternative fuels and energy efficiency in the maritime sector were also consulted to identify which measures represent the most relevant solutions based on vessel type and fishing pattern, and the potential effect on kW and GT.

For each scenario, the fleets were assessed regarding whether the available capacity ceiling at an overall Member State level (Annex II in the CFP) and status for the fleet (Member State reports) would be a hindrance or be aligned with initiating decarbonisation measures.

3 FLEET CAPACITY AVAILABILITY

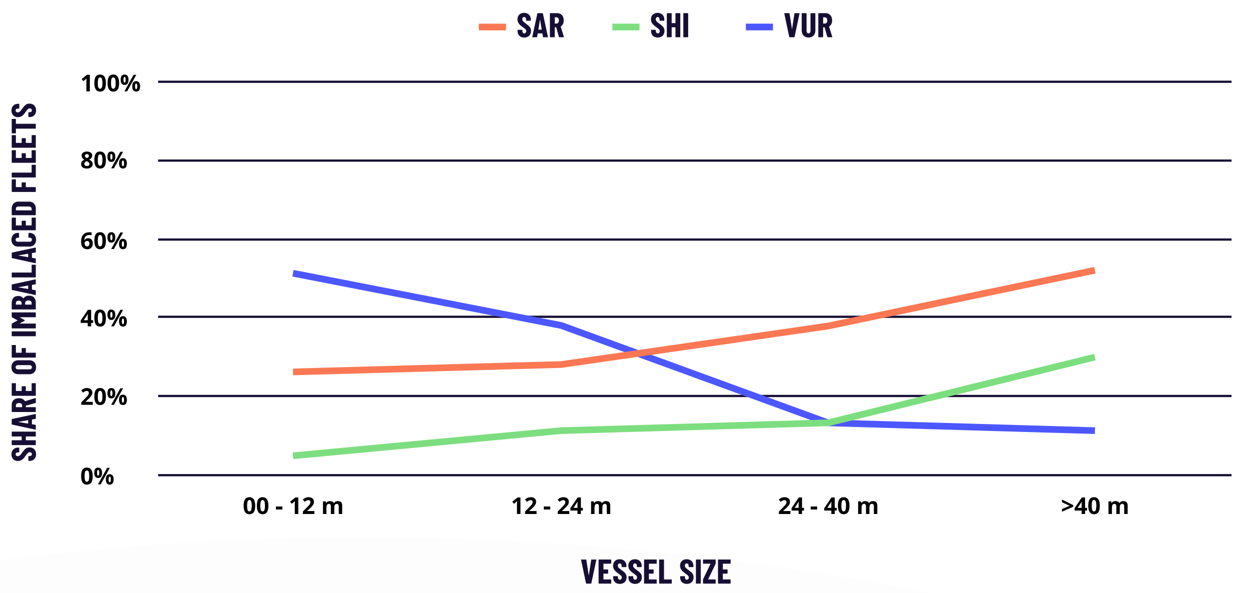
No EU Member State currently exceeds the ceiling set in Annex II of the CFP (Table 2). The overall average "available room" for increase in nominal capacity, if needed for storage of alternative fuels, relative to the EU capacity ceilings was 27% for GT and 18% for kW. Variability exists between Member States. Cyprus, Latvia, Lithuania and Malta represent Member States with opportunities to increase GT with over 50%. In general, there is more room to increase GT than kW installed.

Table 2 Capacity ceilings (Annex II of the CFP) and "available room", i.e. difference between ceiling and current GT and kW based on the most recent Member State report.

SCENARIO	CFP CEILING		"AVAILABLE ROOM" TO CEILING	
	GT	KW	GT	KW
Belgium	18,962	51,586	27%	13%
Bulgaria	7,250	62,708	19%	17%
Denmark	88,762	313,333	22%	33%
Germany	71,117	167,078	24%	25%
Estonia	21,677	52,566	25%	6%
Ireland	77,568	210,083	12%	10%
Greece	84,123	469,061	26%	23%
Spain*	425,550	964,826	21%	19%
France*	214,282	1,166,328	18%	19%
Croatia	53,452	426,064	19%	18%
Italy	173,506	1,070,028	18%	14%
Cyprus	11,021	47,803	65%	16%
Latvia	46,418	58,496	53%	35%
Lithuania	73,489	73,516	52%	45%
Malta	14,965	95,776	57%	26%
The Netherlands	166,859	350,736	40%	29%
Poland	38,270	90,650	8%	7%
Portugal*	114,549	386,539	25%	10%
Romania	1,908	6,356	15%	0%
Slovenia	675	8,867	0%	2%
Finland	18,066	181,717	19%	6%
Sweden	43,386	210,829	35%	31%
AVERAGE			**27%**	**18%**

At a higher detail, different fishing fleets within Member States vary in terms of current status for overcapacity and/or overfishing. Fleets with smaller vessels appear to a larger extent be in balance biologically (SAR and SHI), while as the vessel sizes get larger, more are in balance technologically (VUR). This implies that fleets with larger vessels utilise their boats more but are also to a higher degree dependent on and thus impact overfished species/stocks. Of note, the fleets with larger vessels were also identified in the report by Our Fish as being most dependent on fossil fuel subsidies[8].

Figure 1 Figure 1 For active fleets in France, Italy, Spain, Portugal, and The Netherlands combined, the percentage of fleets that are out of balance in terms of sustainable exploitation levels, informed by the indicators Species At Risk (SAR), Sustainable Harvest Indicator (SHI), and the Vessel Utilisation Ratio (VUR), when information is available.



4 SCENARIOS

For the case study fleets, most of the vessels (88%) are below 12 metres in length. Overall, small vessels operating near the coast will benefit from other solutions for the energy transition compared to larger vessels fishing further offshore, the latter requiring larger storage capacity for fulfilling the demand of less energy-dense fuels to support longer trips. Smaller vessels, however, may often have lower financial capacity to invest in e.g., installation of new technology.

