

# Assessments of measures for the greening of transport logistics systems from three use cases in the Swedish section of the Scandinavian – Mediterranean corridor

FINAL REPORT FROM THE PROJECT GET GREENER

FRANS PRENKERT  
ÖREBRO UNIVERSITY SCHOOL OF BUSINESS

MAGNUS SWAHN  
NTM/CONLOGIC



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# Preface

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This report constitutes the final reporting from the project GET Greener. GET Greener started as an initiative by CLOSER, and was financed by the Swedish Transport Administration (Trafikverket, TrV). The project started in September 2016 and ended in March 2017.

We wish to thank all the respondents in participating organizations for unselfishly having shared their time, data and invaluable knowledge. We also acknowledge the valuable input from the members of the project group during the entire project.

We are also indebted to input from the members of the reference group, which helped ensure relevance and quality of the work.

Nicklas Blidberg, CLOSER



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# Executive Summary

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## **Introduction and purpose of *GET Greener***

While many initiatives and measures exist that hold the potential for greener transports and logistics systems, studies show that the relative importance of environmental efficiency for transport purchasing managers has been on the same level since the early 2000s. There seem to exist a gap between identified measures and large-scale industry implementation.

In an attempt at closing this gap, CLOSER took the initiative to this investigation into the existing measures from the projects Swiftly Green (Sweden-Italy Freight Transport and Logistics Green Corridor) and GreCOR in the project reported here called GET Greener. The investigation has been financed by the Swedish Transport Administration (Trafikverket, TrV)

This report accounts for the methodologies and results of GET Greener. The aim of the project was to identify “low-hanging fruits” among the more than 130 measures identified in the project Swiftly Green. These measures are also referred to as the ‘*toolbox*’.

The purpose of the project was to identify measures from the Swiftly Green collection of measures that can be implemented within a near future in the Swedish section of the ScanMed corridor *and* contribute to significant reductions in emissions of greenhouse gases.

## **Overall results and recommendations**

Implementing measures always entail costs. One issue to manage in these circumstances is *who will bear the cost for a given measure*. This issue is generic and is emphasized regardless of modality, measure or context.

At a general level, it is a question of how costs, benefits, responsibilities, ownership, maintenance and investments are distributed among a set of heterogeneous actors in a complex socio-technical-economic matrix. In this case it has to do with transports and transport systems and the initiatives, measures and attempts that exist to make these more sustainable. However, if these issues can be overcome, our results indicate some considerable potential.

Our results indicate that by systematically and persistently implementing two or three measures from the toolbox it is possible to reach the ambitious GHG-emissions targets from transports set by the Swedish government already before 2030.



Combining HCT-road measures such as longer trucks to allow for 34m<sup>1</sup> vehicles fuelled by HVO with long and heavy 730m-trains (LHT) on the core relation Malmö – Hallsberg of the ScanMed corridor alone creates reductions in GHG-emissions on a scale that enables the transport sector to reach its emission targets.

This leads us to conclude that there are no significant technical obstacles hindering achieving the targets. Although considering the results of this report from an EU-wide perspective changes this somewhat. Especially the availability of biomass for biofuels soon becomes a bottleneck if the entire EU choses to go in that direction (which probably is unlikely, but nevertheless, it must be considered). We need to find holistic solutions, while letting some countries take a leading role in certain areas. This is an example of where Sweden can lead the way in bio-based fuels such as HVO aiming at reducing the level of palm oil content etc. From a strictly Swedish national perspective, the obstacles that exist are more of legal, regulative, organisational and economic character. To fully harness the potential identified in this report, issues such as EU-regulation concerning HCT-road, the development of open business models, neglected infrastructure maintenance and investments, and the harmonizing of railway regulations and control across Europe must be dealt with.

- **We recommend** that **TrV** take a leading role in ensuring maintenance and infrastructure investments to enable more HCT-road as well as LHT. Road and rail are not opposing parties in a zero-sum game in this, but complement each other in moving towards a green transport system.
- **We recommend business actors** in the sector to work on developing more open business models that enables cooperation and more systematic synchronization and coordination of cargo flows.
- **We recommend policy institutions and regulators** to create long-term systematic regulations that ensures that the rules of the game are coherent, stable and geared towards creating a fossil free transportation system in 2050 at latest.

In addition, the following more specific recommendations are given.

Recommendations for TrV as the infrastructure owner:

- Secure competence and knowledge on what mechanisms that can be used to distribute benefits and responsibilities and use these strategically to green the transport system
- Prioritize investments in rail infrastructure to enable an acceleration of the utilization of LHT

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<sup>1</sup> The HCT configurations in this report are 32 meters, but in order to enable two 45 feet containers, 34 meter is needed.



- Prioritize investments in rail infrastructure that enables a further and smoother shift from road to rail transports – for example by making Hallsberg shunting yard a state-of-the-art node in Scandinavia and Sävenäs shunting yard in Gothenburg an ocean gate, and Malmö shunting yard capable of managing LHT from the continent.
- Use the methodology from this report to identify potential measures and assess their TRL and MRL.

Recommendations to shippers and service providers in the sector:

- Learn how to become an efficient network actor in the Swedish transportation sector
- Learn how to open up your business model to other actors in the sector, without unacceptable increases of business risk
- Ensure that your business model is aligned with the development towards greener transport systems
- Ensure that you are an important actor for others – for example by enhancing your business model or through strategic collaboration
- Cooperate and collaborate with other actors in order to realize potentials and revenues that are otherwise inaccessible
- Become a wizard at understanding the mechanisms by which rewards and responsibilities are distributed among actors in your particular network
- Learn how to leverage the sustainability-aspects of your role in the transport system

## **Results from the Road use case**

### *HCT-road*

In this case we have explored three measures in the toolbox. First, larger vehicles through *amendment of Directive 96/53/EC*, where the potential cost and emission savings are substantial. Second, Increasing load factor through a *collaborative business model (FTL and LTL)*, where our cases involved two large transport operators co-loading the cargo of several shippers. Cargo volumes in both directions, that is, achieving sufficient load factors is a pre-requisite for larger vehicles. Third, using alternative fuels by *introducing LNG-based propulsion* indicates small climate gains as this fuel is based on fossil gas. If the gas is based on biomass it has a substantial reduction potential. Another drawback is that a compression engine requires a certain fraction of diesel for ignition. Since gas fuels are incompatible with fluid fuels the study also looked into HVO as an optional renewable fuel that is easier to introduce, as it is fully compatible with present diesel fuel and engines. This fuel indicates very high saving potentials.

### *Conclusions from the HCT-road*

General conclusions from the road use case are:

- From a cost saving perspective the duo trailer vehicle provides a better solution as 100 % more volume cargo can be loaded in comparison to the Tractor and





single semitrailer and 30 % more volume cargo can be loaded in comparison to the 25.25 m vehicle meanwhile it only requires one driver. Equipment also seems to be less expensive and is useful in other applications.

- Coordination of cargo flows is needed to utilize larger HCT-vehicles
- For swift introduction of renewable fuels it needs to fit smoothly into the present propulsion systems
- Traffic safety is not significantly affected by the duo semitrailer.
- Functionality of services is fairly similar. One advantage may be that the semi-trailer can be delivered to the shipper early in the day for loading and picked up in the afternoon.
- Quality is not influenced since this contains the same handling and service.
- Minor operational challenges occur when connecting and disconnecting the road train.

A concluding remark is that we presently seem to have relevant knowledge and tools to de-carbonize the long-haul transport. The challenging question is how to scale this up in a sustainable way.

### **Results from the Rail use case**

#### *Long heavy trains (LHT):*

Our results show that while LHT alone creates very small aggregated savings, this measure does create a more environmentally efficient solution as the GHG-emissions per ton cargo transported decreases. This means that by increasing this LHT operation itself, the total CO<sub>2</sub>-emissions increase but it assumes that it will eliminate other transport solutions with higher GHG-emissions. The *CO<sub>2</sub>-emissions per ton goods transported decreases* through the LHT, however these decreases are quite small as compared to the effects from this in combination with a shift from road to rail. Our scenario-analysis from the rail use case clearly shows a potential for GHG-emissions savings, especially when cargo is shifted from road to rail.

When going from a relatively small shift to a larger with increasing volumes of cargo going from road to rail, the savings is linear in relation to the amounts of cargo volumes transferred. This is because the relative share of GHG-emissions from rail compared to road is so small, and because the length of the stretch is assumed equal for both road and rail.

- A 10 % shift results in 28 169 tonnes CO<sub>2</sub>e in annual savings.
- A 30 % shift results in 84 505 tonnes CO<sub>2</sub>e in annual savings.
- A 50 % shift results in 140 843 tonnes CO<sub>2</sub>e in annual savings.

#### *Conclusion from LHT:*

Due to the linear relationship between cargo volumes and GHG-savings in the Swedish part of the ScanMed RFC, the total GHG-emissions savings equals that of the magnitude



of the shift itself. Our results show that a 10 % shift from road to rail renders a 10 % decrease in GHG-emissions, a 30 % shift renders a 30 % decrease, and a 50 % shift renders a 50 % decrease. This conclusion is valid for both the use case as well as for the Swedish part of the ScanMed corridor with reasonable reliability because it is largely (within reasonable frames) scale-independent.

This means that as cargo shifts from road to rail, the savings from decreased emissions from road transports are so significant and the increase in emissions from rail so insignificant so that the total GHG-emissions savings equals that of the magnitude of the shift itself.

#### *Digitization of rail:*

The digitization of the railway in itself create little or immeasurable *direct* effects on GHG-emissions. However, the *indirect* effects are measureable.

Our results show that in the current use-case scenario derived from an estimated modest 2 % shift from road to rail, 773 tons GHG-emissions would be saved every year. If the shift is 10 % the saving is 3 864 tons annually in this use case.

#### *Conclusions from the digitization of rail:*

The main argument for investing in the digitization of the railway is not primarily because its greening effects, neither indirect nor direct, rather it is due to a perceived need to constantly increase the service level of the transport offering to customers in order to make rail a more attractive option for transport buyers. Their main requirement is service reliability. If this is neglected, there is a risk that the rail option becomes less attractive.

### **Results from the infrastructure use case**

#### *The Varberg tunnel*

Infrastructure projects are initiated by numerous societal needs but politically decided and publicly funded. This suggests the involvement of many environmental dimensions – not least when it comes to railway infrastructure such as the tunnel underneath the city of Varberg. Most environmental aspects are considered during the environmental consequences analysis phase (“miljökonsekvensbeskrivning” in Swedish) that together with the railway investigation (“järnvägsutredning” in Swedish) and the railway plan constitutes decision support when deciding on infrastructure projects.

Based on the railway investigation and the railway plan the environmental consequences of the new tunnel have been assessed influencing the conditions that need to be fulfilled by the construction. Many constraints exist: local, regional and national. On top of local and regional requirements the national railway requirements is a major constraint that must be fulfilled. This creates various forms of more or less far-reaching compromise solutions. Although there is a formal requirement to carry out a final



climate analysis of rail tunnel projects, presently it seems that other considerations are perceived as more important. One manifestation of this is that, at the moment, there are no stringent format requirements on this report that would make feedback more accessible. There are in other words still risks that previously made mistakes could be repeated.

In addition, in the process of procurement of material and construction processes there is a general concern to not exceed regulations linked to public procurement regulations. There is an anxiety to establish conditions that may cause competitive distortion that can be appealed. In general this seems to be an area that can be improved to enable knowledge transfers from other types of public procurement processes.

#### *Conclusions from the Varberg tunnel:*

Our results show that every infrastructure project has its unique characteristics when it comes to geography, geology, demography and political processes. Acknowledging this, the planning and construction process overall is good although the construction seems to be traditional and highly dependent on certain individuals and their skills and experiences from earlier projects in Sweden. However, this can make the project vulnerable and susceptible to inconsistent practices and lacking of systematic knowledge transfers.

While there exist international benchmarking on how comparable traffic infrastructure projects are carried out and on how specific requirements have been solved, it seems that this is not harnessed in a systematic way in the Varberg tunnel use case. The measures in the toolbox on these issues remain unknown and unused when it comes to this type of infrastructure issues. While experience from other national tunnel projects are used, structures for systematic feedback of experiences from previous international tunnel projects are not fully in place.

#### **Methods: How we arrived at the results**

This project is based on a case-study methodology and comprises three cases each one with its individual characteristics, issues and contexts, but with the common denominator that they all relate to the cargo flows in the ScanMed corridor in Sweden.

The three cases chosen are that of a road use case; a rail use case and an infrastructure use case. For each use case some lead-users were identified. Lead-users are actors that are on the forefront of developments in its respective field, and that can be considered forerunners regarding technologies, organisation, volumes or responsibilities. They are actors that have a say in the sector in which they operate. These lead users and the use cases serve as contexts against which measures in the toolbox are assessed for ease of implementation. The table below summarizes the use cases and the lead users of this project.



<i>Case</i>	<i>Use case</i>	<i>Use case illustration</i>	<i>Measure in toolbox</i>
Road	HCT Road	DB Schenker	<ul style="list-style-type: none"> <li>• Collaborative business models (FTL and LTL)</li> <li>• Introduction of LNG-based propulsion</li> <li>• Amendment of Directive 96/53/EC</li> </ul>
		PostNord	<ul style="list-style-type: none"> <li>• Collaborative business models (FTL and LTL)</li> <li>• Introduction of LNG-based propulsion</li> <li>• Amendment of Directive 96/53/EC</li> </ul>
Rail	HCT Rail	ScandFibre Logistics (SFL)	<ul style="list-style-type: none"> <li>• Marathon - Longer and heavier trains (LHT)</li> </ul>
	Digitization of Rail	ScandFibre Logistics (Transwaggon)	<ul style="list-style-type: none"> <li>• Digital enquiry form for freight wagons (RFID chip)</li> <li>• Arrival estimation for freight vehicles (freight vehicle tracking devices using GPS)</li> </ul>
Infra	Green Infrastructure	Trafikverket	<ul style="list-style-type: none"> <li>• Recycling of tunnel spoil</li> <li>• Thermal use of drainage water</li> <li>• Unreinforced tunnel inner lining</li> <li>• Tunnel lining potential energy exploitation</li> <li>• 3D temperature mountain mapping</li> <li>• Tunnel 3D surface mapping</li> </ul>

We used the use cases as a backdrop against which the measures in the toolbox were assessed for relevance and ease of implementation.

To assess the readiness for implementation we used the technology- and market readiness level scales (TRL/MRL) from the Swiftly Green toolbox. For a measure to be considered having an implementation potential it must score at least a level 7 (pilot test) in relation to the specific use case in question, to be eligible.

Once the measure was identified we assessed the effects of its implementation at two levels: First, for the specific cases in question; and second, for the Swedish part of the ScanMed corridor as a whole. This latter assessment was made with the respective case as a basis, however results from such an up scaling must always be interpreted with care and depends heavily on the assumptions made. These assumptions are accounted for and discussed in detail when this analysis is performed and in the methods section.



# Svensk sammanfattning

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## **Introduktion och syftet med *GET Greener***

Det finns en mängd initiativ och åtgärder med potential för grönare transporter och logistiksystem. Trots detta visar studier att för transportköpare ligger den relativa betydelsen av miljörelaterade effekter av transporter på samma nivå som sedan början av 2000-talet. Det tycks finnas ett glapp mellan de åtgärder som finns och hur branschen implementerar dem.

I ett försök att minska detta glapp har CLOSER initierat en genomgång av de existerande åtgärder som identifierades i projekten *Swiftly Green* (Sweden-Italy Freight Transport and Logistics Green Corridor) och *GreCOR*. I denna rapport rapporteras resultaten från detta arbete inom ramen för ett projekt som heter *GET Greener*. Projektet har finansierats av Trafikverket (TrV).

I denna rapport redogörs för de metoder och resultat som *GET Greener* genererat. Målsättningen med projektet var att identifiera så kallade "långt hängande frukter" bland de mer än 130 olika åtgärder som identifierades i *Swiftly Green*. Dessa åtgärder hänvisas också till som "*toolboxen*".

Syftet med projektet var att identifiera åtgärder ut *toolboxen* som har potential att implementeras inom en inte allt för avlägsen framtid i den Svenska delen av *ScanMed*-korridoren och som bidrar till en signifikant minskning av utsläpp av växthusgaser.

## **Övergripande resultat och rekommendationer**

Att implementera åtgärder medför alltid kostnader. En viktig fråga att hantera i dessa sammanhang är *vem som bär kostnaderna för en given åtgärds implementation*. Denna fråga är generisk och betonad oavsett modalitet, åtgärd eller kontext.

På en generell nivå är det en fråga om hur kostnader, nyttor, ansvar, ägarskap, underhåll och investeringar distribueras bland ett antal heterogena aktörer i ett komplext socio-tekniskt-ekonomiskt sammanhang. I detta projekt handlar det om transporter och transportsystem och de initiativ, åtgärder och försök att göra dessa mer hållbara som för närvarande existerar. Kan man hantera dessa frågor så visar resultaten från projektet på en icke oväsentlig potential.

Resultaten pekar på att genom att systematiskt och ihärdigt implementera två eller tre åtgärder från *toolboxen* så är det möjligt att nå de ambitiösa utsläppsmålen från transporter uppsatta av den Svenska regeringen, redan före 2030.



Genom att kombinera HCT-väg åtgärder i form av långa lastbilar och tillåta 32-metersbilar som går på HVO-bränsle med långa tunga 730-meterståg (LTT) på kärnrelationen Malmö – Hallsberg i ScanMed RFC så kan man enbart med dessa åtgärder möjliggöra att nå sektorns utsläppsmål.

Detta leder till slutsatsen att det är inte tekniska hinder som hindrar att man når utsläppsmålen. De hinder som existerar är snarare av legal, regulativ, organisatorisk och ekonomiskt karaktär. För att till fullo realisera den potential som identifieras här så måste frågor om EU-regleringar av HCT-väg, utvecklingen av öppna affärsmodeller, eftersatt infrastrukturunderhåll och investeringar, och harmonieringen av järnvägens reglering och styrning i Europa, lyftas upp och åtgärdas.

- Vi rekommenderar att TrV tar en ledande roll för att säkerställa underhåll och investeringar i infrastruktur för att möjliggöra en expansion av HCT-väg såväl som LTT. Väg och järnväg är inte kontrahenter i ett nollsummespel, utan komplementära då det gäller att förflytta oss i en riktning mot grönare transportsystem.
- Vi rekommenderar affärsdrivande organisationer och företag i branschen att arbeta med att öppna upp sina affärsmodeller för att möjliggöra utökat samarbete för att mer systematiskt synkronisera och koordinera varuflöden.
- Vi rekommenderar offentliga aktörer och policymakers att skapa långsiktigt systematiska regleringar av branschen som säkerställer att det finns enhetliga, stabila och meningsfulla regelverk som syftar till att skapa ett fossilfritt transportsystem senast 2045.

