SIEMENS energy

Decarbonizing maritime transport

A study on the electrification of the European Ferry Fleet



Study in cooperation with

BELLONA

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Electrification of the European Ferry Fleet

1. Executive summary

With small and large ferries playing an important role in European transport, electrification of such traffic is becoming an effective and readily available solution for reducing carbon emissions.

And the great news is that European ferries can go electric today. But what does this mean and what are the benefits of this change? In short, electrification is a proven solution, not just in cutting emissions drastically but in improving air quality in ports, with standardised, cost-effective and commercially available technology. With electrification and hybridisation, ferries can now become part of our zero-emission transport system. With solutions for engine hybridisation and connection to shore power in port being something that can be implemented both quickly and efficiently too.

In fact, the first fully electric ferry, "Ampere" entered operation in Norway in 2015, becoming evidence that the solution was feasible in a technical, economical and operational sense. In the same year, Bellona and Siemens Energy published a study showing that electrification of 7 out of 10 ferries would be economically viable. And it's since 2015, our findings have been validated with 70 electric ferries entering operation in Norway, driven by economic considerations and strong requirements in public procurement.

Investing in technology
The following report, made in a cooperation between Siemens Energy and Bellona, estimates that nearly 50% of ferry emissions can be cut by investments in such standard technology. These emissions typically happening in port and within the first hour of travel. The other half of the emissions, linked to longer voyages, can be tackled by substitution with low and zero emission fuels such as hydrogen, ammonia, biofuels or carbon capture.

Ferry operations in Europe are concentrated in a number of key locations. The four countries analysed including Germany, Greece, Italy and the UK – all having extensive ferry activity and accounting for 35% of European ferry emissions. And the largest ferry country in Europe, Norway is adding another 17%, although they are already well on the path to electrification with more than 70 zero emission ferries currently in operation or under construction.

Measurement of shore power
The report also highlights the role of shore power as the single most important measure to implement. In general, vessels need to run engines in port, to keep necessary systems going. In Germany and the UK, emissions in port add up to 20% of total emissions from the sector, while in Greece the share is a staggering 37%. The average emissions in port for the four countries combined being 26%, equal to 440,000 tons of CO_2.

To fully exploit the electrification potential, full-electric vessels should be incentivised to replace older vessels on all routes up to one-hour in length. Such vessels will likely need to be dedicated to specific routes than current fleet operations dictate and retrofitted with a range of hybrid systems. Thus facilitating electric operation in the first hour of travel.

The ferry fleet in Europe is on average 35 years old, with 65% of the vessels more than 20 years old. Meaning that during this decade, more than half of the fleet will be subject to replacement.

Average age of European ferry fleet	**35 years**
Share of fleet older than 20 years	**64,59 %**
Share of fleet older than 30 years	**44,70 %**
Share of fleet older than 40 years	**25,46 %**

When replacing vessels with new builds, better hull and propeller design and lighter materials, e.g. aluminium will make them far more energy efficient. Thus reducing the need for power to perform the same level of transport work. And during this decade, hydrogen and ammonia will be available as fuel alternatives for the shipping sector replacing fossil fuels like diesel and LNG.

Ferry fleets also perform a range of public services with local and national governments responsible for these services and the issuing of tenders for the various routes. That gives those governments the opportunity to set the conditions for operational ferry connections in line with climate goals and to invite operators to offer climate smart technology solutions. The political system is therefore providing opportunities to kick-start the electrification of the shipping industry. Stimulating the shipyards and suppliers to develop solutions and the right competencies needed to achieve the climate goals for all types of vessels, faster.

2. Key countries in the electrification of European ferries

This study also looks at the potential for electrification in some of Europe's most ferry-intensive countries. The countries represent major differences in geography, route grids and population demography, but are united in their reliance on ferries as an important mode of transportation.

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Italy

Ferries provide an important transport alternative in Italy. With a coastline of 7600 km and several large and small islands require connections to the mainland making the Italian ferry fleet the second largest in Europe, behind Norway.

Italian ferries travel between the mainland and the islands of Sicily and Sardinia, as well as neighbouring countries of France (Corsica), Albania and Greece. There are also many routes to smaller islands all along the coast. The highest frequency crossing is the Sicily ferry (Villa San Giovanni-Messina), while the most emission intensive crossings are between mainland Italy to Sardinia (Civitavecchia-Cagliari) and mainland Italy to Sicily (Naples-Palermo).

The Italian ferry fleet consists of 107 vessels, with 94 flagged in Italy. Most of their fleet are more than 25 years old consisting of mainly smaller ferries (<150m). Although there are only 15 larger ferries, they account for 43% of ferry-related emissions under voyage. Whereas smaller ferries emit 29% of emissions under voyage, with the remaining 28% occurring in port. Total ferry-related emissions in Italy are 697 000 tons CO_2.

Greece

Seafaring is a vital part of the history of Greece. Its geography, a large peninsula and thousands of islands throughout the Aegean and Ionian Sea, requires transport of people and cargo. This includes local residents and in recent decades a large number of tourists.

The Greek ferry fleet consists of 98 vessels, with 88 flagged and most of which forming smaller ferries (<150m). These vessels mainly traffic routes to Greek islands and close neighbouring countries such as Turkey, Albania, and Italy. The highest frequency crossing is the short route between Piraeus and Paloukia, while the most emissions intensive crossing is from Aegina to Piraeus (mainland) and Rafina Port (Pikermio, mainland) to Tinos (island in Aegean Sea).