4.1 BASELINES FOR THE YEAR 2021

4.1.1 SPAIN – DEMERSAL TRAWLER FLEET

The Spanish demersal trawler fleet comprised 870 vessels of which most (93%) were between 12-40 m, combined consuming over 233 million litres of diesel in 2021. Only 2% of the vessels were under 12 m and the remaining 5% over 40 m. The fleet is separated into 10 fleet segments based on vessel size and fishing area (the Mediterranean, the North Atlantic or Other fishing Regions). **All fleet segments were imbalanced biologically, suggesting overfishing occurs. Two were imbalanced economically but all were in balance in terms of vessel utilisation (when seasonality is considered).** The development of the fleet during the period 2017 to 2021 shows a deteriorating economic trend[13], while the nominal capacity (kW, GT, active vessels) has decreased for most segments which reduce overall fuel consumption. Exceptions include vessels 12-18 m operating in the North Atlantic which have increased slightly in GT and kW, increasing the fuel consumption with 35%, and vessels over 40 m operating in Other Fishing Regions which also have increased in GT, kW and fuel use.

The fleet has an action plan for the Mediterranean[12], driven by the status of some species (in particular red shrimp and hake). These aim to reduce effort (through decreasing number of trawling days, temporal closures and incentivising use of selective gears) and reduce GT and kW through decommissioning vessels.

4.1.2 FRANCE – DISTANT WATER PURSE SEINE

The French distant water purse seine fleet (≥ 40 m) comprised 21 vessels consuming over 74 million litres of diesel. **The fleet targets large pelagic fish such as tuna in the Indian- and Atlantic Oceans and was imbalanced biologically, suggesting overfishing occurs. The vessel utilisation was however in balance, but the economic conditions are unclear as none of the standard economic indicators were assessed, nor any temporal trends.** However, the latest assessment report on one economic indicator (NVA/FTE) indicates that the fleet is in balance economically. This fleet has since 2013 increased in capacity – 17% in number of vessels, 26% in kW and GT – which has led to an increase in the total fuel consumption of 78%.

No action plan was identified for the fleet.

4.1.2 ITALY – SMALL VESSELS UNDER 12 M

The Italian fleet with small fishing vessels (≤12m) comprised 7,193 vessels operating in the Mediterranean, which consumed nearly 33 million litres of diesel. The fleet utilises multiple gear types, including demersal trawls, purse seines, and passive gears. **All fleet segments are imbalanced biologically, suggesting overfishing occurs. They were also imbalanced economically and in terms of vessel utilisation**[12]. Overall, the fleet with vessels sized between six to 12 metres had the highest degree of inactive vessels in Italy[12] – 968 vessels (16%) in 2021. Capacity reductions have, for the most part, been made continuously – in 2021 the fleet comprised of 58-88% of vessels depending on fleet segment compared to the year 2013, 66-85% in terms of kW and 70-88% in GT respectively – overall reducing the total energy consumption down to 40-61% of the consumption in 2013. However, vessels 6-12 m using purse seine have shown an increase in vessels, both in kW and GT.

The fleet is currently under several different action plans, including closure periods (limitations of fishing days) and fleet reductions with percentage targets per fishing area and gear type (10-20%). Improved selectivity is also of interest for achieving the objectives to reduce overfishing.

4.1.2 THE NETHERLANDS – PELAGIC FREEZER TRAWLERS

This fleet operates in the North Atlantic and comprises eight vessels (≥40 m) with a fuel consumption of around 35 million litres of diesel. **It is imbalanced biologically (mainly related to catching horse mackerel), suggesting overfishing occurs, but is in balance economically and technically**. The economic trend is improving, but there is no clear trend for the other indicators. The fleet had by 2021 made considerable capacity reductions – comprising 62% of active vessels, 49% of kW and 50% of GT compared to 2013 – combined using 61% of the total fuel consumption.

No action plan was identified for the fleet.

4.1.2 PORTUGAL – LONGLINERS

This fleet comprised 58 vessels of 24–40 m and consumed over 12.5 million litres of diesel in 2021. They operate both in the North Atlantic and Other Fishing Regions, targeting large pelagic species such as swordfish and deep-sea species. **All are imbalanced economically, half of them also imbalanced biologically, suggesting overfishing occurs**. The fleets that are imbalanced biologically are also imbalanced in terms of vessel utilisation if looking at the full year (VUR_{220}) but not if seasonality is taken into account (VUR).

Capacity (in GT and kW) is managed at regional levels (separated into mainland, the Azores and Madeira respectively). In 2021, the fleet had generally reduced capacity for most segments compared to 2013 – depending on segment, down to 62% of GT, 83% in vessels and 74% of kW. The segment operating in Other Fishing Regions shows, since 2016, an increase in fishing days and fuel consumption (while nominal capacity has slightly reduced) and another segment in the North Atlantic has increased their total fuel consumption with 56% although nominal capacity (active vessels, kW and GT) has decreased.

The fleet is subject to an action plan to improve the economic balance through decommissioning vessels. Energy efficiency is mentioned in the action plan to be a guiding principle for choosing vessels to exit.

