GreCOR GREEN CORRIDOR Oslo-Randstad

The Interreg IVB North Sea Region Programme

Investing in the future by working together for a sustainable and competitive region

Potential of High Capacity Transport solutions (Road)

Two case studies in the Region of Örebro, Sweden

European Union

The European Regional Development Fund

Title Potential of High Capacity Transport solutions (Road)

Publishing date November 2014

Publisher Örebro Regional Development Council.

Contact Fabian Ilgner, Development Manager Logistics, fabian.ilgner@regionorebro.se

Patrik Benrick, Consultant, patrik.benrick@wspgroup.se

Distributor Swedish Transport Administration, S-781 89, Borlänge, Sweden.
Telephone +46 771 921 921. www.trafikverket.se

Content

GreCOR – Green Corridor in the North Sea Region 5
Introduction 6
Purpose of the activity 6
Description Current Situation 6
Proposed activity 6
Defining high capacity transport systems 7
Regulatory framework of today 7
Swedish regulatory framework of today 8
Introduction of 74 ton allowance 8
ETT 10
ECT 11
Iron ore express 11
Duo2 11
Description of case studies 12
Zinkgruvan Mining plc 12
Transport structures used today 12
Potential HCT systems 13
Kopparberg Brewery plc 15
Transport structures used today 15
Potential HCT systems 16
Calculation assumptions 19
General assumptions 19
Specific assumptions – Zinkgruvan Mining 19
Specific assumptions – Kopparberg Brewery 20
Results and Analysis 22
Zinkgruvan Mining plc 22
Transport emission calculations 22
Transport economic calculations 25
Need for short- and long term adjustments 25
Kopparberg Brewery plc 27
Transport emission calculations 27
Transport economic calculations 30
Need for short- and long term adjustments 33

Conclusions from case studies **35**
Case study: Zinkgruvan Mining 35
Transport emissions 35
Transport economy 36
Critical parameters and necessary adjustments 36
Dispensation matters 36
Case study: Kopparberg Brewery 37
Transport emissions 37
Transport economy 38
Critical parameters and necessary adjustments 38
Dispensation matters 39
Impact Evaluation **40**
Transport emissions 40
Transport economy 40
Societal perspective 41
Process Evaluation **42**
Factors enabling or hindering success 42
Infrastructure 42
Regulatory framework 42
Stakeholder commitment 43
Suitable transport relation and roundtrip optimisation 43
Type of goods and vehicle optimisation 44
Recommendations **45**
International aspect 45
Technical aspect 45
Behavioural aspect 46
Logistic aspect 46
References **47**

GreCOR – Green Corridor in the North Sea Region

GreCOR – Green Corridor in the North Sea Region – is an Interreg IVB North Sea Region project that started 1 January 2012 and will end in June 2015. GreCOR promotes the development of a co-modal transport corridor in the North Sea Region. Important in this collaborative approach, is the that the focus is not only on the corridor itself, but also on secondary networks and the hubs, and the regional hinterland around the Green transport corridor between Oslo and the Randstad area (Amsterdam, Rotterdam, The Hague and Utrecht).

GreCOR has 13 partners and a total budget of 3.7 M€. The overall aim is to improve knowledge about the logistic needs and conditions and develop a strategy for the further promotion of environmentally friendly transports in the corridor. GreCOR focuses simultaneously on infrastructure and logistics for "greening" of transport and to make the region more competitive. The activities in GreCOR and the strategy will be a contribution to the EU objectives for transport as expressed in the White paper from 2011 "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system"

The work in GreCOR was performed in seven work packages. More information at: www.grecor.eu

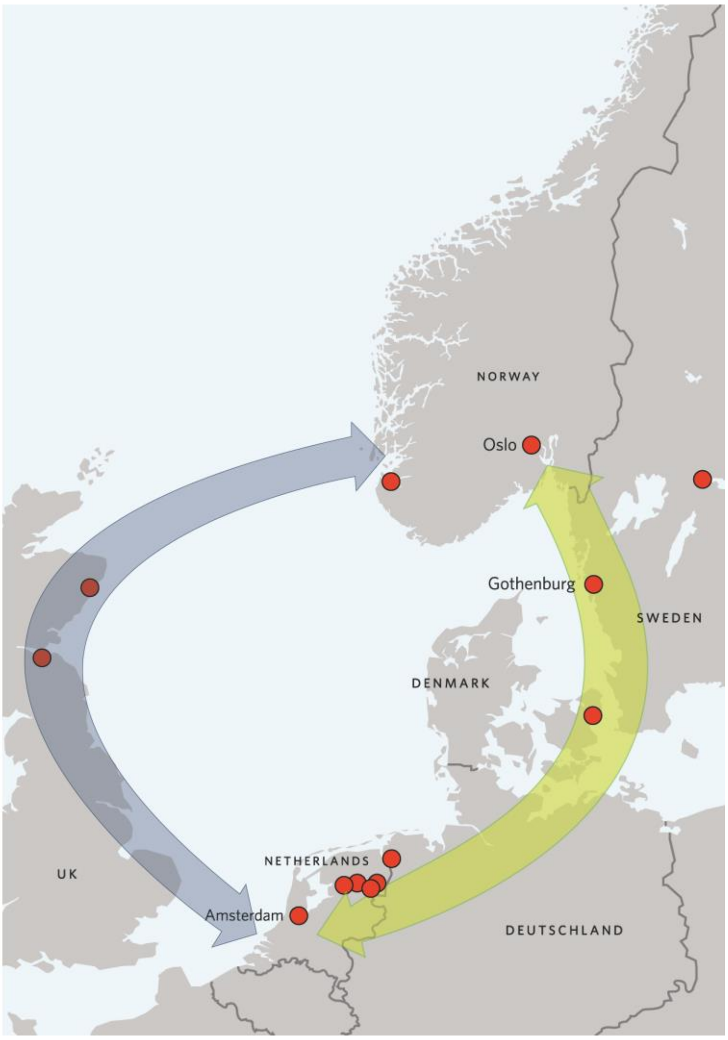

Figure 1. Map of the Corridor including locations of all project partners

Introduction

Purpose of the study

This case study is done as a part of the GreCOR project, work package 7, activity 1. The purpose of the study is to identify sustainable HCT solutions for a given transport relation and to show their potential for energy savings and positive effects on the environment. This is done by looking closer at two cases in the region of Örebro (Sweden). The results will then be made transferable to similar cases by analyzing the influence of different parameters.

Description Current Situation

One case is about looking at the transports of Sweden's southernmost underground mine, Zinkgruvan Mining. The company is located in a village called Zinkgruvan. The ore produced (more than 200 000 tons per year) is then by truck transported to the harbor of Otterbäcken on lake Vänern for further transport. The transport distance from Zinkgruvan to the harbor comprises around 120 km, the transport is carried out using trucks with a length of 22 m and a weight of up to 60 tons.

The other case is the transport of goods from Kopparbergs Brewery (located in Kopparberg) to the intermodal terminals in Örebro and Hallsberg. Nowadays trucks with a length of 24 m and a weight of up to 60 tons are used for the distance of around 110 km. The yearly volume exceeds 100 000 tons. The goods of both companies (Zinkgruvan Mining and Kopparbergs Brewery) are then leaving Sweden by going through Gothenburg.

Proposed activity

A report which will focus on the following points:

1. Mapping of existing and promising HCT solutions with the potential to be implemented as transport solution in the named cases
2. Calculation of energy saving potential and profitability of selected HCT solutions (in comparison to today's solution) in case of implementation in one or both of the named cases
3. Mapping of actions which would have to be implemented in order to enable the use of selected HCT solutions in the named cases
4. Mapping of the Swedish process which would have to be taken in order to implement one selected HCT solution in each of the named cases
5. Analysis of parameters which affect the potential of HCT solutions in cases similar to the one analyzed in this work

Defining high capacity transport systems

The exact definition, as well as the designation, of high capacity transport systems (HCT) varies between countries. In Europe the term of use is *Longer and/or Heavier Vehicles*, in Australia *Higher Productivity Vehicles* and in North America *Long Combination Vehicles*[1].
The common ground is that freight transports are carried out by longer and/or heavier vehicle combinations than what is permitted according to a nation's regular allowances.

Such exceptions from the general allowances have been tested in many countries for a relatively long time, notably often in countries where distances are vast and often where the mining and/or timber industries are prominent.

The calls for allowing and increasing the use of HCT vehicles are clear and the arguments multiple.

High capacity transport systems exist for both road and railway transports. This report focuses on HCT road transports.

Why HCT?

Robust and efficient goods transport systems – within and between countries – are an important basis for the competitiveness of industry and trade, and therefore for society at large. The main arguments linked to the use of HCT systems revolve around the fact that larger volumes of goods can be transported by a smaller number of vehicles. This in turn implies that HCT systems

- Increase the capacity and efficiency in the existing infrastructure
- Increase the return on investments made in the existing infrastructure and decrease the demand and need for further infrastructure investments
- Increase energy efficiency and reduce carbon dioxide and other emissions
- Increase road safety by reducing the number of heavy vehicles
- Increase transport industry efficiency, which reduces costs in the supply chain

Regulatory framework of today

The regulatory frameworks for operating HCT systems differ between countries or even between states within one country.

Generally the operation of HCT vehicles is restricted to a designated road network and the vehicles need to comply with strict specifications, e.g. specific characteristics of the vehicles, limited hours of operation and specific experience of drivers.

Table 1 summarises examples of the maximum length and weight of vehicles around the world.

[1] VTI, Report 676, 2010

*Table 1: Examples of maximum length and weight of vehicles in different countries. Source: Gröndahl, 2012 and Road map: High Capacity Transports-road. *Special cases with even longer vehicles exist.*

Country	Maximum length	Maximum weight
Australia	60 m*	132 ton
U.S.A.	35,5 m (Colorado)	74 ton (Michigan)
Mexico	31 m	66,5 ton
Brazil	30 m	74 ton
South Africa	42 m	176 ton

In October 2013 Finland introduced a general allowance for vehicles up to 76 ton (gross weight) on the general road network. The maximum length is still limited to 25.25 m. The basis of the regulatory framework is that the more axles on the vehicle and trailer, the heavier load is allowed. Vehicles of 76 tons will need to be equipped with nine axles and that at least 65 % of the gross weight will need to be distributed on axles with double-mounted wheels[2].

Within the EU the maximum allowances are 18.75 m and 40 ton for length and weight respectively (see GreCOR inventory report for country specific regulations within the GreCOR area). An exception applies for intermodal domestic transports with railway of 40 feet containers. In these cases the maximum weight is 44 ton[3].

Swedish regulatory framework of today[4]

In Sweden longer and heavier vehicles than in the EU are allowed on the general road network, and there has been a long tradition of larger vehicles. During the last forty years the regulatory framework has been revised several times in this direction:

- 1975: 51,4 ton gross weight
- 1990: 56 ton gross weight
- 1993: the introduction of load capability category BK1, allowing for 60 ton gross weight

As of today 97 % of all bridges and 95 % of the national road network in Sweden allows for BK1.

HCT systems in Sweden refer to vehicles with a gross weight that exceeds 60 ton and/or a length of more than 25.25m[5].

Introduction of 74 ton allowance[6]

Currently, the possibility of introducing a new load capability category – BK74 – has been investigated and resulted in a referral from the Swedish Transport Administration and Swedish Transport Agency.

---

[2] TRV 2014:102, 2014.
[3] Gröndahl, 2012.
[4] TSV 2014:1419, 2014.
[5] www.energiffektivatransporter.se
[6] TRV 2014:102, 2014.