Utöver detta ges följande mer specifika rekommendationer:

Rekommendationer för TrV:

- Säkerställ kompetens och kunskap om de mekanismer som finns för att distribuera nyttor och ansvar och använd dessa strategiskt för att miljösäkra transportsystemen
- Prioritera investeringar i infrastruktur för att möjliggöra en acceleration av nyttjandet av LTT
- Prioritera investeringar i järnvägsinfrastruktur som möjliggör ett utökat och smidigt skifte från väg till järnväg – exempelvis genom att göra Hallsbergs rangerbangård till en state-of-the-art nod i Skandinavien och Sävenäs rangerbangård i Göteborg till en ocean gate och Malmö rangerbangård utrustad för att ta emot LTT från kontinenten
- Använd metodologin från detta projekt för att identifiera potentiella åtgärder och bedöm dess TRL och MRL för lämplighet och potentiellt införande



Rekommendationer till varuägare och logistikaktörer:

- Lär er hur man blir en effektiv nätverksaktör i den Svenska transportsektorn
- Lär er hur ni kan öppna upp era affärsmodeller till andra aktörer i branschen utan att skapa oacceptabelt höga affärsrisker
- Säkerställ att er affärsmodell ligger i linje med utvecklingen mot grönare transportsystem
- Säkerställ att ni är en viktig aktör för andra – till exempel genom att stärka upp affärsmodellen genom strategiska samarbeten
- Samarbeta och samverka med andra aktörer för att realisera potentialer som annars är oåtkomliga
- Bli extremt bra på att förstå de mekanismer som fördelar och distribuerar nyttor och ansvar bland aktörer i ert specifika nätverkssammanhang
- Lär er hur ni kan använda er roll för att skapa hävstångseffekter i transportsystemet för att skapa hållbara system

## Resultat från väg-caset

### *HCT-väg*

I detta case har vi utforskat tre åtgärder från toolboxen. Den första är större fordon genom tillägget till direktivet 96/53/EC där de potentiella kostnadsbesparingarna och utsläppsminskningarna är avsevärda. Den andra handlar om att öka fyllnadsgrader genom samarbetsorienterade affärsmodeller (FTL och LTL). Här studerar vi två speditörer som samlar gods från flera varuägare i långa och tunga bilar. Den tredje handlar om alternativa bränslen. Att introducera LNG-baserade framdriftssystem tyder på små miljöeffekter då detta alltjämt är en fossilbaserad energikälla. Om gasen är gjord på biomassa har det däremot en avsevärd reduktionspotential. Men en nackdel är att en kompressionsmotor kräver en fraktion av vanlig diesel i bränslet för att kunna antända bränsleblandningen. Eftersom gas-baserade bränslen är inkompatibla med flytande så har vi istället tittat på HVO som ett alternativ som är enklare att introducera eftersom det är fullt ut kompatibelt med existerande dieselbränslen och motorer. Detta bränslealternativ är helt biobaserat och visar på stor reduktionspotential.

### *Slutsatser från HCT-väg*

De allmänna slutsatserna från HCT-väg är följande:

- Från ett kostnadsperspektiv är duo-trailerfordonet en bra lösning då 100 % mer volym last kan lastas i jämförelse med en bil med semitrailer, och 30 % mer last kan tas jämfört med 25,25-metersfordonet trots att det endast kräver en förare. Utrustningen verkar dessutom vara billigare och är också användbar i andra applikationer.
- Koordinering av varuflöden krävs för att kunna utnyttja större HCT-fordon
- Introduktionen av förnybara bränslen måste passas in i befintliga lösningar på ett smidigt sätt
- Trafiksäkerheten påverkas inte nämnvärt av duo-semitrailern



- Servicefunktionaliteten är ganska lika i de olika alternativen, men semitrailern har en fördel med att den kan anlända till en varuägare på förmiddagen, lastas under dagen och sedan hämtas upp igen på eftermiddagen.
- Kvaliteten påverkas inte eftersom samma hantering och service krävs för alla alternativ.
- Mindre operativa utmaningar uppstår i samband med att vägtåget kopplas ihop och isär.

Avslutningsvis noterar vi att vi för närvarande verkar ha de nödvändiga kunskaperna och verktygen för att kunna skapa fossilfria långväga transporter. Frågan är hur vi får det att ske i stor skala på ett hållbart sätt.

## **Resultat från järnvägs-caset**

### *Långa tunga tåg (LTT)*

Resultat från såväl use-case analysen och korridor analysen pekar på att även om LTT i sig knappast skapar några större aggregerade utsläppsbesparingar om det jämförs med andra redan miljövänliga tåglösningar, så medför LTT miljömässigt mer effektiva lösningar då växthusgasutsläppen per transporterat ton last minskar. Detta betyder att de totala CO<sub>2</sub>-utsläppen ökar, men att *CO<sub>2</sub>-utsläppen per ton transporterat gods minskar*. Denna minskning är dock förhållandevis liten i jämförelse med de effekter som detta har i form av överflyttning från väg till järnväg. Våra scenarionanalyser från järnvägscaset visar på en potential för minskade utsläpp, särskilt då last flyttas över från väg till järnväg.

Om man går från ett ganska litet skifte till ett större så är besparingen linjär i förhållande till de volymer av gods som överflyttas. Detta på grund av att den relativa andelen av utsläpp från järnväg i förhållande till väg är små och på grund av att sträckan antas vara lika lång för väg och järnväg.

- En 10 % överflyttning resulterar i en årlig utsläppsbesparing om 28 169 ton
- En 30 % överflyttning resulterar i en årlig utsläppsbesparing om 84 843 ton
- En 10 % överflyttning resulterar i en årlig utsläppsbesparing om 140 843 ton

### *Slutsatser från LTT:*

Som ett resultat av det linjära sambandet mellan fraktvolymer och utsläppsbesparingar i den Svenska delen av ScanMed RFC så utgör magnituden av de totala utsläppsbesparingarna motsvarande storleken på skiftet som sådant. Resultaten visar att om 10 % gods skiftas så får man en 10 % minskning av utsläpp. Om 30 % skiftas minskar man 30 % i utsläpp och om 50 % skiftas så minskar man 50 % i utsläpp.

Detta betyder att då gods skiftas från väg till järnväg så är minskningen av utsläpp från insparade vägtransporter så signifikanta att ökningen av utsläpp från järnvägen som skiftet medför nästan blir helt icke-signifikant vilket gör att de totala





utsläppsbesparingarna är i samma storleksvolym som skiftet i sig. Denna slutsats gäller för såväl use case som för den Svenska delen av ScanMed korridoren med rimlig tillförlitlighet eftersom den är i hög grad skaloberoende (inom rimliga gränser).

#### *Digitaliseringen av järnvägen*

Digitaliseringen av järnvägen i sig självt skapar mycket små näst intill omätbara *direkta* utsläppseffekter. *Indirekta* effekter kan dock identifieras.

Våra resultat visar att scenariot med en överflyttning av gods från väg till järnväg uppgående till 2 % av volymen skulle medföra en utsläppsbesparing om 773 ton växthusgaser per år. En överflyttning om 10 % av volymen skulle medföra en utsläppsbesparing om 3 864 ton växthusgaser per år.

#### *Slutsatser från digitaliseringen av järnvägen*

Huvudargumentet för att investera i digitalisering av järnvägen ligger inte preliminärt i dess hållbarhetseffekter, vare sig direkta eller indirekta. De ligger mer i ett uppfattat behov av att kontinuerligt öka service-nivåerna i transporterbjudandet gentemot kunderna, för att på så sätt göra alternativet mer attraktivt som transportalternativ. Om man bortser från detta finns en risk att järnvägsalternativet blir mindre attraktivt.

### **Resultat från infrastruktur-caset**

#### *Varbergstunneln*

Infrastrukturprojekt är politiskt initierade och beslutade och omfattar ett flertal miljödimensioner – inte minst vad gäller järnvägsinfrastruktur så som tunneln under Varberg. Flera av dessa tas i beaktande under arbetet med miljökonsekvensbeskrivningar som tillsammans med järnvägsutredningarna och järnvägsplanerna utgör beslutsunderlag för beslut om infrastrukturprojekt.

Baserat på järnvägsutredningarna och planerna så har miljökonsekvenserna av den nya tunneln bedömts och konstruktionsarbetet har anpassats utifrån krav från dem. En hel mängd begränsningar existerar: lokala, regionala och nationella- Ovanpå lokala och regionala krav utgör nationella järnvägskrav restriktioner som måste uppfyllas. Detta skapar olika former av mer eller mindre långtgående kompromisslösningar. Även om det finns formella krav på att genomföra en avslutande klimatanalys av järnvägstunnelprojekt så verkar det som om andra frågor uppfattas som viktigare för närvarande. En manifestation av detta är att det för närvarande inte finns några stringenta formella krav på denna rapport som skulle möjliggöra återkoppling av erfarenheter. Det finns med andra ord fortsatt en risk att tidigare gjorda misstag repeteras.

Utöver detta visar vår analys att inköpsprocesserna vid byggen av detta slag kan utgöra ett problemområde vad gäller offentlig upphandling och reglerna kring denna. Det finns en oro att vissa krav på att underleverantörer skall tillhandahålla exempelvis mobila



betonganläggningar, etc. kan utgöra konkurrensmässiga snedvridningar och därför vara otillåtna utifrån lagen om offentlig upphandling. Här tycks finnas utrymme för förbättringar och kunskapsöverföring från andra typer av stora statliga och kommunala upphandlingar.

#### *Slutsatser från Varbergstunneln*

Våra resultat visar att varje infrastrukturprojekt är unikt och särpräglat avseende geografi, geologi, demografi och politiska processer. I ljuset av detta får planeringen och genomförandeplanerna sägas vara goda även om tillvägagångssättet tycks vara ganska traditionellt och starkt beroende av vissa individer och deras kunskap och kompetens från tidigare Svenska projekt. Detta kan dock göra projektet sårbart för inkonstent handlande och för bristande systematisk kunskapsöverföring.

Även om det finns internationella jämförelser för hur liknande trafikinfrastrukturprojekt genomförts och hur specifika krav har hanterats så tycks det som om detta inte fångas in på ett systematiskt sätt i Varbergstunnelprojektet. De åtgärder som finns i toolboxen om detta förblir okända och oanvända i denna typ av infrastrukturprojekt i Sverige. Låt vara att nationella erfarenheter från andra tunnelprojekt tillvaratas, men det saknas strukturer för systematisk återkoppling från andra internationella tunnelprojekt.

#### **Metod: Hur vi kom fram till resultaten**

Detta projekt baseras på en fallstudiemetod (case) och omfattar tre case med sin respektive individuella karaktäristik, problem och kontexter, men med den gemensamma nämnaren att de alla relaterar till godsflöden i ScanMed-korridoren.

De tre case som valts är ett väg-case, ett järnvägs-case och ett infrastruktur-case. För varje case har några "lead-users" identifierats. Lead-users är aktörer som ligger långt framme i sina respektive sammanhang och som kan betraktas som föregångare vad gäller teknologi, organisation och volym eller ansvar. De är aktörer som har något att säga till om i sitt respektive fält. Dessa lead-users och deras "use-cases" fungerar som sammanhang mot vilka åtgärderna i toolboxen bedöms med avseende på grad av implementerbarhet. Tabellen nedan summerar de use-cases och lead-users som använts i detta projekt.



<i>Case</i>	<i>Use case</i>	<i>Use-case illustration</i>	<i>Åtgärd i toolboxen</i>
Väg	HCT-väg	DB Schenker	<ul style="list-style-type: none"> <li>• Kollaborativa affärsmodeller (FTL och LTL)</li> <li>• Introduktion av LNG-baserad framdrift</li> <li>• Tillägg till direktiv 96/53/EC</li> </ul>
		PostNord	<ul style="list-style-type: none"> <li>• Kollaborativa affärsmodeller (FTL och LTL)</li> <li>• Introduktion av LNG-baserad framdrift</li> <li>• Tillägg till direktiv 96/53/EC</li> </ul>
Järn-väg	HCT Järnväg	ScandFibre Logistics (SFL)	<ul style="list-style-type: none"> <li>• Marathon – Långa och tunga tåg (LTT)</li> </ul>
	Digitalisering av järnvägen	ScandFibre Logistics (Transwaggon)	<ul style="list-style-type: none"> <li>• Digital förfrågan för järnvägsvagnar (RFID)</li> <li>• Ankomstbedömning av vagnar (godsvagns spårning med GPS-sändare)</li> </ul>
Infra-case	Grön Infrastruktur	Trafikverket	<ul style="list-style-type: none"> <li>• Återanvändning av tunnelmassor</li> <li>• Termisk användning av spillvatten</li> <li>• Icke förstärkt tunnel-liner</li> <li>• Energiutvinningspotential från tunel-lining</li> <li>• 3D temperatur bergskartläggning</li> <li>• Tunnel 3D yt-kartläggning</li> </ul>

Use-casen användes som en bakgrund mot vilka de olika åtgärderna i toolboxen utvärderades med avseende på relevans och implementerbarhet.

För att bedöma implementerbarheten så använde vi de teknologi- och marknadsberedskaps-skalor (TRL/MRL) som tagits fram i samband med arbetet med toolboxen i Swiftly Green-projektet. För att en åtgärd skall betraktas ha tillräcklig potential för implementation så måste den nå minst nivå 7 (pilottest) i förhållande till det specifika use-caset för att komma i fråga för analys i detta projekt.

När en åtgärd har identifierats med potential utvärderas effekterna av åtgärdens implementation på två nivåer: Först på den specifika case-nivån i respektive use-case i fråga, och sedan på en makro-nivå i form av den svenska delen av ScanMed-korridoren som helhet. Makro-utvärderingen gjordes med respektive case som bas, men resultaten från en sådan utvärdering måste alltid tolkas med stor försiktighet och medvetenhet om de antaganden som ligger till grund för densamma. Dessa antaganden redovisas och diskuteras i detalj i anslutning till respektive analys och i metod-delen.



## List of terms and abbreviations used

3PL	Third-Party Logistics Provider: An actor that organizes a logistical system for its customer's and uses its own infrastructure or vehicles.
4PL	Fourth-Party Logistics Provider: An actor that organizes a logistical system for its customer's flows, but owns no infrastructure or vehicles.
Biodiesel	See FAME and RME. A non-fossil diesel fuel made of long chains of alkyl esters.
CH <sub>4</sub>	Methane: A greenhouse gas.
CLOSER	The national Swedish platform for transport and logistics research and development.
CNG	Compressed Natural Gas: A fuel.
CO <sub>2</sub>	Carbon dioxide: A greenhouse gas.
CO <sub>2</sub> e	Carbon-dioxide equivalents: A harmonized measure of many types of GHG-emissions.
ERMTS/ETCS	European Train Control System. The European standard for train control.
FAME	Fatty Acid Methyl Ester. An ester of fatty acid and methanol. Usually called 'biodiesel'. See also Biodiesel.
FC	Fuel Consumption.
FTL	Full Truck Loads. A load requiring a whole truck.
FVTD	Freight Vehicle Tracking Devices: examples are GPS and RFID-devices.
GHG	Greenhouse gases: A collective term for CO <sub>x</sub> - and NO <sub>x</sub> -gases, etc.
HCT	High Capacity Transport: Transports capable of higher capacities than current standards.
HTK	CLOSER Roundtable on Sustainable Transport Corridors
HVO	Hydrogenated Vegetable Oil: A renewable biomass based fuel.
LBG	Liquefied Bio Gas: A renewable biomass based fuel.
LHT	Longer and Heavier Trains: An HCT-concept for rail.
LNG	Liquefied Natural Gas: A fossil based fuel.
LTL	Less Than Truck Loads. A load not requiring a whole truck.
Measure	Any idea or solution that aim to reduce GHG-emissions from transports.
MRL	Market Readiness Level: An indicator of the maturity of a measure.
NRL	Network Readiness Level: An indicator of the maturity of a measure.
PFAD	Palm Fatty Acid Distillate. A bi-product from the extraction of palm oil.
Rc4	An older type of locomotive manufactured by ASEA.
RFC	Rail Freight Corridor. A corridor comprising rail infrastructure.
RME	Ribs Methyl Ester is a type of FAME based on ribs oil and methanol. Usually called 'biodiesel'. See also Biodiesel.
ScanMed	A corridor from Italy in the south to Scandinavia/Finland in the north.



SFL	ScandFibre Logistics AB: A 4PL operator in the paper industry.
Swiftly Green	Sweden-Italy Freight Transport and Logistics Green Corridor: A project aiming to identify measures for greening the corridor between Sweden and Italy.
TEN	Trans-European Network. The Network of transports across Europe.
TEN-T	Trans-European Transport Network: The EU Core Transport Corridor Network. A Network of the major freight flows across Europe.
(the) Toolbox	The set of measures identified in Swiftly Green.
TRAXX	A newer stronger type of locomotive manufactured by Siemens.
TRL	Technology Readiness Level: An indicator of the maturity of a measure.
TrV	Swedish Transport Administration (Trafikverket).
TWA	Transwaggon: A company offering rail cargo wagons for rent.
wtw	Well-to-Wheel. A measure of the GHG-emissions from the production source of the energy to the use in a vehicle.



# 1 Introduction

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This report accounts for the methodologies and results of the project called “GET Greener”. The aim of the project was to identify “low-hanging fruits” among the more than 130 measures identified in the project Swiftly Green (Sweden-Italy Freight Transport and Logistics Green Corridor) and GreCOR. These measures are also referred to as the ‘*toolbox*’.

Swiftly Green was finished and reported in December 2015 and the toolbox represents one important output from this project aiming to create greener transports in the ScanMed corridor from Italy in the south end to Sweden, Norway and Finland in the north end. GreCOR promoted the development of a co-modal transport corridor in the North Sea Region and was finished in December 2014. GET Greener is a Swedish follow-up on these projects financed by the Swedish Transport Administration (Trafikverket).

The objective of GET Greener is to frame and enhance the results from Swiftly Green through practical implementation. This can be done by looking at how the toolbox can contribute to the development of a climate neutral transport system in Sweden. Developing the Swedish part of the core and comprehensive trans-European transport network is well in line with current Swedish transport policy.



## 2 Scope

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### 2.1 Aim and purpose of GET Greener

The aim of GET Greener is to identify improvement measures in terms of “low-hanging fruits”, i.e. technical and organizational activities, which individually or in various combinations can be implemented in the Swedish section of the ScanMed corridor.

The purpose is to identify measures, or ‘packages’ of measures, that contributes to significant reductions in emissions of greenhouse gases that can be implemented within a near future.

### 2.2 Scope

An important part of the scope from the commissioner was to discuss effects of measures at the level of the Swedish part of the ScanMed corridor. This scope was early on identified as somewhat problematic because it required a scaling of results from a use-case level to corridor level, which is problematic from a methodological point of view. Nonetheless, these corridor-level analyses remained required and an important part of the scope of the project.

The scope is summarized as:

- Identification of measures with a minimum TRL/MRL level 7 (pilot test) thus showing a potential for implementation from a Swedish perspective
- Assessment of effects of the implementation of these measures
- Assessment of effects of a larger-scale implementation of these measures at a corridor level
- Dissemination of results by CLOSER through dialogue with EU and Swedish stakeholders

Hence, the project delivers assessments of potential measures at two levels: First, for the specific cases in question; and second, for the Swedish part of the ScanMed corridor as a whole as reflected in the scope summary above.

### 2.3 Environmental considerations

All measures that are analysed in the project come from the Swiftly Green toolbox and have been generated with the aim of reducing transport-related climate impact, that is, other environmental issues were only partially included, for example noise reductions in a tunnel. The measures that are identified in this project are considered especially interesting for the Swedish section of the core ScanMed network and will be further



assessed in order to estimate environmental consequences of a potential implementation in Sweden. This implementation is evaluated at two levels as described above

## 2.4 Organization of the project

The work was carried out by an operational group with input from workshops, interviews and dialogue in a collaborative process between academia, industry and public sector agencies. Table 2.1 show the organisation of the project

**Table 2.1** Project organisation

Commissioner	Swedish Transport Administration
Operational group	<p>The operational group consisted of representatives from the following organizations:</p> <ul style="list-style-type: none"> <li>• CLOSER (chair)</li> <li>• The Swedish Transport Administration</li> <li>• NTM/Conlogic</li> <li>• Örebro University School of Business</li> </ul> <p>Additional partners in the CLOSER network was mobilized as necessary</p>
Reference group	<p>The reference group consisted of representatives from the following organizations:</p> <ul style="list-style-type: none"> <li>• The Swedish Transport Administration</li> <li>• Region Örebro County</li> <li>• COOP</li> <li>• Jesjo Konsult AB</li> <li>• Swedish Shipowners' Association</li> <li>• The Swedish Confederation of Transport Enterprises</li> <li>• Luleå Technical University</li> <li>• Ramböll</li> <li>• The Swedish Association of Road Transport Companies</li> </ul> <p>CLOSER Roundtable on HTK – Sustainable Transport Corridors supported with in-kind resources.</p>





## 3 Background - Sustainable logistics: opportunity or threat?

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In order to successfully develop greener transport it is necessary to better understand the business logic and real drivers behind operation of transport logistics. This is of course valid for all industries that aim towards more sustainable solutions but to some extent it is even more profound in the market of transport. The 'bad news' for this business is very low margins; hence low willingness to pay for additional attributes that brings more costs to the operation. The 'good news' are the simple fact that many greening measures often reduces use of resources and in fact increases margins meanwhile negative environmental impact is lowered. Initiating required sustainability change therefore needs to focus on activities that increases profit margins and at the same time reduces emissions.