Ferry traffic itself accounts for only about 2/3 of emissions. In Greece, ferries spend more time in port and correspondingly a larger part of emissions are produced there - calculated to about 37%. The main port of Piraeus handles the bulk of port calls and represents around 1/3 of all port emissions. Total ferry-related emissions in Greece are 310 000 tons CO_2.

Germany

German ferry traffic is mainly focused on the Baltic Sea and to its neighbouring countries of Denmark and Sweden. While there is major maritime activity along the larger German rivers, these vessels often fall into other categories than passenger ferries. The Elbe crossing between Wischhafen and Glückstadt is, however, the highest frequency route, while the Denmark ferry (Puttgarden-Rødby) and the Sweden ferries (Travemünde-Trelleborg, Rostock-Trelleborg) are the most emissions intensive. The ferries that operate the Puttgarden-Rødby connection today have hybrid-electric propulsion that reduce emissions for this route. There are now plans for fully electric ferries to operate this route and what will soon become the world longest course operated by a full electric ferry. This measure alone having the potential to reduce the total German ferry emissions by 13%.

Consisting of mostly smaller ferries (<150m), the German fleet has 105 vessels, with 77 flagged in the country. Although there are only 15 larger ferries, they account for 60% of ferry-related emissions. These vessels operate the routes mentioned above, to Sweden, Denmark, and Poland. Smaller ferries emit 20% of emissions under voyage, while another 20% occur in port. Total ferry-related emissions in Germany are 309,000 tons CO_2.

United Kingdom

Connections over the English Channel to Ireland, Isle of Man, the Inner and Outer Hebrides and a further 6 000 smaller islands are connected mainly by sea through history. Although air travel and the Eurotunnel have reduced the need for ferries, they still play a key role, especially in Scotland and the islands in the west and north.

The British ferry fleet consists of 88 ferries, with 72 flagged in the UK. Most vessels are less than 150m, with only five in the region of 150-220m long. The fleet is also relatively new, with more than half of all vessels (56%) built over the last 25 years. The highest frequency crossing is the connection between Cumbrae Slip and Largs (mainland), while the most emission intensive crossing is the ferry from Newcastle to IJmuiden, Netherlands.

Although there are only five ferries between 150 and 220 meters, they account for a quarter of ferry-related emissions. Smaller vessels make up 55% of the emissions, while 20% of UK ferry-related emissions happen in port. Total ferry-related emissions in UK are 359,800 tons CO_2.



Picture: Color Hybrid

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3. Electrification can reduce ferry emissions by 800 000 tons CO_2

Analysis shows that electrification of ferries in Italy, Greece, Germany and the UK can reduce emissions by as much as 800,000 tons of CO_2, when relying on available technology: shore power, hybridisation, and electric for routes of up to one hour. This reduction corresponding to a 50% decrease in ferry-related emissions in these countries.

- Emissions in port are a relatively large part of total emissions. From 20% to 37% in the countries shore power build-out to reduce port emissions would make a big change in the overall picture. With the 10 most emissions-heavy ports in each of the four countries accounting for a total of 444,278 tons of CO_2 or 64% of the port emissions.
- Full electrification is possible for a range of routes today. These routes account for 155,000 tons of CO_2, 12.6% of emissions under transport and are in the analysis routes with transit duration of 60 minutes or less operated by ferries of up to 150m in length.
- Hybrid electrification is the current main option for longer routes. Operated by both small and larger vessels with a duration of more than 60 minutes, the emission reduction potential from these routes is mainly linked to the first hour of potential battery operations, representing 227.400 tons of CO_2, 13.,6% of all emissions under transport.
- Combining shore power build-out, full electrification of shorter routes, and hybridisation of all routes, the potential for emission reduction is estimated at 800,000 tons of CO_2 for the four countries analysed.

Although the four countries in the analysis are very different – geography, types and usage of ferries, and staying time in port, the conclusions are in fact quite similar. There are also further considerations that hold across these different countries.

- AIS data shows that ferries operating short routes in many cases are used on other and longer routes as well. With current operations it will be necessary to consider hybrid electrification, rather than full electrification. In these cases, batteries provide energy for the first hour, complemented by a diesel-electric engine. With the current route grid and disposition of vessels, hybrid electrification combines the ability for reducing emissions and managing longer routes.
- To enable fully electric operations, there is a need for increased specialisation of vessels, dedicating certain ones to particular types of routes. This will require a shift in thinking regarding fleet management, with new conditions imposed. Added to this, there is also a clear expectation that battery energy density and price will enable extended range for fully electric ferries beyond 60 minutes.
- Hybrid electrification does not automatically cause fossil fuel lock-in. For longer routes hybridisation will likely be both necessary and efficient with zero-emission fuels, providing steady operations for fuel cells, peak shaving or other applications. Direct electrification is also efficient energy use, complementing the use of hydrogen, ammonia, or other low/zero emission fuels.
- New builds with use of lightweight material, improved propeller and hull design are more energy efficient and will extend the range significantly.