4.2 SCENARIO 1

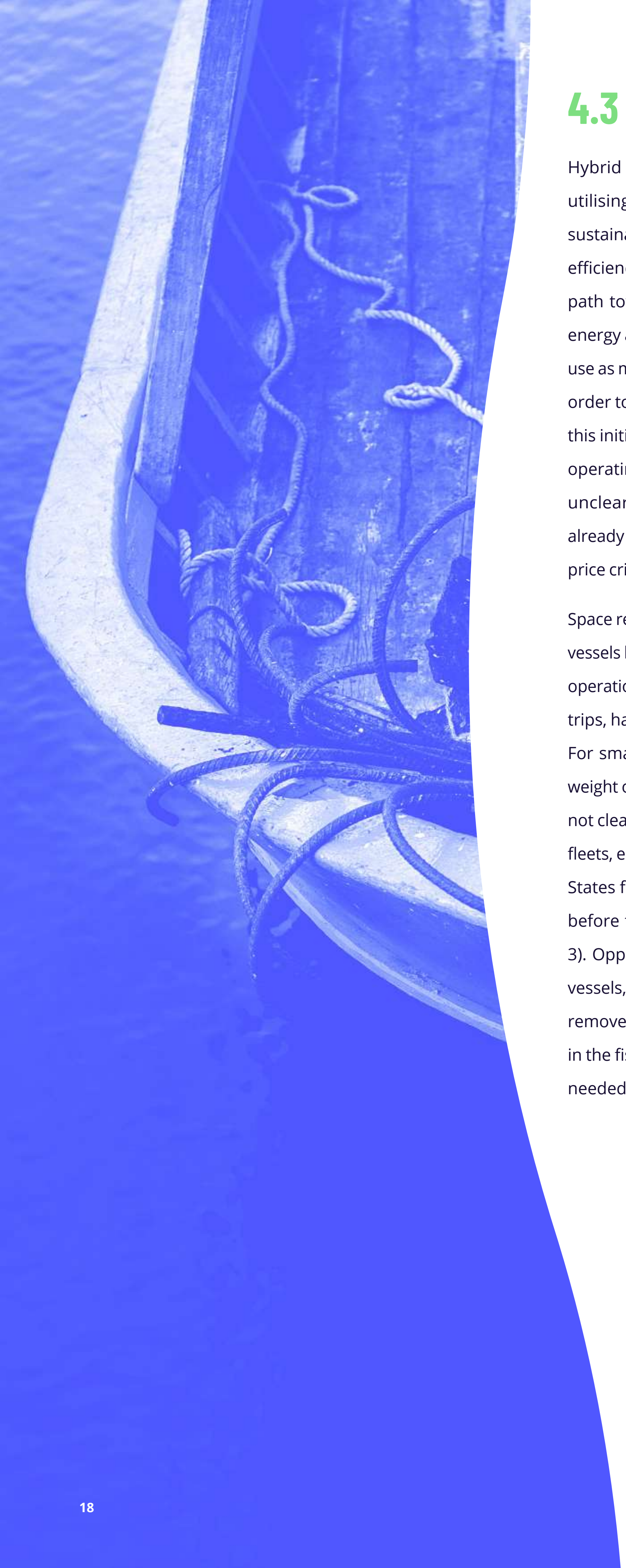
Many opportunities exist to enable a considerably improved energy efficiency without compromising the capacity ceilings in terms of kW or GT. Overfishing occurs in all case study fleets, suggesting that the intention of Article 22 of the CFP regulation – which calls for further actions to reduce overcapacity if identified– is still not being fulfilled. Action plans for the fleets in Portugal, Spain and Italy mention decommissioning of vessels based on energy efficiency, improving selectivity and reducing effort to mitigate overfishing – all representing measures that could facilitate scenario 1 on improved energy efficiency.

To favour energy efficiency, changes in ***behaviour*** such as speed optimisation and efficient use of energy onboard may effectively decrease fuel use by around 30%, affected by the vessel size and fishing pattern[18]. In addition, depending on current ***gear*** use, shifting the type of fishing gear has the potential to save up to 30% of current fuel use[6] – although adding selective devices to demersal trawls may negatively affect fuel use efficiency[7], thus calling for change in gear type rather than 'quick-fixes', in order to benefit both selectivity and energy efficiency. Changes to the ***vessel*** may also be carried out, including both those needing vessel investments (such as use of stabiliser fins, autopilot, addition of bulb, change in hull design or propulsion system) or those that may only require improved maintenance (such as efficient antifouling and improved maintenance of e.g., engines). Vessel investments to favour energy efficiency may be more costly, and the reduction potential will depend on current status of the vessel and operating pattern.

Overall, an important starting point for improved energy efficiency are **vessel energy audits, which can effectively identify energy use patterns and how the energy use may best be optimised by looking at different components**. Monitoring devices can be installed for around €4,500 per vessel. Some fleet-specific measures that could be taken are summarised in Table 3.

Table 3 Scenario 1 for the case study fleets. Solutions offer most opportunities when combined.

Case study fleet	Main measures to efficiently reduce fuel use intensity by around 30%	
SPAIN **DEMERSAL TRAWLERS**	The fleet uses demersal trawls, relatively fuel-intensive gears with many fuel saving opportunities, e.g., through reducing drag or change to other gear types that may also benefit selectivity. Behavioural changes in combination with energy audits and monitoring can cost-efficiently enable improved energy efficiency and even identify opportunities to reduce installed kW on a vessel. In summary:	
	SHIFTING GEAR TO MORE ENERGY-EFFICIENT TRAWLS OR OTHER GEARS	**ENERGY AUDITS AND TRAINING FOR A MORE EFFICIENT USE OF ENERGY (E.G., OPTIMISE SPEED)**
FRANCE **PURSE SEINE IN DISTANT WATERS**	Purse seining is already a relatively fuel-efficient fishing technology, although vessels are large and use large volumes of fuel. Reducing fuel use further must be achieved through changes made to the vessel or optimisation of the fishing operations, such as heat-recovery systems. Energy audits, monitoring and training including behavioural changes are key. The fleet's financial capacity to make major investments to improve energy efficiency is unclear. In summary:	
	OPTIMISING VESSEL OPERATION	**ENERGY AUDITS AND TRAINING FOR A MORE EFFICIENT USE OF ENERGY (E.G., OPTIMISE SPEED)**
ITALY **SMALL SCALE FISHERIES**	The fleet utilises many different gear types. Opportunities therefore exist to promote the most energy efficient gear categories which may also lead to less bycatch and benthic impact if reducing the effort with demersal trawls, supported by Article 17 in the CFP. The demersal trawl fleet has on average a considerably higher consumption per vessel (~16,000 litres) than the passive gear fleet segments (~2–5,500 litres). Energy audits and monitoring, including behavioural changes, would also for this fleet offer cost-effective opportunities for fuel use reduction. In summary:	
	SHIFTING GEAR TYPE	**ENERGY AUDITS AND TRAINING FOR A MORE EFFICIENT USE OF ENERGY (E.G., OPTIMISE SPEED)**
THE NETHERLANDS **PELAGIC FLEET**	Pelagic trawling is more energy intensive than purse seining – change of fishing gear could improve fuel use efficiency. Given that this fleet is profitable, opportunities may exist for investments that promote increased energy efficiency. Large vessels often monitor energy use, but from more detailed energy audits and training to support behavioural changes, further reductions may be enabled. In summary:	
	SHIFTING GEAR FROM PELAGIC TRAWL TO PURSE SEINE	**ENERGY AUDITS AND TRAINING FOR A MORE EFFICIENT USE OF ENERGY (E.G., OPTIMISE SPEED)**
PORTUGAL **LONGLINERS**	Given the poor economic performance of this fleet, energy audits and monitoring to support behavioural changes may offer cost-effective opportunities for fuel use reduction which could improve profitability. Hook and line fisheries have a highly variable fuel use efficiency, where catch per unit effort and targeting pattern is important. Based on the data at hand, it appears that vessels operating in Other Fishing Regions have around four times higher fuel consumption, and that sub-fleets operating in the North Atlantic generally have a lower fuel use consumption per vessel when not imbalanced biologically (SAR), suggesting possible influence of stock status on fuel use efficiency, or that the species targeted has a lower catch per unit effort. In summary:	
	ENERGY AUDITS AND TRAINING FOR A MORE EFFICIENT USE OF ENERGY (E.G., OPTIMISE SPEED)	**AVOID OVERFISHING IN THE NORTH ATLANTIC**