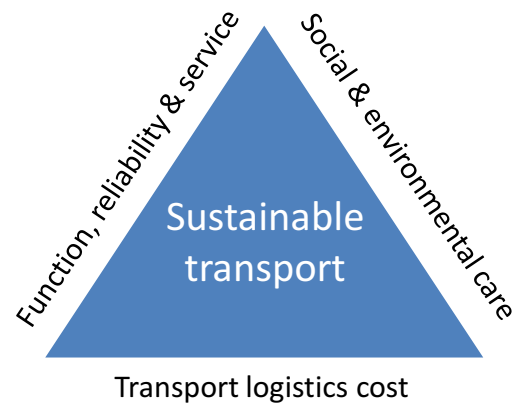
To arrive at the right focus there is a need to consider the basic conditions for transport. In general, the market for transport logistics services, to a large extent revolves around three main pillars of general performance criteria:

- Suppliers of transport logistics must provide functionality, reliability and service degree that in essence comprise a relevant solution of lead times, capacity, delivery on time, right place and in right condition. Flexibility is a factor of somewhat less importance but considered more important in some specific situations, often related to high value cargo or where a delivered item solves costly standstills.
- Suppliers of transport logistics must offer services at competitive cost, which commonly is ranked highly important by shippers. Another defining cost parameter would be the alternative cost of non-delivery. A standstill in a large factory due to lack of inputs of raw material or components may cause huge cost in a value chain. The non-delivery is crucial also for consumer products. An empty shelf in a store means short-term loss of sales and long-term a risk of losing loyal customers.
- Suppliers of transport logistics must ensure social responsibility embedded in the services. Safety and security risks as one example of social responsibility are prerequisites for transport logistic and a legally mandatory requirement for dangerous goods transport. There are on the other hand few shippers that consider the safety risks from social dumping through low wages in order to reduce labour costs. Environmental care is mostly connected to emissions of



greenhouse gases. Other negative environmental effects are at present seldom included in the supplier evaluation, partly because air pollutants have been profoundly reduced in road transport. Overall, social and environmental issues have mostly been driven by legal requirements.

Figure 3.1 illustrates the three basic pillars for sustainable transport.



**Figure 3.1** Basic conditions for sustainable transport logistics operations

### 3.1 Shippers

Customers of transport logistics services (shippers<sup>2</sup>) give different priority to the various aspects of transport performance. Different ranking of important performance criteria often relates to type of industry, general market conditions and specific activities linked to the actual transport logistics services needed. In an attempt to describe this in general terms, various shippers' surveys highlight conditions in more specific and general terms.

According to a shippers<sup>3</sup> survey in Sweden carried out every second year, the environmental aspects are generally ranked of low importance in relation to other requirements. In the latest survey from 2016, while not yet fully assessed, environmental aspects in relation to traffic mode choice were considered least important. This is in line with previous results as described in the survey from 2014.

**Table 3.1** Ranking of criteria affecting choice of major traffic mode in 2014.

Rank scale: 1 = not important at all, through 7 = very important.

Reliability	6.3
Geographic coverage	6.2
Flexibility	6.1
Infrastructure	6.0

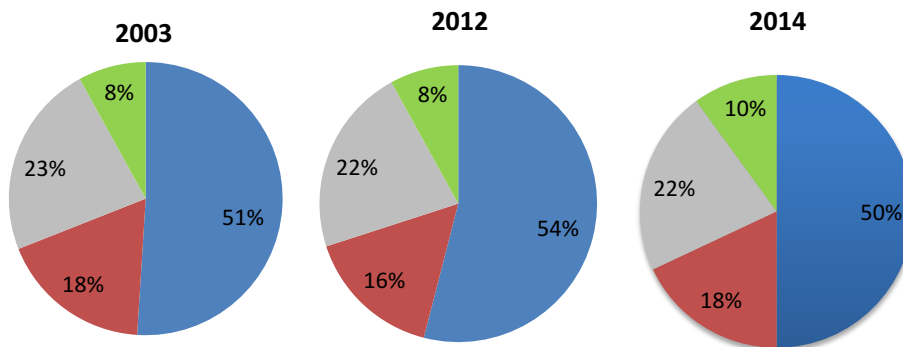
<sup>2</sup> Also named transport procurer or transport purchaser.

<sup>3</sup> <http://www.chalmers.se/en/centres/lead/TransportPurchasingPanel/Pages/default.aspx>. Accessed 2017-03-05.



Time limitations	5.9
Cost	5.7
Simple for customer use	5.6
Environmental aspects	4.5

In the survey shippers also make a distribution of relative importance, in total 100 % of different attributes of transport services when selecting a specific transport solution. Below is the outcome from previous surveys.



**Figure 3.2** Relative importance of different attributes of transport services. Legend: Blue = Price; Red = Transport time; Grey = Time precision; Green = Environmental efficiency. Source: Andersson, et al. (2016).

As can be seen in Figure 3.2, the environmental concern has remained much at the same level since 2003<sup>4</sup>. It should be noted that data from 2003 comes from another study by the University of Gothenburg<sup>5</sup>.

Even though environmental aspects in general terms are low ranked there are positive indications of a small change. There is a trend towards an increasing willingness to pay for transport services with a lower impact on the environment. Only 3 % claimed they paid more for transport with less environmental impact in 2012. In 2014 some 9 % made the same statement. In the latest survey in 2016 some 21 % stated they paid more for transport services with less environmental impact. This increase could potentially be related to emission offsetting schemes or simply lip service. On the other hand it shows a positive increase of shippers' general ambition.

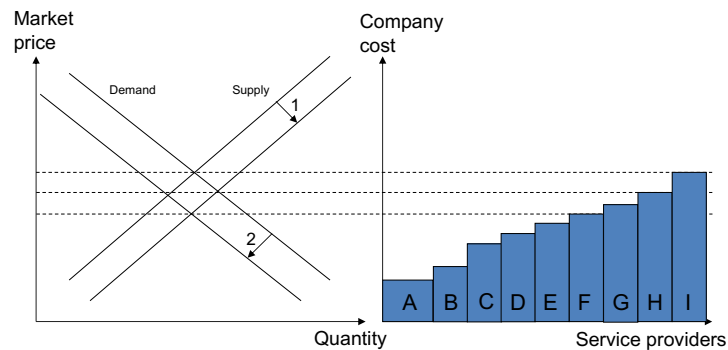
### 3.2 Transport costs and productivity

<sup>4</sup> Andersson, et al., (2016).

<sup>5</sup> Lammgård, C., & Andersson, D. (2014); Lammgård, C. (2007).



A key aspect for the transport industry is the need of high productivity driven by a severe market price pressure. Since much of the service is linked to the ability to deliver capacity at low costs this puts a continuous pressure on the market price. As is shown in Figure 3.3 barriers of entry are low in the market (1) and the long-term economic downturn in the EU since 2008 have decreased or slowed down demand of transport logistics services (2) in certain markets. The effect of this is a lower market price, which puts the service providers with higher operational costs under pressure (F-I in Figure 3.3).



**Figure 3.3** A Salter diagram illustrating the on-going need for increasing productivity among the transport service providers A-I.

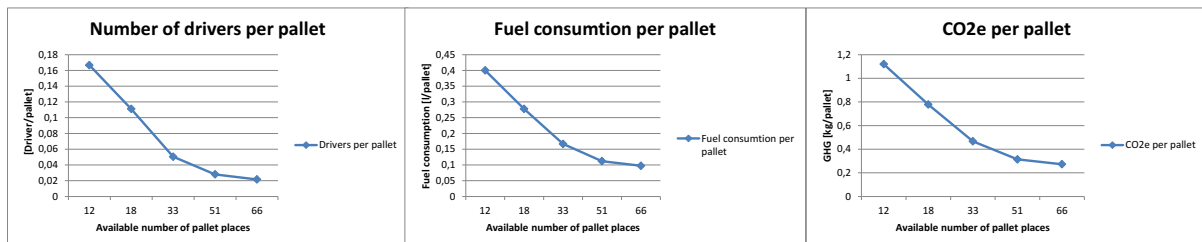
As a consequence of low margins, a general and necessary way to survive in the market of transport logistics is a continuous program to increase the operational productivity. There are many ways to accomplish this but, one key element and recurring theme in transport operation is use of larger units. Within all modes of traffic there has been a long term development towards larger vehicles and vessels, all driven by lowering relative traffic costs meanwhile average revenue increases per unit. In this general development there is an element of an ironic rebound effect since larger units adds capacity to the market that puts further pressure on the price. According to interviews among road hauliers, the higher capacity trucks (HCT) and their productivity gains expect to be quickly adopted by the market and new lower market price resulting in consistent economic margins.

Through history, development drives towards larger and larger units for transportation (Figure 3.3). Within road transport the productivity gains of larger vehicles can be measured in many different ways. Relevant units may be:



**Figure 3.3** Examples of HCT-solutions: PostNord's 32m duo-trailer (bottom) and Hector Rail's TRAXX locomotive pulling a long and heavy train (top right). Compared to the first truck in Sweden (top left), the cargo capacity in a HCT truck is some 80 times higher at a low increase of fuel consumption per km.

1. Number of drivers per pallet
2. Fuel consumption per pallet
3. CO<sub>2</sub>e emissions per pallet



**Figure 3.4** Performance indicators illustrate the achieved productivity gains with larger vehicles.



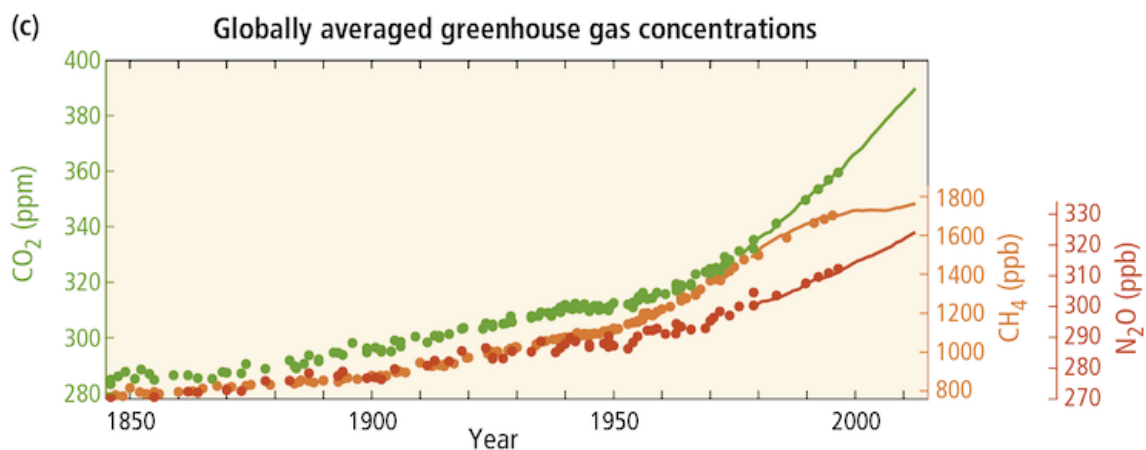
As Figure 3.4 show, larger trucks well used have the ability to reduce relative cost and emissions substantially. In this assessment the load factor is 50 % for the two smallest trucks, 60 % for the medium truck and 70 % for the largest trucks.

In order to introduce larger vehicles in transport operation it requires an understanding of the connection between supply chains and transport production systems. Large units by itself without sufficient utilization will only increase operational costs and not be able to gain from the additional capacity. Large units also reduce flexibility to handle smaller shipments as well as they reduce redundancy ability in the transport system.

An important note is that the utilization degree includes transport flows in both directions and structural imbalances are a well-known challenge in all countries. This means that larger vehicles may have difficulties to reach an economic break-even in circumstances where there are structural imbalances. The most useful application for large vehicles is line-haul between two terminals or factories where cargo volumes are fairly even in both directions, predictable and the time span for loading and unloading is less critical.

### 3.3 Climate change

The understanding and acceptance of the risk of climate change (Figure 3.5) is growing and the number of people denying the problem is far less today. The urgency for change is however growing rapidly and every industrial sector need to take their responsibility. On a global basis, transport in total emits some 15 % of all greenhouse gases. In the EU the same number is some 20 % and in Sweden this is somewhat more than 30 % due to previous replacement of fossil energy in heating and industry as well as electricity production based on hydropower, nuclear power and windmills.



**Figure 3.5** Global atmospheric CO<sub>2</sub>-concentrations now nearing 400 ppm<sup>6</sup>

<sup>6</sup> IPCC Assessment Report 5. SPM 1, Chart c). <https://www.ipcc.ch/report/ar5/syr/>. Accessed 2017-03-07.



According to EU climate and energy targets by 2020 the aim is to:

1. Reduce emissions of greenhouse gases by 20 % compared to 1990-levels
2. Increase the share of energy from renewable sources to 20 %
3. Reduce energy use by 20 %

If other large economies reduce their emissions EU promise to further reduce their emissions by 30 %. By 2030 the EU aims are:

- 40 % lower greenhouse gas emissions than 1990
- 27 % renewable energy
- 27 % improved energy efficiency

By 2050 the EU aims are to reduce emissions by 80–95 % from 1990 levels if other countries are doing the same. The European Council reconfirmed this target in February 2011.

The EU Climate Action Plan<sup>7</sup> aims to support the EU to become a competitive low carbon economy by 2050. The approach is based on the view that innovative solutions are required to mobilize investments in energy, transport, industry and information and communication technologies. More focus is needed on energy efficiency policies in general. EU is currently on track to meet two of the 2020-targets, but will not meet its energy efficiency target unless further efforts are made. Hence, the priority remains to achieve all the targets already set for 2020.

Together with the White Paper on Transport and the Energy Efficiency Plan<sup>8</sup>, this communication is a key deliverable under the Resource Efficiency Flagship. It presents a Roadmap for possible action up to 2050. The transition towards a competitive low carbon economy means that the EU should prepare for reductions in its domestic emissions. The Commission has carried out an extensive modelling analysis with several possible scenarios showing how this could be done, as explained in Table 3.2 below.

**Table 3.2** GHG reductions compared to 1990, sectoral reductions

Sector	2005	2030	2050
Total	-7 %	-40 to -44 %	-79 to -82 %
Power (CO <sub>2</sub> )	-7 %	-54 to -68 %	-93 to -99 %
Industry (CO <sub>2</sub> )	-20 %	-34 to -40 %	-83 to -87 %
Transport (incl. CO <sub>2</sub> aviation, excl. maritime)	+30 %	+20 to -9 %	-54 to -67 %
Residential and services (CO <sub>2</sub> )	-12 %	-37 to -53 %	-88 to -91 %
Agriculture (non- CO <sub>2</sub> )	-20 %	-36 to -37 %	-42 to -49 %
Other non- CO <sub>2</sub> emissions	-30 %	-72 to -73 %	-70 to -78 %

<sup>7</sup> [https://ec.europa.eu/clima/citizens/eu\\_en](https://ec.europa.eu/clima/citizens/eu_en). Accessed 2017-03-07.

<sup>8</sup> European Commission (2011).

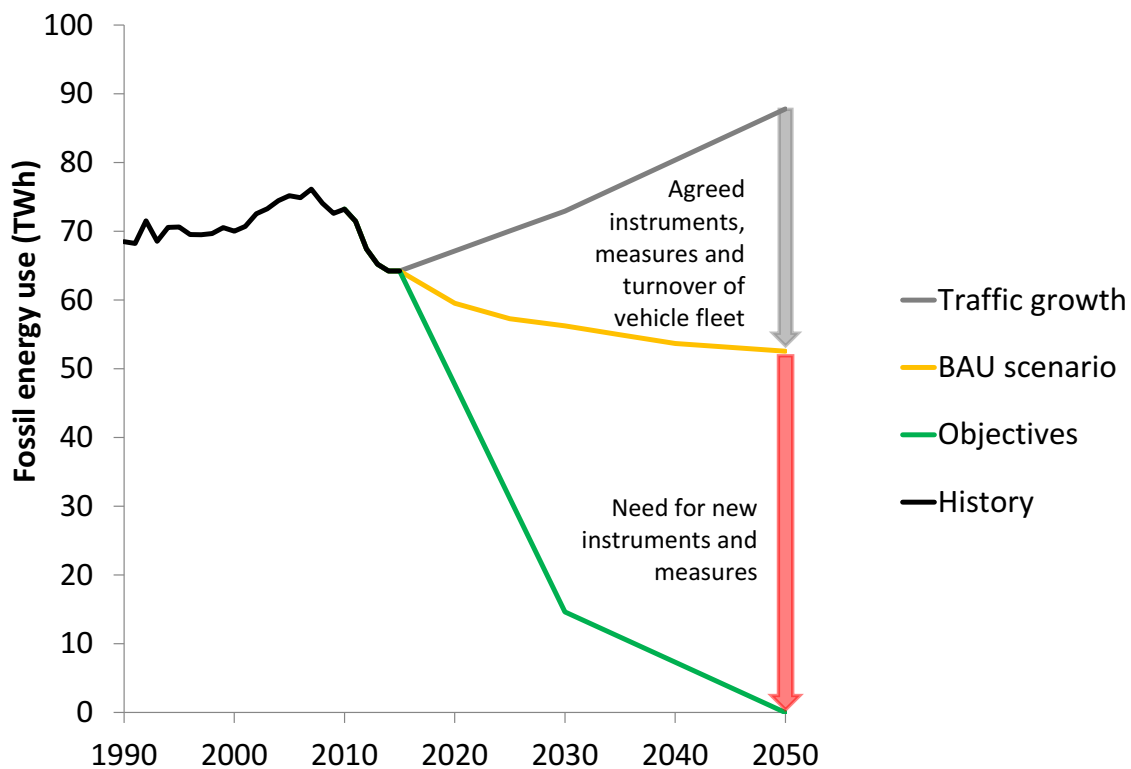


The EU Climate Action Plan is criticised, considered to be too low and slow. On the other hand there are countries within the EU that already are lagging behind.

According to the Swedish Government<sup>9</sup> Sweden will:

- Be one of the first fossil free countries in the world
- Take a leading role in implementing the new UN targets on sustainable development

Sweden is also challenging EU and the world by ambitious reduction targets of 70 % by 2030 and 85 % by 2045 for the transport sector. This means challenging requirements described in Figure 3.6 below.



**Figure 3.6** Traffic emissions in Sweden and the need for new measures as well as market and legal based instruments in order to reach the targets.<sup>10</sup>

<sup>9</sup> <http://www.sou.gov.se/m-201004-miljomalsberedningen/>. Accessed 2017-03-07.

<sup>10</sup> <http://www.cedr.eu/publication-cedr2016-5-acting-climate-change/>. Full report, p.16. Accessed 2017-02-26.





### 3.4 Concluding remarks on sustainable logistics

The viability of transport logistics companies relates very much on decreasing costs through higher productivity. The measures leading to lower costs are commonly also related to reducing relative emissions of greenhouse gases, i.e. these actions go hand in hand.

There is however a risk that higher productivity reduces relative GHG-emission but a rebound effect occurs as cheaper transport services increases the transport components share in the value chain, hence a risk of increased total emissions. A relevant follow up of performance should therefore include relative and absolute emissions in order to avoid sub-optimizations.

Another interesting aspect of Sweden being the primary advocate for larger trains and trucks to compensate for distance disadvantages. In central Europe larger trains and trucks are also relevant but more common as a measure to compensate for congestion challenges.

In total, our opinion is that sustainable logistics is more of an opportunity than a threat but it needs to be considered in every aspect of transport logistics operation and further development regarding modal choice and efficiency. .