The background to the investigation is that the volumes of transported goods continue to increase at a higher pace than infrastructure can be put in place. Furthermore, increasing the efficiency of the transport system is critical in order to reach the environmental targets. Therefore the development of measures to increase the efficiency of both road and railroad transports has been brought into focus.

In short the suggestion outlines to:

- Increase the general gross weight allowance from 60 to 64 ton on the BK1 road network.
- Introduce a gross weight allowance of 74 ton (25.25 m) on a designated road network.
- In the longer perspective allow for vehicles up to 32[7] m on this designated road network.

Even if the BK1-road network at large would manage 74 ton vehicles, primarily the load capability of bridges has shown to complicate the demand and challenge of forming a continuous network. The network that has been selected for 74 ton vehicles is included in the designated road network for goods transportation – representing two thirds of the total road goods transports – and therefore already is robust and adapted for heavy vehicles. Nevertheless about 100 bridges will need to be adjusted in order to form a continuous network.

The Swedish application process[8]

The Swedish application process for dispensation of HCT systems is described in figure 1.

In the first step the applicant submits a notice of interest to an evaluation Commission. This commission consists of representatives from the Swedish Transport Administration, the Swedish Transport Agency, the Forestry Research Institute of Sweden, CLOSER and the automotive industry.

Among else, the notice of interest shall include:

- Information about the applicant.
- Description of the transport structure currently used.

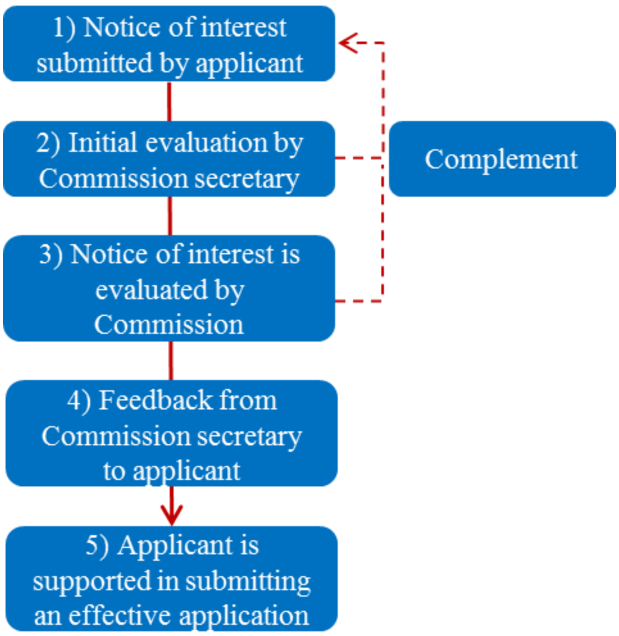

Figure 1: Overview of the Swedish application process for dispensation of HCT-systems. Source: Skogsforsk, 2014.

7 Report on heavier and longer vehicles on the general road network, Swedish Transport Agency, TSV 2014:1419, 2014

8 www.skogforsk.se

- Description of the transport issue that the applicant wishes to resolve and of how this can be solved by introducing HCT vehicles.
- Layout and dimensions of the suggested HCT vehicle.
- Targets linked to the introduction of HCT system, e.g. reduce the number of vehicles or reduce fuel consumption by 10 %.
- Suggested transport route for the HCT system.
- A motivation to why the applicant is willing to contribute to value-adding knowledge within the area of HCT, and in particular in specific research areas with a lack of knowledge.

The notice of interest is initially evaluated by the Commission secretary. Additional information or clarifications might be needed before the Commission evaluates the notice of interest. Such notices of interest might be submitted at any time, the Commission then meets on a monthly basis.

When the Commission finds the notice of interest satisfactory, the applicant is encouraged and supported in formulating an effective application.

For longer vehicles than 25.25 m, the application is handled by the Swedish Transport Agency, for heavier vehicles than 60 ton the recipient is the Swedish Transport Administration.

Overview of existing HCT systems in Sweden

Up until recently HCT systems generally have been linked with the mining or timber industries, e.g. for transports of heavy bulk goods from the forest to the mill or from the mine to a terminal or port. Often these industries are located in sparsely populated areas with low traffic volumes.

More recently there has been an increasing interest from stakeholders transporting voluminous goods. In 2012 Volvo and Schenker developed the Duo2 concept (see below) for package freight transports between Schenker's terminals in Hisings Backa (Göteborg) and Malmö (280 km one-way), and in July 2014 Scania released a similar vehicle combination of 31,5 m to operate on the route from Södertälje to Helsingborg (520 km one-way). For these transport systems the length rather than the weight of vehicles is the restricting parameter.

Below an overview of some existing HCT systems in Sweden is given. It is clear that different types of goods require different types of HCT systems.

ETT[9]

- Year of introduction: 2009 (pilot tests)
- Type of goods: timber
- Gross weight/length: 90 ton/30 m
- Transport route: Överkalix-Piteå, 150 km

[9] Gröndahl, 2012

ECT[10]

- Year of introduction: 2012
- Type of goods: steel coils
- Gross weight/length: 74 ton/21,4 m
- Transport route: Sölvesborg-Olofström, 35 km

Iron ore express[11]

- Year of introduction: 2013
- Type of goods: iron ore
- Gross weight/length: 90 ton/24 m
- Transport route: Kaunisvaara-Svappavaara, 162 km

Duo2[12]

- Year of introduction: 2012
- Type of goods: various package freight
- Gross weight/length: 80 ton/32 m
- Transport route: Göteborg-Malmö, 280 km

[10] First year evaluation of ECT, 2013.
[11] Interview with Peter Engström, Cliffton plc, 2014
[12] Final report Duo2, 2013

Description of case studies

This section describes the two case studies under investigation; Zinkgruvan Mining and Kopparberg Brewery respectively.

Zinkgruvan Mining plc

Zinkgruvan Mining is an underground zinc and copper mine located about 250 km southwest of Stockholm, and 65 km south of Örebro. It is the southernmost underground mine in Sweden and also one of the oldest, having been in continuous operation since 1857. The site produces concentrates of zinc, copper and lead.

Since 2004 the Zinkgruvan mine is owned by Swedish-Canadian Lundin Mining. Mine access is currently via three shafts and the deepest mine level reaches a depth of more than 1100 m. The number of staff is around 350 employees. In year 2013 1.15 million ton of ore was processed, generating about 190 000 ton of concentrates. The forecast for 2014 is an increase of about 7-8 %.

Transport structures used today

From the Zinkgruvan site the full annual volume of concentrate is trucked to the inland port of Otterbäcken, on the shores of lake Vänern.

The concentrates are loaded on trucks in the storage building using a wheel loader. The loading of one vehicle (truck and trailer) lasts for about 25 minutes. All goods are classified as dangerous goods, class 9 – miscellaneous goods.

From the site the fully loaded trucks travel north, mainly along road 50, west on European route E20 and further northwest along road 200 to reach the port of Otterbäcken (figure 2).

The concentrate is unloaded by tipping the truck and then the trailer (total duration of about 25 minutes). A conveyor transports the concentrate to a storage building, awaiting further transport by ship – around five departures per month – via canal and sea directly to another European port. Each shipment estimates 4000 ton and fills an entire vessel. There is no intermediate stop in the port of Gothenburg or any other Scandinavian port. Often the concentrates are transhipped in port and further transported by barge to European smelter customers, mainly located in the Netherlands and Germany.

Since production is continuous all year around, transport operations take place as follows:

- Five vehicles – truck and trailer – operate in shift from Sunday to Friday.
- 22 roundtrips per week per vehicle, 52 weeks per year.
- Gross weight 60 ton, with a goods net weight of 42 ton.
- Goods weight transported per week estimates 4 600 ton.

On the return trip, trucks follow mainly the same route, however when unloaded and cleaned they are allowed to take a shortcut along road 205 through a water protection area.

The relevant distances travelled are:

- Zinkgruvan-port of Otterbäcken: 125 km

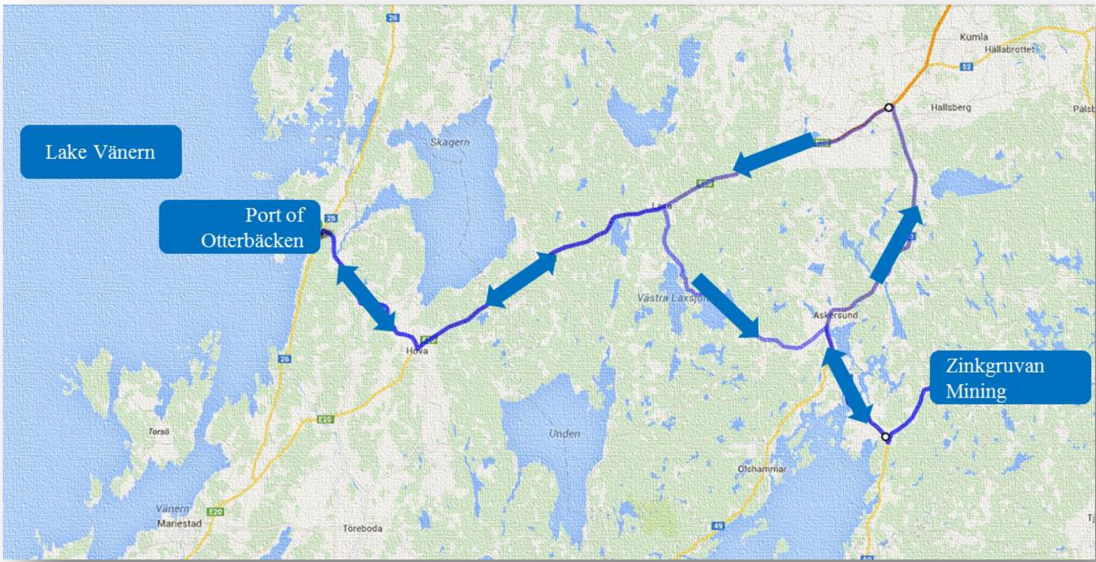

Figure 2: Overview of routes used from Zinkgruvan Mining to and from the port of Otterbäcken.

Potential HCT systems

Given the type of goods being transported a potential HCT system is based on weight rather than volume. This means that the governing parameter is the weight of the vehicle rather than the length. Also, based on the current transport structure and planning there were a number of opportunities and difficulties to take into consideration:

Opportunities

- The road network from Zinkgruvan to the port of Otterbäcken is of a good standard and is to a large extent included in the designated Swedish road network for goods transportation.
- Current vehicles have a length of only 21 m, maximum length allowance is 25.25 m.
- Storage space is available in both ends, in particular in the port of Otterbäcken.
- With relatively minor adjustments, loading and unloading can be carried out more effectively and save time.
- The companies involved (Zinkgruvan Mining, A.L.I. Transport and ports of Vänern) have a strong relationship. Zinkgruvan Mining and A.L.I. Transport have recently committed to a new five year agreement.

Prerequisites

- As an important prerequisite the roundtrip must be completed within 4.5 hours.
- Also, in order to comply with the European drivers hours rules for goods vehicles, the roundtrip of 4.5 hours must allow for the driver to rest 45

minutes at once, or 15 minutes plus 30 minutes, during or after the roundtrip.

- The distance between Zinkgruvan and the port of Otterbäcken indicates that potential HCT vehicles must be able to travel at an average speed of about 65 km/h.
- The unloading facilities at the port of Otterbäcken currently restrict the length of the load carrier to 9 m.
- The scale at Zinkgruvan does currently not function in a reliable manner, whereas the scale at the port of Otterbäcken is limited to 70 ton.

As a result of the initial analysis the following three HCT systems could be identified (table 2):

Table 2: Potential HCT-systems for transports between Zinkgruvan Mining and the port of Otterbäcken.

