Environmental and climate progress within transport logistics

- Examples on reduced climate impact 2019

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1. Introduction

Environmental work in transport logistics has been in progress since the late 1980s. Initially, it was primarily focusing on pollutants harmful to health and the environment through emissions to air, water and soil. Noise disturbance and intrusion into our natural environment has also been prioritized in the early environmental work.

Thanks to technical development, organizational measures and legal requirements, the transport sector has achieved substantial improvements, curbing the polluting emissions through cleaner propulsion systems. The biggest success is however a fairly strong consensus that environmental impact is significant and must be solved by the transport industry itself.

The biggest remaining challenge for the transport industry is a growing global demand for transport services, where propulsion system still is dominated by a strong dependence on fossil fuels and other finite minerals. The related negative consequences are emissions of greenhouse gases.

Sweden is a sparsely populated country with a large international trade exchange, leading to an extensive demand of long freight transport. Long-distance freight transport is dominated by the pulp, paper and steel industries. Most of these transports leave the country as finished products or as input goods to other industries. Significant product flows are also generated by the industries; engineering, telecommunications, construction, minerals and energy. Sweden, with its large trade exchange, also means significant volumes of freight flows that are imported and transported domestically to consumers. Hence a well functional and efficient logistics system is highly essential for Sweden's economy and prosperity.

From an energy and climate perspective, Sweden has been a pioneer in using renewable energy for heating and electricity generation. The latter is due to existing conditions for hydropower.

The Swedish transport sector has also attempted conversion to renewable fuels but solutions that can be scaled have been difficult to identify and establish. The exception is the electrified railway, which to a great extent is driven by renewable electricity.

Sweden's transport has, apart from the railroad, largely the same propulsion technology and fossil dependence as the global average. The consequence is that transports' share of greenhouse gas emissions in Sweden is higher than in other countries that have not succeeded in converting their heating and electricity production to renewable energy sources.

Domestic transport accounts for just over 30% of Sweden's total greenhouse gas emissions. By including foreign transport by air and sea, transport accounts for more than 40% of total GHG emissions. About 10 to 20% of these are linked to freight transport and consequently remaining part is linker to passenger traffic. In other words, the transport sector is of great importance in Sweden's ambition to achieve overall national climate objectives. The challenges are great, but if Sweden succeeds it would mean significant progress towards a climate neutral country. The target expressed by the Swedish minister of Infrastructure "Sweden as a permanent world exhibition for a climate-neutral industrialized country" may in such case be within reach. The challenge cannot be seen in isolation. The climate issue is global, and establishing transport solutions that are based on other countries' raw material resources does not provide a truly scalable solution.

There is however good hope. In this compilation we want to highlight good examples in all types of traffic modes that strive for more energy efficient and climate-smart solutions. Hopefully, they can inspire more companies to implement similar measures. Technical and organizational innovations are necessary if the transport industry as a whole shall implement a change that meets global and Swedish climate goals. The major challenge in all reported case studies is whether and how these solutions can be implemented on a larger scale without adversely affecting other countries' opportunities to develop their transport and logistics systems towards climate neutrality.

In addition to the climate benefits that new solutions can achieve, there is a huge international market for products and services that are more energy efficient and substantially reduce greenhouse gas emissions. Establishing a "future lab" for products and services that, with the power of the example, concretely shows how measurable progress can lead to future export successes.

Achieving real progress that reduces climate impact in absolute emissions of greenhouse gases requires extraordinary solutions. Before there are completely emission-free transport and logistics solutions, current organization and associated demand for transport must be challenged as well. With increasing demand for transport, we may be able to keep emissions at present levels, but this is insufficient. According to Swedish targets, carbon dioxide emissions should in total numbers be reduced by 70% by 2030 and by 2045 the net emissions of greenhouse gases should be zero.

To achieve the necessary progress, the following areas of action in transport and logistics are required:

- Demand management
- Increasing efficiency
- Introduce new clean and fossil-free techniques

This paper presents examples from all three areas of action above, which gives hope on new opportunities for progress. This paper aims to highlight pioneers and their actions, which hopefully can be followed by many more examples on a larger scale and that leads us to new transport and logistics solutions that are completely fossil-free without eliminating the opportunities for other countries to introduce similar measures.

The compilation is prepared for the conference “Climate Neutral Freight Transport”, which is jointly arranged by KNEG, the Swedish Transport Administration and NTM. The report is written by Magnus Swahn, NTM after interviews with participating actors. Any errors and misunderstandings in text and calculations are entirely Magnus's responsibility.

2. The perspective of the transport buyer

2.1 New transport solutions enables climate efficient bread delivery

In this case study, two examples show how organizational and technical measures can reduce greenhouse gas emissions as well as costs in fresh bread distribution. The compilation is based on interviews with Hannu Nylander, Logistics & Service level Director at Vaasan in Finland and Niels Kristian Holm, Supply Chain Manager at Schulstad in Denmark. Both companies are part of Lantmännen's Unibake.

Lantmännen is an agricultural cooperative owned by 25,000 Swedish farmers with operations throughout the value chain. Operations are run in the divisions:

- Agriculture offering products and services for agricultural activities
- Machinery that imports, markets and sells agricultural and construction machinery
- Energy, which is one of Sweden's largest producers of bioenergy products
- Food that develops, refines and markets food products and meal concepts

The Food Division has the business areas; Lantmännen Cerealia and Lantmännen Unibake. Production takes place at 46 plants and within the division there are brands such as AXA, Kungsörnen, Amo, Regal, FINN CRISP, Bonjour, GoGreen, Gooh, Hatting and Korvbrödsbagarn.

In this case study, we focus on the Unibake business area and their distribution of fresh bread in Denmark and Finland. Overall, Unibake's energy and climate work is based on energy efficient bakeries 'furnaces, switching to LED lighting and constantly measuring and monitoring the savings from such measures via a digitized monitoring tool. By improving energy efficiency and other initiatives Lantmännen's overall climate goal is to reduce carbon dioxide emissions by 40% by 2020 compared to base year 2009.

Lantmännen's overall climate target for the Group's purchased transport is to reduce greenhouse gas emissions (CO2e wtw) by 70% by 2030 from the base year 2009. The target is set relative to sales and also applies to Unibake. In both Denmark and Finland, active work is underway to make the distribution of fresh bread with trucks being more efficient with regard to emissions of GHG.

2.1 Distribution of fresh bread in Denmark

In Denmark, Unibake delivers fresh bread under the Schulstad brand. The business covers the entire country. Previously, each bread supplier in Denmark had its own distribution, which was expensive and increased congestion in the vicinity of the store reception. In order to streamline the flow of goods, Coop decided that they only wanted one delivery of bread per day to their stores. The assignment to distribute the other bread producers' bread to the Coop stores went to Schulstad with a logistics agreement that included all producers in the bread distribution. The solution was later expanded to several other retail chains in Denmark.

In order not to conflict with competition law, a common distribution solution was made open to all bread suppliers who wanted co-distribution in Denmark. The ideas were successful and today Schulstad distributes fresh bread from Kohberg, Pågen and 15 other smaller bakeries. This resulted in considerable cost savings and reduced the total greenhouse gas emissions. There are still food chains that supply bread outside this coordinated distribution system.

Schulstad distributes fresh bread 7 days a week to 2,400 stores around the country. The fresh bread is mainly delivered before 7:00 and at 9:00 at the larger supermarkets. A challenge in this distribution is congestion problems which significantly lower the productivity of the distribution trucks. The problem is greatest between 07:00 and 9:00 and this is also when delivery should take place. Schulstad analysed the situation which showed great potential.

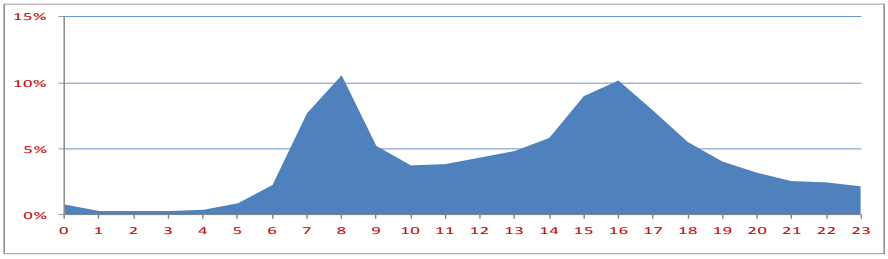


Figure 2.1 24 hour cycling behaviour in Copenhagen

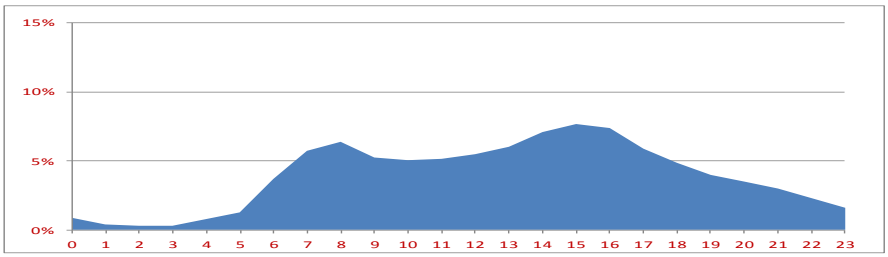


Figure 2.2 24 hour car traffic in Copenhagen

In larger cities, mainly Copenhagen, a discussion was held about the challenges of the low productivity of bread distribution. Contact was made with the City of Copenhagen about the possibility of distributing the bread at night as other traffic is almost non-existent. The arguments for night distribution were:

- Bread must be delivered no later than 8 a.m. to the larger department stores
- There is severe congestion between 6.30 a.m. and 9.00 a.m.
- Distribution trucks' productivity drops by 17% between 7 a.m. and 9 a.m.
- More efficient distribution reduces carbon dioxide emissions
- Reduced idle driving reduces emissions and noise
- Less stress for drivers because rush hour traffic can be avoided
- Shorter transport time, which provides greater delivery flexibility
- Improved operating economy

The city understood the arguments and was open to these ideas but felt that the noise problem must first be solved for local residents before night distribution could be allowed. The solution was the purchase of three electric / diesel hybrid trucks from Scania. With these, Schulstad could deliver to the store almost silently. The City of Copenhagen approved the solution and it was quickly clear that the solution significantly improved the bread distribution productivity. Previously, a truck could deliver to 2 stores an hour in the morning. With the new solution, the truck could deliver to 6 stores per hour when delivered at night. Two more hybrid trucks are now ordered from Scania to expand night distribution.

Today, the driver has keys to 75% of the receiving stores (1700 stores) and access to code to turn off alarms. In these cases, delivery takes place entirely without receiving staff who are instead met by bread to put up on the store shelves when they come to work. In 400 of the stores, delivery must not take place before 7:00 a.m. because of specific local requirements. Furthermore, 200 stores are not interested in handing out their keys. Interestingly, drivers prefer to drive at night than during the day when it involves less stress. In addition, they receive extra compensation. The trucks run all night until 10:00 in the morning.

Hybrid trucks with silent electric drive were a prerequisite for this solution. Schulstad has also invested in equipment that reduces other noise sources when loading and unloading bread and so far no one has made any complaint that the business is noisy. The distribution takes place with 68 trucks, all of which have a Euro 6 engines and are Piek approved as "low noise". 54 trucks have noise-cancelling equipment approved according to Piek. The drivers are also trained in driving technique for quiet departure.

Add to these general activities the three hybrid trucks from Scania, all of which are Piek certified. The trucks are powered by conventional diesel but below 30 km / h they go into electric power. Night-time distribution has been going on for three years in fixed routes with silent vehicles where there are specific noise restrictions.