## 4 Methodology

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### 4.1 Some fundamental assumptions

Any investigation or analysis rests on some taken for granted or preconceived points of views. The first section of this methodology section will spell out the fundamental assumptions of this report. First we provide a definition of how we interpret the task of identifying “low-hanging fruits” and what the relevant contexts are. This leads us to a discussion of the importance of maintaining industrial relevance when identifying measures and of the importance to involve lead user in this process.

After that we discuss the choice of use cases and the characteristics of case methodology in general. We conclude this section with explaining how we have used the toolbox in relation to the chosen use cases.

### 4.2 Definitions and limitations

The focus of this project is on “low-hanging fruits” that can be identified among the more than 130 relevant measures previously identified in Swiftly Green. First, we need to define what we mean by “low-hanging fruits”.

In order to assess whether a measure is a low-hanging fruit or not, the measure in question must be related to a specific context. Thus, a measure that is considered a low-hanging fruit is that in relation to a specific context in which it is fairly easily implemented or for which it is intended. This means that we need to be able to define and specify the contexts in some way in order to be able to discern if a measure is a low-hanging fruit or not. It could mean that in relation to the context, the measure is relatively easy to implement and that the effect is considerable. In addition a measure that may be less ready for implementation may still be considered due to its high effect. The level of readiness of measures is assessed using the technology- and market readiness level scales from the Swiftly Green toolbox. This will be discussed in detail later.

In this project, the relevant contexts are defined as the business network structures of organizations that enable the freight transport in the Swedish part of the ScanMed corridor (see Figure 4.1). The corridor represents major flows of goods. These flows are created by the business networks of organizations that organize the logistics systems as a response to the needs of producers and consumers to move goods<sup>11</sup>. Without these

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<sup>11</sup> Dubois, A., Hulthén, K., & Pedersen, A-C. (2004).



networks, there are no flows and would be no corridor. Hence, these networks are the relevant contexts for the measures of the toolbox from Swiftly Green.



**Figure 4.1** The Scandinavian section of the ScanMed corridor.

Given this definition of context, we identify three cases, which serve as the context for an evaluation of measures. The three cases are identified in relation to the Swedish part of the ScanMed corridor with major flows on road and rail, but less on sea. We therefore focus on the road and rail cases. In addition, infrastructure was identified as a key context with relevance to the Swedish section of the corridor.

Hence, we identify the road freight modality as one case, the railway freight modality as another case and infrastructure as a third case. This helps us specify the significant domains against which measures can be assessed for relevance and as low-hanging fruits. It also enables us to keep an analytical focus as it creates a specification and delineation of empirical data and enables a focused analysis<sup>12</sup>.

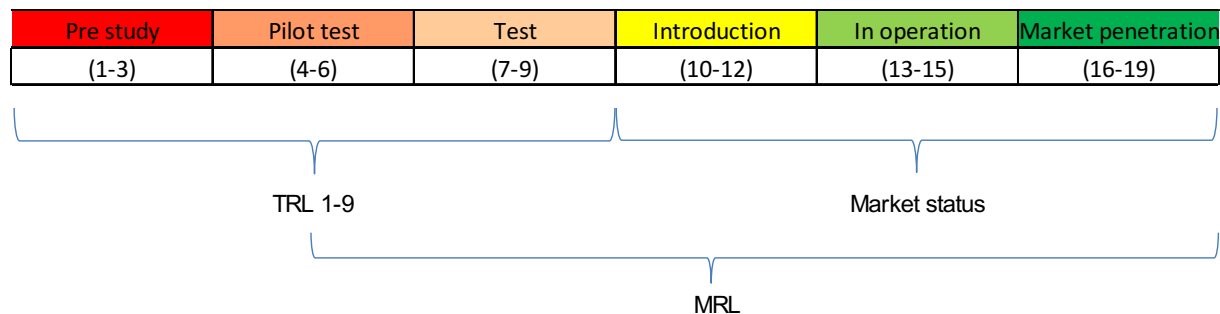
Low-hanging fruits are accordingly identified as measures that possess one or a combination of the following characteristics in relation to the given context (use case) for which it claims relevance:

<sup>12</sup> Miles & Huberman (1994).



1. It is technologically feasible and possible to implement – it has a sufficient “Technical Readiness Level (TRL)”
2. It is economically feasible and possible to implement – it has a sufficient “Market Readiness Level (MRL)”

Each measure is evaluated using a scale for assessing the TRL and MRL as shown in Figure 4.2. This scale is a composite of TRL and MRL as is shown in Figure A1 and it has been used previously to evaluate measures in the Swiftly Green project. Market readiness is seen as building on and overlapping with technological readiness. TRL comprise nine levels (1-9) in three stages defining its technology status, whereas MRL comprise 15 levels (5-19) in five stages defining its market status.



**Figure 4.2** The scale for assessing TRL and MRL.

The European Commission definitions of the different levels of TRL are:

- TRL 1. Basic principles observed
- TRL 2. Technology concept formulated
- TRL 3. Experimental proof of concept
- TRL 4. Technology validated in lab
- TRL 5. Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6. Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7. System prototype demonstration in operational environment
- TRL 8. System complete and qualified
- TRL 9. Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

The market readiness level (MRL) is assessed according to the following criteria:



1. Availability and acceptance
2. Functionality and productivity
3. Approvals and legal restrictions
4. Standards
5. Service and after market
6. Residual value

For a measure to be deemed as having a potential to be implemented without too much investment in resources, it must score at least a level 7 on the TRL/MRL-scale (above pilot test level). In addition it must not require substantial investments or adaptation in existing technological and market contexts. This is derived from literatures on the relationship between science, technology and society (STS) recognizing that technological contexts are stable and fine-tuned systems that develop over time<sup>13</sup>. Introducing new ideas and changes always require relating what is new to the already existing structure and that which is already in use. The larger the gap, the more costly the change is – sometimes it is too costly and thus impossible to implement<sup>14</sup>.

This context-dependence of technological and market measures is crucial to understand when identifying measures from the toolbox. Measures that can come into question are those that both score a minimum level 7 on the TRL/MRL-scale and which requires relatively little change and adaptation to the existing technological context.

The first criteria is assessed based on the measure itself using the TRL/MRL-scale, the second is derived from the use case from which the measures originates. This is also the main reason to why this use-case approach was chosen at the outset – it is one of the few approaches that enables the identification of measures that do not require extensive adaptation and change to existing technological contexts. In other words, this is how we define, conceptualize and operationalize measures that could be said to be some kind of “low-hanging fruits”, or the measures that produces the most “bang for the buck”.

However, even if a measure is identified as implementable, it does not automatically follow that it is possible to carry through all the way. A measure that is implementable means that we have identified its potential to be introduced and initiated in the given context. However, *whether it actually yields the expected results is a practical question that needs to be tested and evaluated by actually testing it in a real life context*. Such a test could then be evaluated against the expected results predicted in this project. An alternative way to use the results from this project is to use them to evaluate outcomes from simulation-models.

The scope of this project however is on the potential implementation of potential measures. Every specific measure must eventually be tested in a real setting. While such

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<sup>13</sup> Bijker & Law (1992); Oudshoorn & Pinch (2003).

<sup>14</sup> Håkansson (1987); Håkansson & Waluszewski (2007); Håkansson et al., (2009).



demonstrations are beyond the scope of this project, its results may serve as a foundation for the formulations of demonstration projects

### 4.3 The importance of lead-users

Having central actors involved is decisive for the success of any innovation- or R&D-program. Innovation literature informs us that these actors of lead-users that are the recipients or users of the ideas or measures of a program must be involved early in a successful implementation process<sup>15</sup>.

Due to the interactive character of innovation processes, users, developers and producers of products, solutions, systems and ideas must collaborate<sup>16</sup>. By this collaboration, lead-users<sup>17</sup> may be identified and used as good examples. Moreover lead-users can also be used to re-interpret solutions from one context to another – both in an abstract and a concrete way. In an abstract way, findings from cases with lead-users may be theoretically and analytically generalized<sup>18</sup>. In a concrete way, findings from cases with lead-users may be re-scaled from a micro-level to a macro-level context.

A major issue is that knowledge is usually very context-dependent<sup>19</sup>. This seems to be the case also with knowledge and experience in logistics, which carry marks of path-dependency and situational dependence. This makes it crucial to involve lead-users early in the process where measures towards more sustainable transport systems are identified in order to capture the specifics of the context.

In this project, we identify lead-users related to the three cases identified previously in relation to the ScanMed corridor within the TEN-T core network of freight corridors in Europe. In this way we funnel down the very general issue of implementing measures from Swiftly Green in the ScanMed corridor, via the case of road, rail and infrastructure to specific lead-users within these three cases respectively.

These lead-users represent organizations that participate in the organizing networks around the corridor in Sweden. Table 4.1 show the three cases and the lead users identified in relation to them.

**Table 4.1** The use cases and lead-users of this report

<i>Use case</i>	<i>Lead users</i>
HCT Road	DB Schenker
	PostNord

<sup>15</sup> Ibarra & Hunter (2007); Oudshoorn & Pinch (2003); Prenekert (2012).

<sup>16</sup> Håkansson & Waluszewski (2007).

<sup>17</sup> von Hippel (1976, 1986).

<sup>18</sup> Yin (2009).

<sup>19</sup> von Hippel (1994).



HCT Railway and Digitization of Railway	ScandFibre Logistics (SFL)
Green Infrastructure	Swedish Transport Administration (TrV)

The benefits with this lead-user and use-case approach are many. Among others the benefits are that:

1. It is a systematic way of funnelling down a complex general problem into concrete context-relevant issues
2. Lead-users are involved early
3. The methodology in itself may be useful in, and transferable to, other problems with similar complexity
4. It enables knowledge re-interpretation at a macro-level

This project is based on a case-study methodology<sup>20</sup> where the focus is on the unique and to acknowledge the distinctive features of something<sup>21</sup>. Case studies are used to generate knowledge in terms of deeper understandings of contexts and complex relationships.

A case can be many things: a company, an individual, a process, a project, etc. How one defines a case affects what questions can be addressed and how the results are to be interpreted<sup>22</sup>.

This project comprise three cases each one with its individual characteristics, issues and contexts, but with the common denominator that they all relate to the flows in the ScanMed corridor in Sweden.

#### 4.4 Case analysis

Within the three wider “use cases” we have identified lead-users who represent organizations involved in the management of the flows in the corridor. Given these cases, the more than 130 measures from the toolbox are analysed in a step-wise analysis. The first step constitutes sorting the measures into one or many of the three case categories<sup>23</sup>. It should be duly noted that one and the same measure might be found in more than one case if it is relevant for more than just one case. Some measures are not relevant for any of the here identified use cases and are thus excluded from further analysis. This is discussed in detail below.

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<sup>20</sup> Stake (2003).

<sup>21</sup> Morgan & Smircich (1980).

<sup>22</sup> Ragin & Becker (1992).

<sup>23</sup> Vaughan (1992).



In the second step, the measures are analysed in relation to the context and requirements of the case in question. The feasibility is assessed in this step and it is here that potentially low-hanging fruits are identified according to the previous discussion.

This second step requires a case description against which the feasibility of the measure is evaluated. This case description is based on empirical data collected through interviews and field observations at the lead-user organizations. In this way, the lead-users are involved early in the process, as this case description must be available in order to perform the second step of the analysis. The case descriptions also functions as a description of a current situation and they are found at the introduction of each case section of this report.

In step three, the effects of implementation of measures are calculated and discussed by identifying a number of scenarios. The results of those scenarios are discussed in relation to the specific lead-user use case at a micro-level. Moreover, effects are also calculated and discussed in relation to the entire Swedish part of the Scand-Med corridor at a macro-level.

#### 4.5 Assessing potential effects

The potential climate effects of the implementation of measures were assessed by calculating GHG-emissions using the emission factors developed by NTM<sup>24</sup>. In creating the scenarios, we made some assumptions concerning, for example, volumes, savings, increases, etc. These assumptions are explicitly stated and described in relation to each scenario in the results part of this report.

When possible, we use verified data from the lead-users, and when we do so, we indicate such data. When that is not possible for whatever reason, we have made an assumption based on expert verification, if possible and as a last resort based on common sense and general knowledge of the issue among the project members and its reference group.

Assessments of greening effects were made at two principal levels. First, assessments were performed at the use case level. At this level the measures that has been identified and considered relevant are used as a basis for a number of scenario-analysis from which greening effects are calculated. These GHG-emission savings are based on case data.

Second, being an absolute requirement and part of the project scope, assessments were also performed at the corridor level. This entailed scaling up results from the measures at the case level. This scaling constitutes a challenge because there are no clear methodologies or established praxis for how it can be done. One way is of course to rely on official statistics. However, when it comes to the Swedish part of the ScanMed

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<sup>24</sup> [www.transportmeasures.org](http://www.transportmeasures.org).





corridor, finding relevant and reliable data on volumes and flows is difficult, not to say impossible. Import/export data are too blunt since that accounts for more flows than the ones in the corridor (including all import export entry and exit of cargo at many points that are not in the corridor), and cargo flow data in Sweden is also problematic because of cargo being diverted from the core corridor into peripheral networks along the stretch.

Finally we resorted to using the use cases as a basis also for the scaling. Since the cases are solid and data-driven, this approach was considered the best possible in this circumstance. However, this also means that one must take great care when interpreting the results from the assessments of greening effects at the corridor level. This is an extremely important caveat that cannot be disregarded.

**The results from the scaling to macro level must be used cautiously and with care and should not be considered definitive. Nevertheless, they do provide an indication of what a scaled implementation of this measure in the Swedish part of the ScanMed corridor could entail, given that the assumptions made here hold true.**

We strongly recommend readers to evaluate the validity of these results in relation to their respective setting. One way to do so is to compare the assumptions made here to those made by the reader or made in the reader's setting to see whether they hold true also for this context.

#### 4.6 Working with the toolbox and identifying measures

In order to identify low-hanging fruits from the toolbox, we used the use cases as a basis for evaluating and assessing the measures in the toolbox. First all 130 measures were identified and extracted in a format enabling the processing and sorting by means of computer software.

As a first step, the 130 measures were sorted into three rough categories: those measures related to road, railway and infrastructure, respectively based on the choices of use cases in this project. However, that action turned out not to yield any precise categories because many measures link to two or all of these categories as they are not mutually exclusive. In addition, even if a measure is – in principle – relevant for, for example a railway solution, it may not be relevant *in practice*. And since we are much concerned here with identifying practically relevant measures we had to find another way to identify them.

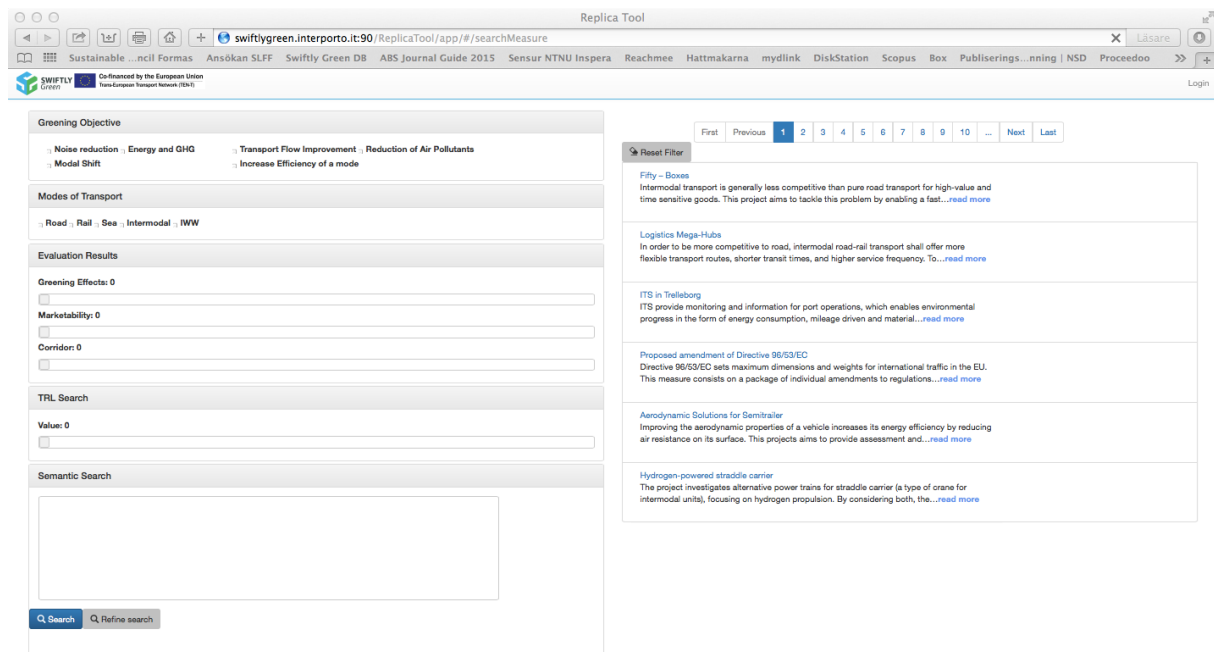
Therefore we turned to the use cases for guidance in step 2. The use cases provided a much more focused way of identifying relevant measures in the toolbox. Based on core issues identified in the three general use cases of PostNord and Schenker together for



road, SFL for railway and TrV for infrastructure we then moved on to identify *relevant measures related to these core issues*.

This meant that we started in the use cases and identified relevant issues that were significant in these cases (these are discussed in detail in relation to each use case respectively later). Then, based on these issues, we started a matching process with the measures in the toolbox to match the issues to measures. This matching process was rather cumbersome and had to be done manually since it was impossible to produce any search-strings that produced reliable results. Two versions of the database of measures were used. First, the database in MS excel format was used. It was obtained from the Swiftly Green-project and is essentially a huge table of data. However, it enabled us to screen the entire database for potentially relevant measures and also to perform simpler searches to identify potential measures based on the issues in the use cases. At this stage it was a process of matching what was identified as important and relevant in the use cases with measures in the toolbox.

Once these potential measures were matched and identified, we turned to the version of the database from Swiftly Green available online<sup>25</sup>. This “replica tool” is a web-based shell around the database that provides search opportunities with free-text searches as well as searches based on modalities, etc. Figure 4.3 show the interface of this tool.



**Figure 4.3** The interface of the Swiftly Green Database on the internet

<sup>25</sup> <http://swiftlygreen.interporto.it:90/ReplicaTool/app/#/searchMeasure>. Accessed 2017-02-13.



While the excel-database gave us overview, the web-database provided depth. From the web-database we could obtain in-depth information about each potential measure which enabled us to single out the final measures which could be considered as having a potential based on their TRL- and MRL-assessments and anchoring in the use cases. In this way we reduced the initial set of measures to 17 potential measures, which were considered as relevant, significant and implementable, based on the three use cases of this project. Table 4.2 below show the issues identified and the associated measures from the toolbox as identified by this process.

It should be noted that each issue from the use cases might match with one or more measures from the toolbox, as shown in Table 4.2. These 15 measures are thus identified as scoring at least a level 7 on the TRL/MRL-scale and requiring a minimum of changes and adaptations in the existing technological contexts. However, most of them require investments to be made and we discuss this issue in our analysis.