HCT-system, gross weight	Investment needed	Potential net weight increase
64 ton	Modification of load carriers.	+8 %, to 45,4 ton.
74 ton	New trucks and potentially trailers and load carriers.	+24 %, to 52 ton
90 ton	New trucks, trailers and load carriers.	+52 %, to 63,8 ton.

The 64 ton concept can be achieved by increasing the height of the current load carrier from 120 to 130 cm. Other than that, the same vehicles can be used.

The 74 ton concept is similar to the vehicles used by Boliden Mining on the 85 km long route between Boliden and Rönnskär in northern Sweden. A second example is the *One More Coil*-concept used to transport steel coils between the port of Sölvesborg and Olofström, in southern Sweden.

The 90 ton concept is the same as the one used by Cliffton to transport iron ore from the mines of Kaunisvaara to the railway terminal of Pitkijärvi in the far north of Sweden.

Calculations have been executed for each of these types of HCT systems, on the route between Zinkgruvan Mining and the port of Otterbäcken described earlier. The results of the current transport structure as compared to the potential HCT systems will be described in chapter *Analysis and Results* below.

Kopparberg Brewery plc

Kopparberg Brewery is primarily a cider brewery located in Kopparberg, about 220 km northwest of Stockholm and 80 km north of Örebro. Founded in 1882, the brewery is since 1994 owned and managed by two brothers Bronsman. It is today the largest cider brewery in Sweden. Kopparberg Brewery owns also to 100 % cider companies in Finland, Spain, the U.S.A. and South Africa. The turnover has increased steadily over two decades and was in 2013 estimated to be 2.4 billion SEK.

Operation at the brewery is continuous, producing around 1000 sea pallets (l/w/h: 1000x1200x1330 mm) each 24 hours. About 80 % of the annual production is exported, primarily to the U.K., the U.S.A. and – increasingly – to Australia.

Transport structures used today

From the brewery wrapped pallets are trucked to a number of destinations, some for direct distribution to selling points and some to distribution hubs, for example Stockholm. However, the largest share of production is trucked to intermediate storage points, either in Örebro (the Mosås terminal) or Hallsberg (the Hallsberg terminal).

Kopparberg Brewery let several different transporting companies carry out the transports to the terminals. Both 24 m and 25.25 m vehicles are used. The number of sea-pallets in the vehicles is 38 and 40 pallets respectively. The weight of the pallets varies from 800 to 1200 kg, with an average of about 900 kg.

Pallet in international ocean freight.

The routes to both terminals follow road 50 south for about 80 km, before heading southwest on European route E18/E20. The same routes are used for the return trip (figure 3).

The relevant distances travelled for the roundtrips are:

- Kopparberg-Mosås terminal-Kopparberg: 184 km
- Kopparberg-Hallsberg terminal-Kopparberg: 222 km

At these terminals the pallets are unloaded and stored before being stuffed in containers for further transport, mainly on train from Örebro or Hallsberg to the port of Gothenburg. Also, the ports of Helsingborg and Västerås are used.

Each roundtrip requires about 4.5 hours, including loading and unloading.

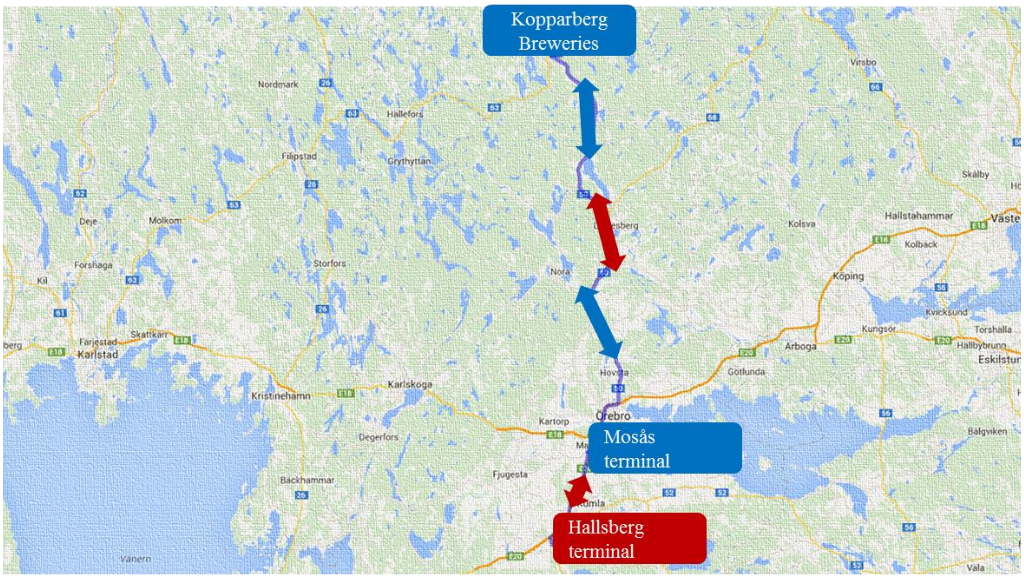

Figure 3: Overview of routes used from Kopparberg Brewery to and from the terminals of Mosås (blue) and Hallsberg (red).

Potential HCT systems

Given the type of goods being transported, a potential HCT system is based on volume and loading meter available rather than weight. This means that the governing parameter is the length of the vehicle rather than the weight. Also, based on the current transport and planning structure, there were a number of opportunities and difficulties to take into consideration:

Opportunities

- The road network from Kopparberg Brewery to the terminals of Mosås and Hallsberg is of a good standard and practically fully included in the designated road network for goods transportation.
- Current vehicles have a net weight of 34 to 36 tons. This allows for more goods on the vehicles before reaching the maximum weight allowance of 60 ton.
- The full volume of the vehicles is not used. Because of packaging practices the sea pallets have a height of 1 330 mm, whereas the inner height of trailers is around 2 700 mm. Also, because of the weight of one pallet (around 900 kg) it is not feasible to stack them.
- There are four loading areas at the brewery site, each with two gates.

Prerequisites

- As mentioned above, the standard height of the pallet with load is 1 330 mm, which because of packaging practices is difficult to increase on the short term.

- Since most of the pallets will be exported, the weight of the pallets will need to be planned so that the total weight of a 20- or 40-foot container can be transported along the whole supply chain.
- As an important prerequisite the roundtrip must be completed within 4.5 hours.
- Also, in order to comply with the European drivers hours rules for goods vehicles, the roundtrip of 4.5 hours must allow for the driver to rest 45 minutes at once, or 15 minutes plus 30 minutes, during or after the roundtrip.
- The distance between Kopparberg and the terminals indicates that potential HCT vehicles must be able to travel at an average speed of about 65 km/h. Even so the distance to the terminal of Hallsberg is difficult to meet within 4.5 hours given that unloading of larger quantities will take longer time. In the calculation assumptions an average speed of 70 km/h will be used, as this is a reasonable average speed on the route.

As a result of the initial analysis any weight-oriented HCT system needed to be rejected. The only relevant HCT system to be further investigated is therefore Duo2 (figure 4):

Table 3: Potential HCT-systems for transports between Kopparberg Brewery and the terminals of Mosås and Hallsberg.

HCT-system, length	Investment needed	Potential number of sea pallet increase
32 m	New trucks, trailers and load carriers.	+35-37 %, to 52 sea pallets.

This 32 m concept is the same as the Volvo Duo2 concept. The maximum gross weight is limited to 80 ton, distributed over eleven axles, whereof the weight of the vehicle (truck and two trailers) estimates 20 ton. Duo2 is used by Schenker and Kallebäck Transport between the Schenker terminals of Hisings Backa (Gothenburg) and Malmö. The net weight of the transports estimates 32 ton. The main restriction is that Duo2 is allowed for transports between 19:00 and 06:00 only[13].

Figure 4: The Duo2 concept. Source: Swedish Transport Administration, 2012.

Calculations for the Duo2 concept have been executed on the routes between Kopparberg Brewery and the terminals of Mosås and Hallsberg respectively. The results of the current transport structure as compared to the potential HCT system will be described in chapter *Analysis and Results* below.

[13] Final report Duo2, 2013

Calculation assumptions

This chapter describes the general and company specific assumptions made in the execution of the transport emission and economic calculations respectively.

General assumptions

In the execution of the calculations the following general assumptions are made:

- Number of days with transport operations: 5.5 per week, or 292 per year. The calculations are based on 275 production days per year (including assumed production disturbances and days with complete stops).
- Annual working hours: 1 600 per driver.
- Time buffer for uncertainties and disturbances: 20 minutes per roundtrip.
- Costs of handling (e.g. loading equipment) and administration as well as profit are excluded.
- Depreciation period of vehicles: 10 years.
- Fuel type: Diesel from Sweden of category MK1, for which at least 5 % FAME/RME is included.
- All vehicles are assumed to be of category EURO5.

Specific assumptions – Zinkgruvan Mining

In the execution of the calculations for Zinkgruvan Mining the following specific assumptions are made:

- The emission calculations are based on an annual transport volume of 240 000 ton.
- All HCT systems are assumed to be allowed to travel the same routes, i.e. 125 km with load from Zinkgruvan Mining to the port of Otterbäcken and 100 km without load via road 205 on the return.
- Average speed: 65 km/h.
- Time for loading including weighting and unloading including cleaning: 25 minutes each. This is valid for the 60 ton concept (42 ton net weight) and increases proportionally with the load volume. For a net weight of 64 ton, the time for loading and unloading estimates 38 minutes each.
- It is assumed that all HCT systems can complete the roundtrip in 4.5 hours. No costs are added for extra personnel or equipment to shorten the time for loading and/or unloading.
- No time restrictions, i.e. the HCT vehicles are assumed to be permitted to operate 24 hours.
- The type of vehicles and assumptions for each type is summarised in table 4.

Table 4: Specific assumptions for vehicles used in the calculations for case study Zinkgruvan Mining. Sources: interview with Tomas Pettersson, A.L.I. Transport; First year evaluation of ECT, 2013 and work paper ETT - Modular System for timber transport, 2010.

HCT-system, gross weight	Type of vehicle	Total cost per vehicle (MSEK)	Net weight per vehicle (ton)	Fuel consumption – without load (litre/km)	Fuel consumption – with load (litre/km)
60 ton	Truck (3 axles), dolly (1 axle) and trailer (3 axles)	2,4	42	0,38	0,49
64 ton	Truck (3 axles), dolly (1 axle) and trailer (3 axles) Modification of load carrier from 60 ton concept	2,5	45,4	0,38	0,50
74 ton	Truck (4 axles), dolly (2 axles) and trailer (3 axles)	3,0	52	0,45	0,58
90 ton	Truck (4 axles), dolly (3 axles) and trailer (3 axles)	3,3	63,8	0,51	0,65

Specific assumptions – Kopparberg Brewery

In the execution of the calculations for Kopparberg Brewery the following specific assumptions are made:

- The daily production volume is 1000 pallets. The emission calculations are based on an annual transport volume of 365 000 sea pallets, i.e. 7 days of production per week. As of today not all of this volume is transported along the possible HCT routes. This does not affect the calculations, however. The important conclusion from the emission calculation is the relative difference between the types of vehicles. The results regarding transport economy are presented on a continuous scale in terms of number of pallets per year.
- The entire annual volume is either transported to the Mosås terminal or the Hallsberg terminal.
- All HCT systems are assumed to travel the same routes between Kopparberg and the Mosås and Hallberg terminals respectively. Thus the vehicles travel with load to 50 % and without load to 50 %.
- Average speed: 70 km/h.
- Time at terminal (SWE24): 45 minutes, whereof loading or unloading is estimated to 25 minutes at each terminal. For the Duo2 concept time at terminal estimates 110 minutes at each terminal.