Ferry examples

Vessel	Ampere	Color Hybrid[1]	Elektra	Bastø Electric
LOA [m]	81	160	98	143
B [m]	21	27	16	21
GT	1 598	27 000	1 275	7 911
Build year	2015	2019	2017	2020
Construction	Catamaran aluminium hull	Conventional hull	Conventional hull, ice class 1B	Conventional hull
Route	Norway: Lavik-Oppedal, Sognefjorden	Norway/Sweden: Sandefjord-Strømstad, Oslofjorden	Finland: Parainen-Nauvo, Turku Archipelago	Norway: Moss-Horten, Oslofjorden
Length of route	20 min 6 km	2h 30 min	15 min 1.6 km	30 min 1.8 km
Trips per day	34	4 (2 round trips)	25	20-24
Capacity	399 pax, 120 cars	2000 pax, 500 cars	375 pax, 90 cars	600 pax, 203 cars
Propulsion type	Fully electric	Hybrid (diesel electric + battery)	Hybrid (diesel electric + battery)	Fully electric

[1] Menon Economics - Construction and operation of Color Line's hybrid ferry: Ripple effects and other societal effects (2017)

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Ferry examples

Vessel	Ampere	Color Hybrid[1]	Elektra	Bastø Electric
Propulsion power	Two electric motors of 450 kW	2 x 6L (3,6 MW) and 2 x 8L (4,8 MW) Electric generators: 2x 4 450 kWh	2 x 900 kW (+ 3x diesel generators)	4 x 1100 kW electric generators (+4x backup diesel generators)
Battery capacity	1 040 kWh Li-ion battery	4.7 MWh battery system	1 MWh total (160 Li-ion batteries)	4.3 MWh
Charging system	410 kWh battery quayside both sides, allowing "quick charging" upon arrival (1 MW in 9 minutes)	11.5 kV charging system (only in Sandefjord (for now)	Charges directly from grid	Direct fast-charge
Charging power	1.2 MW, 1250-1650 A	7 MW	NA	Up to 9000 kW charging power in both Moss and Horten
Charging time	10 min + overnight	25 min at lunch stop + overnight	5.5 min + overnight	"Within minutes"
Comments	World's first fully electric car ferry. During the transit, the ferry is estimated to use between 130-200 kWh per crossing. Ampere was named "Ship of the year" (Skipsrevyen) 2014.	Battery capacity for 2x 30 min (12 nm) sailing. Current operational profile of 30 min out of 2.5 hour sailing on electric saves about 20 % of fuel (and CO_2). "Ship of the Year" (Skipsrevyen) 2019.	Deploys diesel generators to handle ice conditions in winter. Fitted with several solar panels, which feed into the power system. "Ship of the Year" (Sulphur Cap 2020 Conference in Amsterdam)	World's largest fully electric car ferry. Crossing the Oslo fjord, Norway's busiest ferry crossing. Yearly transports 3.8m pax and 1.8m vehicles on 36,000 departures (2019).

Batteries are energy efficient

For an internal combustion engine, you will have several energy losses such as heat which will typically range from40 to 60%. For a battery, you will have losses during charging and discharging that are significantly lower than an internal combustion engine. This varies based on many factors like air temperature, charging intensity and type of battery. For a battery as an energy source, you may experience somewhere between 80-95% efficiency, disregarding the necessary heating needs.

Developers of batteries, especially to cars and maritime applications are searching for new and better solutions, e.g., new types of cells that will provide improvement like energy density, charging characteristics and better fire safety etc. Research and development take time but with a growing market, more resources are being allocated to making more solutions and continuing to improve battery quality overall.

There are several battery factories under construction or planning in Europe, which reflect the growing annual sales of batteries and the transformation to electric propulsion in vehicles and vessels. By 2030 the market for batteries and propulsion systems will be completely different than today.

For charging in port, how fast connections can be made will be crucial. For ferries with a short stay in port, automated connection systems will facilitate this fast connection. For charging, the CP (constant power) shows just how intensive charging can be done. One CP means that a battery size of one MWh can charge with one MW capacity with batteries available in the range of 0,6-3 CP. However, a connection with more time in port, means the need for automated connection with high charging power being lower.

Overall, the total demand for energy can range from 80 to 1500 kWh depending on the size of the ferry, length of route and speed.

[1] Menon Economics - Construction and operation of Color Line's hybrid ferry: Ripple effects and other societal effects (2017)

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4. The Political Landscape for Electrification

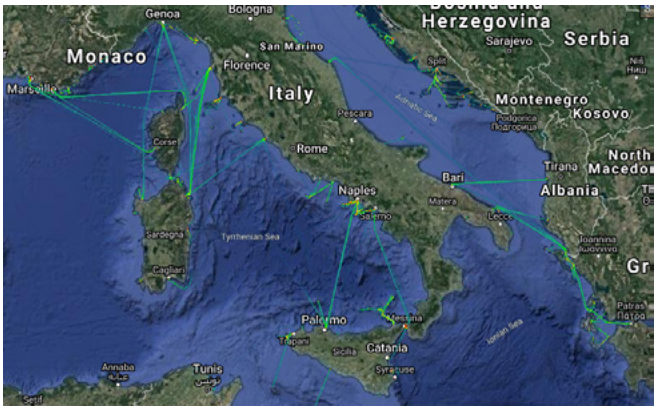
Tools and National strategies

Freedom to provide services for maritime transportation is applied in accordance with the Council Regulation (EEC) n. 3577, 7 December 1992. States can conclude public service contracts as a condition for the provision of cabotage service to ensure the adequacy of regular transport services to, from and between islands. Public service contracts provide a clear opportunity to impose requirements for emissions reductions in ferry services. This has been one of the key success factors for electrification of ferry transport in Norway.

