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Strategic tendering process in accelerating the transition to zero-emissions domestic ferries in Norway

Stephen Kwasi Nkesah, stephen.k.nkesah@nord.no, Nord University Business School
Gisle Solvoll, gisle.solvoll@nord.no, Nord University Business School

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Abstract

This study investigates how the authorities in Norway have managed to reduce greenhouse gas (GHG) emissions from the ferry sector by implementing a strategic tendering process for domestic ferry services. The study was conducted using interviews and document analysis. The authorities used competitive dialogue to implement zero-emissions technology in the procurement process, rendering the tender process and contract period longer than traditional tenders. The authorities' first competitive environmental bid process was announced in 2011, and all new ferry tenders are now based on hybrid or zero-emissions technology. The authorities employed push and pull strategies to advance a successful green transition in ferry operations. These measures have led to a significant reduction in GHG emissions from this transport sector but an increase in investment costs compared with traditional diesel ferries. How the authorities have used the tender system to make ferry transport more environmentally friendly is useful knowledge for others with similar objectives.

1. Introduction

Many countries are working persistently with policy initiatives to reduce greenhouse gas (GHG) emissions and reach climate neutrality by 2050. Norway, which joined other nations under the Paris Agreement (United Nations, 2015) has set an ambitious target for a 90%–95% GHG reduction by 2050 compared with 1990 levels (Ministry of Climate and Environment, 2021).

Ferries are a vital aspect of the transport systems in countries with many populated islands. Norway has the largest European ferry fleet (Siemens Energy & Bellona Foundation, 2022) largely due to its long coastline, high mountains, and numerous fjords and islands (Nkesah & Solvoll, 2022). Inhabitants and enterprises use ferries for community connections, enabling efficient transportation operations and employment access (Jørgensen & Solvoll, 2018; Odeck & Høyem, 2021). To ensure that citizens and businesses have access to good ferry services, the Norwegian government procures transport services from shipping companies by putting ferry services out for competitive bids, setting fares, ferry size, frequency, and other requirements. The company that meets the requirements for the lowest compensation is awarded a contract to operate the service, often for a 8–10-year period.

In 2022, Norway had approximately 137 ferry connections operated by around 180 ferries (Norwegian Public Road Administration, 2022a). Before 2015, ferries on the Norwegian coastline were predominantly

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dependent on fossil fuels and released a considerable amount of carbon dioxide (CO_2) emissions (Anwar et al., 2020; Opdal, 2010). In 2020, approximately one-third of total GHG emissions in Norway were attributed to transportation, of which road transportation accounted for 17% of the total emissions (Norwegian Ministry of Climate and Environment, 2022). In 2017, 12.7% of Norway's total CO_2 emissions were from domestic shipping (Sæther & Moe, 2021), and Norway's ferries account for 17% of emissions in Europe (Siemens Energy & Bellona Foundation, 2022). Therefore, transportation is one of the sectors where CO_2 emissions must be reduced to meet national targets.

With the 2015 introduction of the world's first battery–electric (BE) ferry, Ampere, growth in the number of ferry connections operated by BE and hybrid vessels is high. Around 72 electric ferries were in operation in Norway in 2022, and 14 more are expected to be put into service in the years to come (Energy and Climate, 2022). Of the approximately 330 global vessels using electric batteries or hybrid propulsion, 200 of them can be found in Norway (Siemens Energy & Bellona Foundation, 2022). Today, Norway is considered to be a world leader in electrified ferry operations. The technological transition in Norwegian ferry operations is a crucial aspect of the nation's green transition (Solvoll & Hanssen, 2022,p.57). Numerous low- and zero-carbon (LoZeC) technologies; for example BE solutions, biofuel, hydrogen, ammonia, and other approaches can be deployed to control ferry service emissions. This study focuses on BE and hydrogen zero-emissions technologies. The term zero emissions refer to energy that emits no CO_2 or nitrogen oxides (NO_x) emissions during transport operations without considering life cycle emissions.

The aim of the study is to investigate how the Norwegian authorities have reduced GHG emissions from the ferry sector through the tendering process for domestic ferry services. Specifically, the research questions to be answered are:

1. How have the environmental claims been expressed in the tendering process for *the transition to zero-emissions domestic ferries in Norway?*
2. How has the adopted procurement strategy impacted the economic and environmental consequences of this *transition?*

This study is inspired by the multi-level perspective (See e.g., Geels, 2002). Noticeably, minimal literature has provided authorities with step-by-step processes for attaining the monumental transformation that has occasioned the desired outcomes thus far; therefore, a foundational qualitative study to understand the role of the authorities in this transition is essential. The contributions of this study are threefold. Firstly, we describe how the authorities in Norway actively contributed to promoting the transition to zero emissions in the ferry sector, which is relevant for developing strategic practices and policies to further improve the sustainability of the sector. Secondly, we contribute to the literature on green technological transitions, using the zero-emissions ferry sector in Norway as a typical example with valuable insights into the transition and its consequences. Finally, we suggest future research opportunities related to the sector's transition to zero emissions.

2. The state of zero-emissions ferry services

Procurement of ferry services is organized by the Norwegian Public Roads Administration (NPRA) and county councils. The NPRA manages 16 ferry routes, and county councils oversee the remaining 121 ferry routes (Solvoll & Hanssen, 2022). Sæther and Moe (2021) maintain that this split opens the possibility of emissions reduction by altering procurement practices and economic opportunities in the ferry tendering process.