- It is not assumed that all HCT system can complete the roundtrip in 4.5 hours. Costs are added for extra personnel or equipment to shorten the time for loading and/or unloading. This applies for the Duo2 scenario for the Mosås terminal and for all scenarios for the Hallsberg terminal.
- As regards the aspect of time restrictions two separate calculations have been carried out. In the case with no time restrictions, i.e. the HCT vehicles are assumed to be permitted to operate 24 hours, each vehicle can complete eight roundtrips per 24 hours. Since the existing Duo2 system is allowed to operate between 7 pm and 6 am, an alternative calculation has been carried out including this restriction. In this case each Duo2 vehicle can complete two roundtrips. The rest of the time the vehicles are used as EU18.75 vehicles.
- The type of vehicles and assumptions for each type is summarised in table 5.

Table 5: Specific assumptions for vehicles used in the calculations for case study Kopparberg Brewery. Sources: Network for Transport Measures (NTM), Transport Research Institute (TFK) 2013:3, TFK 2007:2, TFK 2009:3 and TFK 2008:3.

HCT system, length	Type of vehicle	Total cost per vehicle (MSEK)	Number of sea pallets per vehicle	Fuel consumption – without load (litre/km)	Fuel consumption – with load (litre/km)
24 m	SWE24 m	2,5	38	0,36	0,50
25.25 m	EMS25.25 m	3,0	40	0,37	0,51
32 m	Duo2	3,2	52	0,45	0,63

Results and Analysis

This chapter presents and describes the results from the transport emission and economic calculations for Zinkgruvan Mining and Kopparberg Brewery respectively.

Zinkgruvan Mining plc

The results of the transport emission and economic calculations respectively, as well as the needs for short- and long term adjustments, are presented below.

Transport emission calculations

The basis of the transport emission results (figure 7) are the total distance covered (figure 5) and fuel consumption respectively (figure 6).

Total distance covered

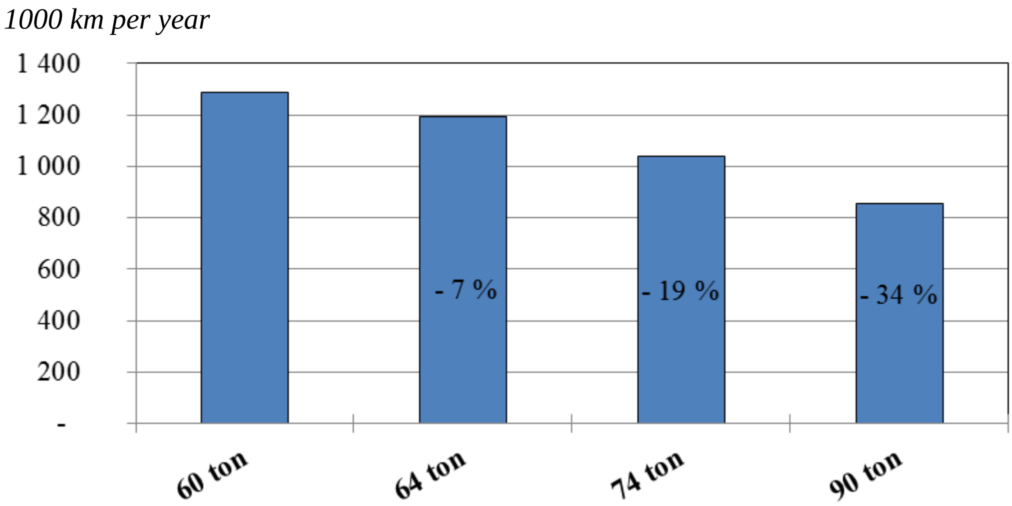

Figure 5: Total distance covered (1000 km per year) for the different transport concepts in case study Zinkgruvan Mining.

Since heavier vehicles can carry a larger net weight of goods, fewer roundtrips are required and therefore the total distance covered is reduced. This means that any of the suggested HCT systems leads to a reduction in distance covered as compared to the current transport structure. Distance reduction for the different scenarios:

- From 60 to 64 ton: -7 % (km per year)
- From 60 to 74 ton: -19 % (km per year)
- From 60 to 90 ton: -34 % (km per year)

Total fuel consumption

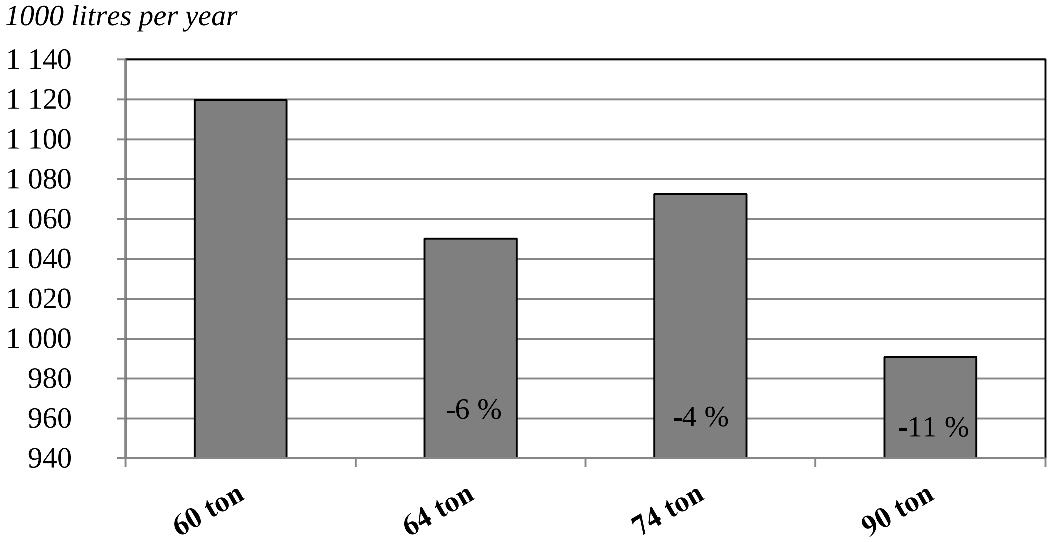

Figure 6: Total fuel consumption (1000 litres per year) for the different transport concepts in case study Zinkgruvan Mining.

Heavier vehicles generally have higher fuel consumption, however the correlation is not linear. As shown in the figure, the 74 ton concept actually leads to higher total fuel consumption than the 64 ton concept, even if the total distance covered is lower. This is explained by the fact that this sort of vehicle has higher fuel consumption in relation to the possible net weight it can carry. Notably, the 90 ton vehicles have almost 40 % higher fuel consumption per kilometre than 60 ton vehicles. The changes in total fuel consumption for the different scenarios:

- From 60 to 64 ton: -6 % (litres per year)
- From 60 to 74 ton: -4 % (litres per year)
- From 60 to 90 ton: -11 % (litres per year)

Total CO_2 emissions

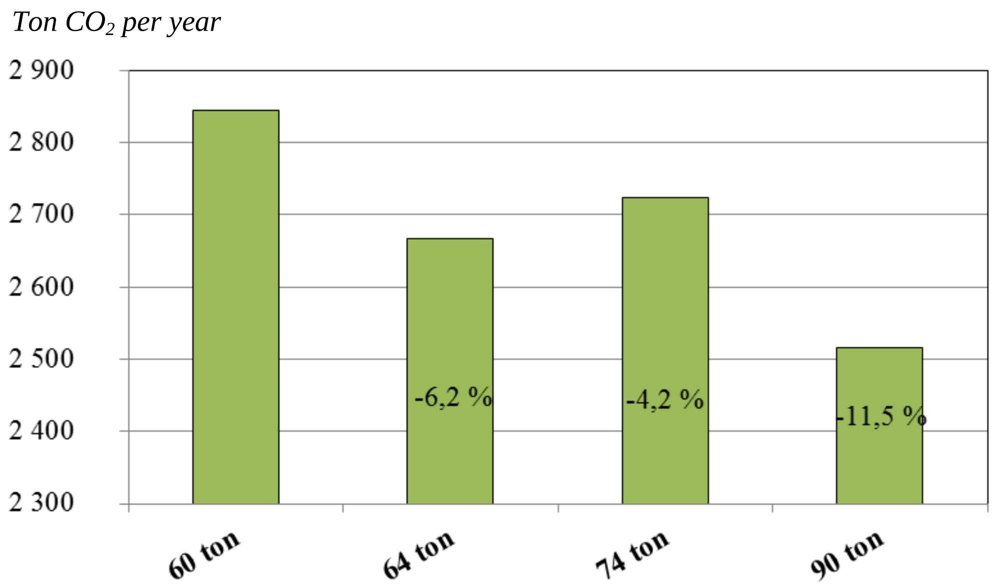

Figure 7: Total CO2 emissions (ton per year) for the different transport concepts in case study Zinkgruvan Mining.

The emission of CO_2 (figure 7) correlates to the fuel consumption of the vehicle of study. Since all vehicles are of the same Euro class, and use the same fuel, the differences of CO_2 emission follow the same pattern as for fuel consumption.

- From 60 to 64 ton: -6 % (ton CO_2 per year)
- From 60 to 74 ton: -4 % (ton CO_2 per year)
- From 60 to 90 ton: -11 % (ton CO_2 per year)

Transport economic calculations

The results of the transport economic calculations are presented in figure 8 (Y-axis: transport cost SEK/ton, X-axis: annual transport volume, interval 150 000 to 290 000 ton per year).

Total transport cost per ton

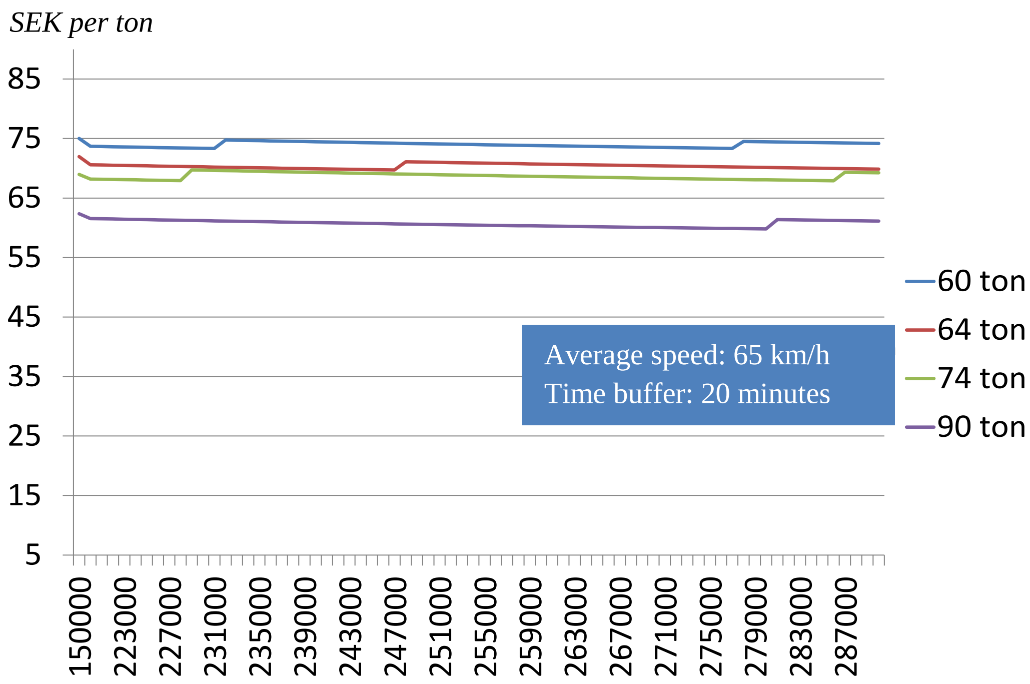

Figure 8: Total transport cost (SEK per ton) for different annual volumes (ton) for the different transport concepts in case study Zinkgruvan Mining.