**Table 4.2** The linking between the use cases and the measures in toolbox

<i>Case</i>	<i>Use case</i>	<i>Use case illustration</i>	<i>Measure in toolbox</i>
Road	HCT Road	DB Schenker	<ul style="list-style-type: none"> <li>• Collaborative business models (FTL and LTL)</li> <li>• Introduction of LNG-based propulsion</li> <li>• Amendment of Directive 96/53/EC</li> </ul>
		PostNord	<ul style="list-style-type: none"> <li>• Collaborative business models (FTL and LTL)</li> <li>• Introduction of LNG-based propulsion</li> <li>• Amendment of Directive 96/53/EC</li> </ul>
Rail	HCT Rail	Scandfibre Logistics (SFL)	<ul style="list-style-type: none"> <li>• Marathon - Longer and heavier trains (LHT)</li> </ul>
	Digitization of Rail	Scandfibre Logistics (Transwaggon)	<ul style="list-style-type: none"> <li>• Digital enquiry form for freight wagons (RFID chip)</li> <li>• Arrival estimation for freight vehicles (freight vehicle tracking devices using GPS-trackers)</li> </ul>
Infra	Green Infrastructure	Trafikverket	<ul style="list-style-type: none"> <li>• Recycling of tunnel spoil</li> <li>• Thermal use of drainage water</li> <li>• Unreinforced tunnel inner lining</li> <li>• Tunnel lining potential energy exploitation</li> <li>• 3D temperature mountain mapping</li> <li>• Tunnel 3D surface mapping</li> </ul>

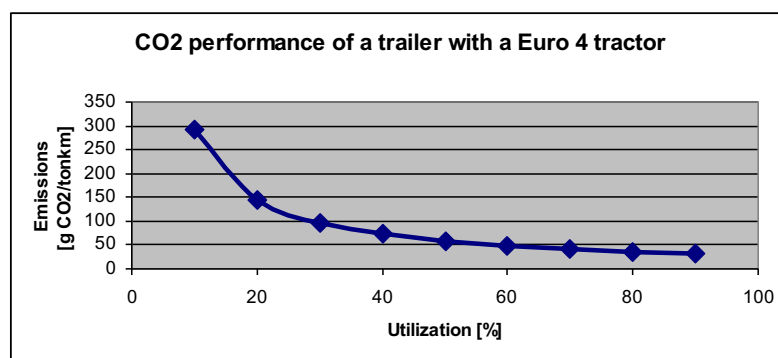


## 5 The Road Use Case

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### 5.1 Business rationales linked to profitability and GHG-emissions

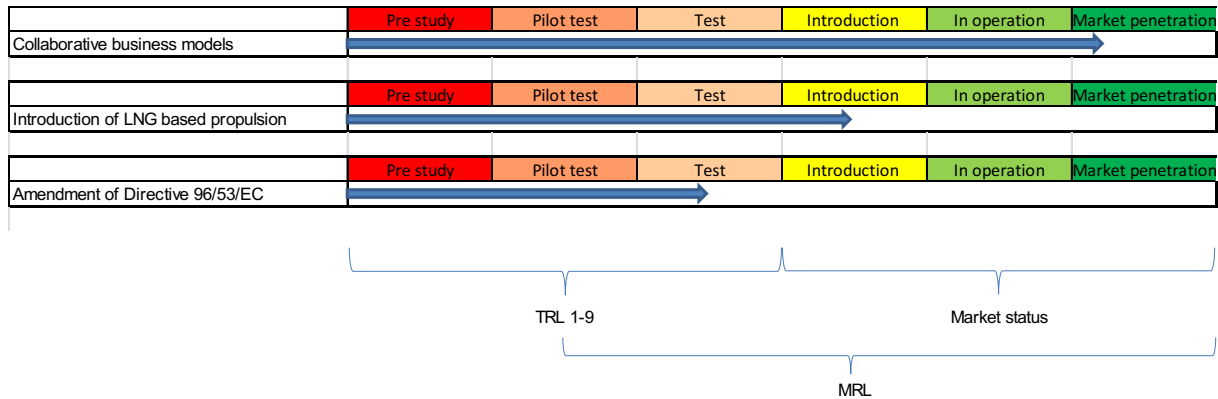
The business rationale in road freight transport is linked to short term challenges due to a general price pressure. Long-term road transport hauliers also need to reduce their climate impact as transport by road contributes significantly to emissions of greenhouse gases. Cutting cost and reducing greenhouse gas emission can be achieved through overlapping measures that is, improving efficiency through better utilization degrees and larger vehicles.



**Figure 5.1** Relative emissions from a trailer in relation to its degree of utilization.

The main success factor for all transport operation is a sufficient utilization degree. This entails sufficient cargo flows in both directions enabling economic feasibility through high productivity but also lowering the relative environmental impact. For stretches with large general cargo volumes this means that longer and heavier trucks (HCT) increases its efficiency and lowering relative GHG-emissions significantly. The main trade-off is decreasing ability for redundancy, as access to optional road infrastructure thereby is limited. Furthermore is higher capacity by road potentially increasing competition towards rail transport solutions, but could as well also better feed in modular units to the rail transport system. Based on this background we identify the following measures from the toolbox as relevant for this case:

- Collaborative business models (FTL and LTL)
- Introduction of LNG based propulsion
- Proposed amendment of Directive 96/53/EC



**Figure 5.2** Assessment of TRL- and MRL-levels of the three actions described in the case.

### 5.1.1 Collaborative business models (FTL and LTL)

This is an area of little controversy and since long time well implemented in the transport market. It is probably the oldest principle of transport operation since its very beginning. In using present buzzwords, the concept could be described as examples on “shared economy” and “horizontal collaboration”.

The most efficient transport systems, i.e. most profitable are those that puts utilization degree as their core activity. By definition utilization degree optimization must include production and sales criteria’s. It needs continuous short and long-term nursing and will deteriorate quickly if given insufficient attention.

The new possibilities in this field are access to more data and supporting IT-tools and more developed models for cooperation. Some argue that big data driven collaboration will make the transport system comparable to internet<sup>26</sup> where cargo flows is delivered by any truck in a large production system. To understand the system effects of larger vehicles with regard to their practical utilization is a key evaluation element for further development of HCT.

### 5.1.2 Introduction of LNG/LBG based propulsion

Liquefied natural/bio gas (LNG/LBG) predominantly methane, CH<sub>4</sub> is liquefied through a modest pressure and cooling process. LNG achieves a higher reduction in volume than compressed natural gas (CNG) so that the (volumetric) energy density of LNG is 2.4 times greater than that of CNG but only 60 percent of diesel fuel. LNG/LBG can be used in diesel engines but requires a certain amount of diesel to start the combustion process. If the primary energy derives from biogas the emissions of CO<sub>2</sub> is close to zero. Using fossil based LNG gives small climate benefits in comparison to regular diesel,

<sup>26</sup> Physical internet compares the transport system with servers and networks for data distribution.



especially considering slip of the greenhouse gas methane from the combustion that may occur.

Our somewhat wider interpretation of this measure within the toolbox is the introduction of renewable fuels in road transport. In this circumstance, it is worthwhile mentioning some other solutions:

Future gas driven vehicles may develop towards use of hydrogen where hydrogen is potentially a fuel that could be provided along the ScanMed corridor.

Electrification of trucks<sup>27</sup> for long haul and short distance is presently also developed and tested in various applications. Promoting charging stations along the ScanMed corridor could push this development forward.

For the second case the fuel used is HVO<sup>28</sup> being easily adopted by hauliers since it is fully compatible to regular diesel.

### 5.1.3 Proposed amendment of Directive 96/53/EC

Heavy goods vehicles, buses and coaches must comply with rules on weights and dimensions for road safety reasons and to avoid damage of roads, bridges and tunnels. The Directive (EU) 2015/719 sets maximum dimensions and weights for international traffic, also ensuring that Member States cannot restrict the circulation of vehicles, that complies with these requirements. The directive also aims to avoid national operators to benefit from undue advantages over their competitors from other Member States.

Concerning the issue of cross-border traffic of vehicles heavier, longer or higher than the limits set in the initial Directive (EU) 2015/719 ended with the conclusion that the rules of Directive 96/53/EC should not be modified.

Even though the debate of larger vehicles in cross-border traffic seem to be difficult it is relevant to evaluate the effects of larger vehicle dimensions. It should also be noted that vehicle combinations adding to 32 meters were historically allowed in Sweden until 1968/69 and remained on the roads until 1973.

During 2016 the plan for the Swedish government was to change the traffic ordonnance regarding the article 4.5 in the 96/53/EG. This would enable vehicles or vehicle trains with new techniques or design that not fulfills the regulations in the traffic ordonnance on weight and dimensions whereas they could operate on roads for a limited time period. However, this is still not introduced (February 2017).

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<sup>27</sup> Read more on electrified trucks here: <http://www.conlogic.se/en/news/trend-outlook-electric-driven-heavy-duty-trucks/>. Accessed 2017-03-27.

<sup>28</sup> Hydrogenated Vegetable Oil (HVO).

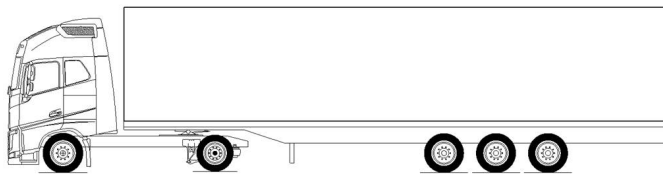


## 5.2 High Capacity Transport (HCT)

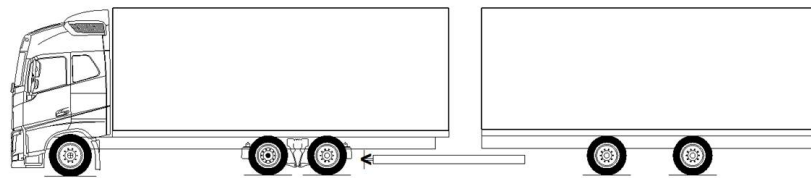
For larger trucks the delimiting factors of transport is either weight or volume. Within extra-large trucks in Sweden (High Capacity Transport – HCT) this has been recognized through two separate solutions:

- Heavy goods adapted trucks: Increasing maximum gross weight from 64 to 74 ton<sup>29</sup>. This is called *baseline vehicle 1* in Table 5.1 below.
- Volumes goods adapted trucks: Increasing maximum vehicle length from 25.25 to 34m<sup>30</sup>. This is called *baseline vehicle 2* in Table 5.1 below.

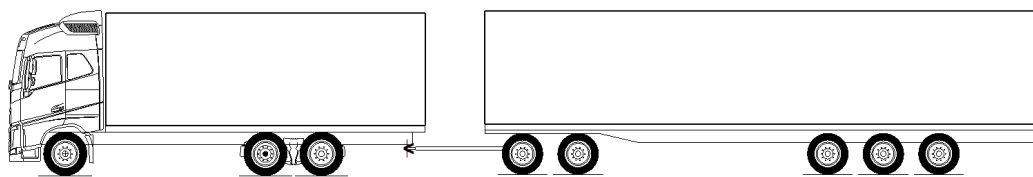
Figure 5.3 shows an illustration of a traditional truck in Europe, a 25.25-meter truck allowed in Sweden and parts of Europe and the alternative HCT-vehicle and their cargo volume capacities.



1. Module vehicle 16,5, Module 13,6



2. Module vehicle 18,75, Module 7,82 + Module 7,82 (EU max)

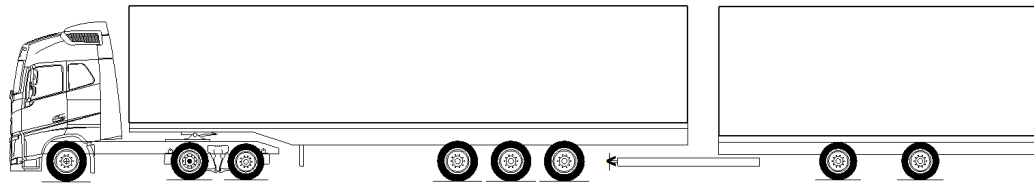


3. Module vehicle 25,25, Module 7,82 + Module 13,6 (dolly semi-trailer)

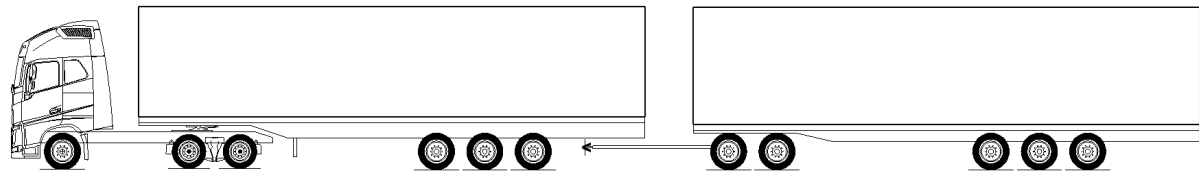
**Figure 5.3** Long haul vehicles.

<sup>29</sup> The 4<sup>th</sup> of October, the Swedish Government initiated a council of legislation regarding an introduction of 74-ton trucks on designated Swedish roads being able to carry the additional weight. These roads are located where there is no ability to transport goods by rail or road. The Swedish Parliament will take the formal decision before the 1<sup>st</sup> of July. Thereafter it will take an additional year to amend required regulations before these trucks can operate on designated roads..

<sup>30</sup> Presently tested in some applications based on special time restricted permits.



4. Module vehicle 25,25, Module 13,6 + Module 7,82



5. Module vehicle 34, Module 13,6 + Module 13,6

**Figure 5.3 continued** Long haul vehicles.

Hence, HCT based on weight means increasing weight from 64 to 74 ton gross weight and HCT based on length means increasing the vehicle length from 25.25 to 34m. In Table 5.1 the increase in cargo capacity compared to a standard vehicle is shown under baseline vehicle 1 for the weight-based alternative, and shown under baseline vehicle 2 for the length-based volume alternative.

**Table 5.1** Cargo capacity comparison among HCT-vehicles used

Vehicle	Cargo carrier capacity				Baseline vehicle 1	Baseline vehicle 3&4
	Length [m]	Width [m]	Height [m]	Volume [m3]	Increase [%]	Increase [%]
1. Tractor and semitrailer (16,5 m)	13	2,4	3	93,6	0%	n/a
3 & 4. Truck and trailer (25,25 m)	20	2,4	3	144	154%	0%
5. Tractor and duotrailer (34 m)	26	2,4	3	187,2	200%	130%

For general cargo the most common delimiting factor is volume, meaning that if higher productivity should be obtained benefits are reaped mostly by introducing longer vehicles. This is also the background for the two cases presented below. The practical implementation of the measures in the toolbox has been analyzed through two case studies. One is DB Schenker in their traffic between Göteborg and Malmö presented in section 5.3. The other case is PostNord in their line haul between Stockholm and Malmö. This case is presented in section 5.4.

### 5.3 Lead user: DB Schenker

For DB Schenker the general aim of testing HCT in operation is to evaluate if it increases productivity on a continuous basis meanwhile GHG-emissions are reduced. With regard to this general aim the HCT is a solution that seems to contribute to these two objectives.





It increases cost productivity through more cargo on one transport unit having similar or lower operational costs as the commonly used 25.25 meter units. The HCT also fulfils customer demands as well as enable marketing of better environmental performance.

DB Schenker presently operates three different HCT test vehicles:

1. 1 tractor with 2 trailers running a line haul between Göteborg and Malmö.
2. 1 tractor with 2 trailers between Falköping and Skara with containers to and from the train for the customer Jula.
3. 1 duo wagon operating a line haul between Göteborg and Helsingborg,

This case study concentrates on the duo trailer between Göteborg and Malmö.

The line haul between the terminals in Göteborg and Malmö is operated by the haulier Kallebäck's Åkeri. The transport starts with cargo pick-up that involves single semitrailers with a tractor at the shipper's location. Pick-up also includes terminal handled cargo through pick-up vehicles delivering cargo to the goods terminal. When fully loaded the two semitrailers are connected to one tractor at DB Schenker terminal leaving for the next goods terminal. At the receiving terminal the delivery transport involves single semitrailers with one tractor each and other distribution vehicles if the cargo passes the goods terminal.

### 5.3.1 Challenges for the duo trailer

The temporary permits used for these vehicles only allow traffic at certain stretches. This limits redundancy, as de-routing is impossible. If there is a need for de-route due to a traffic accident, or road maintenance this will stop the vehicle. The only way to by-pass such a hurdle is to call for an additional tractor and decouple the duo trailer vehicle. This happens a few times per year. Initially there were also time restrictions for these vehicles on the road. They were not allowed to be out on the road after 6 a.m., which sometimes stopped the truck and required another tractor. This limit is now eliminated and the vehicle is operational 24 hours. Overall the vulnerability of these vehicles is considered the same as for the previous 25.25 vehicles.

The use of larger road vehicles is not in contradiction with internal efforts to increase rail solutions according to DB Schenker. DB Schenker aims to double their amount of goods on the rail system and still promote HCT-vehicles. Rail is more cost effective but timetables are not sufficiently good for some transport relations as there is commonly a trans-shipment needed. DB Schenker sees these two solutions as complementary: "We do not see HCT as a competitor to rail"<sup>31</sup>

Another aspect of HCT vehicles is that shunting increases lead times. When there is a short distance between terminals the gain is therefore less than for longer distances. At one terminal the practical space for the shunting is a challenge. If HCT would be allowed

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<sup>31</sup> Ida Jonsson, Schenker Consulting AB.



on a national basis there would be a need for a general overview of all terminals and their shunting abilities.

Present timetables in the line hauls are tight and there is little room for speed reductions below allowed speed limits (for example for saving fuels). Between some terminals this may be an option. However, this specific truck also stops on road based weight stations in order to calibrate the on-board weight measuring equipment if there is an indication of a deviation which also means it loses some time.

DB Schenker uses both Scania and Volvo tractors in their operation. The engines for HCT are Euro VI and one is a Euro V. For line hauls, terminal-to-terminal the average load factor in Sweden is 80 % by volume. The average gross weight of the vehicle between Malmö and Göteborg is 59 ton where the maximum allowed weight is 80 ton.

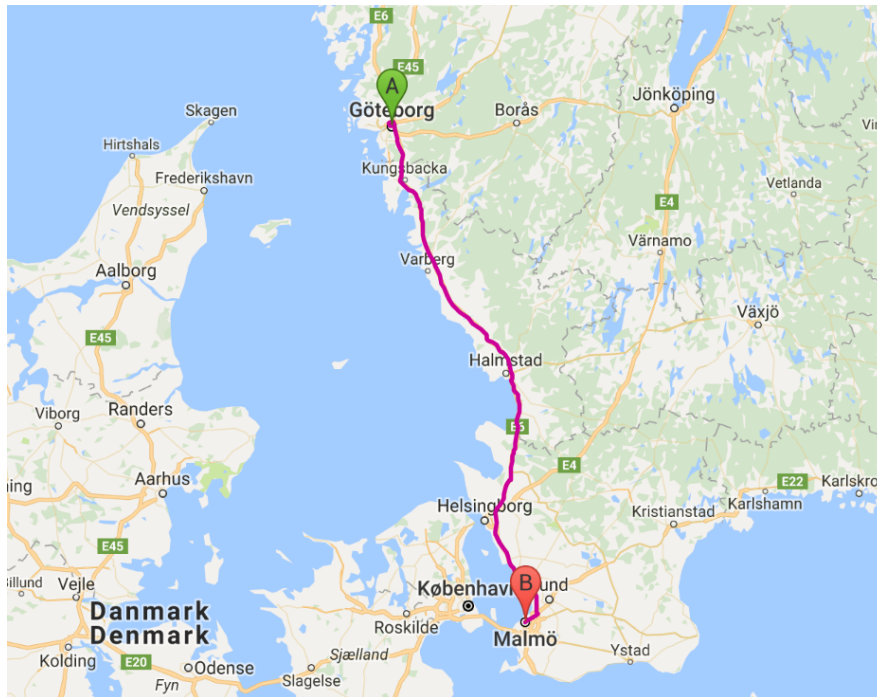


**Figure 5.4** The duo trailer vehicle

Since this is a test vehicle its configuration is a bit heavy and has a strong engine effect. This truck has trailers with a weight of 11 tons each and a heavy tractor. If this type of vehicles will be legally accepted and thereby commonly adopted there will be further optimizations on engine effect linked to gross weights in order to save fuel consumption. An ordinary well-configured tractor and semitrailer with a skilled driver should be able to reach a fuel consumption of 0.25-0.3 litres per km with this type of light cargo. This means that the duo trailer need to use less than 0.5-0.6 litres/km of fuel in order to be environmentally competitive.

### 5.3.2. Facts on the duo trailer

Figure 5.5 show the stretch of the line haul between Malmö and Göteborg for which the duo trailer has been tested.