The contemporary ferry sector has been predominantly using hybrid forms (BE/hydrogen and diesel); however, the Hjelmeland–Nesvik–Skipavik connection with MS Nesvik is run on 100% electricity. The remaining hybrid connections use at least 50% hydrogen or 75% electric propulsion. At the county council level, the amount of ferry electrification (either planned or in operation), including hybrid energy propulsion using diesel and BE/hydrogen from 2020 onwards is presented in Figure 1.

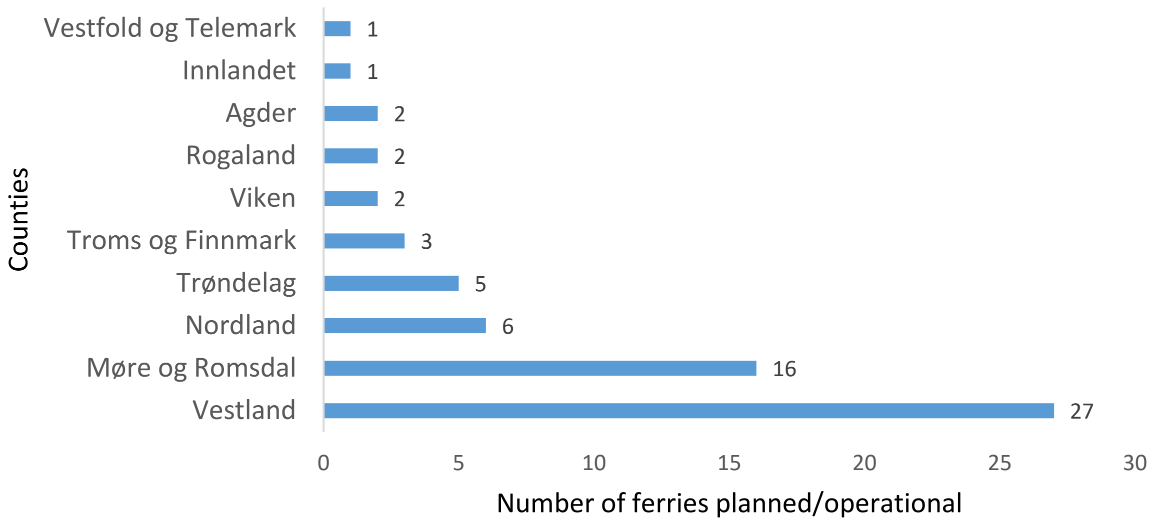

Figure 1: County council development of ferry electrification. (Energy and Climate, 2022; Sæther & Moe, 2021).

3. Public procurement incorporating environmental requirements

The Organisation for Economic Co-operation and Development (OECD) defines public procurement as the 'purchase by government and state-owned enterprises of goods, services, and works performed efficiently and with high standards of conduct aimed at high-quality delivery and protecting the public interest' (OECD, 2023). The European Union (EU) has focused on green public procurement (GPP) for mitigating environmental impact as a fundamental aspect of many policy documents (European Commission, 2001, 2016). Subsequently, EU member state's public authorities include environmental criteria in procurement stages (Testa et al., 2012). The EU target is for 50% of public tendering procedures to be green by 2010, with green referencing compliance with accepted common 'core GPP criteria' (Testa et al., 2012). Specifically, the environmental requirements for a sustainable environment are reduced CO_2, NO_x, sulfur, and particulate matter emissions and noise pollution.

The research on public procurement procedures for transport services has been rich (Hensher, 2021; Official Journal of European Union, 2014; Uttam & Le Lann Roos, 2015). *Selection* and *incentive effects* have been observed in the use of tendering. The *selection effect* occurs when identifying an operator based on tender specifications that can offer the service at the lowest cost, while the *incentive effect* refers to companies with more efficient operations being motivated to submit superior offers to increase the possibility of winning a bid (Nkesah & Solvoll, 2022,p.4). Tender evaluation can take two approaches. Firstly, the lowest price approach evaluates bids solely on price when a set of minimum requirements are met. Secondly, the most economically advantageous tender (MEAT) recognizes different aspects of quality during bid evaluation, e.g. environmental impact (Bergman & Lundberg, 2013). Thus, MEAT 'is the weighted sum of different aspects of a product or service that provide value to the procurer in terms of economy, quality, environmental considerations, and social aspects' (Uttam & Le Lann Roos, 2015,p.404).

The European Commission (2021,p.4) broadly distinguished two types of criteria. First, core criteria, '*designed to allow easy application of GPP, mainly focus on the key area(s) of a product's environmental performance and aim to keep companies' administrative costs minimal*'. Second, comprehensive criteria, which '*consider more aspects or higher levels of environmental performance for use by authorities that want to go further in supporting environmental and innovation goals*'. The European Commission (2021) proposed further GPP criteria requirements for procuring road transport services by separating requirements into (i) selection criteria, (ii) technical specifications, (iii) award criteria, and (iv) contract performance clauses.

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Selection criteria encapsulate the tenderer's relevant experience and competence related to identifying and implementing existing technology, applying procedures to cut GHG emissions and air pollutant emissions, and monitoring and reporting. *Technical specifications*, assuming functional or specific form, consider technical options for cutting GHG emissions. According to Aldenius et al. (2021,p. 2), the term functional requirement is intended to achieve a goal without clearly stating how to accomplish it. An example could be specifying a minimum or maximum level of emissions rather than stating the fuel type. Such requirements have cost implications due to expensive technical development and fewer bidders in the tender competition (Aldenius & Khan, 2017). The *award criteria* bestows extra points to the tenderer for demonstrating innovation for achieving sustainability. *Contract performance clauses* relate to specific conditions that must be met in contract execution.