Figure 2.3 Scania' diesel-electric hybrid truck

Scania's hybrid trucks have no reverse alarm but instead a reverse camera. The cargo compartment floor is designed to reduce noise. Lift trucks have insulated motors and noise cancelling wheels. Schulstad has also invested in separate cabinets for delivery to certain stores with access via own keys. With this technology, delivery windows can be completely changed to increase productivity and reduce emissions. The technology helps the company reach targets on both noise and carbon dioxide.

The company makes no systematic measurement to show reduced carbon dioxide emissions. “The measurability is that we can deliver larger quantities of bread with less fuel consumption” according to Niels Kristian Holm and continues: “We want to be a company that takes environmental and

climate responsibility. That's why we do this. However, we do not communicate these benefits with this distribution to consumers. At the start of the project, however, we had with us Ramböll's noise experts who could verify the solution's potential and utility, which gave weight to the dialogue with the City of Copenhagen and thereby convinced them to give their consent to the change. The measurements showed that the difference between a conventional truck and the electric hybrid at bypass and idle was 15-17 dB.

By starting a renewal process, it has become more natural to continue to try other new solutions. Schulstad sees no limit to what can be achieved. The next step for further reducing noise and emissions is probably pure electric power according to Niels Kristian Holm.

2.2 Distribution of fresh bread in Finland

In Finland, Unibake delivers fresh bread under the Vaasan brand. The customers consist of three large food chains with a total of about 3000 stores around the country. Bread is delivered daily from Monday to Saturday. Distribution on Sundays is extremely rare. In total, this means more than 300 delivery days per year.

In total, Vaasan has 5 bakeries in Finland and 4 in the Baltic countries that supply bread in Finland. Distribution takes place through 6 distribution centres covering defined geographical areas. Some types of bread are only produced in one or a few bakeries, i.e. these bakeries deliver via all distribution centres.

Transportation logistics includes 20 large trucks for the inbound logistics (bakery to distribution centre) and approximately 250 distribution trucks (distribution centre for retail). All trucks are owned and operated by private hauliers. There are a few Euro 4 engines in the fleet of vehicles, but the fleet are dominated by Euro 5 and Euro 6 engines. Vaasan's privately owned customers do not require a specific level of Euro class, but customers in public operations require Euro 6 engines.

For in-house logistics, large trucks of 25.25 meters and some with 34.5 meters in length are used in test operations. As of January 2019, Finnish legislation permits 34.5 meters of trucks on the main routes in Finland. These long vehicles enable transition from transport with two 25.25 meter vehicles to one 34.5 meters vehicle when practicable. The reason for this significant savings is that delivery volumes vary between days of the week. Monday and Friday have the most goods, which require two 25.25 meter trucks. The truck, which is 34.5 meters, can handle these peaks and also the lower volume of other days. From a fuel consumption perspective, long trucks are no challenge. Bread is light with large volume which mainly creates volume challenges in the cargo space. Fuel consumption is not a problem since only the weight affects the vehicle's consumption. Thus achieving significant climate benefits

Figure 2.4 The 34.5 meter truck

The major practical challenge with long vehicles is not the national main roads, but the local road network in municipalities, narrow areas around the bakeries and tight roundabouts. For example, in some roundabouts it is only possible to get through in one direction. To get back, the vehicle must take another slightly longer route back.

However, the Finnish government and the Ministry of Transport are very positive about developing the national road network in order to be able to include long and heavy trucks. The challenge lies more on the local road network owned by municipalities with less resource and therefore less willing to adapt roads for longer vehicles. All in all, Hannu Nylander at Vaasan foresees many opportunities to increasingly introduce and use longer trucks

For those plants where long trucks are already in use, the number of vehicles can be reduced by 30%.

During the period 2009 to 2012, Vaasan initiated a general review of its distribution system to save costs. At this time, bread was delivered twice a day. The service level was too high and the new distribution system meant a switch to only one delivery per day during from 2009 to 2012. The result was considerable cost savings and halved greenhouse gas emissions.

The next step in the streamlining process became an initiative to coordinate bread distribution with several players. Collaboration via subcontractors (to handle antitrust law) with nationwide Fazer was established. With the coordination between Fazer and Vaasan of bread distribution, costs and emissions of carbon dioxide could be further reduced.

In addition to more efficient logistics, an ongoing program for energy-efficient traffic operation is ongoing. Among the haulage companies, great focus is placed on energy efficiency through

economical driving programs. The savings vary, but this measure is essential to limit carbon dioxide emissions. Vaasan receives regular reports from hauliers and their vehicles regarding:

- Total km for the period
- Km for Vaasan
- Average fuel consumption per km

Up to now, previously implemented measures to reduce greenhouse gas emissions have coincided with cost savings. Consequently, there have been no major internal target conflicts regarding emission reductions and costs.

In addition to improved efficiency, the development towards more climate neutral transport is driven by the use of more renewable fuels. At present, there are a few trucks in the vehicle fleet running on LNG (fossil fuel), but the expectation is that access to more gas stations with LNG will increase in the country, which should enable the introduction of more LNG-driven trucks. The next step must then be the transition to liquid biogas in the pumps.

The next step to reduce greenhouse gas emissions is the introduction of biodiesel. The fuel is called “My diesel” and is supplied by Neste. The cost is slightly higher for this fuel compared to conventional fuel.

The introduction of new powertrains and renewable fuels will be a test of what climate work can cost. Through past and planned activities, Hannu Nylander is not concerned about the possibility and costs of achieving the Group's overall target of a 70% reduction of greenhouse gases by 2030 for all purchased transports.

3. Environmental and climate work within aviation

Aviation offers fast long-distance services for goods and travellers. Air transport with passenger planes and cargo planes separately, but it is also common to carry goods with passenger planes. Globally, about half of all freight transport takes place by air with a passenger plane. This combination is called "belly freight". The airline's share of climate emissions from domestic transport is 3%. If foreign transport to and from Sweden is included, this share increases.

The conversion to fossil-free aircraft is hampered by the aircraft's high energy use per km in combination with ever-larger aircraft flying long distances. The implication is that in the foreseeable future, climate change can primarily be achieved through the transition to renewable fuels. It is already technically possible today to produce renewable aviation fuel that can be used in existing aircraft engines without technical adjustments. The challenge lies mainly in the lack of access to biomass and the lack of large-scale fuel production.

Electrification of the aircraft may take place, but first in small aircraft designed for shorter distances and with fairly low load weight capacity.

3.1 BRA

With the home base at Bromma Airport, BRA (Braathens Regional Airlines) offers domestic flight services to 14-15 destinations in Sweden. By offering fast and punctual transport, the country is connected through an airborne public transport. BRA flies partly with the Avron jet aircraft, which is

gradually being phased out in favour of the more modern turboprop aircraft ATR. ATR is both quieter and more fuel efficient. In addition, ATR flies at lower altitudes, which means that emissions hardly need to be calculated with the high altitude effects (Radiative Forcing Index)

Figure 3.1. ATR at Bromma Airport. The propellers are driven by turbine engines.

BRA's operations are climate requirements are governed by aviation's part of the EU's emission allowance trading system. This means that carbon dioxide emissions must be reported annually. With changed emission quotas, this requires a need for reduced emissions so that the operating costs of the business do not rise too much. Locally, operations are governed by the fact that airports have regulations for permissible noise levels and thus permitted flight times.

Otherwise, aviation is surrounded by a strong focus on safety through strict governing regulations. This is something that also has an impact on conversion to bio-based aviation fuels. The fuel specifications must meet international requirements to ensure reliable combustion and thus adequate air safety. Reliability requirements are the same regardless of whether the aircraft is powered by the jet A1 fuel, Biojet A1 or later electricity.

In addition to legal requirements, there is a clear trend that customers are starting to set more and more harsh climate and, to a certain extent, environmental requirements on their air travel. A fossil-free aviation business requires a comprehensive restructuring of the business. To enable an introduction of biofuel, BRA's customers can pay a biofuel supplement.

At present, bio-based aviation fuel costs four to five times more than conventional fossil aviation fuel. Thanks to the fuel supplement, BRA can buy enough volume for it to be delivered on a large scale rationally to the airport. Delivery is made to the airport's regular fuel tank where it is mixed with other fossil fuels. This means that all departing aircraft may have access to the fuel. The reason is that refuelling to aircraft must take place in a common way for the entire airport. This ensures security requirements and cost effectiveness at the airport. Initially, biofuel was purchased from California, but now it is purchased from Neste in Finland. In addition to customers' climate requirements, they also question the presence of disposable packaging on board.

The short-term most important climate measure is to implement energy efficiency that reduces the need for aviation fuel. For aviation, the measures include:

- Speed Reduction
- Energy-efficient landing, CDA[1]

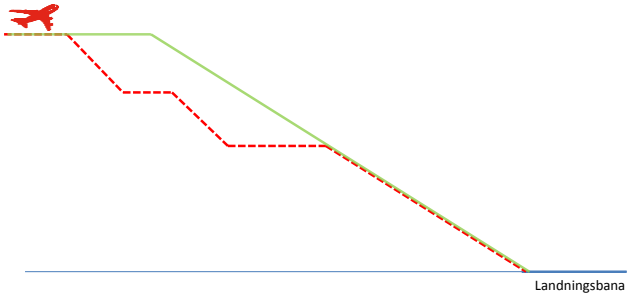


Figure 3.2 Approach for landing with conventional descend in relation to a greater degree of gliding. A prerequisite for a more energy efficient approach is that traffic management and traffic situation allow for such conditions.

- Optimized route, although this can be difficult in prioritizing Arlanda traffic
- Minimize the amount of cargo in the form of optimal amount of fuel. However, this must be weighed against regional price differences in aviation fuel and the need to demand sufficient volumes for maintained service in several locations.

BRA releases about 180,000 tonnes of CO2 per year (ttw). By switching to more efficient turbo propellers, both fuel consumption and emissions are reduced. Furthermore, BRA buys as much biofuel as possible, but this is limited by costs and lack of access. In 2018, BRA purchased 37 tonnes of biofuel whose emissions of biogenic carbon dioxide should formally be counted towards the climate compensation[2]. These represent only a very small fraction of the total emissions. The total emissions of climate are compensated by two wind power projects. BRA compensates for 190,000 tonnes of CO2, which is slightly more than the total emissions[3].

BRA's long-term climate ambitions in relation to official climate targets are to:

2025
Halve the emissions per passenger. The big challenge is to get biofuel coupled with both price and available volumes.

2030 (-70%)
- Offer a fossil-free flight

2045
Zero net emissions where electrification of the flight is available and electric powered aircrafts is part of BRA's aircraft fleet

[1] Continuous descend approach
[2] Ett via Gold standard samt ett via Voluntary Carbone Standard
[3] 2018 var utsläppen 173 000 ton

In order to demonstrate the reduction possibilities that can be achieved through today's technology, BRA presented”The Perfect Flight project". With a full propeller aircraft[4], BRA made a climate-optimized flight between Halmstad and Bromma. The flight was collaboration between BRA, aircraft manufacturer ATR, the suppliers of biofuel Air BP and Finnish Neste. The project also included Halmstad City Airport and Bromma Stockholm Airport.

The flight was carried out with 50% fossil-free biofuel in the tank, an optimized flight altitude, a slower approach, the fastest possible flight route. Through these measures BRA reduces net emissions of carbon dioxide by 46% compared to the same flight with fossil fuels. The example shows that domestic aviation can make major improvements with known technology that reaches the targets for 2030 towards long term targets for 2045.

In order to achieve a comprehensive and systematic climate change of the aircraft, BRA wishes for a national priority on domestic airline restructuring.