The cost per ton decreases with an increased volume, until an investment in an added vehicle is needed.

For the current annual volume of approximately 250 000 ton, the potential cost reduction per ton for the different HCT systems of investigation estimates around:

- From 60 ton to 64 ton: -4 % (SEK per ton)
- From 60 ton to 74 ton: -7 % (SEK per ton)
- From 60 ton to 90 ton: -17 % (SEK per ton)

Need for short- and long term adjustments

An investigation of the facilities at Zinkgruvan Mining and the port of Otterbäcken as well as along the route between the Zinkgruvan site and the port of Otterbäcken highlights the following matters that will need to be further examined:

Logistical and planning adjustments

- Detailed planning of the roundtrip to ensure that the driver can comply with the European drivers hours rules for goods vehicles.
- Practical solutions to decrease the time needed for loading at Zinkgruvan, for example by using a second wheel loader. The 25 minutes needed for

the current vehicles – if no measures are taken – will be extended to approximately 60 and 75 minutes for the 74 and 90 ton vehicles respectively. This will strongly affect the possibility of making the roundtrip including the necessary time for driver's rest within 4.5 hours.

- With the potential introduction of the 90 ton concept, either three or four vehicles will be needed. With three vehicles, one vehicle of the type used today will need to be kept in operation, making about 10 roundtrips per week. If four 90 ton vehicles are used, the total weekly volume of concentrates will be approximately 1000 ton more than today. This means that the extra volume transported corresponds to one additional ship departure per month. The question arises whether this is possible to meet from a production perspective and called for by the market.

Infrastructural adjustments along route

- Load capability of parts of the road leading from the Zinkgruvan site and onto road 50 (applies to 74 and 90 ton vehicles).
- Load capability of bridges across the Hammar straits (applies to 90 ton vehicles).
- Potential difficulties to travel up and down the slopes at Finnerödja and close to Hova on European route E20.

Infrastructural adjustments at start and end-points

- The scale at the Zinkgruvan site does not function in a satisfactory way.
- The scale at the port of Otterbäcken has a maximum of 70 ton and therefore needs to be replaced (applies to 74 and 90 ton vehicles).
- The matter of replacing scales may be resolved by equipping the vehicles with internal scales. This would probably also help to decrease the time needed for loading.
- In order to save time while unloading – by tipping both the truck and trailer simultaneously – the tipping pocket at the port of Otterbäcken needs to be elongated.
- Possibly, depending on the future load carrier, the roof of the unloading shed will need to be adjusted in order to allow for higher load carriers.
- The load capability of the ramp at the unloading station as well as the possibility to manoeuvre heavy vehicles on the ramp.

Kopparberg Brewery plc

The results of the transport emission and economic calculations respectively, as well as the needs for short- and long term adjustments, are presented below.

Transport emission calculations

The basis of the transport emission results (figure 11) are the total distance covered (figure 9) and fuel consumption respectively (figure 10).

Total distance covered

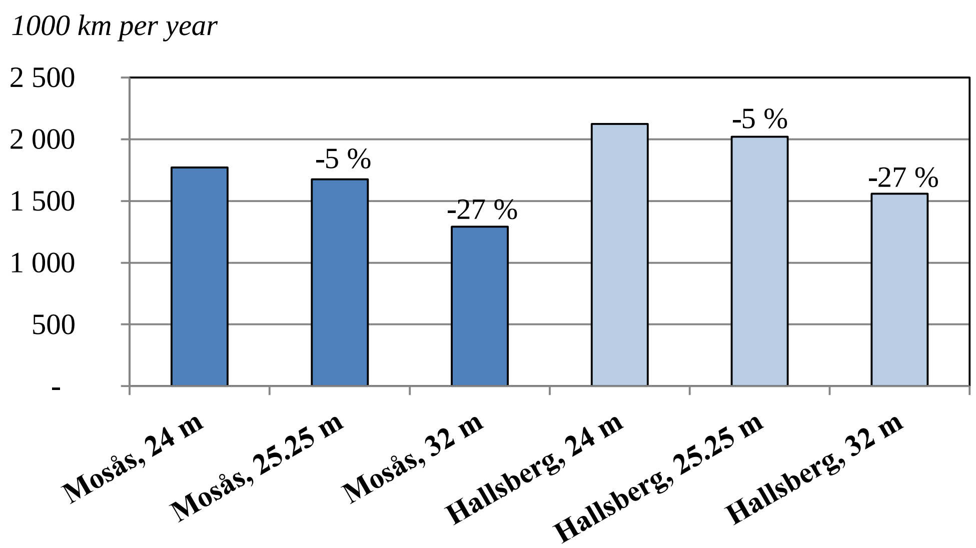

Figure 9: Total distance covered (1000 km per year) for the different transport concepts and routes in case study Kopparberg Brewery.

Since longer vehicles can carry a larger number of pallets, fewer roundtrips are required and therefore the total distance covered is reduced. The Duo2 concept will – for either terminal – lead to a substantial reduction of 27 % in terms of distance covered, as compared to the current transport structure. The relative distance reductions for the different scenarios are equal for both transport relations:

- From SWE24 to EMS25.25: -5 % (km per year)
- From SWE24 to Duo2: -27 % (km per year)

Total fuel consumption

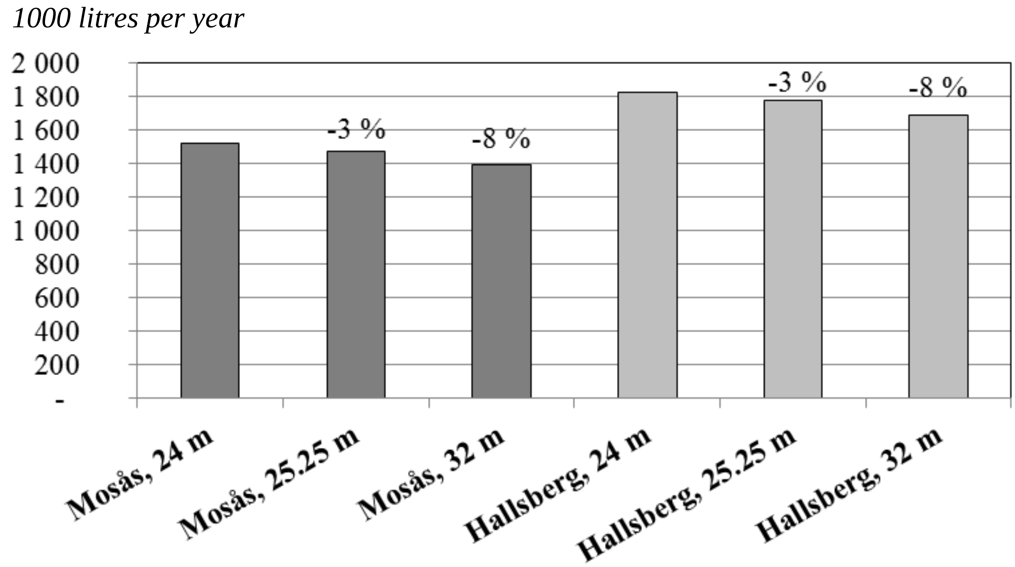

Figure 10: Total fuel consumption (1000 litres per year) for the different transport concepts and routes in case study Kopparberg Brewery.

Heavier vehicles have higher fuel consumption, however the correlation is not linear. The Duo2 vehicles have about 25 % higher fuel consumption per kilometre than SWE24 vehicles. This explains why – despite leading to a 27 % reduction of distance covered – the fuel consumption for the Duo2 concept is only 8 % lower than for SWE24 vehiclces. The relative fuel consumption reductions for the different scenarios are equal for both transport relations:

- From SWE24 to EMS25.25: -3 % (litres per year)
- From SWE24 to Duo2: -8 % (litres per year)

Total CO_2 emissions

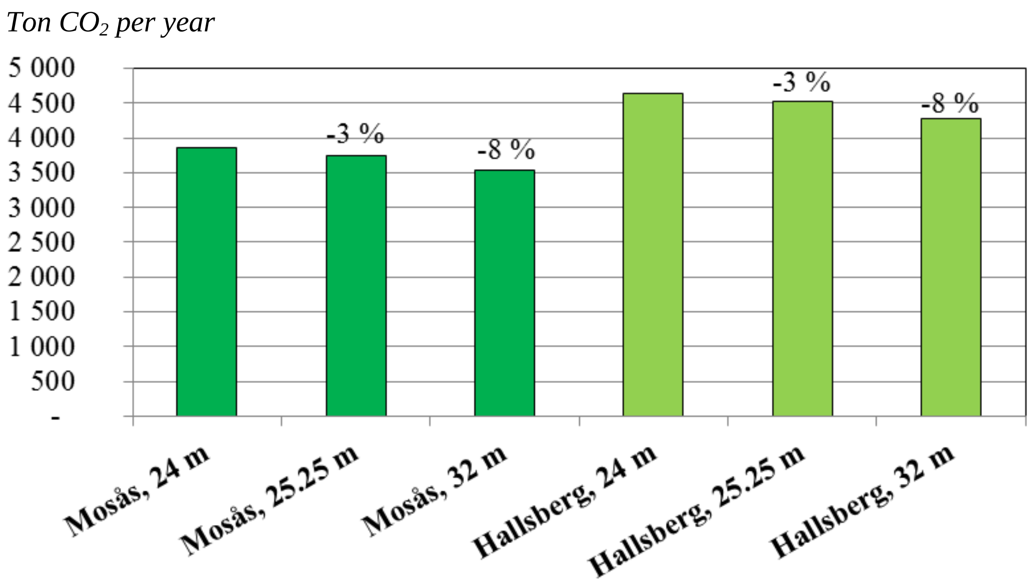

Figure 11: Total CO2 emissions (ton per year) for the different transport concepts and routes in case study Kopparberg Brewery.

The emission of CO_2 (figure 11) correlates on the fuel consumption of the vehicle of study. Since all vehicles are of the same Euro class and use the same fuel, the differences of CO_2 emission follows the same pattern as for fuel consumption. The relative emission reductions for the different scenarios are equal for both transport relations:

- From SWE24 to EMS25.25: -3 % (ton CO_2 per year))
- From SWE24 to Duo2: -8 % (ton CO_2 per year))

Transport economic calculations

The results of the transport economic calculations for the transport relation Kopparberg to Mosås and Hallsberg terminals are presented in figures 12-13 and 14-15 respectively (Y-axis: transport cost SEK/pallet, X-axis: annual transport volume, interval 300 000 to 440 000 pallets per year).