Cheng et al. (2018) observed that environmental requirements in procurement, technical specification requirements, standards, and eco-labelling for products or services have limited the number of qualified bids. Alhola (2012) assessed 30 environmental award criteria adopted in calls for tenders in three Scandinavian countries—Finland, Denmark, and Sweden—identifying the outstanding criteria of environmental policy and the environmental management system. The author examined tenders' award criteria for evidence of emissions to air/water, environmental impact assessments, production emissions, and the environmental effects of transport per km, among other criteria, but these criteria were not found. The overall weight for environmental criteria was around 5% to 20% compared with common criteria such as price (51%) and quality (37%).

Palmujoki et al. (2010) conducted a comparative analysis of environmental criteria in Finnish and Swedish public procurement and call for tenders. The authors suggested that environmental criteria could be based on bidder prequalification, mandatory requirements, and contractual/special terms in implementing environmental considerations. The transportation-related criteria considered included an eco-driving system, the type of fuel used, vehicle age, bottom hull paint (no tin or copper pollutants), and oil leakage. Michelsen and De Boer (2009) conducted an empirical study of Norwegian counties' and municipalities' environmental criteria in the procurement process. Environmental demands encompassed an environmental management system, the requirement of environmental knowledge (for service suppliers), the use of environmental labels and standards for environmental performance, including the type of energy and chemicals used, and other considerations. The authors also found that larger municipalities' purchasing departments focused on green procurement more strongly.

A study of Swedish public procurement of transport services (specifically buses) by Aldenius et al. (2021) focused on environmental requirements based on fuel guidelines (e.g. more use of renewable fuel or a decrease in CO_2 emissions), energy use (e.g. maximum energy use per kilometre), local emissions (e.g. a decrease in NO_x and particles) and noise (maximal decibel level). The authors maintained that considerable attention is given to technical and functional requirements in the environmental guidelines, rather than specific requirements (e.g. the type/choice of fuel). However, the study primarily focused on technical specifications and contract performance clauses.

3.1 Public procurement legislation in Norway

The public procurement legislation in Norway advises state agencies to undertake the procurement process in a manner that reduces harmful environmental impacts and promotes climate-friendly solutions where necessary and possible. The commitment to the green transition is amply demonstrated at the national level, where the 2015 budget agreement specified that all new tender competitions for ferries must incorporate requirements for zero- or low-emissions technologies as a priority (Bjerkan et al., 2019; Norwegian Ministry of Climate and Environment, 2015). In 2019, the Norwegian government published a white paper on public procurement detailing how contracting authorities can contribute to achieving environmental targets as efficiently as possible (Ministry of Climate and Environment, 2019). Bjerkan et al. (2019) underscored the centrality of governance in making the ferry sector more sustainable. As such, Norway requires a minimum weight of 30% to be applied to environmental requirements and criteria in all procurement processes (Bjerkan et al., 2019).

3.2 Overview of ferry operations tendering in Norway

Before 1990, Norwegian ferry companies operated under a grant system and the NPRA covered the difference between companies' revenue and costs (Solvoll & Hanssen, 2022). In 1990, a fixed subsidy system was introduced to give ferry companies incentives to improve operational efficiency. To control increasing costs within the transportation sector and the anticipation of the EU regulation (1370/2009) rendered competitive tendering obligatory with limited exceptions (Aarhaug et al., 2018). A subsequent amendment was made to the Norwegian Transport Act in 1991 to ensure competitive tendering starting in 1994; however, full-scale competitive tendering was first implemented in 2003 with four ferry crossings (Bråthen et al., 2004), and another 47 crossings were added over the following seven years (Odeck & Høyem, 2021). As of now, ferry operations have seen significant consolidation with the introduction of tenders (Oslo Economics, 2012). Torghatten, Fjord1, Norled, and Boreal are the four main companies operating domestic ferries in contrast to the 16 companies in 1993 (Solvoll & Hanssen, 2022).

3.2.1 Battery–electric tendering

The NPRA's announcement of a 'development contract' on the Lavik–Oppedal connection in 2011 to operate in 2015 was the first environmental tender with a 10-year contractual duration. The development contract aimed at '*stimulating zero or low-emissions technology in the development, yet commercial, tendering process*' (Sjøtun, 2019,p.19). Environmental friendliness and energy cost savings were the two main underlying factors for advancing Norway's 'future is electric' agenda.

3.2.2 Hydrogen ferry tendering

A dialogue conference was held regarding the use of hydrogen as an energy source under the auspices of the NPRA and partners such as the Zero Environmental Organisation (Solvoll & Hanssen, 2022). Political backing followed in the state budget for 2017, and Solvoll and Hanssen (2022,p.70) referenced Decision No. 873,13 June 2016 which stated '*The Storting [Parliament] asks the Government to consider the use of development contracts for hydrogen ferries*'. This resulted in the Hjelmeland–Nesvik–Skipavik connection using the hydrogen propulsion ferry, Hydra. The connection sought to operate on a minimum of 50% energy produced by hydrogen (Solvoll & Hanssen, 2022). The second tendered ferry connection using hydrogen propulsion was Bodø to Lofoten, which was awarded to Torghatten for operation in 2025. The two operating vessels will employ a minimum of 85% hydrogen propulsion as the supporting vessel using either biodiesel, biogas, electricity, hydrogen, or a combination (Norwegian Public Road Administration, 2022b).

4. Materials and methods

This study adopts a qualitative research method, which is suitable for studying complex, continuing processes of technological and sectoral change (Bergek et al., 2021; Steen, 2016). Qualitative research offers more in-depth information through follow-up questions to produce richer data which the quantitative approach can neglect (Hardman et al., 2017). The use of document analysis and interviews abounds in extant literature (e.g., see, Bathmanathan et al., 2018; Denzin, 2017; Owen, 2014; Shankar & Shepherd, 2019).