[4] ATR 72-600

4. Environmental and climate efforts within shipping

Swedish shipping is part of European shipping that controls over 40 percent of the world merchant fleet. More than 90 per cent of Sweden's trade goes via shipping and shipping employs about 10,000 people on board as well as 100,000 in the entire industry. Swedish shipping's four overall objectives are to…

… Promote growth and competitiveness by making Swedish shipping an important engine for Swedish industry in general.
… Protect the environment in the sea that must be protected and that shipping is a recognized efficient and environmentally friendly mode of transport.
… Develop maritime safety that covers everything from worldwide transport systems to the safety of the individual seaman.
… Conduct research and innovation to achieve the long-term goals of shipping in the areas of safety, climate and the environment.

Concrete environmental ambitions for Swedish shipping are based on goals for a healthier sea and cleaner air.

Cleaner sea issues revolve around:

- Ballast Water Requirements
- Waste and black water which means that the waste, if it is harmful, must be left ashore or burned on board.
- The Baltic Sea has been designated by the IMO as a special area under MARPOL ANNEX IV that prohibits the dumping of toilet waste (black water) from cruise ships when operating the Baltic Sea. However, the ban will not take effect until reception facilities for the waste are in place in busy ports.

Cleaner air issues revolve around:

- Getting the Baltic Sea and the North Sea designated as so-called NECA areas, which has already happened in North America. Within a NECA area, new vessels are required to be equipped with propulsion that reduces emissions of nitrogen oxides by about 80%, compared with 1990. IMO's committee MEPC adopted the NECA regulations in the Baltic / North Sea during the summer of 2017. The rules come into force on 1 January 2021, which means that newly built vessels (keel-stretched) after 1 January 2021 must comply with the NOx Tier III requirements for emissions of nitrogen oxides if they are to sail in the Baltic / North Sea.

In addition to water and air quality, shipping carries out climate work through continuous energy efficiency as well as ambitions to reduce shipping's greenhouse gas emissions. At present, the target is fossil carbon dioxide. Within the IMO, long-term climate targets have been set, which means that, starting from base year 2008, carbon dioxide emissions…

… 2030 decrease by 40% in relation to the amount of goods transported [tonnes]
… 2050 decrease by 70% in relation to the amount of goods transported [tonnes]
… 2050 reduce by 50% total (absolute emissions) from shipping

Shipping's share of climate emissions from domestic transport is 4%. If foreign transport is included, this proportion increases. In the past, domestic shipping reported lower emissions, but in a later

analysis of emissions from domestic and international shipping, it was found that the share of domestic transport emissions in relation to f total emissions was underestimated. This doubled emissions from domestic sea transport.

4.1 Viking Line

Viking Line offers trips, amusement cruises and freight transport to and from Åland. In addition, most of the waste is carried away from Åland by vessels to landfills in Finland and Sweden. In other words, maritime traffic is a necessary prerequisite for daily life in the Åland region, which consists of 6,757 islands connected by road bridges, smaller road ferries and archipelago boats. Maritime traffic to and from Sweden and Finland provides the opportunity to:

- Import and export of goods
- Disposal of waste
- The opportunity for tourists to visit Åland
- Traveling abroad
- Amusement cruises in surrounding waters

From a Swedish perspective, there are similarities with maritime traffic to and from Gotland[5], which is a necessary prerequisite for life on Gotland. The difference is that traffic to and from Gotland takes place with so-called procured traffic financed by the Swedish state. Traffic to and from Åland is mainly financed by the company's own revenues.

The Åland vessels also form part of the Finnish military standby fleet. Furthermore, Viking Line is one of Åland's largest employers. Due to the fact that 5 of the vessels are Finnish-flagged, the company receives back taxes and social security contributions. The same applies to the company's only Swedish-flagged vessels. One ship is registered in Estonia.

Legal environmental requirements for vessels in the Baltic Sea include the Sulphur Directive, which means that fuels must not contain more than 0.1% sulphur[6] since 2015. The Sulphur Directive in combination with upcoming regulations for emissions of nitrogen oxides[7] has been a driving force for the development of vessels powered by liquefied natural gas. The combined effects of such vessels are that emissions of sulphur, nitrogen oxides and particles are reduced significantly.

In Swedish waters, vessels with lower emissions of air pollution receive an environmentally differentiated fairway fees that benefit cleaner ships. Vessels that connect in the harbour for grey and black water[8] as well as cold ironing ships are also charged with a lower port fee.

According to Viking Line, customers primarily ask about the voyage's carbon dioxide emissions. Customers also request information on how the shipping company handles its black water and solid waste. Freight customers want data for calculating their carbon dioxide emissions. Since 1 January 2018, there is a requirement that all vessels exceeding 5000 gross tonnage for journeys to or from ports within the EU must measure, report and verify their CO2 emissions. The regulatory framework for reporting carbon dioxide emissions from the EU is called Monitoring, Reporting and Verification

[5] Denmark has a similar situation with Bornholm
[6] Road traffic within the EU states maximum 10 ppm (0.0001 %) Sulphur
[7] NECA, nitrogen emission control area
[8] Sewage water

(MRV). Perhaps the most difficult, or at least unclear, question is how these emissions should be distributed (allocated) between travellers and goods. Currently, three principles are allowed as long as these do not change over time.

Allowed allocation principles

- Weight of passengers and goods
- Use of tire surface and car tires distributed according to vehicle length
- Use of tire surface and car tires distributed by weight on vehicles

	Mass allocation	Area-length allocation	Area-mass allocation
Operation	Ratio	Ratio	Ratio
Freight	72,63%	4,95%	10,66%
Passenger	27,37%	95,05%	89,34%

Figure 4.1 The above matrix describes various methods for allocation on a typical RoPax vessel. Method choice leads to large differences in emissions per passenger and freight unit.

Before the election and investment in new propulsion technology for Viking Grace, Wärtsilä presented two solutions. Either conventional solution with bunker oil (HFO) or a solution based on liquid natural gas in a Dual fuel technology (DF). The outcome was clear that emissions of sulphur dioxide, nitric oxide and particles would decrease by using LNG. Carbon dioxide was also estimated to decrease. If all the greenhouse gases are included, there is an uncertainty about the climate benefit. However, LNG vessels are leaking some unburned amount of methane gas with a significant impact on the climate.

Annual	DF	HFO	
Fuel energy	251 896	258 345	MWh
Engine energy	119 586	119 559	MWh
NOx	163	1 362	ton
SOx	0,011	451	ton
CO2	50 674	70 297	ton
CH4 slip	390	24	ton
CH4 as CO2 equivalent (x 25)	9 752	598	ton
Particles	9	57	ton
Total CO2 equivalent (CO2 + Methane x 25)	60 427	70895	ton
Relative CO2 equivalent	85 %	100 %	

Figure 4.2 Wärtsilä's analysis showed that the alternative with Dual Fuel was preferable from an environmental perspective, but also from a climate perspective. Recent analyses have shown that methane emissions can be underestimated according to IVL. The strongest reason for the introduction

is to meet legal requirements for emissions of sulphur dioxide and also to meet future requirements for emissions of nitrogen oxides.

In order to meet an expected increase in climate requirements, Viking Line also analyses how climate compensation can be a possible solution. Three analyses in other countries have been included in the analysis work, but the intention is for the compensation to take place closer to one's own market. An alternative is to offer customers the opportunity to offset and reduce their travel's emissions of greenhouse gases by purchasing a certain amount of biogas used on Grace. This is regardless of which Viking Line ship the biogas sponsor is traveling with[9]. This would work as green electricity where organizations buy a production-specific share of electricity.

The Åland Provincial Government also analyses the possibility of making Åland fossil-free, which is considered very challenging. For Åland, with its large dependence on shipping, such a strategy would mean a particularly tough change, as there are currently no comprehensive biofuel-based solutions available.

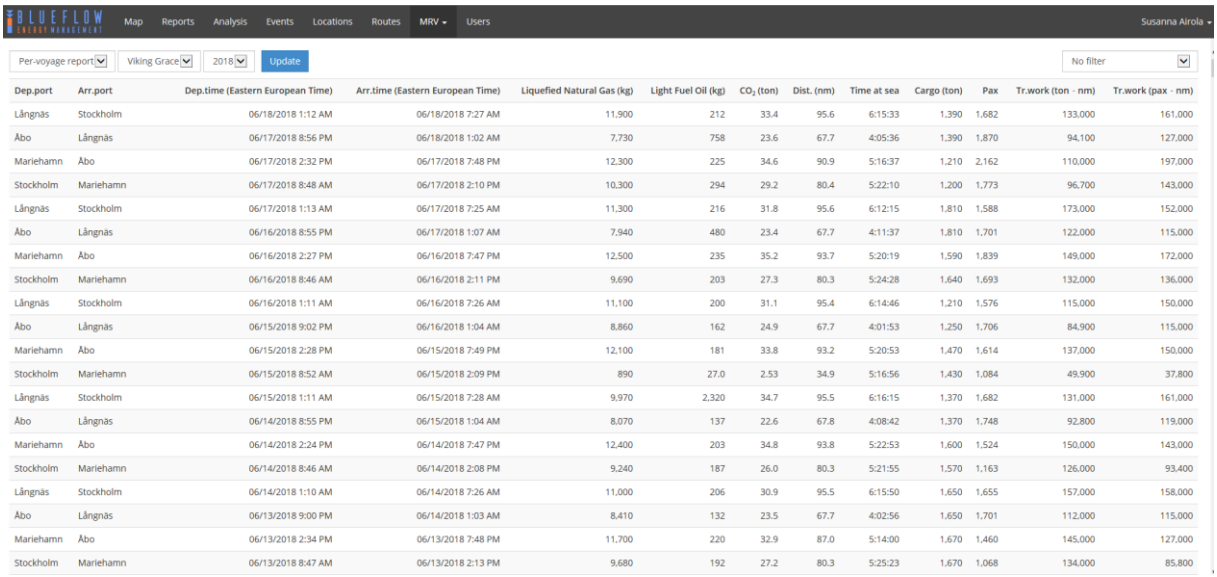
The technical energy carriers that Viking Line considers most reasonable are:

- Biodiesel (FAME and HVO), which, however, is considered to be expensive
- Liquid Biogas (LBG)
- Electricity batteries for shorter distances and energy storage
- Hydrogen with fuel cell for generating electricity
- Methanol

Companies and some other organizations work together in a sustainability network in Åland. This network discusses how biofuel purchases could be coordinated and thus increase availability, which is currently low. One conclusion of lack of access to biofuels is that measures to reduce fuel consumption are the first important measure.

For Viking Line, legal requirements for shipping within the EU on fuel follow-up with reporting have resulted in a significantly improved follow-up of consumption. Viking Line uses a system called Blue Flow for its reporting.