4.3 SCENARIO 2

Hybrid solutions, i.e., combining energy sources (such as utilising batteries to reduce diesel use) or drop-in use of sustainable biofuels would, in combination with the energy efficiency measures from scenario 1, represent a powerful path towards decarbonisation. To maximise effectiveness, energy audits and monitoring are essential to reduce energy use as much as possible before installing hybrid equipment, in order to avoid wasting energy. The return on investment for this initial cost will be relatively quick due to the reduction in operating costs enabled by fuel-saving. However it remains unclear to what extent energy-saving investments have already been made in the various fleets due to the recent fuel price crisis, there is likely still room for further improvements.

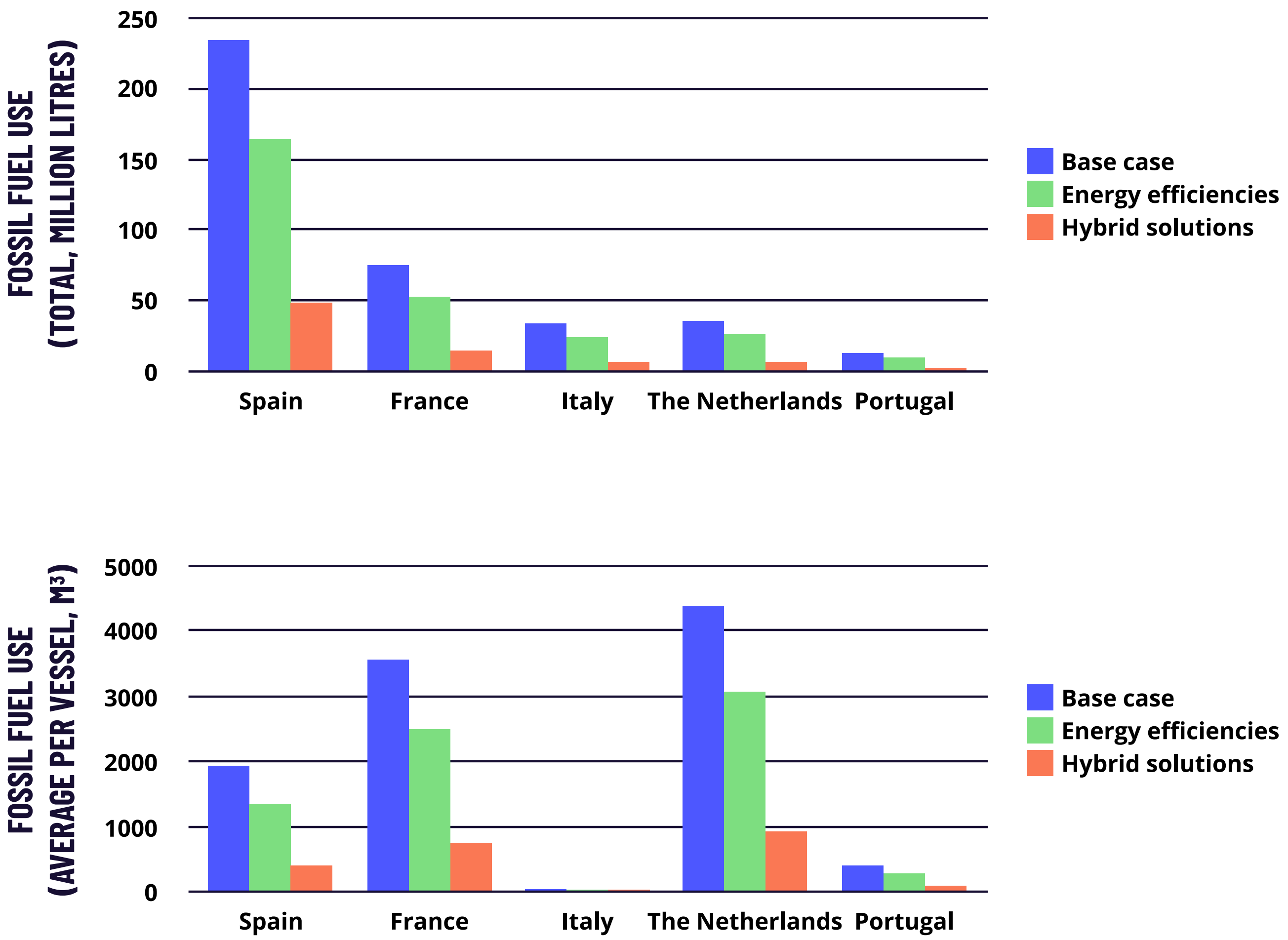
Space required for batteries is not a major challenge for larger vessels but may be for smaller ones. On the other hand, hybrid operation is more feasible for coastal vessels going out on day trips, having the possibility to charge while in port overnight. For smaller vessels operating at high speed, the increased weight of batteries may however pose challenges. Overall, it is not clear if hybrid-solutions may conflict with action plans for fleets, e.g., if change in GT or kW is needed. However, Member States for all of the case study fleets have capacity available before they hit their national capacity ceilings (see chapter 3). Opportunities may also exist through decommissioning vessels, something already being proposed in action plans to remove imbalance, where the kW or GT from vessels existing in the fishery could be transferred to the remaining vessels if needed for increased storage capacity for hybrid solutions.