4.1 Document analysis

Firstly, the study includes document analyses, which are underpinned by online availability for time-efficient and cost-effective data acquisition (Bathmanathan et al., 2018; Bowen, 2009; O'Connor, 2019,p.74). Secondly, documents are stable, non-reactive data sources that can be read and reviewed many times

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without the researcher's influence (Bathmanathan et al., 2018; Bowen, 2009,p.31). Thirdly, document analysis enables the collection of numerous sources of relevant information as many people may not necessarily be interviewed (Bathmanathan et al., 2018). Researchers must be mindful of the authenticity, credibility, accuracy, and representativeness of documents selected for a study (Armstrong, 2020); thus, the decision criteria regarding the documents selected for inclusion had to be established (Flick, 2009). In addition, the document type and source are key considerations for robust analysis (Armstrong, 2020).

This study's document analysis procedure references the steps provided by Aldenius et al. (2021) with some modifications. First, we purposely sought documents from other sources (Gephart, 1993; Shankar & Shepherd, 2019), including public documents such as press releases, county councils' websites, ferry tenders, and contracts. We also examined reported interviews and statements of high officials on ferry electrification. Other relevant documents on the economic and environmental ramifications included articles from Teknisk Ukeblad (TU.no); Sysla.no (now E24.no), the climate and energy website [Energi og Klima], environmental NGOs like the Zero-Emission Resource Organisation (ZERO), research reports from SINTEF, Det Norske Veritas (DNV), Siemens Energy and Bellona Foundation, central policy documents, i.e. the Green Maritime Action Plan (2019) and reports to parliament [Storting] (2015–2016). We also examined documents provided by interviewees. The selected documents were subjected to initial quality checks and assessments to verify objectivity (Bowen, 2009) and to ensure validity and reliability (Aldenius et al., 2021).

In the second step, we examined the documents for concept selection using mind maps. Every document was thoroughly reviewed to understand how issues of environmental claims, related costs, and other relevant matters were expressed. This review process paid particular attention to energy requirements, specific criteria weightings, noise requirements, and local pollution. Specific guiding keywords and concepts included mentions of fuel, energy, emissions, noise, energy efficiency, procurement form, vessel requirements, energy needs, quay requirements, award criteria, and any related costs. The choice of these categories was inspired by the 'environmental friendliness' and 'energy cost savings' related to advancing the 'future is electric' agenda (Sjøtun, 2019,p.21), with the admonition of the Norwegian parliament that new ferry tenders must employ zero-emissions technology when it is fully developed.

In the third step, we reviewed the documents based on the criteria and weightings, insights on strategic tool deployment, and stated economic and environmental outcomes. The specific requirements focused on specific fuel and energy propulsion.

4.2 Interviews

The study employed semi-structured interviews using open-ended questions as the primary data source (Bryman & Bell, 2007).

4.2.1 Sampling, recruitment and analysis

The interviewees were recruited using purposive sampling (Onwuegbuzie & Leech, 2007; Tongco, 2007), obtaining a sample that matched the aim of our study. We first sought to procure detailed information about all of the steps and considerations involved in selecting the winning operator, which required specific best-fit informants who were engaged in the procurement decision-making process. Therefore, interviewees were the key informants (Lo et al., 2013) for providing insights into the research objective. The use of small and purposive samples in such qualitative studies is not uncommon (Miles & Huberman, 1994), particularly when researchers intend to increase the depth of understanding (Palinkas et al., 2015).

Interviewees were recruited via email exchange. One of the pioneers in the use of electric ferry technology, Møre og Romsdal county, granted an audience for the interview. The county is second only to Vestland in terms of the number of connections converted and planned for electric ferry operations; therefore, it was deemed appropriate for the study. An interview guide was drafted and supervised by one senior researcher with expertise in ferry transport and contracting. Finally, we recruited four interviewees connected to strategic planning and ferry services procurement. The interviewees received information about the study's purpose ahead of time. Interviews were conducted in English by the two researchers to avoid interview variability (Hardman et al., 2017).

Interviews were organized into four parts, including (1) the interviewees' background, to determine their position and role and (2) the zero-emissions technologies used (i.e. battery–electric, hydrogen, or hybrid propulsion). Specific questions focused on prehistory, such as 'When did the restructuring of tenders towards the zero-emissions requirement vessels start?' 'Who initiated this?' 'What goals were set?' (3) Procurement and tender processes relative to ECs and weightings. Some questions on the process included 'How was the tendering of zero-emissions vessels for ferry operations in the county done?' 'What tender and contract types were used?' 'How are the environmental, price, and other quality requirements stated on a competition basis?' (4) Economic and environmental consequences, if any. We asked, 'What can you report on the economic and environmental ramifications of the transition?' to determine the amount of emissions that were reduced and any change in cost and contract parameters. The interviews lasted for 2 hours and 30 minutes, and all interviewees were permitted note-taking during the interview (Kvale, 2007) when impressions formed at the time of the interview were noted (Abbasi & Nilsson, 2016).

The interviews were exhaustive, continuing until no further information was needed. After the interview, a report was sent to each interviewee for feedback on the notes taken. No feedback was received, indicating confirmation of the notes. From the NPRA side, information was largely obtained from the individual who held a senior position in ferry operations until 2022. *Bricolage* interview analysis was applied, implying the '*free interplay of techniques during the analysis'* (Kvale, 2007,p.126).