[9] Compare with BRA in section 2 as well as Finnair and KLM that offers biofuels for different routes: https://www.finnairshop.com/en/sustainability-products



Dep.port	Arr.port	Dep.time (Eastern European Time)	Arr.time (Eastern European Time)	Liquefied Natural Gas (kg)	Light Fuel Oil (kg)	CO_2 (ton)	Dist. (nm)	Time at sea	Cargo (ton)	Pax	Tr.work (ton - nm)	Tr.work (pax - nm)
Långnäs	Stockholm	06/18/2018 1:12 AM	06/18/2018 7:27 AM	11,900	212	33.4	95.6	6:15:33	1,390	1,682	133,000	161,000
Åbo	Långnäs	06/17/2018 8:56 PM	06/18/2018 1:02 AM	7,730	758	23.6	67.7	4:05:36	1,390	1,870	94,100	127,000
Mariehamn	Åbo	06/17/2018 2:32 PM	06/17/2018 7:48 PM	12,300	225	34.6	90.9	5:16:37	1,210	2,162	110,000	197,000
Stockholm	Mariehamn	06/17/2018 8:48 AM	06/17/2018 2:10 PM	10,300	294	29.2	80.4	5:22:10	1,200	1,773	96,700	143,000
Långnäs	Stockholm	06/17/2018 1:13 AM	06/17/2018 7:25 AM	11,300	216	31.8	95.6	6:12:15	1,810	1,588	173,000	152,000
Åbo	Långnäs	06/16/2018 8:55 PM	06/17/2018 1:07 AM	7,940	480	23.4	67.7	4:11:37	1,810	1,701	122,000	115,000
Mariehamn	Åbo	06/16/2018 2:27 PM	06/16/2018 7:47 PM	12,500	235	35.2	93.7	5:20:19	1,590	1,839	149,000	172,000
Stockholm	Mariehamn	06/16/2018 8:46 AM	06/16/2018 2:11 PM	9,690	203	27.3	80.3	5:24:28	1,640	1,693	132,000	136,000
Långnäs	Stockholm	06/16/2018 1:11 AM	06/16/2018 7:26 AM	11,100	200	31.1	95.4	6:14:46	1,210	1,576	115,000	150,000
Åbo	Långnäs	06/15/2018 9:02 PM	06/16/2018 1:04 AM	8,860	162	24.9	67.7	4:01:53	1,250	1,706	84,900	115,000
Mariehamn	Åbo	06/15/2018 2:28 PM	06/15/2018 7:49 PM	12,100	181	33.8	93.2	5:20:53	1,470	1,614	137,000	150,000
Stockholm	Mariehamn	06/15/2018 8:52 AM	06/15/2018 2:09 PM	890	27.0	2.53	34.9	5:16:56	1,430	1,084	49,900	37,800
Långnäs	Stockholm	06/15/2018 1:11 AM	06/15/2018 7:28 AM	9,970	2,320	34.7	95.5	6:16:15	1,370	1,682	131,000	161,000
Åbo	Långnäs	06/14/2018 8:55 PM	06/15/2018 1:04 AM	8,070	137	22.6	67.8	4:08:42	1,370	1,748	92,800	119,000
Mariehamn	Åbo	06/14/2018 2:24 PM	06/14/2018 7:47 PM	12,400	203	34.8	93.8	5:22:53	1,600	1,524	150,000	143,000
Stockholm	Mariehamn	06/14/2018 8:46 AM	06/14/2018 2:08 PM	9,240	187	26.0	80.3	5:21:55	1,570	1,163	126,000	93,400
Långnäs	Stockholm	06/14/2018 1:10 AM	06/14/2018 7:26 AM	11,000	206	30.9	95.5	6:15:50	1,650	1,655	157,000	158,000
Åbo	Långnäs	06/13/2018 9:00 PM	06/14/2018 1:03 AM	8,410	132	23.5	67.7	4:02:56	1,650	1,701	112,000	115,000
Mariehamn	Åbo	06/13/2018 2:34 PM	06/13/2018 7:48 PM	11,700	220	32.9	87.0	5:14:00	1,670	1,460	145,000	127,000
Stockholm	Mariehamn	06/13/2018 8:47 AM	06/13/2018 2:13 PM	9,680	192	27.2	80.3	5:25:23	1,670	1,068	134,000	85,800

Figure 4.3 Excerpts from Blueflow that enable immediate monitoring of the vessels' fuel consumption in order to report but also optimize propulsion.

Within the Viking Line, the Eco shipping program has been going on for a long time with the goal of improving energy efficiency. Measures include:

- The staff's knowledge and behaviour with regard to energy use
- Road selection and speed adapted to operational conditions
- Adjustments to timetables
- Continuous on-board energy use monitoring, which is seen as a natural part of the business
- Technical upgrades (e.g. streamlining of ventilation systems on vessels, modification of Gabriella's stabilizing outriggers (sponson), etc.)

Viking Grace is powered by electric motors that are powered by four LNG powered generators. For lower speeds with lower power requirements, only two generators are used. In open waters, power outputs are increased and three generators are used. The fourth generator provides additional power if needed, but primarily adds security. The ship never has less than two generators running, although one would suffice. The reason is that for safety reasons there must always be two parallel operating options. An alternative to the second generator would be a larger battery that could replace LNG combustion for limited distances and redundancy.

There is a continuous energy-saving program on Viking Grace. It includes everything from energy recovery in the ship's lifts to electricity recovery to the excess heat of the ship's machinery. All possibilities are investigated and tested if they are deemed viable. In 2018 and 2019, the vessel has been equipped with a rotor sail with the aim of reducing fuel consumption for the ship's progress by 3-5%.

Fig. 4.4 The rotor sail based on the so-called Magnus effect.

Unfortunately, the expected reduction in fuel consumption seems to have been difficult to measure hence the rotor sail is difficult to get profitable, probably because the many different directions of the fairway.

During the entire life of the vessels, a continuous process is ongoing to make them more energy efficient. However, it is becoming increasingly expensive to make older ships more energy efficient. This means that a substantial part of the energy efficiency consists of new modern vessels. Viking Grace when launched and put into traffic was essentially more energy efficient than her predecessors. By 2020, the latest addition to the fleet will be launched, which is estimated to be 20% more energy efficient than Grace.

In addition to progress with LNG, Viking Line has tested fuel cells at Mariella for power supply to various support systems. However, the technology did not have a sufficiently reliable function. The fuel cell proved to be very sensitive to vibrational operating environments, which is characteristic of vessels. Towards the end of the testing period, the technology began to work better after extensive adjustments. For now, however, fuel cells are not used on any vessel.

Viking Grace has an unusual system for recovering food and food waste that is collected for biogas production onshore. Liquid biogas is not yet used for Grace due to lack of access, but there are no technical concerns for such use.

Viking Line also has a wholly owned bus company that runs entirely on biodiesel. Today's supply covers the whole need, but there is some uncertainty about the content of palm oil.

Viking Line's new ship delivered in 2020 and will be operated by LNG. The planned rotor seal is doubtful considering previous experiences at Grace.

In the future, Viking Line is evaluating several different renewable fuels, but biofuels are still not considered profitable and few customers who want to pay extra for this. Here, legislators play an important role in the transition. With more expensive renewable fuels, policy instruments and a reduction obligation are required from the authorities that are driving the development in the right

direction. The assessment is that fuel costs will increase and therefore contributions are also requested during such a conversion.

Challenges in the short term 2025

- Possibility to buy liquid biogas (LBG)
- Clarification of allocation between passengers and goods for valid comparisons between traffic types and transport companies. The issue must continue to be clarified for fair comparisons
- Assessment of methane emissions from LNG of approximately 15% - 20% is data from engine supplier Wärtsilä. According to Erik Fridell at IVL, emissions are rather 20% - 25%. Given the large climatic impact of methane, this is something that needs to be clarified with more and more ships powered by methane. IMO has also highlighted the need to clarify the issue of methane emissions at the industry level.
- Continued energy efficiency improvement of older vessels (in the continued work it will be increasingly challenging both financially and technically)

Challenges in the medium term 2030

- The availability of alternative fuels;

Long-term challenges in 2045

- Uncertain about this long time horizon

4.2 ForSea

The ferry link between Helsingborg and Helsingör is an essential regional transport service that connects the region's residents in two countries. About 4 million people live in the Öresund region. The aim of the ferry connection is to make it a reliable, fast, comfortable and secure connection.

ForSea's ferry connection between Denmark (Helsingör) and Sweden (Helsingborg) is part of the European road network (E47 / E4). Ferry services take place 7 days a week, 24 hours a day with departures every 15 minutes during the day. On an annual basis, 7 million people and 1.3 million cars and 453,000 trucks travel with these ferries. The traffic is operated by four vessels, which together make 50,000 trips per year. Two of these vessels operate 24 hours a day and the other two for more frequent daytime.

The transport time across the strait is 20 minutes and the port time is 8-12 minutes. This gives a total turnaround time of the vessels of 1 hour. The ferries maintain a speed of 10-11 knots outside the port areas

In addition to shipping's general environmental requirements regarding fuel, waste management etc., the Port of Helsingborg has a specific agreement with ForSea that gives the shipping company an incentive to have a catalyst on ferries with internal combustion engines. The catalysts have been installed since 2006 and they minimize emissions of nitrogen oxides. In the early 1990s, low-sulphur fuel was introduced for ferry traffic, which reduced sulphur dioxide emissions. This also meant that the emission of particles could be reduced significantly. In Helsingborg, there have been problems with environmental quality standards that have been exceeded, which was the basis for the environmentally differentiated port fee. At the same time, the more extensive passing maritime

traffic has probably had a greater impact on these emissions and problems with environmental quality standards. In Helsingörs harbour, there are no environmental requirements on the ferries, but the majority of the harbour is owned by the shipping company itself.

In 2016/2017, two of the ferries were rebuilt for pure electric operation and officially put into service on November 9, 2018. To make the ships working smoothly meant extensive tuning and has taken time. When the first Tycho Brahe vessel went into operation on June 20, 2017 she was fully in operation in November 2018. When the project was launched, there were no batteries, charging infrastructure with charging connections. Everything has evolved gradually. The driving force has been the company's strategic conviction that electric power is the future solution for this type of short-distance sea traffic.

Figure 4.5 Aurora in the Sound between Denmark and Sweden

Discussions on electric power supply with batteries started in 2014. The aim of these discussions was a ferry connection with zero emission vessels. Finally, the work came to include two vessels with pure electric power. According to the shipping company, the discussion of an intended fixed link between Helsingborg and Helsingör did not force them to the investment. Nor has competition with the bridge between Malmö and Copenhagen (Dragör) affected the shipping company's investment plans.

Since the vessels with electricity supply from the battery were put into operation, the emissions of CO2 have decreased significantly in traffic across the strait. In the first quarter of 2019, emissions were reduced by 50%. For total traffic, the goal is to reduce emissions by 65%. The reason for this great potential is that the two electrically powered vessels are the ones operating around the clock.

Figure 4.6 Battery pack on board with extensive control technology for optimized use

The operating economy is better with the electrically driven vessels compared to the ferries with conventional propulsion with internal combustion engines. However, a total investment of SEK 300 million should be added to this. Although the company has received support of SEK 120 million from the "INEA - Executive Agency for Innovation and Networking", the investment is still large and surrounded by a number of unknown factors. Various large-scale uncertainties for the investment included different scenarios in the 20-year perspective regarding:

- Long term development of oil prices
- Long term development of electricity prices
- The development of batteries

The ferries equipped with batteries were initially built in 1991 and 1992 and optimized for traffic with diesel electric propulsion. They were rebuilt over seven weeks to then undergo a comprehensive test program that was partially done in the running business.

The company's own life cycle analysis show that, from an environmental perspective, an electrified ferry connection is a significantly better alternative when crossing the Sound, than the fixed bridge connection between Copenhagen and Malmö. This analysis was based on a comparison of a transport from Helsinborg to Copenhagen via Helsingör with current ferries with battery and diesel or by road via the bridge. To date, customers have not been particularly motivated to achieve the significantly lower emissions that the business has today.