For all fleets, opportunities for hybrid solutions to achieve ≥50% reduction of GHG emissions exist in:

- Installing batteries that can enable an operation of the engine closer to the optimum (so called 'peak shaving' during steaming). For passive gears in particular, opportunities also exist to use electricity during active fishing (which however only represents a minor share of the total energy use for these fisheries)[5]. Overall, hybrid solutions with batteries may reduce emissions by 70-80%, depending on the vessel and how it is operated.
- Using drop-in biofuels to reduce greenhouse gas emissions. One example provided in a recent report states that reductions up to 80% can be made[19].
- Sail-assisted propulsion, especially for larger vessels operating in distant waters. Trials are already ongoing for e.g., a Spanish fishing vessel operating in distant waters but also small-scale fishing along the coast[18].

When hybrid-solutions are seen as an additive progress towards decarbonisation, building on energy efficiency measures, major GHG emission cuts can in theory be achieved through combining these two steps (Figure 2). The largest cuts in terms of total fuel use and associated emissions can be made for the demersal trawlers in Spain, whereas on a vessel basis, the pelagic fleet in the Netherlands has the highest reduction potentials.

Figure 2 Fuel use savings from energy efficiencies (30% reduction) and hybrid solutions (additional 70% reduction, in total 79% reduction from base case) in terms of total fuel use for the fleets (top panel) and on a vessel basis (bottom panel).



4.4 SCENARIO 3

According to many fishers and crew in maritime operations, the lowest hanging fruit today for alternative energy sources to marine diesel in fisheries is by switching to methanol. This is due to being able to use current combustion engines and that fishers are accustomed to handling liquid fuels. Methanol is, however, often produced using fossil fuels and requires around twice the storage volume compared to diesel. due to its lower energy density[5]. Full electrification is also an opportunity for smaller vessels operating near-shore, however the electricity source is important; the full implications of electrification in terms of reduction of GHG emissions will depend on the emission intensity of the energy production mix of the Member State or interconnected electricity market. For all alternatives to marine diesel, improvements in onshore infrastructure are needed, and are vital to facilitate both bunkering fuels and charging opportunities. Furthermore, it will require financial capacity for vessel owners to make initial investments for vessels, and economic incentives to switch from marine fuel with tax exemptions to alternatives that are more costly today.

The fleets detailed in the case studies have various opportunities depending on operating pattern and current conditions, i.e., the basic conditions driving the current need for diesel and associated storage volume (Table 4).

Table 4 The situation in 2021 for energy demand for the case study fleets.

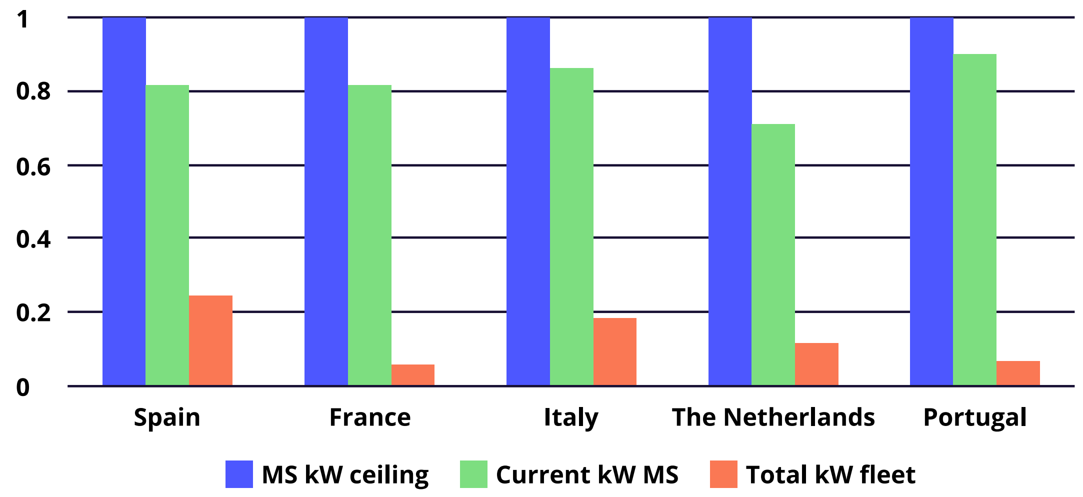
Case study fleet	Total fuel use (million litres)	Average fuel use per vessel (m3)	Average fuel use per fishing day (m3)
SPAIN DEMERSAL TRAWLERS	233	18 - 1906	0.1 - 10
FRANCE PURSE SEINE IN DISTANT WATERS	74	3542	14
ITALY SMALL SCALE FISHERIES	33	2 - 16	0.02 - 0.15
THE NETHERLANDS PELAGIC FLEET	35	4364	26
PORTUGAL LONGLINERS	12.5	139 - 384	1.1 - 1.5