In summary, we compared the interview transcripts with the documents gathered to obtain an overall view of the data. Subsequently, illustrative quotes that were identified in the data ensured the data validity of our analysis (Graham-Rowe et al., 2012). Based on our research objective, we first identified three primary areas of concern, which included EC weightings, policy strategies, and the consequences of introducing ECs. This paved the way for interview and document analyses using descriptive and evaluative categorization (Owen, 2014), where relevant insights were manually categorized into these three main headings. Through this effort, a deeper understanding of historical antecedents, experiences, commitments, and related concerns culminated in the current state of the zero-emissions ferry sector.

5. Findings

5.1 Tendering type used for zero-emissions ferries

Disparate procurement procedures were applied for transport services (Hensher, 2021; Official Journal of European Union, 2014). We found that two of these procedures, the competitive dialogue procurement procedure (CDP) and competitive tendering (CT) were used based on the call for a bid objective.

5.1.1 CDP

CDP was used as the basis of the competition for the development contract that solicited the first environmental tenders for BE and hydrogen ferries. The NPRA had experts frame the call for the development contract, particularly the content concerning energy criteria. CDP deployment is conditioned on certain factors. Please see (Solvoll & Hanssen, 2022) for details regarding the phases of the CDP that are presented in Figure 2.

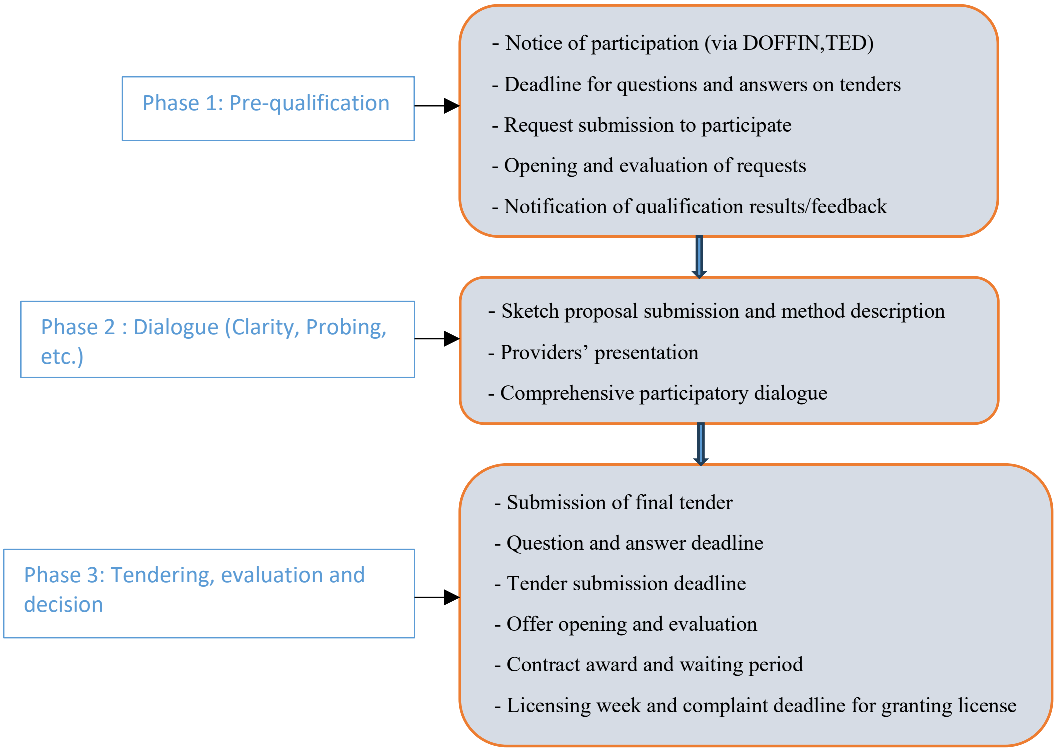

Figure 2: The Norwegian model of CDP for zero-emissions ferry procurement.

5.1.2 CT

Traditional CT was applied to re-tendering for ferry services because of the existence of the technology already in the market and discharged principally at the county council level. The NPRA used CT for the re-tendering of the first electric ferry on the Lavik–Oppedal connection.

5.2 Price and environmental weightings

The two leading energy sources for zero-emissions propulsion include BE and hydrogen approaches. As a result, the primary consideration was energy efficiency and the potential to reduce emissions. We found that the criteria and weightings for the development ferry for the Lavik–Oppedal connection weighted energy consumption and tonnes CO_2-eq./year at 15% each, with price-weighted at 70%.

Table 1: Weighted criteria for the development ferry for the Lavik–Oppedal connection.

Category	Evaluation	Weight
Energy efficiency	kWh/PCE km	45%
	Energy consumption	15%
Environmental efficiency	Tonnes CO_2-eq./year (CO_2/kWh, CH_4/kWh)	15%
	kg NO_x/year	10%
Innovation		15%

Source:(Solvoll & Hanssen, 2022).

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Relative to the hydrogen propulsion weightings, the experiences gained from the first environmental tender offered better insights for subsequent bidding processes. The first hydrogen connection, Hjelmeland–Nesvik, sought a minimum of 50% hydrogen energy propulsion, with an operating period spanning from 2021 to 2031. The environmental criteria and price were weighted at 30% (5% for energy consumption [GJ/year], scalability 25%), and 70%, respectively.

Table 2*:* Criteria used for tenders of the Hjelmeland–Nesvik–Skipavik connection.