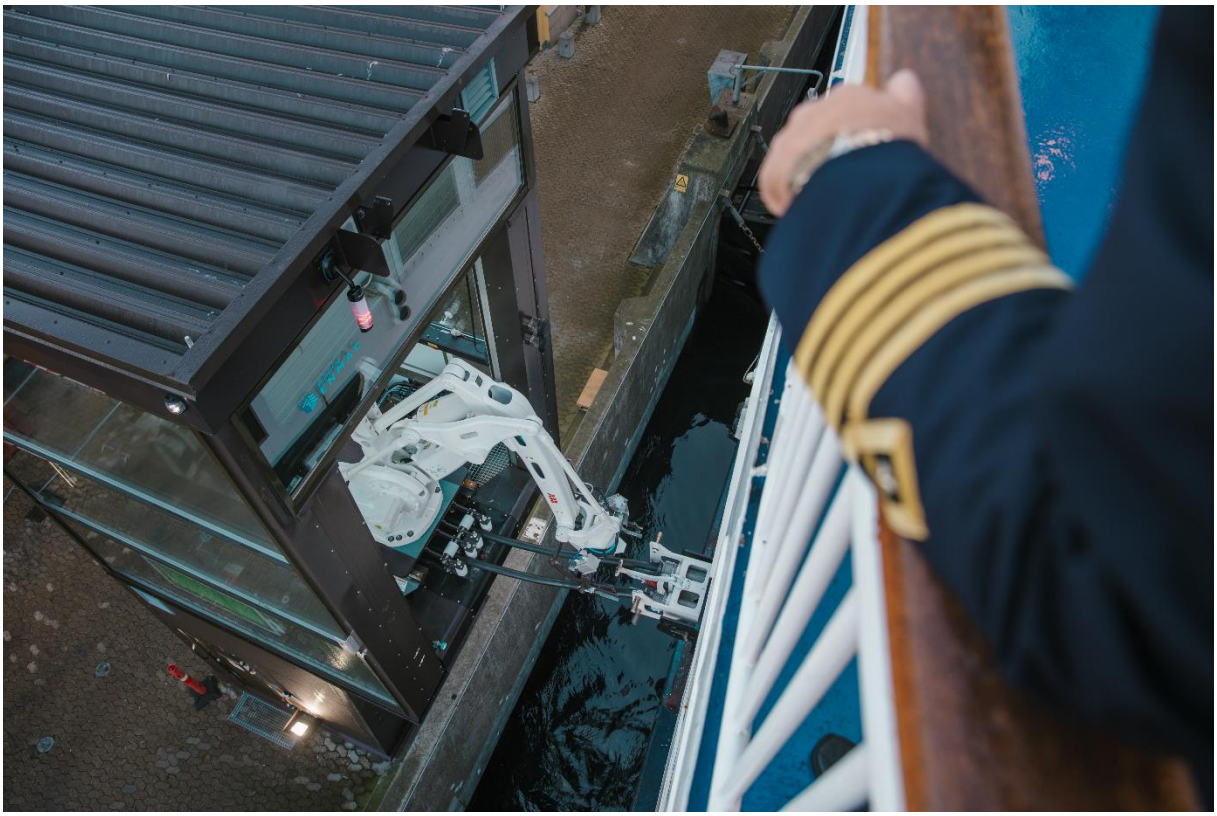


Figure 4.7 Robot for quick and automitic electric charging

The shipping company believes that it is always possible to improve energy efficiency and continuously runs a systematic energy saving program with an energy saving group that works year-round to find opportunities for improvement. In 2018, ForSea succeeded in reducing energy use by 7,260,000 kWh, and another 800,000 kWh has been identified for 2019. Of the total amount of energy use, approximately 35,000,000 are kWh from renewable primary energy, including green electricity. In order for the energy savings to become a natural part of the crew, “Eco Driving” is stimulated by the system Blueflow being installed in all vessels, which provides continuous real-time feedback on how energy efficient the ship is moving. This measure is expected to reduce consumption by 2-3%. The system includes total energy use but differs in progress and other energy use. In order to proceed with the electrification of remaining vessels, an incentive model with lower fees is required to make this investment on strict commercial terms. The switching costs are large as there are no standard rules for vessels with battery operation. These must be developed on their own to meet all requirements set by the IMO. A limiting factor for continued electrification is the length of the traffic agreement for ferry traffic, which runs until 2029. Delivery time for new vessels is four years, which means that the remaining time for repayment will only be about six years if the order is placed immediately. This gives a too short payback time for such a large investment. Furthermore, new shipping charges have been introduced in Sweden based on CSI. With the new fairway fee principles, the shipping line's fees have increased from SEK 17 to 31 million per year. This is despite the fact that the shipping company never has had a "cleaner" business. However, it should be pointed out that if the shipping company had not introduced the battery operation on 2 vessels, the cost increase would have been another 2 million greater. All in all, continued investments in electric power are difficult to justify under these conditions. At the same time, the company's aim is to be completely emission-free. Future goals for the shipping company are:

2024

The business will soon have reached the targets of reduced emissions by -70% (baseline 2017)

2030

Two remaining vessels from 1987 and 1997 have been converted to emission-free vessels (TT) or replaced by new emission-free vessels. However, the incentives for investment must be strengthened in the form of reduced port fees and fairway fees.

2045

The business has zero net emissions of greenhouse gases

4.3 Stena

The Stena Group consists of several different operations where shipping accounts for approximately 50% of the Group's turnover. Of shipping operations include:

- Stena Line 40 ferries operating in Europe
- Stone bulk that operates 120 tankers
- Stone drilling that has four drilling vessels and 2 oil rigs
- Stena RoRo, which offers ship services after calls internally and externally
- Stone technology that offers internal consulting services in the development of vessels and shipping operations

Stena's technology consists mainly of 20 shipbuilders who, with their expertise they drive the Group's development of shipping. In the past, this type of internal competence was common in most shipping companies, but today this function is only available in a few shipping companies. Stena believes that the shipbuilding yards do not drive the development of tomorrow's ship structures sufficiently forward-looking. With his own expertise, Stena can make clearer demands on shipyards and engine developers.

Currently, Stena is building nine new ferries in China, which occupies much of Stena's technology pooled resources. In addition to purely technical support, Stena technology also follows and influences shipping's international regulatory development, primarily in the IMO[10], but also in the EU.

In the short term, the most important measures are a focus on energy efficiency, which according to Stena Line means that the IMO's climate goals by 2030 will most likely be achieved. Today's new vessels are 30-35% more energy efficient than vessels from the late 1990s. In addition, Stena has been running a very active energy efficiency program for daily operations for over 15 years.

The most important parameter for reducing energy use is a reduced speed. For the timetable controlled ferry traffic this is difficult. The trip from Gothenburg to Fredrikshamn takes 3 hours

[10] International Maritime Organizarion, www.imo.org

and 15 minutes, adding 45 minutes in port. To speed up to six trips per day, the speed cannot be lowered. The number of trips is an economic prerequisite for traffic.

Another example is the Gothenburg to Kiel route. Previously, this traffic was operated by four vessels, but today there are only 2 vessels, which create scarce time margins. At the same time, overall energy use has been reduced thanks to fewer vessels.

Meeting customer requirements for accessibility is guiding and the ordinary consumer rarely sets specific environmental and environmental requirements. Professional transport buyers (goods) usually make demands via trade associations[11]. However, these requirements are relatively constant and are relatively easily reached.

The ferry traffic's energy challenge, in addition to speed, is that the vessels also offer a hotel business that uses significant amounts of energy. RoRo[12] and RoPax[13] mean that the cargo weight is relatively low in relation to the ship's load capacity. The number of tires for passengers and vehicles represents a significant volume requirement. This means that a RoRo vessel has approximately the same climate performance as a modern truck per transported amount of goods. The advantages of shipping in this context are that it can travel more directly to other countries and reduce transport distances. It also offers rest times for drivers.

A comparison of emissions per ton of goods between a car ferry (RoRo/RoPax) and one of Stena Bulk's vessels clearly shows the climate benefits per ton for bulk shipping.

Stena's technical energy efficiency in maritime operations means a continuous review of:

- The speed of the vessels
- Consumers on board (pumps and fans)
- Hull design and continuous cleaning
- Replacement of propellers suitable for speeds and other conditions
- New bulbs that minimize water resistance. Since the energy efficiency became more systematic, 10 bulbs have been changed on ships
- New more energy efficient rudders
- Machine learning to establish smart vessels that can advise crew on ongoing optimization that can save up to 10% fuel consumption.

In total, energy use has decreased on average by 2.5% per year since the program was started.

IMO's climate goals for 2050 are deemed difficult to achieve and these will require a transition to renewable fuels. As part of Stena's own environmental and climate goals, Stena technology monitors developments in future fuels for shipping. The Group's main development paths in renewable fuels consist of:

[11] Exempelvis Clean Shipping Index
[12] Roll On Roll Off
[13] PAX refererar till passagerare

- Methanol for long distances that require large amounts of energy on board. This is being tested today on a machine at Stena Germanica. The methanol comes from natural gas but can be produced from raw material. The disadvantage of methanol is that it has lower energy content and therefore higher volumes are required. In the engine combustion the same efficiency is obtained as for conventional bunker oil. Operation with methanol works technically well, but unfortunately the price has increased since the trial began.

- Electricity for shorter distances (up to 50-60 nautical miles) is assessed realistically. The balance for electric power is the weight of the fuel/engine in relation to a system with battery / electric motor. To begin this development, Stena is conducting a research project aimed at them

The charge hybrid is developed and installed on the vessel Stena Jutlandica, which operates in Gothenburg and Fredrikshavn traffic. Stena Jutlandica has a capacity of 1500 passengers and 120 trailers or 550 cars.

Figure 4.8 Battery pack on Stena Jutlandica's deck

The aim of the project was to develop three main system functions:

1. Drive bow thrusters with power supply from battery
2. Eliminate on-board consumption peaks while walking
3. Increase safety in local waters by providing a standalone auxiliary engine that reduces the risk of "black-out"

The project has been able to report all three system functionalities

- Bow thrusters require a power output of 3MW which requires powerful cabling and cooling. To ensure safety on board, batteries were placed in a container on deck to handle risks of powerful heat generation and fire risks. The system is also externally verified and classified as secure and robust.

- The 3 MWh energy storage with a power of 3 MW could handle the ship's bow thrusters and manoeuvring in port. Previously, this was done with three generators. Today, a generator and

battery are used and the operation requires about 300 kWh. After the operation, approximately 65% of the battery capacity remained. To ensure a long battery life, the lowest level of batteries has been set to 55%. In other words, the project was able to achieve this level by a margin.

- In the past, operation of bow thrusters via generators has required some advance planning. With power from the battery, the power comes immediately, which means that generators do not have to be started prematurely.

- Cutting consumption peaks has also worked with the support of the battery storage. This has required a modification of the ship's power management system in relation to generators.

- The battery storage has also worked as a "back-up" for unexpected downtime. After the installation of the system, a stop on open water occurred that the crew did not notice at all, as all electric power could be immediately taken from batteries. This type of system increases safety at sea.

- With the charging hybrid, fuel consumption could have been reduced by about 150 kg of fuel per trip. Savings have also increased over time. Furthermore, future charging shore land electricity in Fredrikshavn will further increase the savings when this is completed. All in all, 150 kg of fuel per roundtrip means a saving of 240 tonnes of fuel per year. After adjusting the current solution, the target is 200 kg of fuel per roundtrip. With charging in Fredrikshavn, an additional saving of 100 kg of fuel is expected. This would mean that the project's fuel saving target of 300 kg per roundtrip, corresponding to a reduction of 1500 tonnes of carbon dioxide per year can be achieved.