**Figure 5.5** The line haul route between Malmö and Göteborg used to test the duo trailer.

This stretch has a distance of 284 km one way. Below are some additional facts on the duo trailer test.

- |                 |                     |
|-----------------|---------------------|
| 1. Cargo weight | 25 - 30 ton         |
| 2. Cargo volume | ~140 m <sup>3</sup> |
| 3. Staffing     | One driver          |

Since this is a test of duo trailer vehicle and it is operated in parallel with regular trucks on this line haul. At present Schenker only have one dolly, that is, only one duo trailer ability but another dolly was recently approved funding through the HCT research programme. This should enable one additional duo trailer vehicle.

### 5.3.3 Conclusions

DB Schenker has during the tests of all HCT vehicle combinations gathered a lot of practical results and experiences including risks and challenges. If the HCT becomes a regular vehicle concept DB Schenker will be able to swiftly adapt according to these experiences. At a given amount of cargo the number of trucks would thereby be reduced if HCT were implemented at full scale.

From a cost perspective the duo trailers are good solutions. Driver's salary is a big cost burden for hauliers. In addition it is very difficult to find qualified drivers. Introduction of HCT with higher margins will most likely however render a lower market price hence stabilize the same profit margin as today.



The duo-trailer is not more difficult to operate than an ordinary truck and trailer of 25.25 meter. It makes its ways similarly good. Schenker also investigates optional roads for the future if this concept is approved onwards. Increasing the redundancy ability is something that requires additional work.

The duo trailer gives significant gains when operating in line hauls between terminals where there is sufficient amount of goods. By using semitrailers it also enables delivery and pick-up at customers smoothly.

It should be noted that the HCT concept gives some volume advantages but in comparison with the 25.25 vehicles the difference is not so profound. A modern 60-ton truck (25.25m) consumes on average 0.4 liters/km where the presently best vehicle consumes 0.35 liters/km. From a strict environmental perspective this challenges the gains from the duo trailer vehicle (see Table 5.2).

**Table 5.2** Table of results for Schenker and additional improvement measures

No	Type	GHG-emissions wtw	Unit	Savings	FC [l/km]	Fuel	Load factor w [%]	Comments
1	Tractor with a semitrailer	64	g/tonkm	0%	0,3	Mk1 B7	57%	Common EU-truck
2	25,25m truck and trailer base	53	"	-18%	0,495	Mk1 B7	63%	Common Swedish truck
3	25,25m truck and trailer	44	"	-31%	0,57	Mk1 B7	85%	Common Swedish truck, increasing load factor
4	25,25m truck and trailer LBG	13	"	-80%	0,57*	Biogas	85%	Common Swedish truck, increasing load factor biogas fuelled
5	25,25m truck and trailer LBG +	11	"	-83%	0,49*	Biogas	85%	Common Swedish truck, increasing load factor biogas fuelled, ecodriving
6	1 duo semitrailer base	42	"	-35%	0,39	Mk1 B7	57%	Duo trailer base configuration
7	1 duo semitrailer +	33	"	-49%	0,42	Mk1 B7	77%	Duo trailer base configuration, increasing load factor, ecodriving
8	1 duo semitrailer LBG +	10	"	-85%	0,42*	Biogas	77%	Duo trailer base configuration, increasing load factor, ecodriving biogas fuelled

\* Dieselequivalent energy use

It is obvious that greening long distance road transport consists of three basic elements that must be included in the GHG reduction work:

1. Fuel efficiency of the vehicle
2. Large vehicles being well utilized
3. Low content of fossil coal in fuel

If this can be obtained the GHG-reduction possibilities are significant. In this test the truck is running on diesel, Mk1 B7.



#### 5.3.4 Sensitivity analysis

**Info Box: Sensitivity discussion**

By operating larger vehicles, well utilized, significant savings can be achieved. If the operator fails to utilize the capacity the gains will turn into increased emissions as larger vehicles consumes more fuel. Regarding the use of LNG the analysis is based on biogas. The LBG (and LNG) configuration requires diesel in combination with gas. In this hypothetical case 25 % diesel fuel. If we had made the calculation based on fossil gas (LNG) there would have been no GHG-emission savings. By using biogas it leads to significant GHG-emission reductions, hence the sensitivity lays in the ability to utilize large vehicles and to swap to fuels with less content of carbon coal. It should be noted that the diesel used contains 7 % of FAME.



## 5.4 Lead user: PostNord



**Figure 5.6** The duo trailer operating for PostNord. Note that there are only two axles on the tractor

This line haul operation between PostNord's goods terminals in Stockholm and Malmö is operated by the haulier AlGuns Åkeri, using four duo trailers pulled by four tractors (Figure 5.6). Previously six 25.25 meters trucks and trailers operated it. The cargo consists of parcels and some palletized goods that are mainly very light volume goods but which requires large volume capacity. The gross weight of the duo trailer vehicles is normally around 40 tonnes per trip.

All tractors are equipped with Euro VI engines and are on the northbound trip running on 100 % HVO<sup>32</sup> delivered by Circle K. During 2016 Circle K guaranteed PFAD<sup>33</sup> -free HVO, but from 2017 the supplier can no longer assure this.

Southbound the tractors are running on ordinary Mk1 B7<sup>34</sup>. There is no difference on the fuel consumption or other performance deviations for the two types of fuels used in this operation.

The engines in the tractors have a fairly small effect sufficiently adapted to this application of flat terrain and low cargo weight. The cargo weight is approximately 6 tons per semitrailer. The fuel consumption of this configuration of the duo trailer vehicle is 0.32 litres per km.

The loading of each semitrailer takes some three hours and is carried out by the terminals' staff at PostNord.

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<sup>32</sup> Hydrogenated Vegetable Oil, HVO.

<sup>33</sup> PFAD, Palm Fatty Acid Distillate is a bi-product from the palm oil refinery process. PFAD is used for animal feed, detergents, and soap and in the cosmetic industry. PFAD can also be used in HVO production.

<sup>34</sup> Environmental class 1 diesel with 7 % blend of FAME (Fatty Acid Methyl Ester).

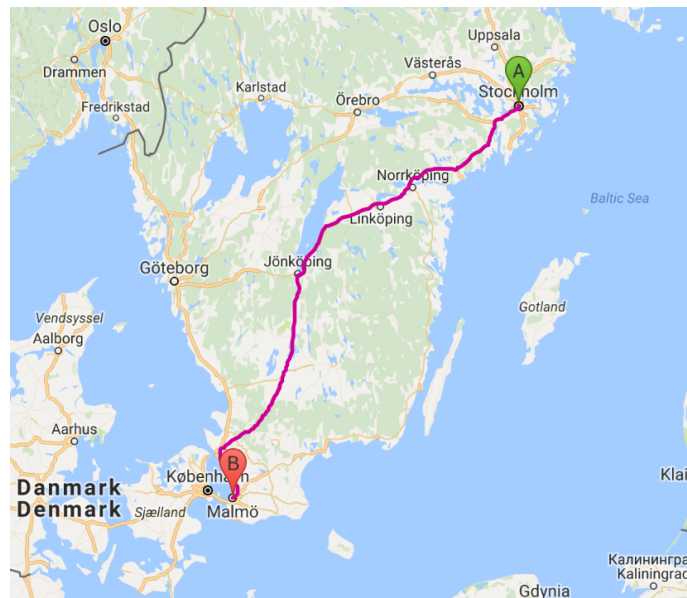


#### 5.4.1 Challenges for the duo trailer vehicle

These vehicles must only drive on designated roads where there is no meeting traffic and are only allowed on three routes in Sweden so far. The hauliers also need a special speed permit maximized at 80 km/h<sup>35</sup>.

The vehicles are part of the Swedish HCT research programme and therefore report experiences to the HCT research programme, for example the total distances, weights and tonkm achieved for each quarter of a year and each duo trailer vehicle. They should also be available for potential other studies within the HCT research programme, such as evaluation of traffic safety effects or other performance studies.

The duo trailer vehicles operate between the Circle K gas station outside Malmö, 2.5 km away from the PostNord terminal to Södertälje. The four semitrailers are pulled to this location by four tractors. Thereafter they are connected and pulled to Södertälje by two tractors. In Södertälje the road trains are disconnected and a tractor each pulls the two semitrailers to the PostNord goods terminals in Veddesta and Segeltorp in the Stockholm area. In the simultaneously on-going southbound traffic the operation is inverted (see Figure 5.7).



**Figure 5.7** The route Malmö – Stockholm.

#### 5.4.2. Transport facts

<sup>35</sup> Without this special speed permit they are only allowed to operate at maximum 40 km/h.



- Distance PostNord to Circle K 2.5 km
- Distance Malmö to Södertälje: 580 km
- Distance Södertälje to Veddesta: 66 km
- Distance Södertälje to Segeltorp: 23 km

#### Transport schedule per day

- 2 semitrailers northbound from Malmö to Veddesta
  - 2 semitrailers northbound from Malmö to Segeltorp
  - 2 semitrailers southbound from Veddesta to Malmö
  - 2 semitrailers southbound from Segeltorp to Malmö
- 
- Cargo weight: 6 – 7 ton/trailer
  - Load factor: Trailers are full by volume in both directions
  - Staffing Four long distance drivers and four pilots for local transport

#### 5.4.3 Conclusions

PostNord and the haulier ALGuns Åkeri have been operating this line haul with four duo trailer vehicles since July 2016 and will continue until the permit expires. In Sweden the modification of the Directive 96/53/EC for HCT seem to prioritize 74-ton vehicles rather than 34-meter road trains at present. The existing temporary permit for this operation is therefore likely to expire after 2017, if nothing changes.

When starting the new solution there were no introduction hurdles. Overall the introduction was equally easy as starting any other new transport operation. The operation now runs smoothly and there have not been any specific incidents, major breakdowns or complaints. The only minor issue is that these trucks arriving in the night disturb sleeping drivers at the Scania parking lot in Södertälje. Since there are no time restrictions on transport activities at this space the other drivers have to accept this small disturbance.

The only technical problem thus far is frozen brakes at one occasion on the last semitrailer due to very low temperatures, but this could just as well have happened on a single semitrailer. The duo trailer vehicles work well and the only different operation compared to previous solutions is the shunting for connecting and disconnecting trailers in both ends of the transport.

If this solution was commonly accepted on all major roads, it is for similar types of light and volume cargo a very efficient configuration that is worthwhile scaling up. Introducing renewable fuels, increasing load factor, and potentially introducing electrified roads for this type of vehicle could accomplish a quantum jump towards fossil free road transport. See Table 5.3.





**Table 5.3** Table of results for PostNord.

MK1 B7	CO2e wtw [kg/l]	2,648							
HVO 100 %	CO2e wtw [kg/l]	0,3							
<b>Initial baseline solution</b>	Journeys [n]	Distance [km]	FC [l/km]	FQ [kg/l]	Trucks [n]	Working days [n]	GHG [ton p.a.]	Saving [ton p.a.]	Saving [%]
Malmö - Segeltorp	2	605,5	0,4	2,648	3	250	962		
Malmö - Veddesta	2	648,5	0,4	2,648	3	250	1030		
<b>Total</b>							<b>1992</b>	<b>0</b>	<b>0%</b>
<b>New solution</b>	Journeys [n]	Distance [km]	FC [l/km]	FQ [kg/l]	Trucks [n]	Working days [n]	GHG [ton p.a.]	Saving [ton p.a.]	Saving [%]
Postnord - Shunting	2	2,5	0,32	2,648	8	250	8		
Malmö -Södertälje	2	580	0,32	2,648	4	250	983		
Södertälje - Segeltorp	2	23	0,32	2,648	4	250	39		
Södertälje - Veddesta	2	66	0,32	2,648	4	250	112		
<b>Total</b>							<b>1142</b>	<b>850</b>	<b>-43%</b>
<b>Present solution</b>	Journeys [n]	Distance [km]	FC [l/km]	FQ [kg/l]	Trucks [n]	Working days [n]	GHG [ton p.a.]	Saving [ton p.a.]	Saving [%]
Postnord Mö- Shunting yard	1	2,5	0,32	2,648	8	250	4		
Malmö -Södertälje	1	580	0,32	0,3	4	250	56		
Södertälje - Segeltorp	1	23	0,32	2,648	4	250	19		
Södertälje - Veddesta	1	66	0,32	2,648	4	250	56		
Veddesta - Södertälje	1	66	0,32	2,648	4	250	56		
Segeltorp - Södertälje	1	23	0,32	2,648	4	250	19		
Södertälje - Malmö	1	580	0,32	2,648	4	250	491		
Shunting yard- Postnord Mö	1	2,5	0,32	2,648	8	250	4		
<b>Total</b>							<b>706</b>	<b>1286</b>	<b>-65%</b>
<b>Further development</b>	Journeys [n]	Distance [km]	FC [l/km]	FQ [kg/l]	Trucks [n]	Working days [n]	GHG [ton p.a.]	Saving [ton p.a.]	Saving [%]
Postnord Mö- Shunting yard	1	2,5	0,3	0,3	8	250	0		
Malmö -Södertälje	1	580	0,3	0,3	4	250	52		
Södertälje - Segeltorp	1	23	0,3	0,3	4	250	2		
Södertälje - Veddesta	1	66	0,3	0,3	4	250	6		
Veddesta - Södertälje	1	66	0,3	0,3	4	250	6		
Segeltorp - Södertälje	1	23	0,3	0,3	4	250	2		
Södertälje - Malmö	1	580	0,3	0,3	4	250	52		
Shunting yard- Postnord Mö	1	2,5	0,3	0,3	8	250	0		
<b>Total</b>							<b>121</b>	<b>1871</b>	<b>-94%</b>
<b>Further baseline development</b>	Journeys [n]	Distance [km]	FC [l/km]	FQ [kg/l]	Trucks [n]	Working days [n]	GHG [ton p.a.]	Saving [ton p.a.]	Saving [%]
Malmö - Segeltorp	2	605,5	0,35	0,3	3	250	95		
Malmö - Veddesta	2	648,5	0,35	0,3	3	250	102		
<b>Total</b>							<b>198</b>	<b>1795</b>	<b>-90%</b>

Obviously the economic productivity is solid as there is only one driver per duo trailer vehicle. The number of long distance drivers is today 4 in comparisons to previous six long distance drivers for the same service. The investment cost for the tractor and semitrailers is considered to be lower than for a similarly configured 25.25 m vehicle. In addition, the tractor and duo-trailer adds flexibility since it is a modular set up where tractors and semitrailers can be used in a range of other applications.

Impact on the traffic safety is the most important performance issue for HCT that has been much discussed. In this solution there have been no reported traffic safety incidents and not more than in the previous set up operating with more vehicles in the traffic i.e. higher likelihood of incidents and accidents.

PostNord have not yet communicated gains from this new and more efficient transport solution. This is likely a tactical decision as it might disappear after the end of 2017. If it is prolonged this could be a good marketing activity. According to PostNord this solution



should reflect the future of how to carry out lightweight long distance goods transport by road in Sweden. How the EU perceives this is of course another issue.

Overall, environmental gains are substantial as can be seen in Table 5.3 even though a modern 25.25 m vehicle would reduce emissions to similar levels if using the same type of fuel. Still there are some additional improvements that can be done in the present solution. If spoilers would be applied on the last trailer the fuel consumption could go down by some 6-7 % to 0.3<sup>36</sup> l/km on a yearly basis. Another politically challenging improvement would be to add one additional semitrailer to the duo trailer (triple trailer). The gross weight would in this specific transport solution be 55 tonnes which is within existing weight regulations. To introduce such a solution is however perceived as impossible from a political perspective.

From this assessment it is evident that the potential total savings of CO<sub>2</sub>e of the duo trailer is considerable (-94 %) (Table 5.3) and would be able to meet present Swedish reduction targets (-85 %) for 2045 already today.

#### 5.4.4 Sensitivity analysis

##### **Info Box: Sensitivity discussion**

By operating larger vehicles, well utilized, significant savings can be achieved. If the operator fails to utilize the capacity the gains will turn into increased emissions as larger vehicles consumes more fuel. Regarding HVO, the analysis is based on 100 % HVO when used. In this case data comes from the fuel supplier that have calculated performance in accordance with the Renewable Energy Directive. If the instructions on assessment of fuel GHG-performance would change or if availability of this fuel would go down it would inflict on the performance. Using HVO leads to significant GHG-emission reductions; hence the sensitivity lays in the ability to utilize large vehicles and to swap to fuels with less content of carbon coal. It should be noted that the diesel used contains 7 % of FAME. The main concern for this HVO is availability of sufficient amount of biomass that does not interfere with other needs. If demand increases this would further amplify these challenges.

## 5.5 Discussion: Core issues from the Road cases

The main enabler for using larger road vehicles is sufficient cargo flows in both directions. Balancing goods flows is a major challenge when organizing transport logistics. About 50 % of all European northbound railway cargo wagons travel empty<sup>37</sup>. Meanwhile significant freight volumes are transported in parallel by road that emit more CO<sub>2</sub> and are less sustainable compared to the railway system<sup>38</sup>. Thus, we have

<sup>36</sup> In good conditions this low fuel consumption is feasible already today without any further technical requirements.

<sup>37</sup> Trafikanalys (2011).

<sup>38</sup> McKinnon (2010).



more sustainable railway transports travelling empty side-by-side with less sustainable half-empty road transports. Obviously, more balanced flows from increased fill-rates and reduced empty transports utilizing more sustainable modes of transportation are desirable.

The two cases based on a baseline road transport indicates overall GHG potentials as shown in Table 5.4:

**Table 5.4** Potential of GHG savings in the road case

Solutions	CO2e wtw index	Savings [%]
Baseline, tractor and trailer conventional fossil fuel based propulsion	100	0
HCT, 25.25 meter or 34 meter vehicle conventional fossil fuel based propulsion	~ 65	35%
HCT, 25.25 meter or 34 meter vehicle conventional bio fuel based propulsion	~ 20	80%
HCT, 25.25 meter or 34 meter vehicle optimized bio fuel based propulsion	~ 10	90%
Semitrailer by electric train running on green electricity	~ 0,8	99,2%

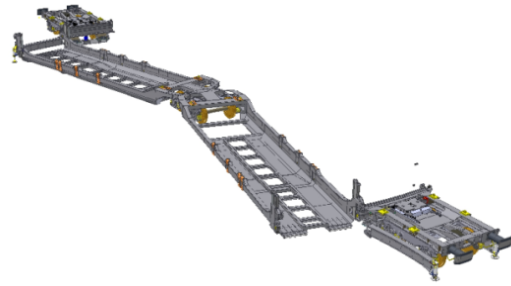
According to a study<sup>39</sup> by the Faculty of Engineering LTH at Lund University (Lunds Tekniska Högskola), more HCT vehicles may risk a shift towards more road transport solutions from rail and sea. Researchers at LTH therefore argues that there is a need to introduce market-based mechanisms that in parallel incentivise rail based transport even though climate performance of road transport improves significantly by HCT. This must also be viewed in the perspective of growing transport volumes in general according to the same study. The study by LTH claim that HCT introduction at large scale is beneficial to society but have a risk of a lock-in situation based on an increasing share of less sustainable road transport solutions.

Building compatible modular system is one item. If intermodality of all semitrailers were ensured this would enable highly efficient transport logistics using road and rail in combination.

According to the European Commission SAIL-report (ICT-System Addressed to Integrated Logistic management and decision support for intermodal port and dry port facilities)<sup>40</sup>, only 3 % of today's trailers within the European community can be lifted by a crane on to a railway wagon and thereby utilize combined rail and road services. Moreover, this means lacking compatibility, which in turn increases transport logistics planning costs as only few trailers can operate freely in this respect. On the other hand these semitrailers would become heavier which would increase their fuel consumption on the roads. One way to overcome the transshipment problem is to implement certain railway wagon-based equipment, some which is described in the toolbox. The Reach Stacker and Mega Swing are two such measures shown in Figure 5.8.

<sup>39</sup> Adell et al, (2016).