In July 2021, the European Commission proposed a legislative initiative called "FuelEU Maritime"[2]. This proposal requires that ships (over 5 000 GT) reduce the GHG intensity of the energy used onboard. This requirement increases over time to secure the track to full decarbonization by 2050. This is one of several proposals in the Fit-for-55 package to help national and local politicians to achieve zero-emission ferries[3].

Italy

The Italian Ministry of Sustainable Infrastructure and Mobility has recently published a ten-year plan for enhancing mobility services in Italy in line with the new global goals for sustainable development, including climate stability. The Ministry plans to carry out a renewal of trains, buses and ships by low- emissions technologies as well as to increase investments for the development of ports, logistics and maritime transport.



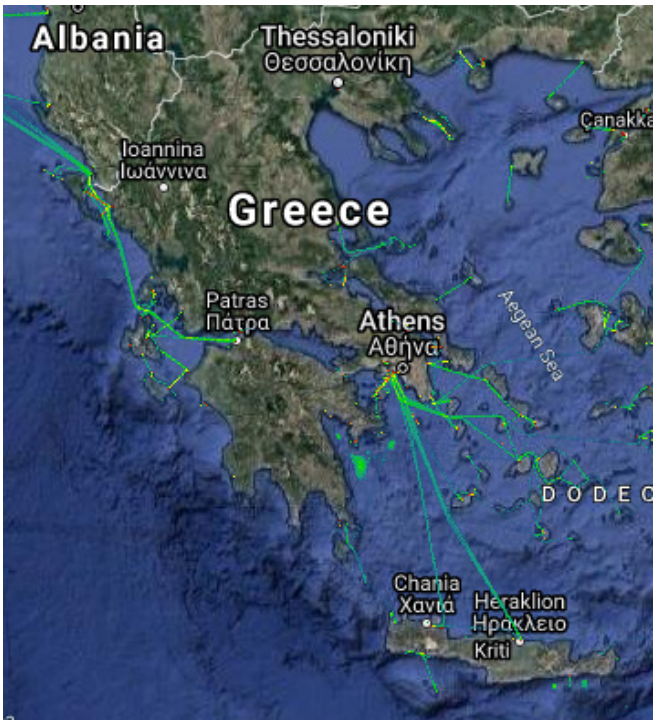
Pictures: Passenger traffic density for key countries.
Source: EMODnet

8.4 billion EUR will be allocated to 'green' local transport and rapid mass transport. This includes the purchase of new 'eco' ships, e.g. for a faster and more sustainable connection over the Strait of Messina to Sicily. More than 3.8 billion EUR will be spent on a transition of the naval fleet, for ship retrofitting and electrification of port operations in order to reduce emissions and pollution in port cities. And 0.7 billion EUR will be allocated to a renewal of the Mediterranean fleet with low environmental impact ships.

The Ministry is currently launching calls for tenders for public service contracts. Invitalia is the national agency responsible for conducting the tenders[4], with Italian investment bank CDP providing financial support to public and private stakeholders.

Greece

The Greek National Recovery and Resilience Plan[5] shows that there are proposals for upgrading and renewing ports and passenger shipping fleets, with 47 ferry routes and 44 island port infrastructure projects in development. There are however no specific targets for emissions reductions in the plan.



[2] Directive 2009/16/EC Proposal for a Regulation of the European Parliament and of the Council on the use of renewable and low-carbon fuels in maritime transport and amending

[3] FuelEU Maritime: T&E analysis and recommendations (February 2022)

[4] Invitalia (National Agency for Inward Investment and Economic Development) Information about ongoing tenders

[5] Next Generation EU - "Greece 2.0 - National Recovery and Resilience Plan (May 2021)

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There is also a program for support to ferry lines with unsatisfactory economies. This is provided through the national budget, totaling slightly more than 90 million EUR in 2019, up from 80 million EUR in 2014. This provision doesn't, however follow the increasing number of ferry passengers, rising from 14 million passengers in 2012 to 19 million in 2019[6]. 13 % of the Greek population are islanders, half of them residing on the island of Crete.

Climate change and emissions reductions is however an important consideration in a recent agreement between Greece and the EU Commission. The agreement on a National Strategic Reference Framework (NSRF) for 2021-2027 encompasses fisheries, aquaculture and the maritime sector. The total program for the six-year period totals 21 billion EUR and includes plans for improving ferry transport and island port infrastructure for 1 billion EUR, sourced from national funds and the European Strategic Partnership Agreement Fund (ESPA). With the program expected to facilitate large-scale emissions reductions from Greek maritime transport.