5. Environmental and climate efforts within road transport

The infrastructure for road transport is, by international standards, well developed with major roads included in the European road network and national and municipal road networks. In Sweden, freight transport is permitted on vehicles with a maximum gross weight of 64 tonnes for roads with load class 1. For some road sections with load class 4, a gross weight of 74 tonnes is allowed. Test operations are also ongoing with longer vehicles of about 34 meters, whose gross weight rarely exceeds 64 tonnes. The possibility of developing more road sections for heavier and longer vehicles is something that is currently being investigated and developed.

Thanks to the fact that larger vehicles are allowed and a tradition of co-loading goods, Swedish long-distance road transport is relatively resource-efficient in an international comparison. Furthermore, Sweden has two of the world's leading manufacturers of trucks, which makes Sweden one of the test platforms for new technical truck solutions.

The introduction of various renewable fuels has also been tried in smaller and more large-scale operations. Since July 1, 2018, Sweden has introduced a so-called reduction obligation for diesel fuel, which means that in 2019 all sold diesel fuel will reduce greenhouse gas emissions by 20%. This is achieved by mixing bio-based diesel from FAME / RME and HVO. Previous tax reductions for biodiesel have been removed and fuel suppliers that do not meet reduction requirements suffer from financial penalties. As a consequence, the cost and thus the sale of pure HVO dropped significantly. In addition, PFAD[14] is no longer considered a residual product, which means that it requires traceability

[14] Betydande råvara för HVO-produktion som är en restprodukt från palmoljeproduktion

all the way to cultivation. This is difficult at present, thus this raw material for HVO falls dramatically. In 2017, 39% of HVO was produced based on PFAD.

Domestic road traffic accounts for 29% of the total national emissions of greenhouse gases. Of these, truck traffic accounts for about 9% (31% of road traffic emissions).

The trend for truck transport is that emissions increase after several years of decline. The reason is that the blend in of biofuels decreased along with increased heavy traffic. The proportion of lighter trucks has increased, which is partly due to an increase in on-line commerce. Emissions from lighter trucks have decreased marginally.

Upcoming challenges for road transport are to establish long-term access to biofuels and to start truck electrification. The biofuel that seems to be most robust is biogas if sufficient quantities can be produced. The electrification is likely to include hybrids, clean electric drive with battery and fuel cell, and electric roads. Electrification involves several challenges. How should electricity be produced? How to secure power outlets? How should distribution be made possible in electricity grids and charging stations? Much indicates that this transition will take time.

In addition to energy and climate challenges, the haulage industry suffers from a lack of drivers, which limits the growth of the industry.

5.1 Alfredsson transport

Alfredsson Transport is a family-owned haulage company that was started in 1937 and is today run by the third generation of the Alfredsson family. The Group currently has about 100 employees and the company runs all types of transport throughout Europe using courier trucks to large heavy duty long distance trucks. Par load and full loads with long-distance trucks make up the bulk of the transport, including in timetable traffic to Norway.

In 2012, the Alfredsson ended its long-standing exclusive collaboration with DHL on the Norway traffic services and now offers transport services directly to customers. Sales have doubled since then, partly due to the fact that the experience and satisfaction of direct contacts with transport buyers increased the job satisfaction in the business. Today, 65% of the company's turnover is transport purchasing companies that buy the transport services directly. Other sales derive from DHL's local and regional traffic for less than truckload goods and packages of about 30 trucks. Alfredsson's goal is for customers to experience that the haulage company supplies its services with environmental considerations, good quality and a personal commitment.

The business is subject to few legal environmental requirements. The most significant are the requirements for environmental classification of engines in the environmental zones in Stockholm and Oslo.

The internal systematic environmental work was established in 2006 and was challenged for the first ten years as neither the clients nor the authorities requested the efforts. In recent years, the climate interest has exploded, and the haulage industry believes that it is now rewarding for all previous wear and tear.

Energy efficiency is the area that has always been the focus of environmental work. It has always been value-creating as it lowers the haulage's operating costs. Significant progress has been achieved by aligning with aerodynamics experts at Linköping University. Together with Linköping University, the haulage company has developed five concept trucks with a focus on minimizing fuel consumption through, among other things, better aerodynamics. For an MB Sprint, consumption was reduced from 1.4 litres / mile to 0.75 litres per mile.

In their contacts with Volvo, they have now full attention where they provide support about the vehicle's aerodynamic optimization. One reason may be that Volvo's vehicles have consumed a little more fuel than their competitors, but with a systematic effort to improve the entire vehicle combination aerodynamics, great progress has been achieved. The support from Volvo together with the collaboration with aerodynamics professor Matts Karlsson has led to significantly lower fuel consumption. In long-distance transport, consumption has been reduced by 3 dl / mile, which is an average of 6-10% savings.

During the development of increased energy efficiency, progress in many areas have been achieved at the same time as some negative side effects have arisen which could later be resolved:

- Difficult noise problems arose in an aerodynamically optimized vehicle which required drivers to use hearing protectors to stand the noise. Only after the installation of special airflow strips did the noise disappear.

- A catalyst caught fire when it did not get enough cooling because the space between the truck and the cabinet was made too tight to avoid turbulent air flow

According to the haulage system, the systematic work for increased energy efficiency includes several measures that must be constantly reviewed and refined. In summary, this means that:

- Custom configuration of vehicles for transport needs

- Resize engine. Often trucks for large engines have the risk of increasing consumption, which also increases weight and leads to increased tire wear. "We have no truck with more than 500 horse power"

- Logistics and degree of filling are essential to create benefits with the kilometres that are being driven

- Customize the tires, which can mean a difference of 6 percent consumption

- Drivers have the biggest impact for us. It distinguishes 17% between best and worst driver

- With the current intelligent driver support, it is becoming very difficult to beat the truck's own ability to save fuel. However, the systems are not mandatory yet, which means that the outcome varies.

- The haulage company has tested two trucks with software that enables a "strangled" power outlet, which saves fuel. Drivers in the haulage industry have not been informed of this action. So far no driver has complained!

- A contradictory dimension of energy efficiency measures to remain an attractive employer is to equip trucks with some comfort-enhancing equipment. It is difficult to find the right drivers with a genuine interest in the profession. Therefore, to attract new employees, a little extra equipment is required. Here is a challenge to attract the next generation to the profession where the current demands on new employees can be perceived too much of a burden.

In order to reduce emissions of GHG, Alfredsson's previously used HVO 100 as a fuel. When the law on reduction was introduced this possibility disappeared. The main part of the fleet is therefore driven with conventional diesel which meets the requirements under the reduction obligation. In addition to this, the reclassification of PFAD[15] from residual product to conventional product means reduced climate benefit with HVO which mixes PFAD.

As a consequence of this, together with financial support from the climate community of SEK 240,000 per truck, Alfredsson's transport has invested in five long-distance trucks from Volvo that are powered by liquid bio methane gas (LBG[16]). One of the vehicles is a 25.25 meter long-distance truck for the haulage's Norway traffic with an average gross weight of 45-50 tonnes. On average, it consumes about 2.8 kg of liquid methane gas per mile and 0.1 litres / mile HVO 100. Additional cost LNG vehicles are SEK 500,000 and the subsidy, in other words, covers part of the additional costs.

Figure 5.1 LBG driven truck in the traffic to Norway

Perhaps the most important financial prerequisite for more extensive conversion of vehicles with liquid biogas is that customers are prepared to enter into long-term agreements. At least five years provide the conditions for a successful transition. The fact that some customers work with one-year agreements makes it impossible to invest in new technology and to optimize its use. In addition to

[15] PFAD (Palm Fatty Acid Distillate) is a feed stock in HVO production being a rest product in food industry production of palm oil. From July 1 2019 PFAD is classified as a regular product; hence need to include all emissions from production and distribution. This is in line with classification of RME.

[16] Liquefied Bio Gas

long-term economically sustainable calculations, it is required that the fuel supply can be secured in the long term. Too many attempts with renewable fuels have stopped the necessary conditions being eliminated by political decisions.

Max gross weight	64	ton
Max cargo weight	44	ton
Load factor	70%	%w
Cargo	31	ton

	Fuel consumption	Unit	CO2e wtw	Unit	CO2e wtw	Unit	CO2e wtw	Unit
Truck baseline desel Mk1 b7	0,4	[l/km]	2,67	[kg/l]	1069	[g/km]	35	[g/tkm]
Truck diesel Mk1 b20* (reduction quota)	0,4	[l/km]	2,19	[kg/l]	877	[g/km]	28	[g/tkm]
Truck HVO 100*	0,405	[l/km]	0,99	[kg/l]	401	[g/km]	13	[g/tkm]
HVO 100 for ignition in LBG**	0,009	[l/km]	0,99	[kg/l]	9	[g/km]	0,3	[g/tkm]
LBG***	0,32	[kg/km]	0,72	[kg/kg]	232	[g/km]	8	[g/tkm]
Total truck with LBG***					241	[g/km]	7,8	[g/tkm]

Source fuel data: www.transportmeasures.org

** Based om recalssification of PFAD den 1/7 2019. Depending on ILUC the data can be higher*

*** Needed for the ndiesel engine ignition*

**** According to dialogue with Volvo there is no methane slip. This may vary between different OEM´s. Emissions of methane increases CO2e substantially*

Figure 5.2 Estimation of relative climate gains based on NTM data. (www.transportmeasures.org)

Thanks to the systematic environmental work, Alfredsson has improved his credibility among transport buyers who want long-term sustainable road transport services. An increasing number of potential customers with climate ambitions are therefore turning to the haulage company with inquiries.

In order to further strengthen the credibility of the improved results achieved, Alfredsson's transport and Malmö LBC participate in a development project aimed at including progress and adversities in the companies' ongoing environmental work in the regular follow-up of operations and in the company's external accounts that are audited through external auditing. The method builds Quality Function Deployment (QFD) where the goal is to quantify a target level and to make its own progress against it. In this way, company management can follow developments in the environmental field. The project is ongoing and results will be published later. Contacts in the project are Peter Cronemyr and Maria Huge-Brodin at Linköping University.

The fuels that Alfredsson's transport is likely to drive the trucks of the future are:

- Liquid Biogas (LBG)
- Electricity
- Hydrogen in the longer term

Some time ago, the haulage company received an assignment that included intermediate storage of chilled products and a warehouse was rebuilt with insulation and refrigeration plant. The cooling plant is operated with liquid carbon dioxide. Electricity for the control of a cooling system and the premises lighting are generated via a solar cell system on the property's roof with a combined power of 130 kW. The haulage company has chosen a smaller plant adapted to the premises own electricity needs, despite the fact that the roof surface allows a larger plant. The reason is that local electricity producers are not allowed to sell surplus electricity, but this must be returned to regular electricity companies with low compensation. The haulage company believes that this regulation is counterproductive as it hinders the growth of this electricity generation. In Germany, with its strong

ambition to convert to renewable energy in "Energiewende", there are no similar limitations and the growth of local solar power plants is considerably greater than in Sweden.

Alfredsson's picture of developments until 2045 is that:

2025

The haulage's vision is to offer a fossil-free logistics business that will be run in 2025

LBG in long-distance traffic (if sufficient and the state does not tax it out of the market)

Local traffic with HVO / Fame or similar biodiesel

Electric trucks

2030 (-70%)

The goal reached

2045 (zero net emissions)

The goal reached

5.2 Berglunds haulage

Berglund's haulage company operates in Eskilstuna and in surrounding regions. Transport services include transport of:

- Truck loads (shipments larger than 1000 kg)
- Less than truck load (goods on pallet)
- Parcel
- Delivery of building materials with crane trucks

In principle, transport takes place locally and regionally in Närke, Uppland and Mälardalen. Some remote transport is also carried out. All transport assignments are performed for DHL. Receivers of the goods are mainly companies, but a growing proportion of deliveries are made to private customers.