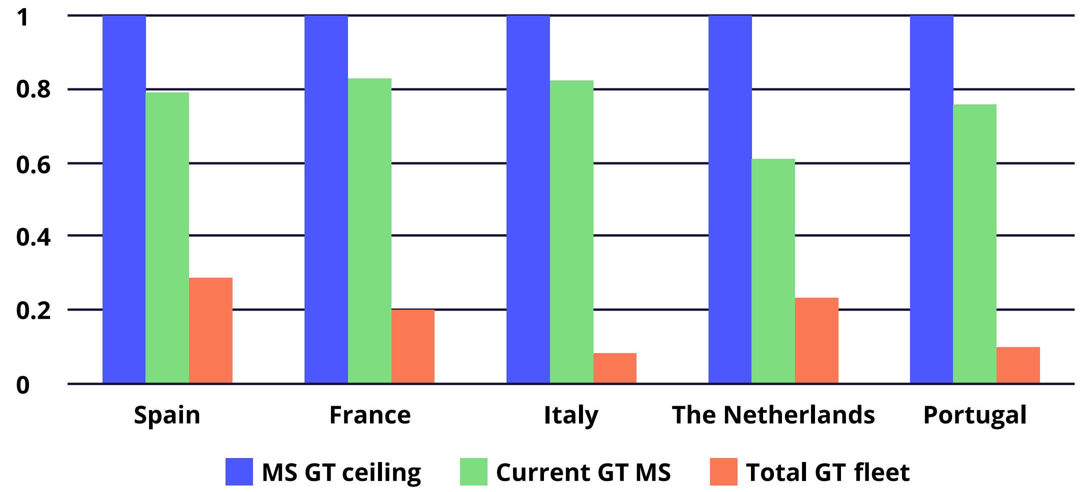
When aiming for a full decarbonisation, the effect on GT and kW will depend on amongst other things, fishing patterns (e.g., operating near shore or in distant waters, speed, gear) and energy source used. A larger vessel requires larger engine effect and a larger fuel storage volume. If e.g., the displacement of the vessel is provided, the effect of the required new engine may be calculated[20]. Using GT is thus not enough in describing the characteristics of a vessel which is needed to better understand the potential effect on both kW and GT from installing alternative energy sources[21]. Noting this deficiency in knowledge, a back-of-the-envelope calculation based on only the linear correlation between GT and volume[22], and indicative estimation of the potential GT needed for larger storage volumes can be made:

- For a theoretical vessel with 6,000 GT, the relationship GT=0.286 per m3 would apply. If the most energy-consuming vessels on a fishing day basis, the Dutch pelagic fleet, would switch to methanol, vessels would then need to accommodate for storage of on average ~52 m3 of fuel per fishing day (instead of 26 m3), and if staying a for one working week (5 days), an additional 37 GT would be needed for the vessel – a minor loss in storage capacity or increase needed relative to the total GT.
- For a theoretical vessel with 1,000 GT, the relationship GT= 0.27 per m3 would apply. For the most energy efficient vessels, the small-scale Italian fleet, and a fishing pattern of going to sea on a daily basis, this would correspond to an extra 0.005 GT that would be needed for the vessel to accommodate double storage volume, i.e. negligible relative to total GT.

Even if these figures are purely theoretical, these indicative values may be seen in the light of current capacity ceilings for Member States, current GT and kW at Member State levels and the share of the case study fleets – allowing for increase in GT if needed for storage and if risks for overfishing can effectively be avoided through fishing regulations (Figure 3). Furthermore, many of the fleets have action plans where decommissioning of vessels is discussed – when vessels exit a fishery, there is even more room relative to the capacity ceilings for a full decarbonisation process, given nominal capacity and risks for overfishing can be decoupled.

Figure 3 Capacity ceilings for Member States (MS), current capacity and the capacity of the case study fleets in terms of kW (top panel) and GT (bottom panel).