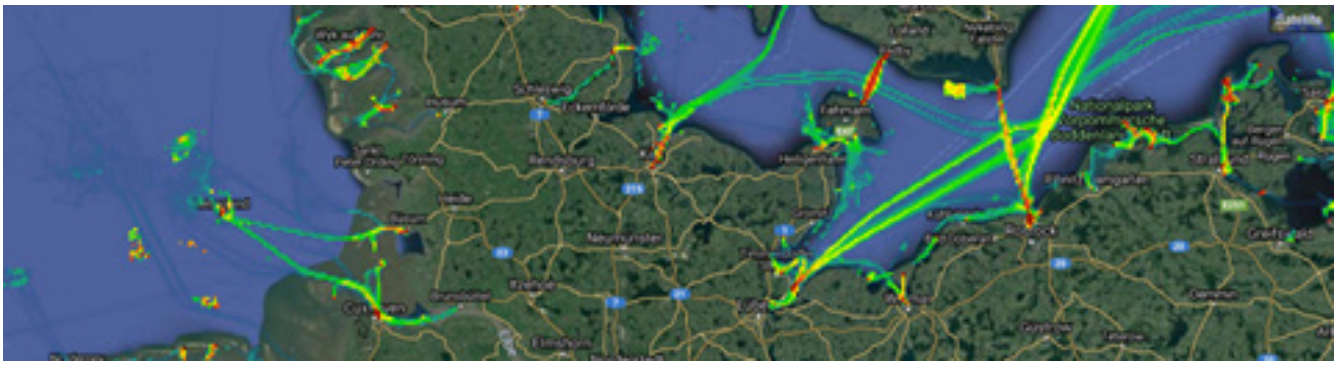
Germany

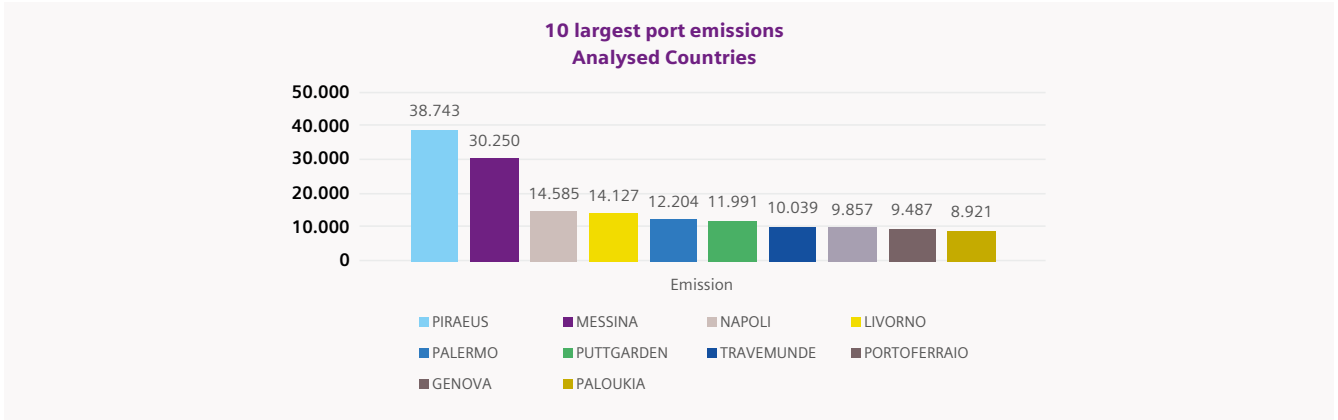
Waterways in Germany are divided between coastal areas and Bundeswasserstraßen (federal waterways) under the political and bureaucratic management of the Federal government, Landeswasserstraßen and the regulation of the respective German Land. The waterways, canals and rivers are a crucial part of the transportation system and there are several initiatives for low- and zero-emission vessel projects.

The Federal and respective Länder (regional) Ministries of Transport are the most important government agencies in shipping and public transport cases. The Federal Ministry of Economy and Climate Protection and the Federal Ministry of the Environment playing an important role in providing funding and support for projects of this kind. However, whether the restructuring of climate action governance on the Federal level will affect different funding mechanisms remains to be seen. The German Agency for the Management of Waterways and Shipping (WSV) plays a key role to assess, initiate and support zero emission projects for public transport.

The ferry connection to Denmark (Rødby - Puttgarden) has already operated with hybrid-electric propulsion for some years already and is now planning for full electric vessels. This will be, up to now, the longest zero-emission ferry connection in the world[7]. Similar potential exists also with shorter coastal ferries to the East-Frisian Isles in the North Sea.

The coastal Länder have focused on shore power for container, cruise and ferry activity in ports. Both the federal government and the Länder administration use both economic and legal measures to accelerate the transformation to zero emission[8] in port. German commitment to reducing emissions and stimulating technology development is strong. Combined with high shipping activity in coastal areas and along inland waterways, Germany is well positioned for a transformation of all shipping related emissions.





[6] Source: Hellenic Statistical Authority

[7] Teknisk Ukeblad - Norwegian deliveries to the longest electric ferry crossing (February 2022)

[8] Federal Ministry for Economic Affairs and Climate Protection: Air in German port cities should become cleaner (October 2019)

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United Kingdom

The UK has set a target of zero emissions from the UK ferry fleet by 2050. This is based on the overarching *Maritime 2050* and *Clean Maritime Plans*, both published by the Department for Transport in 2019[9]. The latter deals with the ferry services in the whole of the UK and related climate and environmental targets. Furthermore, the government has also launched the roadmap "Green Finance: A Roadmap to Sustainable Investing" which will support development of energy value chains needed for zero-emission maritime transport.

Reducing emissions from the maritime sector is also part of the British *Ten Point Plan for a Green Industrial Revolution*, launched in November 2020. In this document, the government states that they "will position the UK at the forefront of aviation and maritime technology to push forward low carbon travel", by establishing a 20 million GBP Clean Maritime Demonstration Programme. This inititative is currently supporting 55 projects across the UK.