In recent years, delivery to private customers has increased by 10-15% from a previously very low level, but this still represents a significant change that is expected to continue. Home deliveries are made mainly through agents but also directly where is a large shipment.

The environmental requirements that Berglund's haulage need to fulfil are the environmental zone in Stockholm, but this requirement is currently relatively easy to meet with the vehicles operating in these areas. Previous opportunities to use HVO 100 were more or less eliminated in connection with the introduction of the reduction obligation. This means that for most of the fleet, the haulier only uses regular diesel but meets the requirements according to the reduction obligation.

Berglund's haulage company does not notice the environmental requirements of the transport buyers, but the requirements come from DHL. The requirements mainly consist of environmental

classification of engines (Euro class). At present, there are no requirements for renewable fuels or specific fuel efficiency.

The environmental and climate initiatives that the company makes are primarily driven by its own view that these are important issues that benefit both the environment and the climate, but that they are also strategic issues for the credibility of the haulage market. Berglund's haulage company says that they try to "pull their straw to the stack" with things that are economically justifiable. However, how the haulage's operations affect the environment and climate is something that they have difficulty describing.

The technical platform chosen by the haulage company for climate adaptation in addition to the market's involvement of HVO and FAME to achieve the reduction obligation is ethanol-powered (ED95) trucks. Initially, smaller gas-powered parcel trucks (<3.5 tonnes) were tested, but these did not work satisfactorily. Since then, the haulage company has chosen to use distribution trucks fuelled with ethanol. The first truck with 18 pallets space was purchased seven years ago and has worked without worries. It consumes about 5.2 litres per 10 km. Since then, two city trucks with 25 pallets space have been acquired. The first truck was acquired just over two years ago and the second a month ago. These consume about 7.5 litres per 10 km, but then the trucks are loaded with heavier goods. The trucks that are driven with the ED 95 are very reliable and work year round regardless of the weather conditions. The haulage also has a gas station from SEKAB in the yard which ensures reliable access to ED 95.

Figure 5.3. The ethanol trucks, the tractor on the left and the distribution truck on the right

Admittedly, the vehicles consume a lot of fuel, which makes them more expensive to operate per km than diesel-powered vehicles, but this works because they only drive about 2500 km per year. A long distance truck is driven about 100,000 km per year. If the fuel economy were to be sufficiently good, ethanol could also be used for long distance transport.

Previously, the haulage industry used HVO 100 on a large scale until the fuel disappeared more or less in connection with the introduction of the reduction obligation. Berglunds has not given up on this alternative since it nevertheless provides the most robust solution where vehicles do not run the risk of standing due to fuel shortages. They can always switch to diesel. At present, a discussion is being held with Neste oil about the delivery of HVO 100 to its own gas station. At present, HVO 100 costs about 60-70 öre more per litter compared to regular diesel.

Berglund's haulage image of developments until 2045 is that:

2025

- Continued distribution with ethanol-powered distribution trucks

- Several loaded hybrids which should be able to work well when the distribution trucks are driven 5-10 miles per day and are rarely limited by the weight of the goods. Furthermore, they could be recharged at lunch.

- Overall, the development will involve the use of many different technologies where electricity is deemed to be large.

2030

Hard to see ground-breaking technological advances but 70% reduction can be achieved with many different technologies. These are judged to be:

- Electricity

- Ethanol

- HVO 100 for remaining vehicles

2045

The goal of conducting transport operations without net emissions of greenhouse gases is possible, but it will require courageous politicians who dare to make the right decision regarding taxation and who give "carrots" to those who do the right thing. It must be made attractive to dare to go ahead.

Facts box ED 95

ED95 is an ethanol-based propellant for custom diesel engines. It consists of about 95 percent ethanol and ignition improvers, lubricants and corrosion protection.

Source SEKAB

5.3 TGM

TGM conducts distribution traffic in Gothenburg and surrounding municipalities for Schenker. The traffic includes tractors with trailers for larger goods deliveries, conventional trucks and parcel trucks. TGM is an essential part of Schenker's brand as it is the hauliers' drivers who meet the receiving customer. Distribution in urban areas in general and especially in large infrastructure redevelopments (Gothenburg) poses challenges that require special knowledge. TGM and Bäckebol's

haulage, which are part of the same group of companies, conduct this traffic exclusively and thus accumulate the necessary specialist knowledge for the region.

The legal environmental and climate requirements that govern operations are mainly the environmental zone requirements for truck emission standards. From 2021, all trucks must comply with Euro VI, which means that older trucks will not reach the required levels. Distribution traffic generally means that trucks are driven short distances, thereby extending their service life. This means a generally older vehicle fleet in distribution traffic. Tougher environmental zone requirements with links to new regulations that allow municipalities to introduce zones with three levels of requirements are likely to require reorganization and adaptation with the replacement of approximately 50 of the haulage's total 200 vehicles. Toughest environmental zone class three means that only electricity and biogas are allowed as fuel.

The internal environmental requirements are defined in collaboration with Schenker, which primarily sets the level of environmental and climate work. Customers communicate their requirements to Schenker.

About a year ago, HVO 100 was used for all vehicles. When the reduction obligation was introduced, the price increased by just one krona and accessibility deteriorated. All in all, it caused the haulage industry to revert to conventional diesel which meets the reduction obligation. Two trucks are operated with compressed methane gas. These only meet Euro V. It is unclear how new environmental zone requirements for Euro VI will affect the continued possibility of using gas trucks in the environmental zone. Previously, eight packaged trucks were also driven with methane gas, but they lost some load capacity and thus productivity, which caused them to be discontinued. RME / FAME[17] have received some renaissance among several haulage companies since HVO 100 was expensive, but TGM does not recommend it. The connection to a raw material that can also constitute food makes the fuel considered questionable from an overall perspective.

For TGM, efficient distribution is crucial for profitability, but also for reducing greenhouse gas emissions. Schenker's remuneration system encourages efficiency, as revenues are fixed and if the subcontracting haulage company can distribute the same amount of goods with less resource use, the profitability will increase. In other words, it is of utmost importance to encourage cost efficiency through, for example, fuel-efficient driving. To disseminate knowledge about driving technology, there is a program in which spar coaches travel with other drivers to instruct them on how to run fuel efficient. However, much is about common sense.

TGM has been a pioneer with electric-powered distribution trucks. In 1992, a package truck with electric drive was tested and already 1997-1998 two trucks that were series hybrids (electric / diesel) from Volvo were tested. In an expected transition to electric power, several challenges are encountered regarding the range and capacity of the vehicles. According to TGM, relatively little has happened around electric drive for parcel trucks and they have about the same restrictions today as 1992. If new municipal environmental zone requirements entail the introduction of class three, it will require electric vehicles to a greater extent. Then, access to electricity, power supply and charging infrastructure will need to be significantly developed. This will put new questions at the forefront.

[17] Rapsmetylester samt Fatty Acid Methyl Ester

- Will more nuclear power plants be required?
- Will restrictions on the use of electricity be required at certain times?
- How should a sufficiently robust infrastructure be built? How are restrictions on scarce minerals handled?

The electrification of freight transport and transport in general will also have to deal with many challenges.

For TGM, future requirements according to environmental zones are governing and currently the strategy is to invest in biogas (LBG and CBG) in combination with electric vehicles. The challenge for the strategy is that no customers pay extra for better climate performance. For TGM, the strategy is to follow and understand the technical and logistical possibilities and to purchase new technology when available, provided that customers are prepared to pay additional costs.

In addition to technological developments that improve the environmental performance of vehicles, Internet commerce is increasing dramatically with more and more small packages with low utilization. The relative energy efficiency of this traffic is deteriorating because of this change and contributes to increased traffic congestion. This phenomenon represents the biggest climate deterioration in urban freight transport. Previous coordination is broken by increased fragmentation of deliveries directly to customers and delivery nodes.

At present, the equation with ambitious climate targets does not coincide with the market's unwillingness to pay for better climate performance and its lack of ability to coordinate its transport. Under these conditions, the state must establish governance and conditions that allow the actors to act in the long term.

Figure 5.4 TGM's electric-powered distribution truck from Volvo in Gothenburg with driver Kent Larsson

To show what is technically possible, Volvo has developed a fully electric powered distribution truck that is a pre-series for a commercial product.

Volvos Electric is designed for goods deliveries and waste management in cities. The electric motor has a maximum power of 185 kW with a continuous power output of 130 kW. The power supply comes from two to six lithium ion battery packs with 50 kWh each. In other words, the total capacity is 100 to 300 kWh, which should allow a range of 100 to 300 kilometres. AC charging up to 22 kW takes about 13 hours for a 300 kWh battery. In addition, the batteries can be recharged quickly with a DC charger up to 150 kW in one to two hours.

Two vehicle has been produced, one for waste management functions (Renova) and one for grocery distribution to the store of fresh and chilled goods and vegetables (TGM to Coop). The truck loads 18 pallets. The design of TGM's vehicles required a comprehensive discussion of range in relation to load weight and battery weight. The truck is driven about 10 km in the inner city environment and is very quiet and reduces stress to drive. Charging takes place at night at the haulage terminal. For optimal use of the vehicle, support charging during lunch of 45 minutes is favourable at a public charging station. Unfortunately, this is also used by private electric cars, which means that it is not always available. If this could be booked via text message would make the distribution more predictable and efficient. The truck makes three trips a day to Coop's stores and generally works satisfactorily. At night, at the freight terminal on Transportgatan the truck is charged. According to the drivers, the driving experience is great. The only negative is probably the price of the truck. At present there is no market price, but probably the truck is significantly more expensive is a regular distribution truck.

In conclusion, Roger Nilsson at TGM believes that TGM will adjust to the requirements set by the state and government, but this can only be done if there are technical solutions available and that these are economically feasible. A general advice to the entire industry from Nilsson is that "we have to do the simple things first instead of just relying on technological advances, and look at Norway that has gone for full electrification.

6. The environmental and climate work within rail transport industry

Rail transport in Sweden has low emissions of greenhouse gases due to the fact that most of the railway network is electrified and that Swedish production of electric power in turn has low emissions of greenhouse gases. The railway also has high energy efficiency thanks to low rolling resistance and relatively large load capacity. Another advantage is that trains only require one driver for several wagons if we disregard traffic management. The challenges of the railroad are that many consider its reliability insufficient and not flexible enough. This is also linked to deficiencies in the infrastructure and that some critical parts of the track suffer from capacity problems that cause delays.

The Swedish Transport Administration, which provides the infrastructure for the railway, also buys the electricity used. All electricity purchased is production specified as green electricity. In total, the railways emit 0.2% of total domestic transport emissions. In other words, moving goods to rail should be an easy way to reduce the total emissions of greenhouse gases from transport. Unfortunately, such a development does not happen. The causes are many, but probably a lack of trust and a rigid organization of rail transport are the main causes. However, there are several good examples of rail solutions and inspiration from these should be taken for more successful train solutions.

Rail transport is done with various technical solutions. One is to use conventional rail trucks that load large and heavy goods. The alternative is intermodal, i.e. A load unit, for example a container placed

on a railway wagon. The advantage of a combination is that the load can be more easily reloaded between the traffic modes in a transport chain including several modes of traffic. The disadvantage is that the payload in relation to the weight of the railway carriage and even container is reduced. This can be seen in the calculation below where relative emissions are higher for goods loaded in a combination truck. At the same time, it should be emphasized that these emissions are still very low. If electricity generation is assumed to occur with fossil carbon or oil, emissions would increase substantially.