Award criteria	Weight (%)
Price	
a) Calculated offer amount (price)	70%
Environment	
a) Energy consumption [GJ/year]. Total energy bunkered per year (measured in gigajoules) for all ferries in the connection	5%
b) Scalability	25%

Source: (Norwegian Public Road Administration, 2019)

The client chooses the offer that presents the best combination of price and quality based on the award criteria. The purpose of the scalability criteria was to stimulate the development of hydrogen technology for zero-emissions ferry connections which were deemed challenging for fully electric operation. At the NPRA level, new vessels are necessary to meet environmental requirements; however, at the county level, regarding the type of vessel to operate a connection, an interviewee stated that the *"requirements can be met by brand-new electric vessels or the retrofitting of existing ships"*. This demonstrated that transition in the ferry sector requires fleet renewal considering that the fleet's average age was between 27 and 30 years. An interviewee commented, "*In all cases, the operator will submit a report of actual environmental values, including fuel, electricity, and overall energy consumption"*.

Reviewing the call for bids from Møre og Romsdal county and the experience of five route packages publicized for tender at Hordaland (now part of Vestland county), the following weightings were identified based on gross contracts:

- A price weight of 80%–85%; energy efficiency (GJ/year) and environmental efficiency (tonnes CO_2-eq./year) with a 7.5% weight each; and NO_x/year in tonnes weighted at 5%.
- Hordaland had a weighted price of 70%, and energy efficiency (GJ/year) and environmental efficiency (tonnes CO_2-eq./year) with 15% weight each.

In the context of zero-emissions ferry services, local pollution refers to NO_x and noise pollution. No functional or specific requirements were expressed regarding noise pollution, possibly because of the chosen energy source, i.e. BE or hydrogen. An interviewee corroborated this, stating "*The vessels are silent when using electricity*".

5.3 Consequences of implementing zero-emissions ferry operations

The implementation of zero-emissions ferry services has resulted in significant environmental and economic consequences.

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5.3.1 Environmental consequences

The study found a degree of hybridization by using diesel or liquefied natural gas (LNG) and a share of non-fossil fuel (i.e. BE and hydrogen) for ferry propulsion. The specified degrees of hybridization involving BE and hydrogen ranged from 30% to 75%. Offers were rejected when the environmental values and the degrees of hybridization fell short of requirements. More BE ferries would yield "*environmental savings resulting in a reduction of 300,000 tonnes of CO_2 emissions yearly, which is approximately 9% of Norway's emissions from domestic shipping, as well as a reduction of 100,000 tonnes of diesel and 8,000 tonnes of NO_x*" (See, dfly.no, 2015; Madaling, 2021; Siemens Energy & Bellona Foundation, 2022). Undoubtedly, particle emissions have health effects. Road transportation remains the strong focus in the transport sector where particles are generated. However, greater attention is put on emissions of nitrogen oxides and sulfur oxides compared to particle emissions (Fridell et al., 2008). This probably could be why not much focus is given in the tendering documents because with zero emission the main focus is on the battery electric and hydrogen technologies.

The transition has seen some level of reduction in energy requirements. A representative from the NPRA stated, *'In contrast, with a diesel ferry, we are talking about a 50% reduction in the energy requirements. The zero-emissions goal will be reached* (see, NRK, 2012). Additionally, the climate neutrality underpinning the zero-emissions ferries was accentuated by the Fjellstrand shipyard officer, '*When we now get a fully electric ferry […] as no one has done before, the energy is completely clean, it is CO_2-neutral, climate-friendly and environmentally friendly*' (See,NRK, 2014).

An emissions cut of approximately 95% by the first BE ferry was reported (Lambet, 2018). The use of hybrid propulsion is considered to be a commendable reduction. As explained by one interviewee, "*For the specific route to be converted, a reduction of 80% emissions was calculated upfront. The largest ferry routes were calculated to 89% reduction. The result of the third quarter of 2022 showed a 98% reduction"*. The same interviewee further commented, "*Of the 16 ferries spread over 10 different routes, the total reduction is approximately 38,000 tonnes CO_2-equivalent*".

On hydrogen propulsion, the Bodø–Lofoten connection will reduce 26,500 tonnes of CO_2 emissions annually against the current ferries using LNG (Norwegian Public Road Administration, 2022b).

5.3.2 Economic consequences

Logically, implementing zero-emissions ferry operations comes with associated costs, including investment and operational costs, among other expenses. Other previously noted costs include technology, energy capacity, infrastructure, and charging or refuelling costs (Bjerkan et al., 2019). As one of the interviewees stated, "*The challenge of building new dockside, technology, vessels, etc. affected the county economy/finance as the existing dockside could allow smaller vessels and substantial investments need to be done*".

Comparatively, zero-emissions ferries are estimated between NOK 50–100 million higher than their fossil fuel counterparts (E24, 2021b). An initial assessment of the electricity grid and energy capacities revealed inadequacy indicating that electrifying 52 ferry services will require approximately NOK 900 million in grid investments (DNV GL, 2015). An assessment of nine contracts conducted by DNV estimated approximately 5% net additional cost for a zero-emissions ferry contract period (Ministry of Climate and Environment, 2019). Considering the cost involved in implementing electric ferries, an interviewee opined, "*the cost for ferry connections far away from grid connection is a problem for the electricity companies. The electrical grid challenge needs to be addressed to avoid substantial costs*", and this was echoed by another interviewee.

One interviewee clarified that '*the tendering cost using "environmental tendering" had more net cost spanning 4%–8% compared to the traditional tendering for diesel ferries'*.