<sup>40</sup> [http://cordis.europa.eu/result/rcn/164183\\_en.html](http://cordis.europa.eu/result/rcn/164183_en.html). Accessed 2017-03-05.



**Figure 5.8** Transshipment of semi-trailer through cranes (Reach Stacker) or the Mega Swing wagon.

In this section we have explored three activities in the Swiftly Green toolbox:

- Larger vehicles through *amendment of Directive 96/53/EC*, where the potential cost and emission savings are substantial.
- Increasing load factor through a *collaborative business models (FTL and LTL)*, where our cases involved two large transport operators co-loading the cargo of several shippers. Cargo volumes in both directions, that is, achieving sufficient load factors is a pre-requisite for larger vehicles.
- Using alternative fuels by *introducing LNG-based propulsion* indicates neglectable climate gains as this fuel is based on fossil gas. If the gas is based on biomass it has a substantial reduction potential. Another drawback is that a compression engine requires a certain fraction of diesel for ignition. Since gas fuels are incompatible with fluid fuels the study also looked into HVO as an optional renewable fuel that is easier to introduce, as it is fully compatible with present diesel fuel. This fuel indicates very high saving potentials.

General conclusions from the road use case are:

- From a cost saving perspective the duo trailer vehicle provides a better solution as 100 % more volume cargo can be loaded in comparison to the Tractor and single semitrailer and 30 % more volume cargo can be loaded in comparison to the 25.25 m vehicle meanwhile it only requires one driver. Equipment also seems to be less expensive and is useful in other applications.
- Coordination of cargo flows is needed for larger HCT-vehicles in order to ensure a sufficient level of utilization.
- Fuel efficiency per cubic metre increases by 10% for a 25,25m vehicle in comparison to a tractor and single semitrailer. The tractor and duotrailer increases fuel efficiency by more than 30% with the same baseline.
- Smooth introduction of renewable fuels need to fit into the present propulsion systems
- The main concern of this solution would be if it were introduced large-scale. Its dependence on a huge amount of biomass that does not exist at present becomes a significant challenge. For smaller markets and in delimited use it can pave the



way for a transition towards vehicles that can operate on renewable fuels. However, large scale transition towards renewable based propulsion requires many other and parallel solutions.

- Traffic safety is not significantly affected by the duo semitrailer.
- Functionality of services is fairly similar. One advantage may be that the semi-trailer can be delivered to the shipper early in the day for loading and picked up in the afternoon.
- Quality is not influenced since this contains the same handling and service.
- Minor operational challenges occur when connecting and disconnecting the road train.

The concluding remark is that we presently seem to have relevant knowledge and tools to de-carbonize the long-haul transport in a small scale. The question and real challenge is how to make it happen large-scale in a sustainable way.



## 6 The Railway Use Case

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### 6.1 Current issues for the railway system

The current railway system in Sweden is the result of a process of deregulation that has been on going since the late 1980s. At the turn of the millennium a number of new operators won contracts for freight and the passenger traffic followed soon after.

An important event was when the Swedish national rail SJ (Statens Järnvägar) was divided and made into a number of separate companies in 2001. These were all separate and independent and this was a step in the process of de-regulating the sector in Sweden. The result of this was that the old national rail was separated into several parts. SJ AB became a passenger operator; Green Cargo a freight operator/3PL as well as operator of shunting yards and Jernhusen was given the ownership of railway stations and some other buildings. The rail infrastructure was made the responsibility of TrV. Maintenance was separated into SweMaint and EuroMaint and cleaning services was outsourced to ISS Trafficare. The operation of the old IT-department was named Unigrind AB (the company has since been bought by EDB Teamco A/S and divided by its owners). The de-regulation of the railway system did not only split up the old national rail monopoly, more importantly it enabled new actors to enter the market for rail services in general and – of special interest here – to rail freight using the Swedish railway infrastructure. ScandFibre Logistics AB (hereafter SFL) is one such actor.

One major issue in this de-regulated system has to do with the efficient management and coordination of the different parts of the railway system. Allocating resources for maintenance and infrastructure investments, digitization, and management and control of the trains are perennial issues that are continuously discussed and worked on. This requires many actors to converge and cooperate, for example TrV (infrastructure maintenance), Green Cargo (shunting yard management and freight operations) and SFL (managing and controlling freight flows).

Another major issue concerns improved integration across infrastructure, 4/3PL actors, operators, freight forwarders, freight owners and terminal operators in order to provide seamless high quality freight services to customers, nationally as well as internationally.

#### 6.1.1 Lead user: ScandFibre Logistics (SFL)

ScandFibre Logistics AB (hereafter SFL) is a fourth-party logistics (4PL) provider<sup>41</sup> offering its customers a product that enables them to ship cargos across Europe in an economically efficient and sustainable way by utilizing the existing European railway infrastructure. The product is a dedicated railway-service, which is constantly under

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<sup>41</sup> Cezanne (2015); Hertz (2003); Jensen (2010).



development to become increasingly efficient and sustainable. Deriving its name from the latest European rail timetable shift the current generation of the service is called 'Rail 17'. The SFL railway-service comprises a network of terminals, routes, operators, and wagons organized to become a packaged service offer. These types of dedicated railway services are not uncommon in the railway sector and other examples exist as well. It draws on the common infrastructure and knowledge on organizing of efficient and balanced flows to create effective logistical systems. Balancing flows and managing constant changes and adapting to varying conditions are recurrent issues in these systems.

For SFL, the creation and realization of its rail system involves considerable organizing as well as cooperation with a large set of independent actors, such as infrastructure owners, train operators, wagon rental companies, shunting companies, terminals, forwarders and – not least – the shippers.

The main characteristic of the rail system in its current version of Rail 17 is formed by the requirements of one dominant group of shippers. These are paper mills in Sweden using the system to transport their products to customers in Europe or via European deep-sea ports to customers in other parts of the world. SFL is a wholly owned subsidiary to one of the largest Scandinavian paper producers – BillerudKorsnäs. While SFL enjoys considerable autonomy and the flows in Rail 17 also comprise products from two other paper producers, benefits from further integration with the owner is recognized. In a sense, SFL could be described as the outsourced function of railway shipping from three main paper producers: BillerudKorsnäs with the majority of the flow of the system, Mondi, and Smurfit Kappa. The mission of SFL is to offer the three paper producers competitive and sustainable transport solutions to terminals in Europe. Table 6.1 offers some characteristics of SFL and its current set-up in Rail 17.

**Table 6.1** Characteristics of the railway service of SFL

Annual turnover in 2016	Approx. 1 000M Sw.kr.
Number of employees	Approx. 25
Total number of wagons in pool	Approx. 1 400 – 1 700
Average load factor Southbound	> 95%
Average load factor Northbound	50-60%
Number of weekly departures in system	300
Annual volume of cargo in system	2,5 M ton
Number of mills served	7

While the focus of this report is on the Swedish part of TEN-T GK3 ScanMed corridor the Rail 17 system aligns well with the ScanMed rail freight corridor (RFC) over the stretch from Sweden to Northern Italy and the flows in Sweden are of course channelled further into the Continental European section and vice versa.



### 6.1.2 A dedicated railway system

SFL represents an actor organizing a dedicated railway system using the current rail infrastructure as a basis. SFL organizes the Rail17-system and have control mechanisms in place in terms of contracts and deals with the suppliers of infrastructure components to form a coherent railway-system. Rail 17 comprises around 30 terminals and/or shunting points and stations across Europe from Northern Sweden to the South of France/North of Spain (see Figure 6.1). The Rail 17 system is not static, but continuously adapted to the honed supply strategies of BillerudKorsnäs based on its customer structure, production streamlining and not least to the ability to attract return cargo.



**Figure 6.1** The Rail 17 core network. Source: ScandFibre Logistics AB, internal records.

Rail17 is based on a closed wagon pool, which means that neither northbound nor southbound wagons ever leave the system. As southbound flows are defined by the paper producers in Sweden and the whole Rail 17 system is designed based on these flows, the major issue for SFL is to channel northbound flows to create and manage the balance in this system to increase overall efficiency.

The railway network ends on the border between France and northern Spain because the Spanish railway system has a different track width as compared to the rest of Europe creating a technical interoperability obstacle. The French system stretches to some border terminals such as Irun. It should be noted that the network charted in Figure 6.1





is incomplete and do not show all details and terminals in the system. It is used only as an illustration.

## 6.2 Issues for SFL

The main issue for SFL is to organize rail wagons with loads in order to enable large-scale rail transport with high productivity for its customers and owners. To this end SFL use a combination of whole trains when possible on core relations and wagonloads to balance flows and cater to customer needs. The aim is to create circular flows in Rail 17 in which economic feasibility and improved productivity are the norms but also where the environmental effects are the greatest. A major issue in this circumstance is the ability to find, create and attract return cargo on the existing relations that SFL already have as a result of serving customers to BillerudKorsnäs across Europe.

Taking the current set-up of the Rail 17 system of SFL as a point of departure with fill rates of approximately 100 % southbound and around 50-60 % northbound, creating effective and high capacity solutions on the core stretches becomes crucial. This means that longer and heavier trains (LHT) is an important issue. Indeed, SFL currently use 730m trains on its core stretch on the relation Hallsberg – Malmö and ponders the potential of perhaps operating 2x750m trains in the future. These trains are operated in collaboration with Hector Rail using modern TRAXX locomotives (see Figure 3.3). One TRAXX locomotive can pull a whole LHT, as opposed to the older Rc4 locomotives that are not strong enough to pull an LHT alone, but are then used in pairs. For some very long train combinations multiple locomotives are used (see Figure 6.2.)

For SFL, the longer heavier trains are a complement to the standard 630m whole trains and wagonloads operated by Green Cargo. For SFL, continuously working with the whole trains and wagonloads to optimise load factors and train utilization is a recurrent tactical issue.

Another important issue is the digitization of the railway industry. “We are developing our business model by focusing on wagon-control and the opportunities that digitization opens up for.”<sup>42</sup> These opportunities represent a major shift in the sector according to SFL representatives. This shift is driven by digitization paired with other megatrends such as globalisation and urbanisation.

From this we identify the following measures from the toolbox as relevant for this case:

- Marathon - Longer and heavier trains (LHT)
- Digital enquiry form for freight wagons (RFID chip)
- Corridor section management

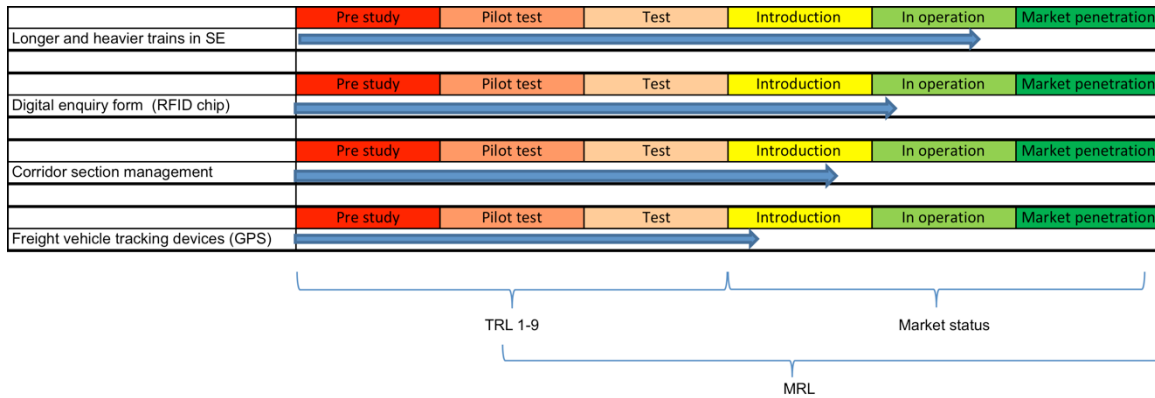
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<sup>42</sup> Interview with SFL logistics developer. Personal Communication.



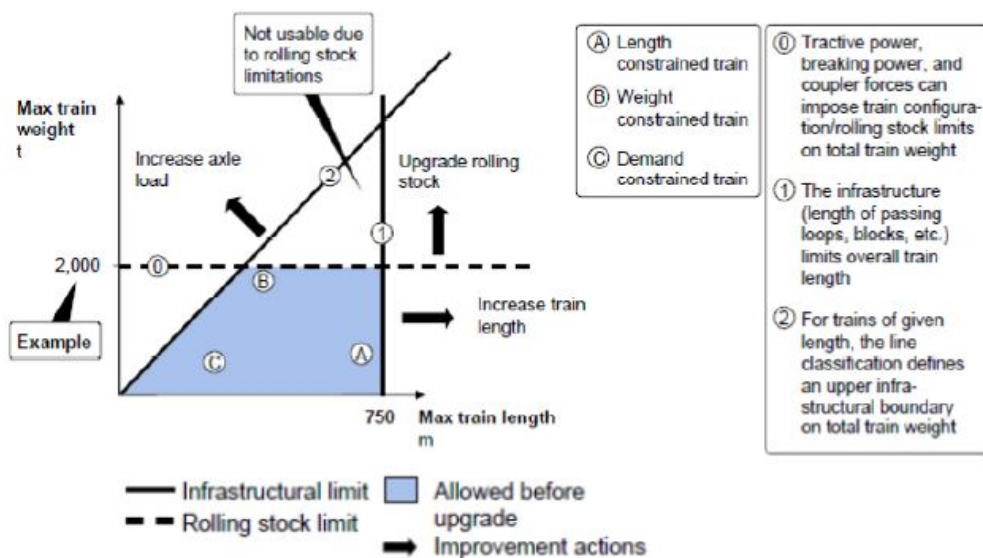
- Arrival estimation for freight vehicles (freight vehicle tracking devices (GPS))

Measure 1 relates to the issue of LHT, and measures 2-4 to the issue of digitization of the railway. The feasibility of these measures in terms of TRL and MRL are shown below in Figure 6.2.



**Figure 6.2.** Assessment of TRL and MRL of the four measures described in the case.

SFL utilize LHT in its Rail 17 system. Longer trains are related to heavier (hence the expression longer and heavier trains – LHT) as illustrated by Figure 6.3 below.



**Figure 6.3** The relationship between train weight, length and rolling stock in LHT.

Source: CER: Business Cases for a Primary European Freight Network<sup>43</sup>.

<sup>43</sup> <http://www.cer.be>. Accessed 2017-03-07.



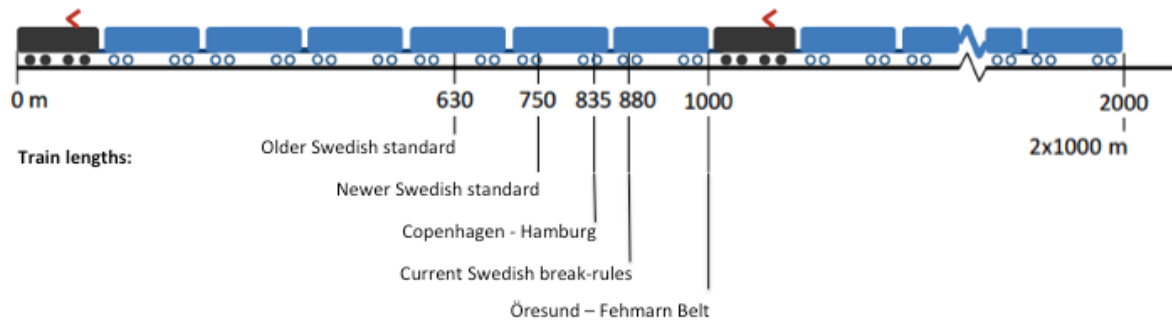
Figure 6.3 illustrates the interplay between weight and length allowed by EU-regulations. The x-axis describes the length of the train and the y-axis the maximum train weight. The solid line marked '2' in the figure illustrates the link between train weight and train length in terms of the upper boundary of the infrastructure on total train weight. The dotted horizontal line marked 'D' in the figure illustrates the weight limit to the rolling stock due to traction, braking and coupling issues of the trains, hence representing a cut-off delimitation. In Sweden this is a real issue due to the use of break-rules that are not synchronized with other parts of Europe meaning that even if trains of a certain length and weight can travel across some routes through Europe based on European break-rules, they cannot continue in Sweden because Swedish break-rules are different. This means that even if the infrastructure may clear a LHT, breaking issues or traction problems (for example on hilly and snowy routes) may cause restrictions.

Efficiency can principally be increased in three ways: 1) by investing in infrastructure so as to allow higher axle weight. 2) by investing in increasing the length of the trains, and 3) by investing in upgrades to the rolling stock. Real efficiency improvements would seem to require concerted investments in all three ways simultaneously. This is a challenge because different actors in the system are responsible for the investments in infrastructure, longer trains and on the rolling stock, respectively. Investments in LHT therefore require considerable collaboration among these actors – in this case between the Swedish Transportation Administration being responsible for the infrastructure and break-rules etc.,

In addition, the complexity of the system means that it is never only about longer and heavier trains – it is also about orchestrating circular flows and efficient utilization of available infrastructure including increased load factors and larger units.

### 6.2.1 Longer and Heavier Trains (LHT)

Longer and heavier trains (LHT) can be seen as a type of High Capacity Transport (HCT) for railway. LHT relates not just to the assembly of wagons and loads – it also affects infrastructure. For example, routes that longer and heavier trains traffic must have meeting-points for longer trains, and bridges etc. must be adapted to the increased exposure to weight, etc. Figure 6.4 shows a principle graphic of train lengths used in the ScanMed RFC. While current Swedish break-rules enable 880m trains, in practice this is impossible due to passenger traffic restrictions on the tracks.



**Figure 6.4.** Train lengths used in some parts of the ScanMed RFC.  
Adapted from Fröidh (2013: 46)<sup>44</sup>.

A problem for SFL is the shunting yards in Hallsberg and Malmö. For example, the shunting yard in Hallsberg was originally designed with wagonloads in mind, which means that the design and layout of the yard is adapted to sorting single wagonloads from many incoming trains to build new whole trains. The logic is that of breaking up trains from multiple origins and re-assign individual wagons to a new train in which all wagons going to the same destination is collected.

With even longer trains this problem increases and even if longer trains are more efficient en route, issues at shunting points creates inefficiencies and reduces the utility of LHT. Yet, SFL currently have two departures daily with longer trains on the route Malmö – Hallsberg. From the Swiftly Green toolbox, the measure called *Marathon* is a measure identified as the most relevant for this issue in this case. In *Marathon*, tests were performed in France with trains up to 1 500 meter of length with positive results. However, both legal and infrastructure issues limits its transferability. The 730-meter trains of SFL and its ideas on 2x750m trains are interesting local applications of this measure which we focus on in this project.

### 6.2.2 The digitization of the railway transportation system

When it comes to the digitization of the railway, this is a concrete issue emphasized in the SFL case involving GPS and RFID-tagging of freight wagons in the Rail 17 system. Digitizing means to create a numeric representation of a phenomenon, which facilitates digital storage, processing and transmission as it “allows information of all kinds in all formats to be carried with the same efficiency and also intermingled”<sup>45</sup>. Digitization represents a great potential for the railway and is something that waits around the corner according to SFL. Drawing on the benefits of the GS1-standard<sup>46</sup> for cargo and information flows, SFL use this to drive the digitization. The global standardization that GS1 enable provides increased control of warehousing and transportation for both buyers and sellers and supports SFL in its endeavour to provide timely cargo information to its customers.

<sup>44</sup> Source: Fröidh (2013).