	Locomotive [ton]	No	Waggon [ton]	Cargo capacity[ton]	No	Total [ton]
Gross weight 630m	78	1	30	60	22	2058
Gross weight 730m	78	1	30	60	26	2418
Gross weight 750m	78	1	30	60	29	2688
Intermodal 630m	78	1	34	26	22	1398

Electric train calculation	**Unit**	**630**	**730**	**750**	**Intermodal**
Max gross weight	[ton]	2058	2418	2688	1398
Cargo capacity	[ton]	1320	1560	1740	572
Gross weight empty	[ton]	738	858	948	826
Load factor South (wagon)	[%]	100%	100%	100%	100%
Load factor North (wagon)	[%]	60%	60%	60%	60%
Load factor South (trailer)	[%]	n/a	n/a	n/a	100%
Load factor North (trailer)	[%]	n/a	n/a	n/a	60%
Total roundtrip gross weight	[ton]	3588	4212	4680	2567
Average gross weight	[ton]	1794	2106	2340	1284
Net weight per round trip	[ton]	2112	2496	2784	778
Average net weight	[ton]	1056	1248	1392	389
Electric distribution losses	[%]	10%	10%	10%	10%
CO2e wtw, Bra miljöval	[g/kWh]	8	8	8	8
Electric consumtion per vehicle km vkm, including distribution losses	[kWh/vkm]	25	28	29	21
Electric consumtion per net-tonne km, including distribution losses	[kWh/tkm]	0,024	0,022	0,021	0,055
CO2e per vehicle km	[g/vkm]	203	220	232	172
CO2e per tonkm using green electricity	[g/tkm]	0,19	0,18	0,17	0,44

Figure 6.1 Overview of the relative climate impact of rail solutions in Sweden. Source www.transportmeasures.org.

6.1 Real Rail Sweden AB

The reason for the company was that the Swedish-Norwegian company Cargonet, which operated Swedish domestic intermodal transport[18], decided to discontinue its operations due to profitability problems in 2011. The underlying problem was a massive cost pressure that has been going on for a long time with too low utilization degree and earning potential. This was accentuated by freer cabotage regulations that increased competition from foreign hauliers. This long-term price pressure broke several intermodal domestic services. One was between Gothenburg and Stockholm.

At that time, Sandahl's Goods & Parcel was a major customer of Cargonet and used several of their lines for its long-distance traffic. In this situation, the haulage industry faced a dilemma. Either you would hope that Green Cargo would take over the traffic or you could enter the business yourself. A third alternative was also to establish more long-distance transport by road.

The decision together with Cargonet was to establish the half-owned company Real Rail to operate Sandahl's business-critical lines Gothenburg to Sundsvall, Luleå and Umeå. Furthermore, the traffic to Nässjö was also driven to Luleå and Umeå.

[18] Normally by train loaded by carrier units as trailers, containers and swap bodies

In 2015, a strategic discussion arose between the owners about Real Rail's operations and its continued development. The discussion ended in the separation of the owners and therefore Sandahls formed Real Rail Sweden AB[19]. As a result, Real Rail Sweden AB took full responsibility for the business, which included the lines:

- Gothenburg to Luleå and Umeå respectively

- Helsingborg / Nässjö to Umeå and Luleå (Gammelstad)

- Gothenburg / Jönköping with exchange in Falköping to Sundsvall

In 2018, a further line was established between Rosersberg and Luleå / Umeå, which was based on a requirement from Polarbröd that these transports must be climate neutral in order to meet their customers 'and consumers' wishes and requirements for bread with minimal climate impact. With these base volumes, the risk of establishing was substantially lowered for the new line.

Real Rail's main success factor is that rail lines are established and operated only if customers commit to transporting specified volumes in the long term during the contract period. It is about defining volumes by rail five days a week as the basis for operations. Truck should instead be used to deal with the more temporary fluctuations in demand for transport. In the past, the combi-truck relationship was usually the opposite. The reason is that the customer participates in and shares some of the business risk. Real Rail Sweden AB's customers are freight forwarders, hauliers and logistics operators. If necessary, a dialogue is held with the customers together with the product owners. The trains are drawn by Green Cargo and CFL cargo. Carrying of load carriers to and from combination terminals is carried out by the customers themselves. An essential functionality that the company prioritized is that the trains should be able to run fast and thus fit into other traffic, which reduces the risk of being set aside in favour of faster passenger trains. Real Rail's train runs at 110 km / h. unfortunately, the traffic management is ignorant of this fact and sometimes local trains must be contacted directly as they favour local commuter trains on the erroneous assumption that these trains are slow when in fact they are faster. The problem is that there are a lot of new people coming into the business who lack basic railway skills and that they lack the overview because they do not have the "digital tools" for operational monitoring and operational optimization.

Shunting of trains takes place almost exclusively with electric locks, but there are diesel locks in some terminal plants where only diesel locks can / can be switched. There is some room for improvement in this business by minimizing unnecessary locating of locomotives.

Sometimes it can be difficult to get rail cars on time, which increases the risk of delivery failure. Real Rail Sweden has therefore established the entire spare train set which is prepared at the relevant combination terminals, which means that if incoming trains are delayed, outgoing trains can still be sent away in time with the spare car kit. This means that Real Rail Sweden has been able to maintain good reliability and punctuality in its services. Admittedly, this ties up some capital, but without this "safety valve" the company's reputation as a reliable supplier would have been significantly worse.

The company's customers have never stated specific environmental and climate requirements. These lie instead as a natural prerequisite in the choice of supplier and type of traffic.

[19] The trade mark Real Rail was owned by Cargonet

Real Rail Sweden has no specific goal to improve its energy efficiency, but has a general ambition to always strive for efficient transport solutions. One such activity is to exchange more trains with electric locomotives.

A significant portion of the customers' load carriers are loaded with goods that require temperature control. This is done with cooling units mounted on load carriers powered by diesel. This is an area that can be developed to reduce greenhouse gas emissions.

The load ratio of the trains measured as the number of carriers in relation to the number of carriages is about 95% in any transport relation it is at 80%.

The number of wagons differs between transport relationships and in some cases the transport chain takes place with different number of wagons for each transport link. Usually there are trains with 22 or 32 wagons depending on the traction of the locomotive.

Figure 6.2 The intermodal terminal in Gammelstad, Luleå. A Reach stacker is used for transhipment

Figure 6.3 The intermodal terminal in Gammelstad, Luleå. Train loaded with trailers

SANDAHLS BOLAGEN

Real Rail Sweden AB

Tidtabell från 1 juli 2019

Från	Till	Period	Senaste inlämning	Första utlämning
Göteborg	Luleå	181209-190804	19.30 Mån-Tors	17.30 Tis-Fre
Göteborg	Luleå	181209-190804	19.30 Fre	07.00 Sön
Göteborg	Sundsvall	181209-190708	19.30 Mån-Tors	06.00 Tis-Fre
Göteborg	Sundsvall	190709-190804	19.30 Mån-Tors	06.15 Tis-Fre
Göteborg	Sundsvall	190401-190708	19.30 Fre	06.00 Lör
Göteborg	Sundsvall	190709-190804	19.30 Fre	06.15 Lör
Göteborg	Umeå	181209-190804	19.00 Mån-Tors	10.40 Tis-Fre
Göteborg	Umeå	181209-190804	19.00 Fre	09.00 Sön
Helsingborg	Luleå	181209-190804	19.00 Mån-Tors	19.00 Tis-Fre
Helsingborg	Luleå	181209-190804	19.00 Fre	07.00 Sön
Helsingborg	Umeå	181209-190804	19.00 Mån-Fre	15.00 Tis-Fre
Helsingborg	Umeå	181209-190804	19.00 Fre	09.00 Sön
Jönköping	Sundsvall	181209-190708	19.30 Mån-Tors	06.00 Tis-Fre
Jönköping	Sundsvall	190709-190804	19.30 Mån-Tors	06.15 Tis-Fre
Jönköping	Sundsvall	190401-190708	19.30 Fre	06.00 Lör
Jönköping	Sundsvall	190709-190804	19.30 Fre	06.15 Lör
Luleå	Göteborg	181209-190804	16.20 Mån-Tors	11.50 Tis-Fre
Luleå	Göteborg	181209-190804	16.20 Fre	11.30 Lör
Luleå	Helsingborg	181209-190804	18.30 Mån-Tors	18.00 Tis-Fre
Luleå	Helsingborg	181209-190804	18.30 Fre	06.00 Mån
Luleå	Nässjö	181209-190804	18.30 Mån-Tors	14.00 Tis-Fre
Luleå	Nässjö	181209-190804	18.30 Fre	06.00 Mån
Luleå	Rosersberg	181209-190804	19.00 Mån-Tors	10.30 Tis-Fre
Luleå	Rosersberg	181209-190804	19.00 Fre	06.00 Mån
Nässjö	Luleå	181209-190804	22.00 Mån-Tors	19.00 Tis-Fre
Nässjö	Luleå	181209-190804	22.00 Fre	07.00 Sön
Nässjö	Umeå	181209-190804	22.00 Mån-Tors	15.00 Tis-Fre
Nässjö	Umeå	181209-190804	22.00 Fre	09.00 Sön
Rosersberg	Luleå	181209-190804	19.00 Mån-Tors	10.00 Tis-Fre
Rosersberg	Luleå	181209-190804	19.00 Fre	07.00 Sön
Rosersberg	Umeå	181209-190804	19.00 Mån-Tors	05.00 Tis-Fre
Rosersberg	Umeå	181209-190804	19.00 Fre	09.00 Sön
Sundsvall	Göteborg	190401-190804	18.00 Mån-Tors	06.00 Tis-Fre
Sundsvall	Göteborg	190401-190804	18.00 Fre	08.00 Lör
Sundsvall	Jönköping	190401-190804	18.00 Mån-Fre	06.00 Mån-Fre
Umeå	Göteborg	181209-190804	19.00 Mån-Tors	11.00 Tis-Fre
Umeå	Göteborg	181209-190804	19.00 Fre	10.00 Lör
Umeå	Helsingborg	190401-190708	19.00 Mån-Tors	18.00 Tis-Fre
Umeå	Helsingborg	190709-190804	19.00 Mån-Fres	06.00 Mån-Fre
Umeå	Helsingborg	181209-190708	19.00 Fre	06.00 Mån
Umeå	Nässjö	181209-190804	19.00 Mån-Tors	14.00 Tis-Fre
Umeå	Nässjö	181209-190804	19.00 Fre	06.00 Mån
Umeå	Rosersberg	181209-190804	19.00 Mån-Tors	10.30 Tis-Fre
Umeå	Rosersberg	181209-190804	19.00 Fre	06.00 Mån

Ändrade in- och utlämningstider kan förekomma i samband med ev. planerade omledningar

Figure 6.4 Real Rails time table of ongoing traffic

7. Conclusions

The overall impression from this compilation of good examples is that there is a strong desire from the freight transport industry to renew their business operation in order to meet climate targets. Technically, there are several solutions, but some have limited scalability. Other solutions are scalable but require a market that is prepared to pay for the additional costs that comes with the new solutions. A balance is required in order to not end up in an unsustainable competitive situation.

The way forward must be based on incremental progress with a holistic approach so that we do not create new concerns with sub-optimizations.

Roger Nilsson at TGM expressed this well as: "we have to do the simple things first instead of just relying on technical progress"

Appendix 1. Interviewees

Anna Soltorp, BRA

Susanna Airola, Viking Line

Jens Ole Hansen, ForSea

Per Wimby, Stena

Erik Alfredsson, Alfredssons transport

Johan Broberg, Berglunds Åkeri

Roger Nilsson, TGM

Pär-Åke Persson, Real Rail Sweden AB

Hannu Nylander, Vaasan

Niels Kristian Holm, Schulstad