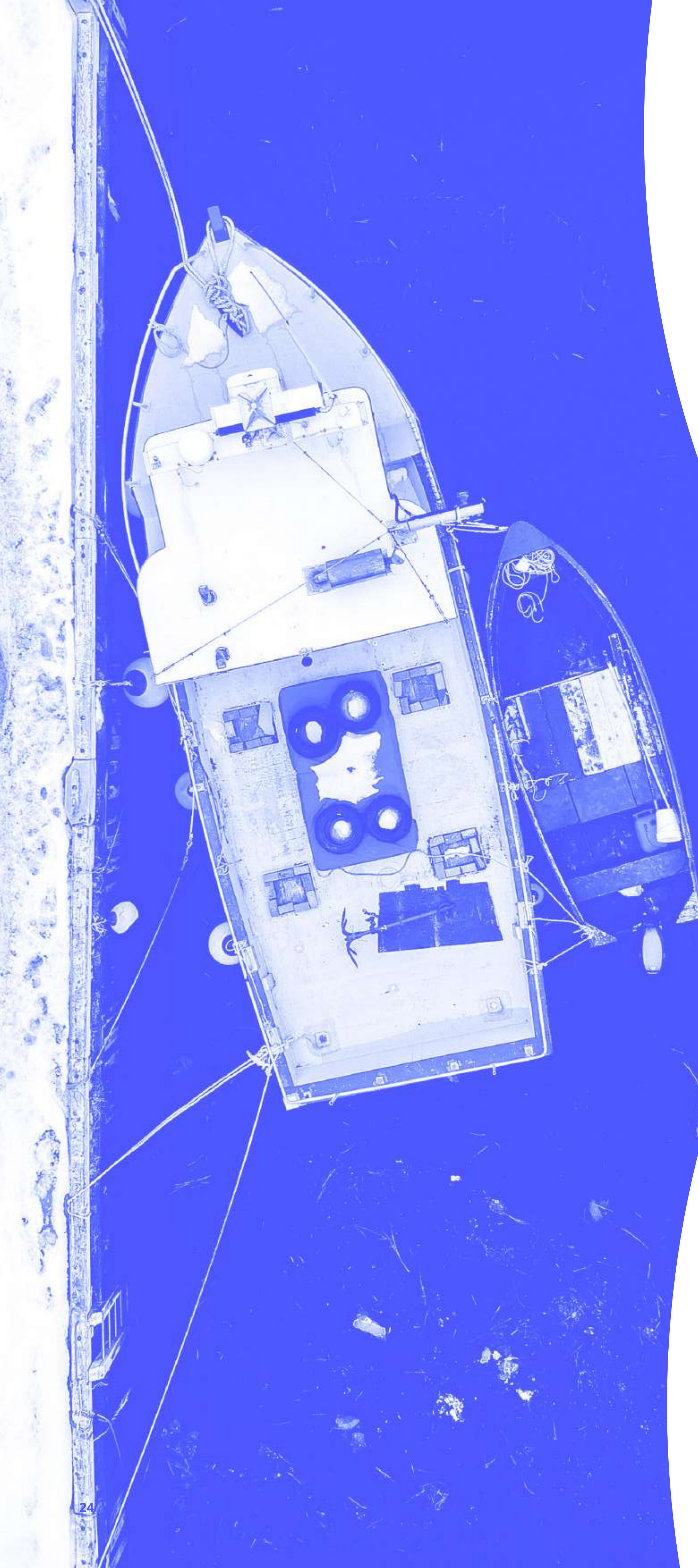




Based on the different conditions for the fleet in terms of diesel consumption, vessel size and targeting pattern, different opportunities and challenges for a full decarbonisation are seen (Table 5). All Member States have room available at national level relative to the capacity ceilings. **Overall, given the fact that many fleet segments are imbalanced biologically, a win-win for decreasing overcapacity and providing room for decarbonisation is decommissioning vessels**. This is also suggested in the action plan for the Spanish fleet in the Mediterranean. For larger vessels operating further off the coast, such as the French purse seine fleet and Portuguese longliners, considerable volumes of diesel are consumed per day and per fishing vessel. Converting to less-energy dense energy sources will require substantial increase in storage volume, but it appears that the percentage increase in GT needed may be small – but it may lead to loss in catch storage capacity. For small-scale fishing, such as the Italian case study fleet, opportunities exist for both electrification (especially for passive gears with lower energy demand, with interesting examples being developed[18]) and switching to e.g., methanol but it is unclear how much extra storage the small vessels can accommodate. However, given 7,193 vessels are active, converting such a vast number of vessels will require large initial investments; given the situation of biological imbalance, further vessel reductions may be motivated first, both from an overcapacity and effective decarbonisation perspective.

Table 5 Current status of the fleet, opportunities for decarbonisation and implications for nominal capacity.

Fleet	Opportunities for decarbonisation and implications for kW and GT	
SPAIN DEMERSAL TRAWLERS	BIOLOGICAL IMBALANCE YES ACTION PLAN YES	Vast difference in energy needs per vessel or fishing day depending on vessel size and fishing area. A 10% cut in number of vessels per fleet segment would allow for a release of ~ 23,723 kW and/or 12,143 GT of current nominal capacity that may be used for changing to less energy-dense fuels in the remaining vessels.
FRANCE PURSE SEINE IN DISTANT WATERS	BIOLOGICAL IMBALANCE YES ACTION PLAN NO	Energy-intensive per fishing day and vessel, requiring major changes in energy storage capacity but likely minor in terms of GT. The fleet has increased in nominal capacity since 2013, with three more active vessels. Given the biological imbalance, by decommissioning three vessels, approximately 14,284 kW and/or 8,501 GT could be available for the remaining vessels to initiate a decarbonisation process.
ITALY SMALL SCALE FISHERIES	BIOLOGICAL IMBALANCE YES ACTION PLAN YES	Low consumption of diesel per vessel and fishing day, with demersal trawlers having the highest consumption. A 10% cut in the number of vessels per fleet segment would allow an increase in ~19,557 kW and/or 1,337 GT for changing to less energy-dense fuels in the remaining vessels.
THE NETHERLANDS PELAGIC FLEET	BIOLOGICAL IMBALANCE YES ACTION PLAN NO	Energy-intensive per fishing day and vessel, requiring major changes in energy storage capacity but likely marginal in terms of GT. Nevertheless, an additional 10% cut in vessels would allow for an increase in ~4,077 kW and/or 3,855 GT for changing to less energy-dense fuels in the remaining vessels.
PORTUGAL LONGLINERS	BIOLOGICAL IMBALANCE PARTIAL ACTION PLAN YES	Variable energy consumption between segments. From following the action plan and decommissioning 16 vessels, the fleet will decrease with approximately 1,330 GT and 3,800 kW which may be used for changing to less energy-dense fuels for the remaining vessels.



5 CONCLUSIONS AND RECOMMENDATIONS

1 Current capacity ceilings are not a hindrance for decarbonisation of fishing fleets as capacity is available in the regulatory framework. Additionally, the purpose of capacity ceilings may be seen as a facilitator. Action plans set out when there is unbalance between fishing capacity and available fishing opportunities within a given fleet segment may become an opportunity to boldly tackle their energy transition in the sector or out of it, even if many technological questions remain open at this stage. Actions are required to decrease overfishing for all case study fleets which would also favour energy efficiency. A full decarbonisation would particularly affect fleets with a high energy demand – but it is still likely marginal in terms of the effect on GT. It is still unknown to which extent individual vessels may accommodate all changes required from either hybrid-solutions or full decarbonisation, and the effect on operations. This calls for more detailed technological analysis on what characterises best available technology for different fisheries.

2 Energy audits and monitoring of energy use of individual vessels are basic conditions required for all measures, regardless of scenario and should become mandatory. It is critical that energy use is reduced as far as possible before converting a vessel to alternative fuels, and this requires better understanding of the optimum operational pattern. For around €4,500, monitoring devices may be installed to initiate this process and offer quick return on investment in the form of energy saving. Measures improving the energy efficiency alone may achieve a 30% reduction in fuel use for all fleets without affecting fishing capacity. It is however crucial that this energy saving may not be utilised to increase fishing effort and by this negatively affect an already identified biological imbalance for several of the fleets.

3 Decarbonisation is a stepwise process – spanning from fishery management to individual fisher and back again – that is crucial to initiate to achieve long-term sustainable fisheries. Eliminating overcapacity and overfishing by fishery management actions sets the prerequisites for long-term sustainability. From a vessel perspective, combining energy efficiencies (scenario 1) with hybrid-solutions (scenario 2) has, in theory, the potential to reduce emissions with 79% relative to current baseline. Here, tailored solutions for different fleets will be crucial, which is also needed for full decarbonisation. Opportunities exist to increase GT or kW relative to capacity ceilings if required for decarbonisation measures but links back to fishery management – it is crucial that the fleets maintain in balance or decrease in fishing capacity (e.g., effort, catch capacity) to avoid overfishing.