More operators bidding extends the competition, which is an integral aspect of advancing economic sustainability. An interviewee noted, "*Before the transition, competition was not good. Previously, the number had been around two; however, four big companies the likes of Norled, Fjord1, Torghatten, and Boreal are making inroads. Now, the average is one to four bidders per contract*". The increased number of bidders for the environmental tendering can be explained by a reduction in operators' potential risk, which arose from the county municipality assuming the responsibility and risk related to the provision of power upgrades at the quay and ensuring that all needed infrastructure improvements and repairs are in place.

The profitability of BE operation also increases with falling battery prices. A senior officer at Siemens affirmed, "*Ampere has given us unique knowledge about profitability for battery ferries … electric operation crushes diesel ferries on profitability for seven out of ten ferries … therefore, we should set ourselves high goals to quickly put in place the next battery ferries in Norway*". (See, dfly.no, 2015; Madaling, 2021). In contrast, higher costs are associated with hydrogen propulsion due to higher production costs and the need for new refuelling infrastructure (Bjerkan et al., 2019).

The transition to zero-emissions ferries required enormous up-front investment costs, including various training programs and infrastructure costs. For example, in 2016, county municipalities received a government grant of NOK 20 million to sharpen their expertise on the inclusion of environmental requirements during procurement (Ministry of Climate and Environment, 2019). Furthermore, Hordaland County municipality received NOK 134 million from ENOVA, a state outlet for financing innovative energy and climate solutions, to construct battery chargers at its quays (E24, 2021a), and Møre and Romsdal county received NOK 30 million to ensure stricter environmental requirements for ferries on Sunnmøre (E24, 2021c).

The increasing number of zero-emissions ferry operations has expanded the benefits of maritime components suppliers, shipyards, and opportunities for business growth and job creation (Nkesah & Solvoll, 2022). In congruence with this, regarding hydrogen ferries from Bodø to Lofoten an official of Torghatten stated, "*We are investing in hydrogen now, but there is no one to sell to. We will be the first major buyer of hydrogen in Norway, and we will also be providing significant opportunities for the shipyard and equipment industry to participate in the development of expertise in the use of hydrogen as an energy source. For tourism, the hydrogen ferries will be a unique opportunity to take the tourism investment and the international brand Lofoten a step further"* (See, Norwegian Public Road Administration, 2022b).

In summary, the transition has evolved through underlying factors resulting in increased ferry electrification. Early ferry operations were extensively dependent on fossil fuels, and underlying external and internal pressures then pushed the urgent need for ferry electrification. The approach employed set the stage to ensure successful rollout involved varied measures. The selection of the operator employed an appropriate procurement procedure with ramifications. These factors are illustrated in Figure 3.

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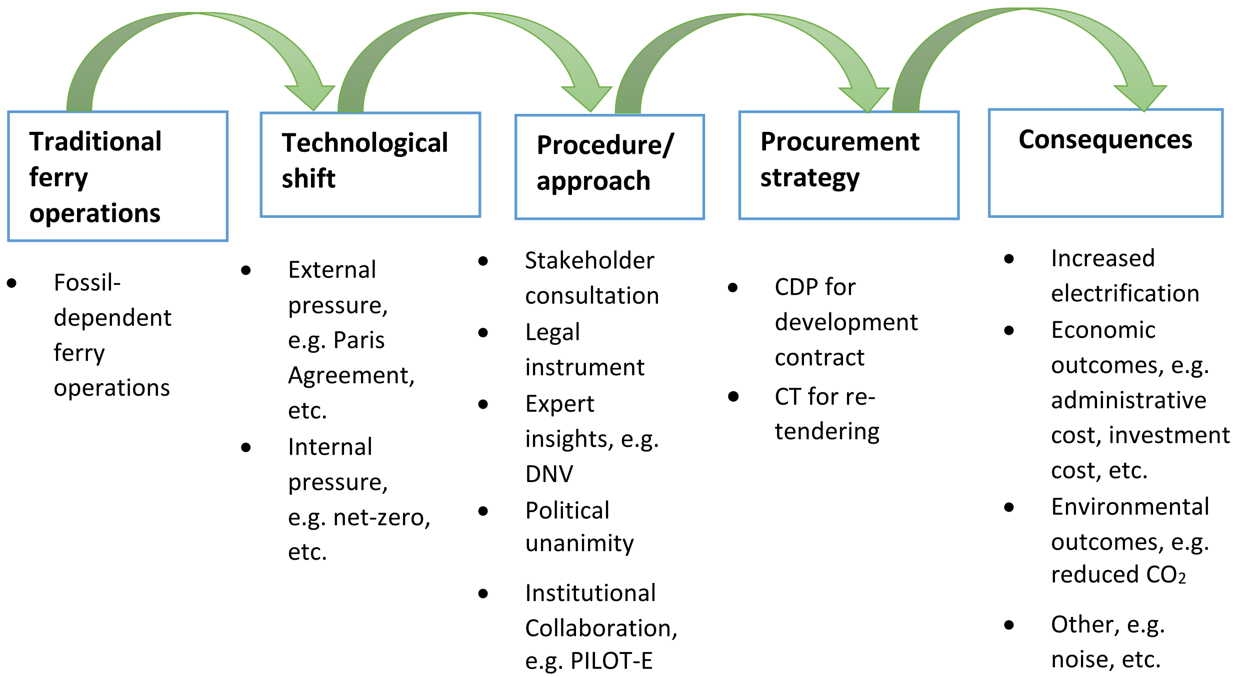

Figure 3: Illustrative framework for process and outcomes towards zero-emissions ferry operations.