Total transport cost per sea pallet, Kopparberg Brewery-Mosås terminal, without time restrictions

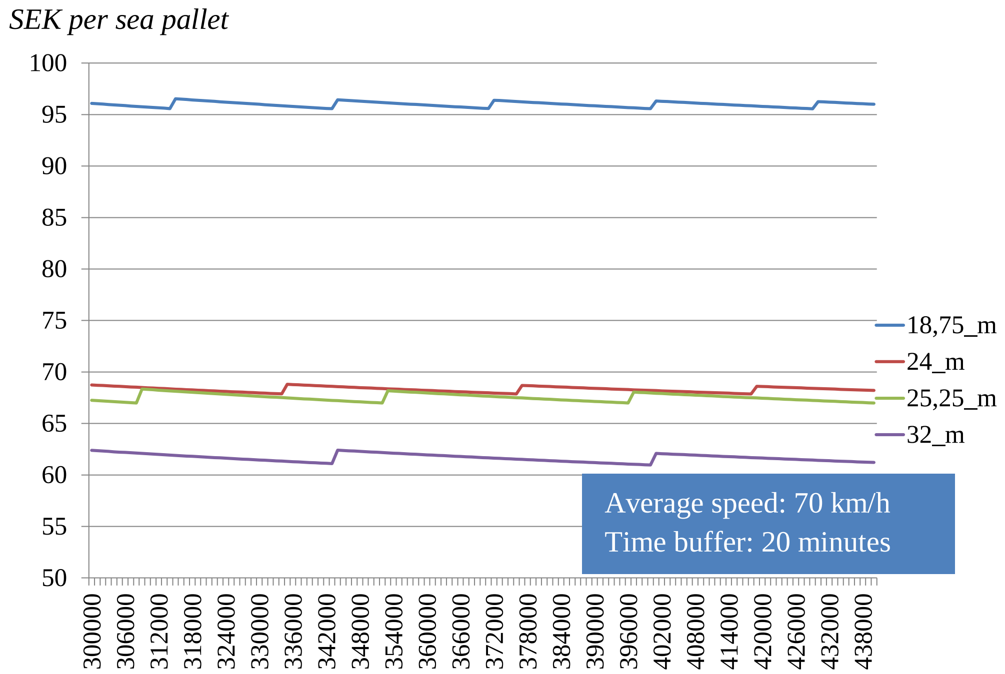

Figure 12: Total transport cost (SEK per sea pallet) without time restrictions for the different transport concepts on the route to the Mosås terminal.

The cost per pallet decreases with an increased volume, until an investment in an added vehicle is needed.

For the current annual volume of approximately 365 000 pallets, the transport costs using SWE24 are practically equivalent to using EMS25.25 (figure 12). EMS vehicles require a larger investment, and therefore a larger cost of capital, but can also transport a larger volume.

With the Duo2 concept, given that the driver also manages the loading and unloading, the roundtrip cannot be completed within the European drivers hours rules. Therefore a cost for added personnel at the terminals has been included. This additional cost per pallet is marginal, and lower than the cost of extra drivers that would otherwise be needed in order to complete the roundtrips within the time limits.

Yet, by introducing the Duo2 concept – without time restrictions – the potential cost reduction on the relation Kopparberg-Mosås estimates 10 % (SEK per pallet) as compared to the current SWE24 or EMS25.25 concepts.

As pointed out above this potential cost reduction applies only under the circumstance that the Duo2 concept can operate without time restrictions, i.e. 24 hours.

In the alternative calculation a time restriction has been introduced (figure 13). In this scenario the Duo2 vehicles are only allowed to operate between 7 pm and 6 am. The remaining time the vehicles are used as EU 18.75, with a capacity of 26 sea pallets.

Total transport cost per sea pallet, Kopparberg Brewery-Moså s terminal, with time restriction to operate only from 7 pm to 6 am

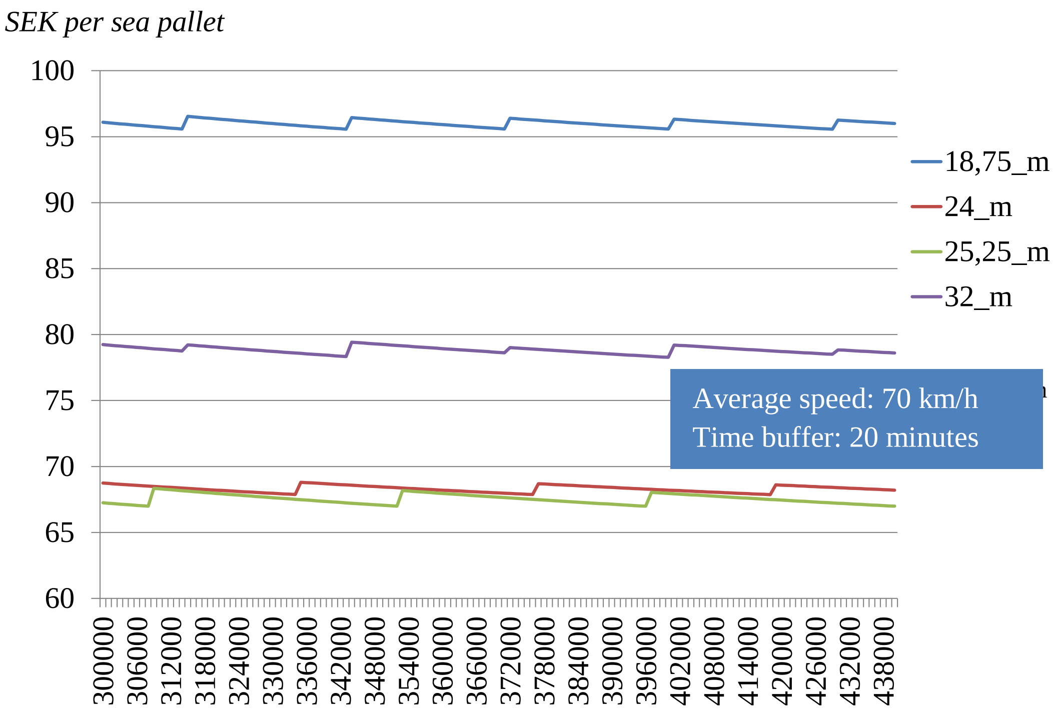

Figure 13: Total transport cost (SEK per sea pallet) with time restrictions for the different transport concepts on the route to the Mosås terminal.

Under the time restriction the cost structure for the combined EU 18.75/Duo2 system increases substantially, about 15 % (SEK/pallet) compared to a regular SWE24 concept. This is mainly due to the fact that the use of the HCT vehicles, and therefore the capital investment, is much less efficient. Nevertheless, this is a better option than not operating the Duo2 vehicles at all during the day.

Total transport cost per sea pallet, Kopparberg Brewery-Hallsberg terminal, without time restrictions

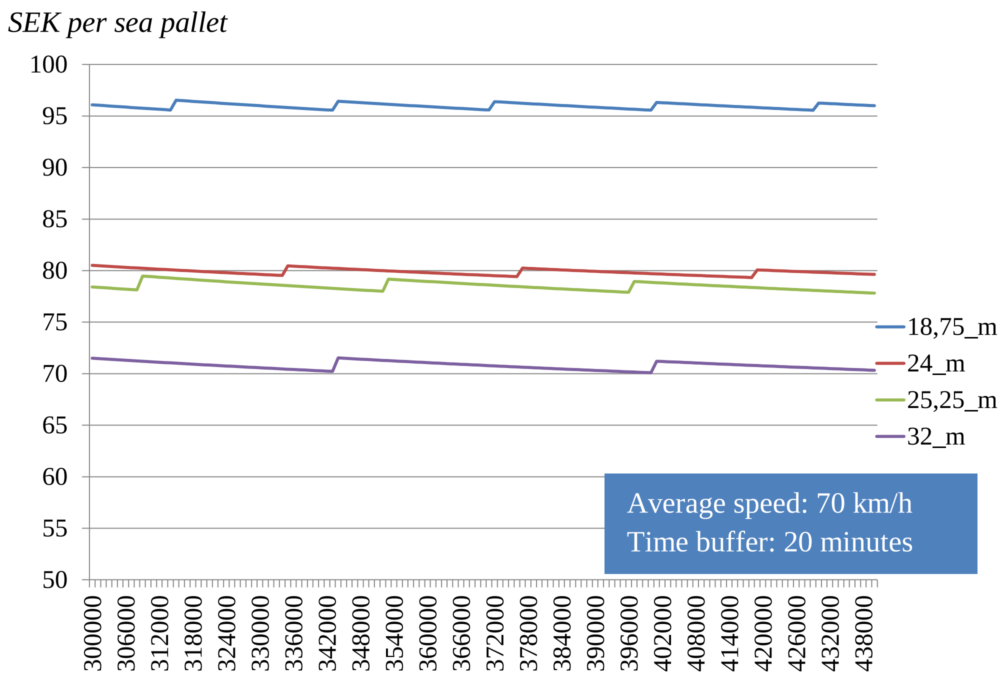

Figure 14: Total transport cost (SEK per sea pallet) without time restrictions for the different transport concepts on the route to the Hallsberg terminal.

First of all it is important to notice that the transport cost to the Hallsberg terminal is significantly higher (about 10-15 % per pallet) than to the Mosås terminal. This is mainly due to the fact that the distance covered to Hallsberg is about 20 % higher than to Mosås. Furthermore, costs for additional personnel at the Hallsberg terminal has been added in order to ensure that the roundtrips can be completed within the time limits.

Apart from being generally more expensive, the pattern of transport costs for the Kopparberg-Hallsberg relation is similar to that of the Kopparberg-Mosås relation described in the previous section.

For the current annual volume of approximately 365 000 pallets, the transport costs using SWE24 are practically equivalent to using EMS25.25 (figure 14).

By introducing the Duo2 concept – without time restrictions – the potential cost reduction on the relation Kopparberg-Hallsberg estimates 10-11 % (SEK per sea pallet) as compared to the current SWE24 or EMS25.25 concepts.

In the same manner as for the Kopparberg-Mosås relation an alternative calculation including a time restriction has been carried out (figure 15).

Total transport cost per sea pallet, Kopparberg Brewery-Hallsberg terminal, with time restriction to only operate from 7 pm to 6 am

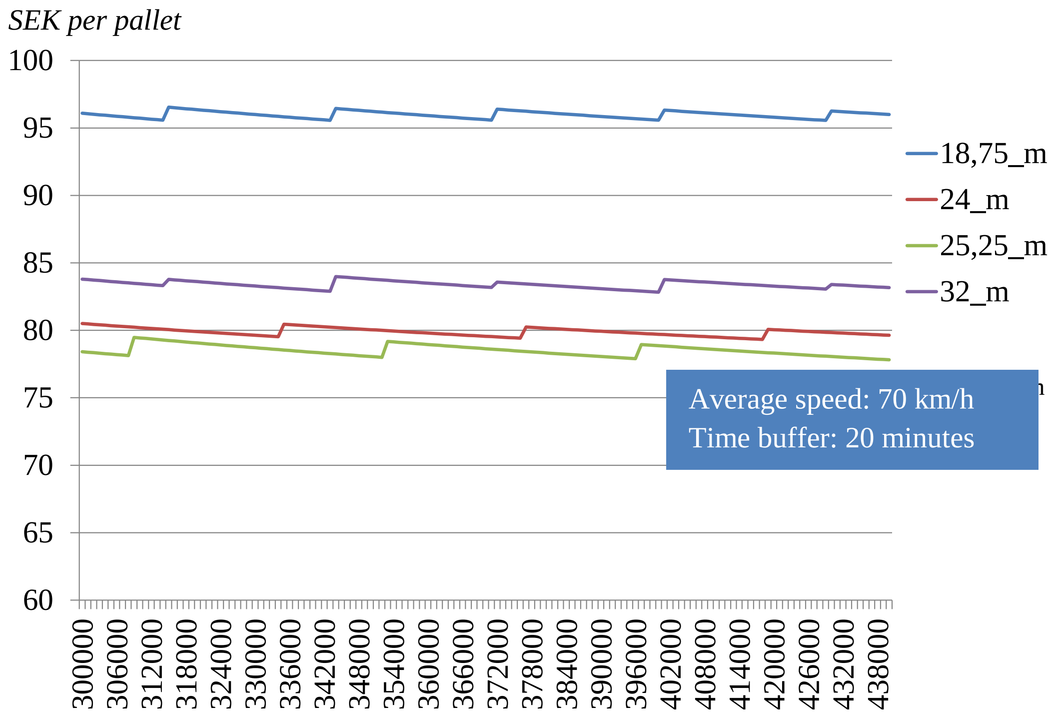

Figure 15: Total transport cost (SEK per sea pallet) without time restrictions for the different transport concepts on the route to the Hallsberg terminal.