Much of British ferry activity is in Scotland. Here, there are several state-funded projects for low- and zero-emission ferry transport and related energy production which have generally focused on hydrogen production and use. One example is the Orkney Islands Horizon 2020 project on hydrogen from wind for use in ferry traffic to the islands. On the Hebrides, also heavily dependent on ferry transport, there are projects concerning both hydrogen production and use in ferries. This project is part-funded by the Scottish Government's Low Carbon Infrastructure Transition Programme.



Benefits of electrification

Electrification greatly improves energy efficiency, eliminates funnel emissions of CO_2, sulphur dioxide, nitrogen oxides and particulate matter. It also vastly reduces noise and vibrations compared to internal combustion engines. Auxiliary engines to power electronics are also no longer needed as this energy is already provided by the batteries on board. Zero emission ferries thus benefit both climate and local air quality. Especially worth noting is the absence of idling with electric propulsion. Because it's by emissions from idling engines in port, a major source of local air pollution, that will yield significant health benefits to the local population. In addition, experience with electric drivetrains and other applications have shown that maintenance costs generally are lower, with service intervals and the expected service life of motors and components both becoming longer. The technology needed to electrify a ship could be considered as being mature in today's world. Much progress has been made due to the electrification of the automotive sector, with major developments in batteries, motors, and associated components. This benefits other sectors too by bringing costs down and improving technology. Moreover, experience gained by use of electric ferries to date has proven the technologies overall reliability and feasibility for this purpose.

[9] Maritime 2050: Navigating the Future, Department of Transport, UK (January 2019)

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5. The frontrunner in Europe

Ferries are a key part of the Norwegian road transport system. With Norwegian fjords both wide and deep, many communities are based on hundreds of islands along the coast, and rely mainly on ferries as their link to other parts of the country. Norway is to date the largest ferry nation in Europe, with 180 ferries operating 112 routes.

Over the last six years, the country has taken a world leading position on electric and hybrid car ferries. In 2015, Ampere became the world's first fully electric car ferry. In 2022, more than 70 of Norway's ferries will be fully or hybrid electric, with 10 more coming after 2022.[10] These results help support the government's target to achieve green transition in shipping for all new ferry licensees delivering zero- or low-emission alternatives before 2023. Of around 330 vessels fitted with batteries for electric or hybrid propulsion globally, around 200 of them are in Norway.

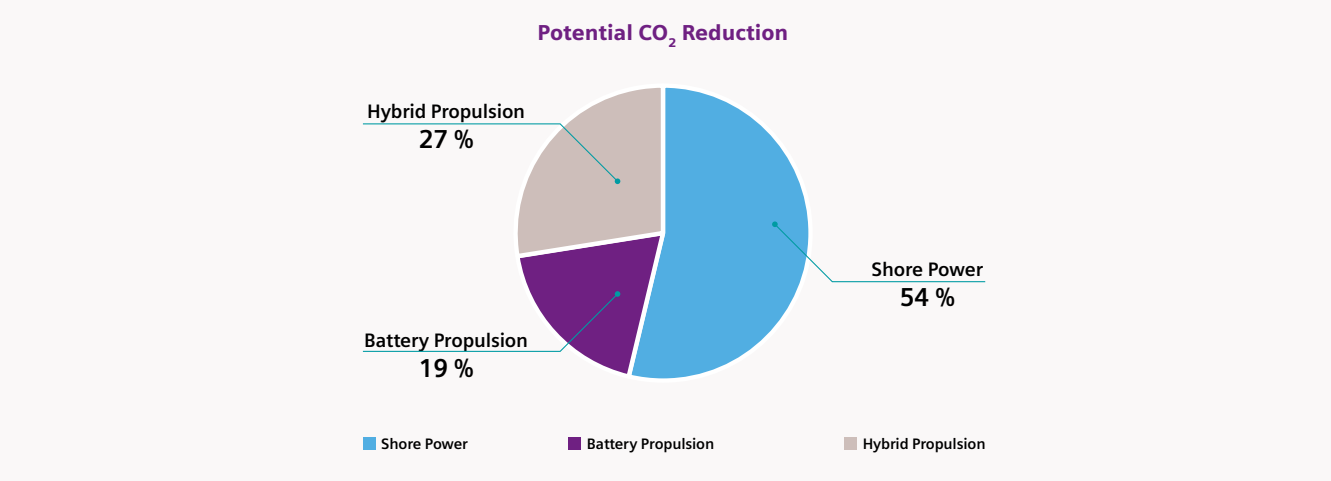
With Ampere commencing operations in 2015, Bellona and Siemens Energy conducted a study on the cost-saving potential for the remainder of the Norwegian fleet in replacing conventional diesel ferries with fully or hybrid electric ferries. The study focused on Ampere as an example vessel, looking at the construction process and operations involved. The 2015 study concluded that more than 70% of Norwegian ferries would benefit economically from being replaced by either fully electric (47%) or hybrid electric (24 %) vessels. Most ferries in Norway operate on shorter routes, crossing fjords and between islands near the coast, and thus have an operational profile that favours electric or hybrid electric propulsion. Although the added investment costs of replacing diesel ferries with fully electric ferries at the time amounted to 3.5 billion NOK (€357 million) total, including grid upgrades in remote areas, the potential for operational cost savings were substantial. The estimate showed that over a 10-year period, the savings in operating costs amounted to 700 million NOK (€71,4 million) annually. The study concluded that replacing the ferries that were economically feasible would save annual CO_2 emissions of 300 000 tons, equivalent to around 9 % of Norwegian domestic shipping emissions.