6. Discussion

This study demonstrates how the authorities have contributed to reducing GHG emissions in ferry operations. The use of environmental claims in calls for bids was crucial. The strict emphasis on environmental claims in tendering demonstrates governmental leadership commitment, ambitions towards GHG emissions targets, stakeholders' acceptance, and the credibility of achieving climate neutrality by 2050. These findings corroborate how essential committed leaders are to advancing environmental purchasing processes (Varnäs et al., 2009).

Bjerkan et al. (2019) noted that price and quality normally weigh higher than environmental considerations; however, environmental requirements in the Norwegian ferry sector were the key considerations for determining the chosen operator. Although, weighted significantly lower than the price between 15%–30%. The degree of hybridization of non-fossil fuel (e.g. BE used in the county examined was between 30%–75%). At the county level, price weightings varied between 80%–85%, and ECs weighted between 15%–30%. In contrast, a study by Alhola (2012) covering the use of MEAT and environmental award criteria in Finland, Sweden, and Denmark identified environmental criteria weighting between 5%–20%, and price was the leading award criteria, with an average weight of 51% and 37% for quality; however, the NPRA's weightings were 70% for price and 30% for ECs.

Contrary to previous studies (Brammer & Walker, 2011; Testa et al., 2016; Testa et al., 2012), we determined that a lack of knowledge regarding environmental regulations in tender design did not emerge as a key concern. This can be attributed to the NPRA's use of experts and county municipalities' targeted training of procurement officials. Online administration of tender documents via Doffin.no and Tenders Electronic Daily cuts transaction costs and excludes the human interface that could compromise transparency.

We observed that both the lowest price approach and MEAT were applied, wherein MEAT was used by the NPRA to determine the preferred operator for the development contract, and the county council relied on the lowest-priced offer. The differences could be attributable to the NPRA's focus on innovative, untested technology in pursuit of emissions reduction and quality service.

More importantly, the successful implementation of advancing the zero-emissions ferry sector is through a combination of *push* and *pull* strategies which have been explored in previous research (See, e.g. Au & Tucker, 2016; Pesonen et al., 2011; Piper & Naghshpour, 1996). In this study, we maintain that the *push* refers to the inclusion of strict environmental requirements and/or directives by the government in procurement processes. Thus, public procurement regulation functioned as a strategic enforcer in setting the conditions required for designing the functionality and performance of public ferry connection services (Siemens Energy & Bellona Foundation, 2022). The procurement process stipulated the tender's requirement for zero emissions, among other things. The *pull* employs state agencies' funding schemes and incentive packages through, e.g. the NO_x Fund and Pilot-E, which is a collaboration among the Research Council, Innovation Norway, and ENOVA. These approaches advance green shift development and practical transitions from idea generation to the market (Bjerkan et al., 2019). For instance, ENOVA's suggestion of county councils bearing the cost of infrastructure upgrades to accommodate green operations and subsequently assuming ownership and responsibility is crucial. This is because as an incumbent operator's contract ends, the infrastructure remains with the county, preventing dismantling and re-investment costs. It is also essential to address the challenge of upgrading the electrical grid to avoid substantial future costs, and the surrounding communities will also benefit from access to an expanded energy grid.

Accelerating zero-emissions ferry services has direct and indirect outcomes. Direct outcomes include reduced GHG emissions, increased investment expenditure, diminishing onboard passengers' and nearby residents' discomfort from noise exposure, and decreased public exposure to fossil fuel fumes. Indirect outcomes include increased innovation in the sector and demonstration effects of example-setting.

7. Conclusion, policy implications, and study limitations

The study has provided an in-depth understanding of the strategic use of the tendering process to accelerate the transition to zero-emissions domestic ferries in Norway. This has resulted in Norway's uptake in the number of domestic ferries run on zero- emissions, particularly battery electric at the global record level. With the increased electrification of domestic ferries, we found that the switch from fossil-dependent ferry operations to zero-emissions propulsion technologies has attracted substantial public funding relative to administrative costs, investment costs, etc. That is, the strict environmental requirements in tenders compel transport providers to think in completely new ways, but in the short term, this results in increased costs for the procurement process itself and in the required investments in infrastructure and vessels. Furthermore, innovative public procurement has strongly contributed to the rapid environmental restructuring of Norwegian ferry operations. Consequently, this contributing to a significant reduction in GHG emissions from this sector. The two main procurement approaches, i.e. CDP and CT were deployed based on the circumstances. For example, the procurement approach of competitive dialogue is well suited to procuring transport services that require significant technological renewal.

This study has some relevant policy implications. Firstly, the experience gained from the green shift in Norwegian ferry operations through our qualitative investigation could be transferable to other countries endeavouring to transition to any type of more environmentally friendly public transport operations. Secondly, given that the green transition within the ferry sector involves technological transition requires an appropriate procurement strategy. Therefore, it is appropriate to employ the CDP approach until the associated technology is commercially proven and available in the market, after which, subsequent calls for bids can use the traditional CT. This view was corroborated by Hensher (2021) on the transition to a green bus fleet.

In terms of limitations, this study mainly focuses on authorities' perspectives regarding the implementation of zero-emissions ferry services and its consequences, and operators' perspectives were almost not included. Operators' perspectives and opinions are worth investigating for an in-depth examination of the development of zero-emissions solutions. Moreover, this study does not cover public procurement of transport services using fast craft vessels which provide crucial services in Norway's coastal areas. These are in the early phase of the green shift. Furthermore, this study is limited to one country. Future research could compare findings from different countries to gain broader insights into how environmental requirements that are geared towards achieving reduced GHG emissions have been expressed. Finally, further research studies could focus on user satisfaction and consumer attitudes towards zero-emissions ferry operations and willingness to pay for low-carbon ferry operations.

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