Under the time restriction the cost structure for the combined EU18.75/Duo2 system increases substantially, about 5 % (SEK/pallet) compared to a regular SWE24 concept.

Need for short- and long term adjustments

An investigation of the facilities at Kopparberg Brewery and the terminals of Mosås and Hallberg respectively, as well as along the route between Kopparberg and the terminals highlight the following matters that will need to be further examined:

Logistical and planning adjustments

- Detailed planning of the roundtrips to either terminal, in particular to Hallsberg, to ensure that the driver can comply with the drive and rest regulations.
- Measures are needed to reduce the time needed for loading at Kopparberg and unloading at the terminals, e.g. by adding personnel for these activities. This will strongly affect the possibility of making the roundtrip including the necessary time for driver's rest within 4.5 hours.

Infrastructural adjustments along route

- There are several roundabouts along the route, most of which with one lane only. A detailed study is needed regarding the possibility to safely manoeuvre 32 m long vehicles through these roundabouts.
- Experience from drivers show that heavy vehicles in wintertime may have difficulties to get up the slopes at Fanthyttan.

Infrastructural adjustments at start and end-points

- Detailed study is needed of the loading area at Kopparberg Brewery, as well as the unloading areas at both terminals, to investigate whether or not it is possible to safely manoeuvre 32 m long vehicles on these different locations.
- The load capability of the bridge leading in and out of the yard at Kopparberg Brewery.
- The access road to the Mosås terminal needs to be further investigated regarding the accessibility of 32 m vehicles.
- The access road to the Hallsberg terminal, as well as the turn from and onto road 50, needs to be further investigated regarding the accessibility and manoeuvrability of 32 m vehicles.

Conclusions from case studies

Conclusions from the case studies of Zinkgruvan Mining and Kopparberg Brewery respectively are described below.

Case study: Zinkgruvan Mining

A summary of the results for the case study is presented in table 6. For the transport cost, the relative difference is valid for the current transport volume of about 250 000 ton per year.

Table 6: Summary of results for case study Zinkgruvan Mining.

HCT-system, gross weight	Net weight per vehicle (ton)	Roundtrips per year (approx.)	Distance covered (km per year)	CO_2 emission (ton per year)	Transport cost (SEK per ton)
60 ton	42	5 700	1 300 000	2 850	74
64 ton	+8 %	-400 roundtrips	-7 %	-6 %	-4 %
74 ton	+24 %	-1 100 roundtrips	-19 %	-4 %	-7 %
90 ton	+52 %	-1 900 roundtrips	-34 %	-11 %	-17 %

The conclusions from the Zinkgruvan Mining case study are presented below, categorised as:

- Transport emissions
- Transport economy
- Critical parameters and necessary adjustments
- Dispensation matters

Transport emissions

- Any of the investigated HCT systems, as compared to the current transport structure, leads to a reduction in distance covered, fuel consumption and emission of CO_2.
- From an environmental perspective the 90 ton concept is clearly the most preferable, as it leads to a 34 % reduction of distance covered and an 11 % reduction of fuel consumption and emission of CO_2 respectively.
- An introduction of the 64 ton or 74 ton concepts would also benefit the environment, with a reduction in fuel consumption and emission of CO_2 of about 5 %.
- Of the potential HCT systems the 74 ton concept is the least feasible from an environmental perspective. Even if the distance covered is substantially reduced, the vehicles have a proportionally higher total fuel consumption and emission of CO_2 than the additional net weight that can be transported.
- The pattern for CO_2 also applies to other emissions, such as NO_x and CO.

Transport economy

- An investment in any of the investigated HCT system, as compared to the current transport structure, is profitable from a transport economy perspective.
- Transport of the current annual volume of goods requires vehicles of one of each type as follows:
  - 60 ton: 5 vehicles *or*
  - 64 ton: 5 vehicles *or*
  - 74 ton: 4 vehicles *or*
  - 90 ton: 4 vehicles
- The 90 ton concept is clearly the most profitable option and possibly (with four vehicles) allows for an increase in transport volume that corresponds to about 1000 ton per week or one added shipping per month.
- Depending on the annual volume, the 64 ton concept could be practically equivalent to the 74 ton concept.
- In particular the 90 ton concept implies substantial investment in new, specialised, vehicles. This means that financial strength and long term commitment from the stakeholders are important factors for success.

Critical parameters and necessary adjustments

- To complete the roundtrip in 4.5 hours is a critical parameter for the planning and resource efficiency of both vehicles and drivers. Calculations show that for the 74 and 90 ton concepts this will be difficult to achieve unless measures are taken at both the Zinkgruvan site and at the port of Otterbäcken to reduce the time needed for loading and unloading. The roundtrip and such necessary measures will need to be further investigated.
- A time restriction on the HCT vehicles will have a substantial effect on the economic profitability. The time restriction aspect will need to be further investigated.

Dispensation matters

- The 64 ton concept will likely be possible to operate on the general road network without special allowance in the short term perspective.
- The 74 ton concept will likely be possible to operate on roads 50 and E18/E20 without special allowance in the short term perspective. This means that the special permission is needed for limited parts of the route only.
- The 90 ton concept will most likely need to go through the complete process of getting a special permission to operate on the entire route.
- In the process of being granted a dispensation on the current routes, the load capability of the road connecting the Zinkgruvan site with road 50, as well as the load capability of the bridges at the Hammar straits, will need to be further investigated.

Case study: Kopparberg Brewery

A summary of the results for the case study is presented in table 7. For the transport cost, the relative difference is valid for the current transport volume of about 365 000 sea pallets per year, and without time restrictions for the Duo2 concept.

*Table 7: Summary of results for case study Kopparberg Brewery. *The change of transport cost for Duo2 is presented both without and with time restrictions (without/with).*

HCT-system, length	Number of sea pallets per vehicle	Roundtrips per year (approx.)	Distance covered (km per year)	CO_2 emission (ton per year)	Transport cost (SEK per sea pallet)*
	Kopparberg-Mosås terminal				
24 m	38	9 600	1 750 000	3 850	68
25.25 m	+5 %	-500 roundtrips	-5 %	-3 %	-<1 %
32 m	+37 %	-2 600 roundtrips	-27 %	-8 %	-10 %/+15 %*
	Kopparberg-Hallsberg terminal				
24 m	38	9 600	2 100 000	4 650	79
25.25 m	+5 %	-500 roundtrips	-5 %	-3 %	-1 %
32 m	+37 %	-2 600 roundtrips	-27 %	-8 %	-10 %/+5 %*

The conclusions from the Kopparberg Brewery case study are presented below, categorised as:

- Transport emissions
- Transport economy
- Critical parameters and necessary adjustments
- Dispensation matters

Transport emissions

- From an environmental perspective the Duo2 concept is clearly more preferable than SWE24 vehicles. The use of Duo2 vehicles leads to a 27 % reduction of distance covered and an 8 % reduction of fuel consumption and emission of CO_2 respectively.
- The sole use of EMS25.25 vehicles would also benefit the environment, with a reduction in fuel consumption and emission of CO_2 of about 3 %.
- This pattern also applies to other emissions, such as NO_x and CO.

Transport economy

- Transport of the current annual volume of goods requires vehicles of one of each type as follows:
  - SWE24: 9 vehicles *or*
  - EMS25.25: 9 vehicles *or*
  - Duo2: 7 vehicles
- The transport cost to the Hallsberg terminal is – for any type of vehicle – significantly higher (about 10-15 % per sea pallet) than to the Mosås terminal.
- For the current annual volume, the transport cost for either transport relation using EMS25.25 vehicles is practically equivalent to using SWE24 vehicles.
- Given that the Duo2 concept is allowed to operate without time restrictions, the transport cost for either transport relation can be reduced with about 10 % per sea pallet as compared to the current SWE24 or EMS25.25 concepts. Thus, such an investment is profitable from a transport economy perspective.
- Under a time restriction equal to what applies to the existing Duo2 concept, the cost structure for a combined EU18.75/Duo2 system increases substantially, about 5-15 % (SEK/sea pallet) compared to a regular SWE24 concept.
- The Duo2 concept implies substantial investment in specialised vehicles and components. This means that financial strength and long term commitment from the stakeholders are important factors for success.

Critical parameters and necessary adjustments

- To complete the roundtrip in 4.5 hours is a critical parameter for the planning and resource efficiency of both vehicles and drivers. Estimations show that for the Duo2 concept this will be difficult to achieve unless measures are taken at both the Kopparberg site and at the terminals to reduce the time needed for loading and unloading. The same difficulty appears for all relations to the Hallsberg terminal. Therefore costs have been added for extra personnel to shorten the time for loading and/or unloading. This applies for the Duo2 scenario for the Mosås terminal and for all scenarios for the Hallsberg terminal. The roundtrip and necessary measures will need to be further investigated.
- Measures to reduce the time at terminal is even more important for the Kopparberg-Hallsberg relation, where the total distance to be covered is almost 40 km longer than to the Mosås terminal. In this relation, even a 50 percent reduction of time for loading and unloading means that the Duo2 concept remains vulnerable for disturbances.
- According to the calculations, the breaking point for completing the roundtrip within 4.5 hours occurs between the terminals of Mosås and Hallsberg.
- A time restriction on the Duo2 concept will have a very substantial effect on the transport economy and is likely to reject the investment at all. The time restriction aspect will need to be further investigated.

- Detailed studies are needed of the loading area at Kopparberg Brewery, as well as the access roads and unloading areas at both terminals, to investigate whether or not it is possible to safely manoeuvre 32 m long vehicles on these different locations.

Dispensation matters

- The Duo2 concept – being longer than 25.25 m – will most likely need to go through the complete process of getting a special permission to operate on the entire route.
- In the process of being granted a dispensation on the current routes, several roundabouts will need to be further investigated regarding the possibility to safely manoeuvre 32 m long vehicles through these roundabouts. Potentially, the ability for Duo2 vehicles to safely get up the slopes at Fanthyttan will need to be further investigated.

Impact Evaluation

The case studies of ZInkgruvan Mining and Kopparberg Brewery respectively show that an investment of a HCT system can lead to significant reductions of transport costs as well as transport emissions.

The basis of such effects is that longer and/or heavier vehicles can carry larger volumes of goods. Thus, for a constant total goods volume, fewer roundtrips are required and therefore the total distance covered, and potentially the required number of vehicles, is reduced.

The case studies also show that HCT systems not necessarily have positive effects on the transport economy. Therefore careful studies of necessary investments, potential effects and necessary logistical adjustments are needed before deciding on a HCT investment.

Transport emissions

The case studies show that from an environmental perspective, the introduction of HCT vehicles is often beneficial.

Longer and/or heavier vehicles have higher fuel consumption, however the correlation between higher fuel consumption and the possible additional goods volume is not linear.

An investment in a radically different transport system will lead to a significant reduction of total distance covered (20-35 %). Since these vehicles often also have a considerably higher fuel consumption per kilometre (>25 %), the reduction of fuel consumption and therefore emission of CO_2 is lower, but still noteworthy (5-10 %). This pattern also applies to other emissions, such as NO_x and CO.

The case studies also show that even a slight increase of the goods volume (e.g. from a net weight of 42 to 45 ton) can lead to a reduction in fuel consumption and emission of CO_2 of about 5 %.

It appears as if the heaviest and longest vehicles (i.e. 90 ton for Zinkgruvan Mining and Duo2 for Kopparberg Brewery) have the most advantageous environmental impact.