Public procurement and economic support as an effective tool for politicians

Public procurement is the ultimate tool for the government to define the conditions for designing the function and performance of public services like ferry route operations. Defining the tender's requirement as a zero-emission service and the rules for ferry operators, shipyards and suppliers. The experience in the National Road administration and the county administration has revolutionized the use of electric propulsion onboard with the procurement regime creating a win-win situation for all parties involved. The first and required success factor is simply that the technology is available, the distances are manageable and the economy makes it feasible to implement and operate.

And whilst it is more expensive to build a ferry with electric propulsion, funding and investment is now available through the ENOVA agency, which is ruled by the Norwegian Ministry of Climate and Environment. The agency has, up to now, supported 42 ferry routes, 53 electric ferries and 623 electric buses with 1.3 billion NOK (€132,5 million).

This support will however be reduced over time. By February 2022, the limit for funding from ENOVA for new ferries is up to 30 % of the additional cost for electric propulsion and even more for innovative projects. Overall, ferry policy in Norway has definitively been a success technologically, operationally and climate wise[11]. And other vessel types are benefitting too from the ferry operator's overall experience gained through design, construction and operation.



In comparison, 826 724 tons of CO_2 represent emissions from 538 500 European cars emissions per year. Source: European Environmental Agency and Enerdata 2001-2022

[10] Energi og Klima: Electric car ferries in Norway (live web)

[11] ENOVA - Electrification of sea transport (live web)

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Picture: Color Hybrid

6. Data source and Methodology

Data and analysis

The method to estimate the potential reduction of GHG emissions from European countries is based on two data sources and a data model. AIS data from ferries, Ro-PAX, passenger ships and ship registry data. This includes information on ship dimensions, installed engine power axillary engines, flag and ownership etc.

The analysis for this fleet is performed by AIS data through DNVs transportation model and voyage mapping and between ports. Based on this data, calculation of emissions from ships, in port and under transit are calculated in a number of ways and for a number of different measures.

The emissions under sailing for example are calculated and counted by speed and length of route. Whereas the emissions in port are calculated and counted by time in port (from arrival to departure).

Selection

- Ships in category passenger, passenger/general cargo, passenger/Ro-Ro cargo
- Ships with design speed under 20 knots
- Ships with capacity over 12 passengers
- Ships under 75 000 GT
- Ships with port of arrival in Europe and with a geographic limitation in the Mediterranean Sea, Black Sea, and the Atlantic Ocean (See map below)



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Assumptions and limitations

The calculation of emissions assume that no ships are connected to shore power in port because no information is available from the ship database or AIS data.

The data contains outside sailing routes, like transport to yard, service locations and refueling. And also includes transportation from one route to another in different regions or countries. Vitaly this activity ensures the necessary service and maintenance between routes.

The four main categories of emission reduction can be defined as:

- Ships under 150 meters with duration (sailing time) under 60 minutes give 100 % electrification and zero emission with full battery-electric propulsion.
- Ships under 150 meters with duration over 60 minutes is subject to hybrid-electrification and zero emission in first 60 minutes.
- All ships over 150 meters are subject to hybrid-electrification and zero emissions in the first 60 minutes of sailing are included in electrification or hybrid-electrification.
- Sufficient electricity is available in all ports for shore power and charging power

All selected vessels are also subject to retrofit or replacement (new builds) with electrification and performance and range. It is important to underline however that the generated estimates are not from physical measurement and that numbers for one ship or one port can be inaccurate because of signal errors from AIS transmitters onboard or receivers on land. With the calculations and analysis giving the best possible average estimates for GHG emissions from the European ferry fleet.

The collection of AIS (Automatic Identification System) data from ship movements, speed, course and position therefore form the main bulk of information. The data records are then aggregated and combined with more specific information from IHS fairplay Ship Registry which then enable us to create the emission estimates.

The estimates however are solely for emission reduction from *ships*. The energy mix of electric energy from the shore grid are not 100 % renewable, generating GHG emissions from fossil fuels. According to IEA, the EU have a carbon intensity in power and heat generation of ~300 gCO_2/kWh[12]. The European energy and heat generation are subject to reduce GHG emissions in future and is not in the scope of this study.

With regards to the four different measures to electrify the ships power use, we assume that ships up to 150 meters with transit duration of up to one hour are suitable for full electrification.

How the potential is calculated

Case I EL: Ferries under 150 meters with voyage duration under 60 minutes

Defined as ready for full electrification

Case I Hybrid: Ferries under 150 meters with voyage duration over 60 minutes

Defined as ready for hybrid electrification and for electric propulsion the 60 first minutes of the voyage

Case II: Ferries over 150 meters

Defined as ready for hybrid electrification and electric propulsion the first 60 minutes of the voyage

Case III: All ferries in all ports

Defined as power supply from shore in port and eliminating all emissions while in port

Emission [Tons of CO_2]