4 Overall, taking steps towards decarbonisation align with the objectives of the CFP – i.e., win-win actions for climate and long-term sustainable fisheries. The energy transition can be aligned with action plans for case study fleets, e.g., allocating more fishing opportunities to the passive gear segment in the Italian small-scale fleet, and also other objectives such as Article 17 of the CFP. Given the urgency of curbing climate change, and the need to ensure a long-term viable fisheries, setting a strict deadline for the phasing out of fossil fuels for all maritime operations, including removal or redirection of subsidies to favour a just transition, can create incentives and speed up the process towards carbon neutral fuels while also contributing to broader objectives.

6 ANNEX 1

Table 1 Recommended indicators for the Balance Capacity reports by STECF.

Indicator group	Indicator and description[23]
Biological	***Stocks-At-Risk (SAR)***. The number of stocks at high biological risk[24] that are exploited by the fleet, i.e., the stock(s) at high risk that each contribute to >10% of the fleet's catches, or the fleet takes >10% of the total catches of the stock). SAR ≥ 1 equals 'out of balance'. ***Sustainable Harvest Indicator (SHI)***. Measured based on current fishing mortality relative to F_{msy}. SHI ≥ 1 equals 'out of balance'.
Technical	***Percentage inactive vessels***. Proportion of vessels that don't fish at all. > 20% is highlighted as red. ***Vessel Utilization Ratio (VUR and VUR220***). Average activity levels of active vessels. Calculated as average days at sea/maximum days at sea, where maximum days may differ between fleets due to e.g., seasonality (VUR) or be set at 220 days (VUR220). VUR/VUR220 <0.7 equals 'out of balance'.
Economic	***(Long-term) Current Revenue (CR) to Break-Even Revenue (BER) ratio (CR/BER)*** <1 equals to 'out of balance'. ***Return on Investment (RoI) and/or Return on Fixed Tangible Assets (ROFTA)***. Compares long-term profitability to other available investments. If smaller than long-term interest rates elsewhere, the fleet may be overcapitalised. RoI/ROFTA <0 equals 'out of balance'. ***Net profit margin (NPM)***. Ratio between current revenue and break-even revenue, should be over one, otherwise economic conditions on a day-to-day basis may be compromised. NPM ≤0 equals 'out of balance'.

7 ENDNOTES

1 - https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

2 - https://climate.ec.europa.eu/eu-action/european-climate-law_en (Downloaded Feb 29th, 2024)

3 - COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. Securing our future. Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society. Strasbourg, 6.2.2024. COM (2024) 63 final https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52024DC0063 (Downloaded Feb 29th, 2024)

4 - https://oceans-and-fisheries.ec.europa.eu/publications/communication-commission-energy-transition-eu-fisheries-and-aquaculture-sector_en (Downloaded Feb 29th, 2024)

5 - Ziegler & Hornborg (2023) Decarbonising the fishing sector. Energy efficiency measures and alternative energy solutions for fishing vessels. STOA Panel for the Future of Science and Technology. The European Parliament, Brussels.

6 - Bastardie et al. (2022) Climate change and the Common Fisheries Policy: adaptation and building resilience to the effects of climate change on fisheries and reducing emissions of greenhouse gases from fishing. European Climate, Infrastructure and Environment Executive Agency. doi: 10.2926/155626

7 - E.g., Ziegler & Hornborg (2014). Stock size matters more than vessel size: the fuel efficiency of Swedish demersal trawl fisheries 2002–2010. Marine Policy, 44, 72-81.

8 - https://decarbonisenow.eu/wp-content/uploads/2021/09/FUEL-SUBSIDIES-FULL-REPORT_EN_2021.pdf (Downloaded Feb 19th, 2024)

9 - REGULATION (EU) No 1380/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on the Common Fisheries Policy

10 - https://www.fishsec.org/app/uploads/2018/10/Fishsec_capacity_report_2018_final.pdf (Downloaded Feb 19th, 2024)

11 - European Commission: GREEN PAPER Reform of the Common Fisheries Policy, COM(2009)163 final, Brussels, 22.4.2009 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0163:FIN:EN:PDF (Downloaded March 1st, 2024)

12 - https://oceans-and-fisheries.ec.europa.eu/fisheries/rules/fishing-fleet-capacities/fleet-capacity-reports-2022_en (Downloaded Feb 15th, 2024)

13 - https://stecf.jrc.ec.europa.eu/reports/balance (Downloaded Feb 15th, 2024)

14 - Eigaard et al. (2014). Technological development and fisheries management. Reviews in Fisheries Science & Aquaculture 22(2), 156-174.

15 - European Commission, Directorate-General for Maritime Affairs and Fisheries, Study on engine power verification by Member States – Final report, Publications Office, 2019, https://data.europa.eu/doi/10.2771/945320

16 - https://stecf.jrc.ec.europa.eu/reports/economic (Downloaded March 5th, 2024)

17 - Bastardie et al. (2022). Climate change and the Common Fisheries Policy: Adaptation and building resilience to the effects of climate change on fisheries and reducing emissions of greenhouse gases from fishing. Final report European Commission.

18 - Personal communication with maritime expert Andreas Bach, RISE

19 - European Commission, Directorate-General for Maritime Affairs and Fisheries, Possibilities and examples for energy transition of fishing and aquaculture sectors, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2771/828897

20 - https://www.wartsila.com/encyclopedia/term/admiralty-coefficient-admiralty-constant

21 - Personal communication with maritime expert Tobias Olsson, RISE

22 - https://www.etf-europe.org/wp-content/uploads/2021/10/analysis-on-gross-tonnage-and-propulsion-power-ceilings.pdf

23 - https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2014:0545:FIN:EN:PDF (Downloaded Feb 19th, 2024)

24 - Risk is defined as below a biomass Blim; under specific advisory context (e.g., directed fisheries prohibited); landings prohibited; or on CITES or the IUCN Red List.

DECARBONISE

NOW