Transport economy

The case studies show that from a transport economy perspective, the introduction of HCT-vehicles is often beneficial.

Longer and/or heavier vehicles imply a higher cost of investment, but since these vehicles also can carry larger goods volumes it leads to direct reductions of fuel costs and potentially that fewer vehicles are required to carry out the transports.

The case studies show that by investing in a fundamentally different transport system, the transport costs can be reduced by 10-15 %.

Even a minor change of the transport system (e.g. from a net weight of 42 to 45 ton) can lead to an un-negligible reduction of transport costs (around 5 %).

Similarly as for the aspect of transport emissions, it appears as if the heaviest and longest vehicles (i.e. 90 ton for Zinkgruvan Mining and Duo2 for Kopparberg Brewery) have the most advantageous impact on transport economy.

Societal perspective

On the basis that HCT systems lead to a reduction of roundtrips needed to transport a certain goods volume, the total time of heavy vehicles being exposed on the road network is also reduced. Thus it can be argued that HCT systems have positive effects on road safety, and from that aspect therefore is beneficial from a societal perspective.

Process Evaluation

Based on the experience from the case studies this chapter describes factors enabling or hindering the success of HCT systems.

Factors enabling or hindering success

Factors enabling or hindering the success of HCT systems comprise wide-spread issues, some of which are in the hands of the authorities, others of the industry. The description is mainly made from a positive – enabling – perspective. Factors are categorised in the areas of:

- Infrastructure
- Regulatory framework
- Stakeholder commitment
- Suitable transport relation and roundtrip optimisation
- Type of goods and vehicle optimisation

Infrastructure

The infrastructure at the start- and endpoints, e.g. intermodal terminals or ports, of the transport relation, and between these locations, must be of good standard and allow for an increase in length and/or weight of vehicles. Also, as will be described below, the infrastructure ideally allows for average speeds of about 65-70 km per hour for the HCT vehicles.

The case studies highlight the need to investigate the infrastructure along the whole route, including access roads and the loading and unloading facilities at start- and/or endpoints. A weak link along the route may lead to rejection of the entire HCT concept.

Typical hinders for heavier vehicles include the load capability of bridges and roads, in particular access roads beyond the national road network. Also, the layout of slopes can be a hinder for heavy vehicles, especially in countries where winter conditions will need to be considered.

Typical hinders for longer vehicles are roundabouts, in particular when a 270-degree turn is needed. Furthermore, the accessibility and manoeuvrability of long vehicles at the start- and/or endpoints as well as entrances and exits of roads might be a hinder.

Regulatory framework

The regulatory framework regarding HCT allowances must be transparent and long-term. This is because the introduction of HCT systems will require relatively substantial investments from the stakeholders, both in vehicles and other equipment, and perhaps even a change in production and transport processes.

The framework must point out where in the road network different HCT systems will be allowed, and what other restrictions will apply (e.g. speed allowances, time of operation and weather conditions). The case study for Kopparberg Brewery highlights that a time restriction for the HCT system, being clearly environmentally beneficial, may lead to an increase in transport costs.

As regards the application process it too must be transparent, especially requirements of documentation and handling times.

Stakeholder commitment

Unless one stakeholder manages the entire transport relation, the introduction of a HCT system calls for long-term stakeholder commitment. Such stakeholders often include the freight owner, the forwarder and terminal operator (e.g. intermodal terminal or port operator).

The long-term commitment is needed because a HCT system often requires:

- Detailed studies in order to understand what HCT systems are available and which is the most advantageous.
- Investments in new vehicles and load carriers. Since HCT vehicles tend to be technically advanced and specialised, the alternative market for these vehicles may be limited.
- Investments at the start- and/or endpoints, e.g. facilities and equipment for loading and unloading.
- Adjustments of production and transport processes, e.g. planning, working times or organisation, in order to maximise the benefits of the HCT system.
- Possible adjustments of business-related agreements between stakeholders, e.g. regarding the distribution of investments and profits that stem from the HCT-concept.
- A cost structure that allows for the HCT transports to be a designated service between a start- and endpoint, and often will have a fill rate of 50 %.

In summary, an important success factor for HCT systems is long-term (at least 5-10 years) relations between key stakeholders.

Suitable transport relation and roundtrip optimisation

One of the most critical success factors is the suitability of the transport relation given the requirements stated in the European drivers hours rules for goods vehicles. In practice this can involve short distances where multiple roundtrips can be completed within nine hours, e.g. continuous goods flows from a production site to a terminal or from a terminal to a port. At the other end of the scale, as for the existing Duo2 concept, a longer distance (300 km one way) can imply that only one roundtrip can be completed. In the latter case the need of finding return freight needs to be highlighted.

For both case studies one critical factor, linked to the scheduling of drivers, was to complete a roundtrip within 4.5 hours, and therefore two roundtrips per driver per working day.

As an example the optimal distance for these case studies can be calculated. Given an average speed of 65 to 70 km per hour, time at terminals at the start- and endpoints of about 25-30 minutes per terminal and a time buffer of 20 minutes per roundtrip, a suitable one-way distance of the transport relation can be estimated to 100-115 km.

Within this distance interval the use of vehicles and drivers' working time – and hence the benefits of the HCT system – can be optimised. Shorter distances make use of vehicles and drivers' working time less efficient. Longer distances causes growing sensitivity to disturbances and potentially measures like extra personnel at terminals or even additional drivers.

This example also highlights the need for efficient handling at the terminals, so that the time on the road can be maximised. This is especially important for larger volumes, so that the handling of such larger volumes doesn't hinder the completion of the roundtrip within the specified time.

The roundtrip optimisation for the one-way transports also means that the chances of finding freight for the return are limited.

Type of goods and vehicle optimisation

In order to maximise the benefits of the HCT system the matching and optimisation between type of goods and vehicle is a critical success factor. The optimisation will be dependent on at least one of the following parameters:

- Weight
- Load meter
- Volume

In the case study of Zinkgruvan Mining, the type of goods (bulk) is ideal to maximise the potential net weight for each type of HCT system.

For Kopparberg Brewery, whose goods are packed on sea pallets, the load meter is the restricting parameter. Even if the Duo2 concept allows for a significant increase regarding the number of pallets – from 38 or 40 to 52 – the maximum gross weight of the vehicle is not reached.

As a comparison Zinkgruvan Mining can increase the payload per transport by 52 %, whereas the corresponding figure for Kopparberg Brewery is 37 %.

By that the case studies highlight that the fact that the currently tested maximum gross weight is a more generous allowance increase (+50 %, from 60 to 90 ton) than the length oriented HCT systems (+27 %, from 25.25 to 32 m).

Therefore is appears as if the gains are greater with weight rather than length oriented HCT systems, especially if the type of goods allows for maximisation of the weight allowance.

The case studies underline that in order to maximise the return on investment the vehicle and load carrier need to be optimised based on the type of goods.

Also, in order to reach the full potential of the HCT system of choice, specialised load carriers are required in certain cases. This aspect limits the chances of finding return freight.

Alternatively, the HCT system can be based on transport of standardised load carriers, e.g. containers. This increases the chances of finding return freight.

Recommendations

The two case studies of this report confirm what pervious reports and case studies of existing HCT systems have showed: HCT systems can lead to significant reductions of transport costs as well as transport emissions.

Also, the investigation, investment and use of HCT systems are possible for replication along GreCOR.

In this section, primarily based on the case studies, recommendations are lined out, categorised in different aspects:

- International
- Technical
- Behavioural
- Logistic

International aspect

The development and use of HCT systems is suitable on the international scene. The positive effects from an environmental and transport economical, as well as societal, perspective may be realised in any country. The potential types of HCT systems will differ depending on the capability of the national road network, to what extent where HCT transports will be allowed on the road network as well as on other restrictions (e.g. time of operation and speed allowances).

However, since the regulatory framework differs between countries, the use of HCT systems is currently not suitable for border-crossing freight transports.

Recommendation:

- Local, regional or national authorities are recommended to support HCT initiatives from the industry along GreCOR.

Technical aspect

The capability and capacity of the infrastructure is critical to allowing HCT systems. Often, the load capability of bridges and roads, in particular access roads to production sites, terminals or ports beyond the national road network, are critical for allowing HCT vehicles.

From an authority perspective, as well as to guarantee fair competition, it is important to ensure that the HCT vehicles operate within the allowances (e.g. designated routes, time of operation or speed restrictions)

Recommendations:

- Identify a designated HCT road network.
- Investigate the load capability of bridges on this designated network.
- Focus on creating a continuous network where HCT vehicles can be allowed. This network may expand over time.

- Identify a manageable control system to ensure that HCT vehicles operate within their allowances.
- Identify IT-solutions to guide drivers within the designated network.

Behavioural aspect

The development of a HCT system may require significant investments from infrastructure owners and industry stakeholders. Furthermore, the potential benefits of HCT systems are such that industry stakeholders may wish to use such systems even over longer distances and potentially for international transports. From an authority perspective, this may lead to unwanted consequences of HCT dispensations.

Recommendations:

- Develop a regulatory framework that is transparent and long-term.
- It is recommended that the regulatory framework outlines for what types of transport HCT systems are allowed, e.g. between a production site and a warehouse, terminal or port.
- The regulatory framework needs to clarify what types of HCT systems are allowed, where in the road network different HCT systems will be allowed, and what other restrictions that will apply (e.g. speed allowances, time of operation and weather conditions).
- Develop a transparent and effective application process.

Logistic aspect

The logistic aspect focuses on the actual stakeholders involved in the development of the HCT system.

Recommendations:

- Depending on the type of goods being transported, investigate what type of HCT vehicle can be the most suitable. What is dimensioning for the optimisation of the vehicle; weight, load meter or volume?
- Analyse the transport relation (distance, average speed and time at terminal) and the possibility to complete roundtrips that correlates with the European drivers hours rules for goods vehicles as well as production and delivery planning.
- Ensure long-term (at least 5-10 years) relations between key stakeholders.

References

Articles & Reports

Coordinated freight transports in Dalarna, calculations from SamTran, Swedish Transport Institute (TFK), 2009:3, 2009

Dagtrans – Intermodal transports in the perishable sector, Swedish Transport Institute (TFK), 2008:3, 2008

European modular system for road freight transport – experiences and possibilities, Swedish Transport Institute (TFK), 2007:2, 2007

External and future analysis - longer and heavier road and railway vehicles, Report 676, VTI, 2010

Final report Duo2-Trailer, FFI, 2013

First year evaluation of ECT, Trivector, 2012

Heavier vehicles on the general road network, Swedish Transport Administration, TRV 2014:102, 2014

High Capacity Transports, case studies, Therese Gröndahl, thesis KTH, 2012

Modular vehicles interaction or competition with intermodal transport systems, Swedish Transport Institute (TFK), 2013:3, 2013

Report on heavier and longer vehicles on the general road network, Swedish Transport Agency, TSV 2014:1419, 2014

Road map: High Capacity Transports – road, FFI/Closer, 2013.

Interviews

Maria Gustafsson, Port manager, Port of Otterbäcken

Mattias Tingström, supply manager, Zinkgruvan Mining plc

Mikael Pellerud, Logistic manager, Kopparberg Brewery plc

Peter Engström, Business area manager, Cliffton plc.

Tomas Pettersson, Business area manager, A.L.I. Frakt

Electronic sources

www.energieffektivatransporter.se

www.skogforsk.se

www.trafikverket.se

www.transportstyrelsen.se

Contact
Fabian Ilgner
Örebro Regional Development Council

www.grecor.eu

The Interreg IVB North Sea Region Programme
Investing in the future by working together

European Union
The European Regional Development Fund