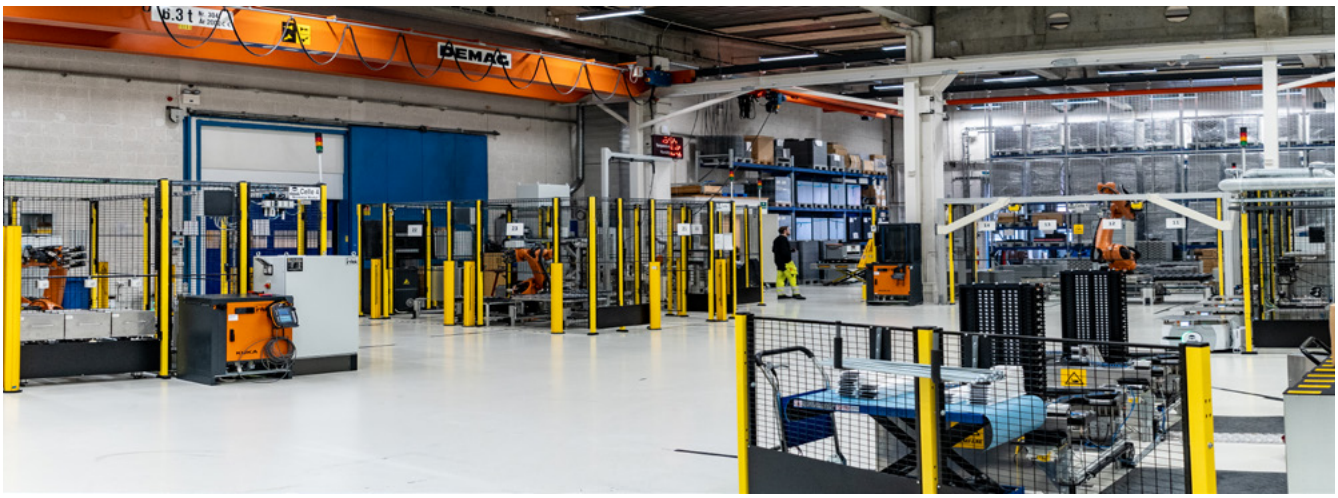
Country	In port	In Transit	Total emissions
Italy	194 067	502 846	**696 913**
Greece	115 170	194 795	**309 965**
Germany	61 712	247 236	**308 948**
United Kingdom	73 329	286 507	**359 836**
Total four countries	444 278	1 231 335	**1 675 613**
Total Europe	1 208 867	3 494 141	**4 703 007**

[12] European Commission - State of the Energy Union 2021

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The potential of emission reduction

Calculated savings per country	Category	Potential savings - tons of CO_2	Reduction in percent	# Ferries	# Ports	# Routes
Italy	Case I – EL	74 191	10,65%	91	70	154
	Case I – Hybrid	41 270	5,92%	89	76	252
	Case II - > 150 m	22 909	3,29%	15	14	49
	Case III – Shore Power	194 067	27,85		All vessels and ports	
	Total – Italy	**332 436**	**47,70%**	**107**	**82**	**320**
Greece	Case I – EL	13 047	4,21%	96	99	182
	Case I Hybrid	55 866	18,02%	93	115	435
	Case II - > 150 m	0	0	1	1	2
	Case III – Shore Power	115 170	37,16%		All vessels and ports	
	Total Greece	**184 083**	**59,39%**	**98**	**124**	**486**
Germany	Case I – EL	29 375	9,51%	86	130	276
	Case I Hybrid	31 066	10,52%	86	114	304
	Case II - > 150 meters	31 066	10,06%	15	14	38
	Case III – Shore Power	61 712	19,97%		All vessels and ports	
	Total Germany	**133 723**	**43,28%**	**105**	**144**	**468**
United Kingdom	Case I – EL	38 431	10,68%	79	129	309
	Case I – Hybrid	38 132	10,60%	79	126	377
	Case II - > 150 meters	26 590	7,39%	5	6	21
	Case III – Shore Power	73 329	20,38%		All vessels and ports	
	Total United Kingdom	**176 482**	**49,05%**	**88**	**148**	**513**
Four Countrys	**Total Four Countrys**	**826 723**	**49%**	**398**	**498**	**1787**



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7. About Bellona and Siemens Energy

Siemens Energy is one of the world's leading energy technology companies. The company works with its customers and partners on energy systems for the future, thus supporting the transition to a more sustainable world. With its portfolio of products, solutions and services, Siemens Energy covers almost the entire energy value chain – from power generation and transmission to storage. The portfolio includes conventional and renewable energy technology, such as gas and steam turbines, hybrid power plants operated with hydrogen, and power generators and transformers. More than 50 percent of the portfolio has already been decarbonized. A majority stake in the listed company Siemens Gamesa Renewable Energy (SGRE) makes Siemens Energy a global market leader for renewable energies. An estimated one-sixth of the electricity generated worldwide is based on technologies from Siemens Energy. Siemens Energy employs around 91,000 people worldwide in more than 90 countries and generated revenue of €28.5 billion in fiscal year 2021.

The **Bellona Foundation** is an international non-profit and science-based environmental NGO with headquarters in Norway. Founded in 1986 as a direct action protest group, Bellona has become a recognized technology and solution-oriented organization with offices in Oslo, Brussels, Berlin, St. Petersburg and Murmansk. Today, more than 70 engineers, ecologists, physicists, chemists, economists, political scientists and journalists work at Bellona. The foundation endeavors to identify and implement sustainable solutions to the world's most pressing environmental problems. The main objective of the foundation is to combat the climate crisis, environmental degradation, pollution-induced dangers to human health and the ecological impacts of economic development strategies. The work of Bellona is anchored in a firm belief in that it is possible to solve the environmental challenges in a constructive and progressive way, and that the industries will be able to adapt to new challenges, providing they get proper long term and predictable framework conditions. Bellona Foundation is accredited and has observer status to the UNEP Governing Council, UNFCCC and IMO.

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