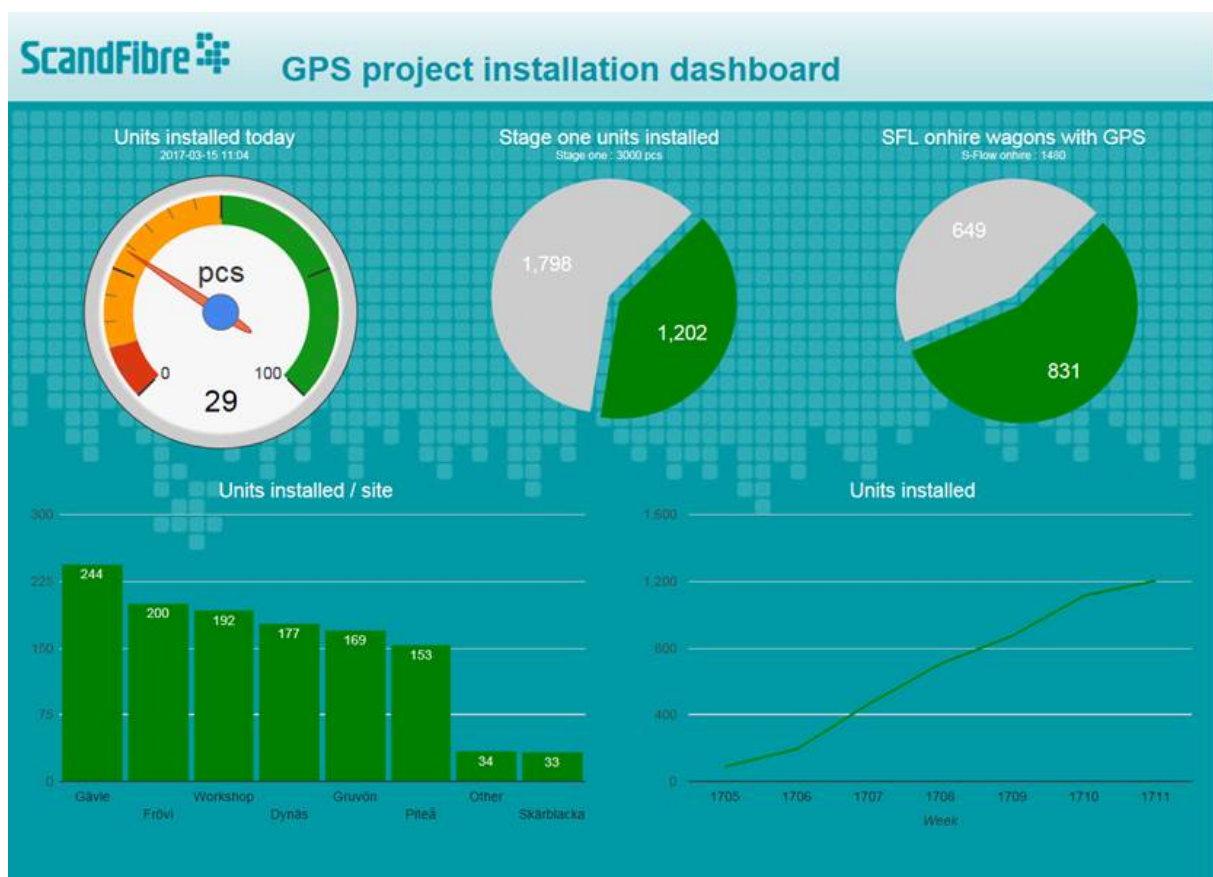
<sup>45</sup> McQuail (2010): p. 39.

<sup>46</sup> <http://www.gs1.org>. Accessed 2017-03-23.



For SFL, digitization originates from a need to increase the monitoring capability of the freight wagons in the system and they use the GS1-standard as a basis for collecting and managing information. Due to the distribution of ownership and use of the wagons between Transwaggon (TWA) and SFL they collaborate on this project and shares the initial investment costs. For tactical reasons, only GPS-trackers are mounted on the wagons. This is a decision made primarily by TWA. It should be noted that TrV currently invests in installations of RFID-readers in the Swedish railway system. Currently 300 readers have been installed (February 2017).

The GPS-trackers mounted on the wagons enables SFL to get more precise up-dated data on wagon positions in the Rail 17 network. For rolling stock wagons data is sent every 30 minutes as well as at starts and stops. The trackers are equipped with accelerometers so that they can sense chock as well, thus detecting when collisions occurs and send the position to SFL. For stationary wagons data is sent every 24 hours. During these conditions of use the batteries in the trackers are estimated to last for circa 5 years. Data transmission intervals can be changed remotely and depending on the configuration profile of the trackers, batteries are estimated to last up to 6 years. It is a trade off between how often data are sent and how long the battery lasts. Figure 6.5 shows the SFL GPS project installation dashboard as per March 2017.



**Figure 6.5** SFL GPS project installation dashboard. Screenshot as of 2017-03-15.



The monitoring capability that this provides is useful for SFL because it means that they can tell the difference between a wagon waiting to be shunted for example in Modena and a wagon waiting at a terminal in Modena to be registered as “arrived”. Without this monitoring capacity, SFL may know that the wagon is “somewhere in Modena” but not exactly where. This, in turn impacts SFL’s ability to more efficiently estimate and predict wagon positions and arrivals and plan the routes of northbound freights. Implementing a digitized track-and-trace system of freight wagons enables SFL to improve its offering to customers as well as to increase overall efficiency of the system.

From the Swiftly Green toolbox, two measures can be identified as having some relevance to this issue. First, the measure involving digital enquiry form for freight wagons (RFID chip) is a relevant measure. Second, the measure involving arrival estimation for freight vehicles (freight vehicle tracking devices – ‘FVTD’) is also a relevant measure. Both are evidently relevant in relation to this issue in this case and will be discussed more in detail below.

### 6.3 Measures and performance assessments

Given the core issue of the use case, which have been broken down into two concrete issues, we have identified a number of measures from the toolbox that holds promise in relation to these particular issues. In this section we discuss these measures in relation to the case and then report on the performance assessments of their implementation.

Adhering to the methodology adopted in this project, we first identify a baseline scenario. This is a scenario reflecting the current situation or the situation in which no measures have been taken. This scenario functions as the benchmark comparison to the performance assessment of a potentially implemented measure. We then evaluate effects on a micro- as well as macro-level scale of implementation of each measure.

#### 6.3.1 Longer Heavier Trains

The implementation of the Marathon measure in terms of LHT in the use case is analysed departing from a base-line scenario. The baseline scenario is that of a standard length train on the relation Hallsberg – Malmö. With this as a baseline, effects of implementing LHT is evaluated according to the following:

- *Current SFL Scenario:* The current SFL scenario is drawn from SFL’s Rail 17 set-up in which LHT serve the relation Hallsberg – Malmö twice a day all week (Interview SFL Marketing Manager). These trains are 730 m (including locomotive) as compared to Swedish standard length of 630 m.



- *Expanded SFL Scenario*: This scenario assumes three LHT a day all week, which is assessed to tangent the maximum volume required for SFL in its current Rail 17 set-up. More departures would probably not yield any more efficiency increases – there is likely a plateau in demand for three departures a day.

As a complement to this – and for reasons of comparison – the GHG-emissions of the *Current SFL Scenario* and the *Extended SFL Scenario* are compared in relation to the emissions of equivalent volumes of freight using trucks in a road transport mode.

For both scenarios, consequences for GHG-emissions savings will be calculated using the base-line scenario as benchmark and in comparison also to road transports. Effects are evaluated on both a micro-level and macro-level scale of implementation.

### 6.3.2 Analysis of LHT

#### *Micro-level assessment*

Calculations for the micro-level assessment of the SFL use case are based on a number of assumptions. These assumptions are summarized in Table 6.2.

**Table 6.2.** Assumptions made in the calculations of the SFL use case

<b>Electric train calculation</b>	<b>Unit</b>	<b>630</b>	<b>730</b>	<b>750</b>
Max gross weight	[ton]	2058	2418	2688
Cargo capacity	[ton]	1320	1560	1740
Gross weight empty	[ton]	738	858	948
Load factor South	[%]	100%	100%	100%
Load factor North	[%]	60%	60%	60%
Total round-trip gross weight	[ton]	3588	4212	4680
Net weight per round-trip	[ton]	2112	2496	2784
Electric distribution losses	[%]	10%	10%	10%
CO <sub>2</sub> e wtw, 'Bra miljöval'	[g/kWh]	8	8	8
Electric consumption per vehicle km vkm, including distribution losses	[kWh/vkm]	25	28	29
Electric consumption per net-tonne km, including distribution losses	[kWh/tkm]	0,024	0,022	0,021
CO <sub>2</sub> e per vehicle km	[g/vkm]	203	220	232
CO <sub>2</sub> e per tonkm	[g/tkm]	0,19	0,18	0,17

Based on the preconditions described in 6.3.1 above where trains are traveling on flat terrain we look at the three scenarios with three train lengths: Baseline Scenario 630 m with a gross weight of 2 058 ton; Current SFL Scenario 730 m with a gross weight of 2 418 ton; and Expanded SFL Scenario 750 m with a gross weight of 2 688 tons. The gross



weight is calculated based on one locomotive (derived from case data) with a gross weight of 78 ton and the sum of 22, 26 and 29 wagons with a gross weight of 90 ton for each scenario respectively. Load factors are based on case data informing us that it is close to 100 % southbound with paper and on average around 55-60 % northbound with return cargo.

The electricity used in Sweden is green, produced from renewable sources labelled “Bra Miljöval” emitting 8 g CO<sub>2</sub>/kWh<sup>47</sup>. With an electricity consumption of 26, 28 and 30 kWh per vehicle km for 630-, 730- and 750-meter trains respectively; the electricity consumption per net-ton/km becomes 0.024, 0.022 and 0.021 kWh respectively. This yields 0.19, 0.18 and 0.17 CO<sub>2</sub>/tonkm in GHG-emissions for 630-, 730- and 750-meter trains respectively. (Table 6.2).

Given these assumptions, the total annual GHG-emissions for the three scenarios are calculated based on the following input variables. Each year comprise 365 working days and each working day enables two journeys on the relation Hallsberg – Malmö round-trip. Table 6.3 shows the results of the calculations.

**Table 6.3** Parameters and annual GHG-emissions and volumes for the scenarios for LHT

<i>Scenario</i>	<i>Length [m]</i>	<i>Wagons [n]</i>	<i>Journeys [n/d]</i>	<i>Total GHG [ton CO<sub>2</sub>e]</i>	<i>Total volume [ton]</i>	<i>Emission/ton [g CO<sub>2</sub>e/ton]</i>
Baseline	630	22	2	142	1 542 000	91.83
Current SFL	730	26	“	153	1 822 000	84.19
Expanded SFL	750	29	“	162	2 032 000	79.57

These results show that using LHT emits more GHG-emissions in total if we assume that the capacity is absorbed by customer demand, which our case informs us it would. However, LHT also increases the total goods capacity and enables more goods to be transported with comparably small increases in GHG. The annual GHG-emissions per ton goods transported in the system decreases from 91.83 g/ton to 84.19 g/ton to 79.57 g/ton when going from baseline 630-meter trains to current SFL 730-meter trains to a future expanded scenario with 750-meter trains. Thus, this is a classic example of scale effects where an implementation of the expanded scenario would produce an annual decrease of the GHG-emissions per ton with 12.36 g. This may sound like a small number but with increasing volumes the scale effect makes it more substantial.

Nevertheless, the net effect of LHT when compared to the baseline is quite small. This is because we compare an already very sustainable low-emitting rail solution with another equally sustainable low-emitting solution. Comparing rail with rail necessarily results in this. The effect one can have is primarily a result of the scale effect. However, as we shall

<sup>47</sup> www.transportmeasures.org. Accessed 2017-03-07.





see at the macro-level assessment, when comparing this railway solution with alternative road solutions we get a more nuanced picture.

#### *Macro-level assessment*

In the following we present the results of the calculations of effects from the implementation of LHT on a wider scale among all (or most) operators in the Swedish part of the corridor on the relation Hallsberg – Malmö.

The assumptions for the railway solution are the same as for the micro-level scenario with the difference that we here look at only the current SFL scenario with 730-meter train lengths. We further assume that 730-meter LHT yields the same results for all operators as for SFL in the micro-level analysis.

The SFL use case informs us that the flows of SFL in the ScanMed RFC constitute 20 % of the total flow of the corridor. If we assume a linear relationship between SFL as a lead user of LHT and the corridor as a whole, the total LHT activity in the corridor is that of five times that of SFL's current activity. This means that in the Swedish part of the ScanMed RFC there are 10 daily round trip 730-meter LHT departures on the relation Hallsberg – Malmö that is 477 km long.

It is worth pointing out with clarity here that this does *not*, however, mean that this is the total capacity of the Swedish part of the corridor as a whole. This is an important caveat. **What we estimate here is a potential level of utilization of LHT in the Swedish part of the ScanMed RFC that can be considered reasonable and realistic based on the rail use case using the lead-user SFL as a benchmark. The results from this scaling to macro level must be used cautiously and with care and should not be considered definitive. Nevertheless, they do provide an indication of what a scaled implementation of this measure in the Swedish part of the corridor could entail, given that the assumptions made here holds true.** We strongly recommend readers to evaluate the validity of these results in relation to their respective setting. One way to do so is to compare the assumptions made here to those made by the reader or made in the reader's setting to see whether they hold true also for this context.

Importantly, we disregard from technical infrastructure obstacles such as limitations in break-tables, scheduling, meeting points, shunting yards, etc. but merely consider this to be the total potential volume of the corridor.

According to our calculations, this would correspond to a total annual volume of goods transported by LHT in the corridor amounting to 9 110 400 tons and a total annual GHG-emission of 767 ton CO<sub>2</sub>e.

As we have seen in the analysis of the effects of using longer and heavier trains above, the effect of this increase is relatively small if the increase in volumes transported by



LHT comes from other train-solutions (e.g., wagonloads or whole 630m trains). But if these flows are attracted from road alternatives, then the effects are significant. In a scenario with an estimated additional 7 288 320 ton annually being transported on LHT in the Swedish part of the ScanMed RFC it is difficult to estimate where these flows would come from: if they are shifted from road or from other forms of rail. We have therefore made calculations on various levels of shifts as is shown in Table 6.4.

Table 6.4 shows the distribution of transport activity and GHG-emissions from five levels of shifts from road to rail utilizing LHT. For this calculation we have assumed the road-alternative being of the same length as for rail (477 km), and that road vehicles being used emits 65 g CO<sub>2</sub>e/tonkm which is a standard Euro VI engine emission figure moderated by average green driving techniques. The corresponding emission figure for rail is 0.18 g CO<sub>2</sub>e/tonkm. Obviously the difference between rail and road is huge – especially in Sweden with access to sustainable electricity from renewable sources. However, this is neither surprising nor anything new and it seems as if comparing rail to road is unrealistic for a number of reasons. First, the reasons to transport cargo by road are motivated because of the requirements and the service levels required are impossible for the railway to cater to. Second, rail is always complemented by other transports the first/last mile. However, if the rail system can expand its current capacity and provide quality services, then *some* of the road-volumes can be shifted from road to rail in the core stretch of the corridor.

Given the parameters discussed above in terms of the corridor length (477 km) and CO<sub>2</sub>e-emissions from road and rail (65 and 0.18 g/CO<sub>2</sub>e/tonkm, respectively) Table 6.4 shows the distribution of CO<sub>2</sub>-emissions among the road and rail options in six scenarios and a baseline scenario.

**Table 6.4** The distribution of annual cargo volumes and GHG-emissions between road and rail in the varying scenario options

Scenario Option	Total estimated volume in corridor	Rail			Road		
		Share of added volume	Rail cargo [ton p.a.]	CO <sub>2</sub> e [ton p.a.]	Share of added volume	Road cargo [ton p.a.]	CO <sub>2</sub> e [ton p.a.]
Scenario 1	9 110 400	100%	9 110 400	782	0%	0	0
Scenario 2	“	90%	8 199 360	704	10%	911 040	28 247
Scenario 3	“	70%	6 377 280	548	30%	2 733 120	84 740
Scenario 4	“	50%	4 555 200	391	50%	4 555 200	141 234
Scenario 5	“	30%	2 733 120	235	70%	6 377 280	197 728
Scenario 6	“	10%	911 040	78	90%	8 199 360	254 221
Baseline	“	0%	0	0	100%	9 110 400	282 468



The baseline scenario represents a scenario where all the added volume in the RFC come from road and constitutes a complete shift from road to rail. However, this scenario might seem unlikely, and we have complemented the analysis with some more scenarios some of which might be more realistic:

- *Scenario 1* represents a shift where all of the added volume in the RFC comes from road
- *Scenario 2* represents a shift where 90 % of the added volume in the RFC comes from road
- *Scenario 3* represents a shift where 70 % of the added volume in the RFC comes from road
- *Scenario 4* represents a shift where 50 % of the added volume in the RFC comes from road
- *Scenario 5* represents a shift where 30 % of the added volume in the RFC comes from road
- *Scenario 6* represents a shift where 10 % of the added volume in the RFC comes from road
- The *Baseline Scenario* represents no shift of the added volume in the RFC to come from road. This means that these volumes are not generating any savings in GHG-emissions from road transports.

These scenarios assume that the corridor can absorb the additional activity and that the supply of cargo is greater than the capacity of the RFC provided by the scenarios above, that is, there is never a problem of filling the LHT with cargo. This is of course a simplification. The use case informs us that it is a continuous work to ensure that wagons are loaded and trains are fully utilized – working with the load factors is a continuous process. Nevertheless, for our purpose being to assess the macro-level effects of the LHT-measure in the toolbox, these are reasonable simplifications.

For the discussion of the greening results of these scenarios, we have chosen Scenario 4, 5 and 6 for further discussion in a later section. This is because we estimate these to be among the more realistic scenarios discussed above.

### 6.3.3 Digitized railway

The digitization of the railway system in itself renders next to zero effects on current emission levels. However, digitization is to be considered a hygiene factor for the railway as a mode of transport. Without this, railway transports risks losing volumes to other modes of transports, primarily road, which in turn constitutes an increase in GHG emissions. On the other hand, with investments in digitization, the potential and utility of the railway as a transport mode increases. We therefore assess the performance of these measures in terms of the savings of GHG emissions that the digitization enables in terms of *the shifting of volumes* from road to rail. Such a modal shift is a common goal for both national and EU-level initiatives.



The implementation of a digitized railway in terms of GPS-tracking of wagons is analysed departing from a base-line scenario. The baseline scenario is that of no trace-and-track system implemented in Rail 17. With this as a baseline, effects of implementing GPS-trackers on wagons is evaluated according to the following:

- *Current SFL Scenario:* 3 000 wagons equipped with GPS-trackers.
- *Expanded SFL Scenario:* All of the SFL rolling stock wagons (approximately 6 000 wagons) equipped with GPS-trackers.

Thus, for both scenarios, consequences for GHG-emissions savings are calculated assuming shifting volumes from road to rail as described below.

### 6.3.4 Analysis of digitized railway

#### *Micro-level assessment*

In the following we present the results of the calculations of effects from the implementation of a digitized railway on SFL's volumes in the Swedish part of the RFC on the relation Hallsberg – Malmö.

In the first scenario *Current SFL* we assume that the digitization attracts 2 % of the corridor volume as an increase in volumes for SFL. In the second scenario *Expanded SFL*, we assume digitization to attract 10 % of the corridor volume as an increase. In both cases we assume these increases to come from road transports, meaning that it entails a shift from road to rail. See Table 6.5. These increases are reasonable considering that BillerudKorsnäs, being the owner of SFL, strives to increase the total volumes of railway transports from its current level of circa 50 % of total volumes to 55-60 % if possible.

**Table 6.5** The volumes shifting from road to rail due to digitization in the two scenarios

Scenario Option	SFL volume in corridor	Rail increase			Road decrease		
		Share	Cargo volume [ton p.a.]	CO <sub>2</sub> e [ton p.a.]	Share	Cargo volume [ton p.a.]	CO <sub>2</sub> e [ton p.a.]
Scenario 1: Current SFL	1 822 080	+2%	+36 442	+3	-2%	-36 442	-1 130
Scenario 2: Expanded SFL	"	+10%	+182 208	+16	-10%	-182 208	-5 649

As with the LHT-measure, calculations here assume a corridor length of 477 km and the GHG-emissions from road and rail to be 65 g CO<sub>2</sub>e/tonkm and 0.18 g CO<sub>2</sub>e/tonkm, respectively. What is an important difference is the total volume in the corridor. Here we



use SFL's current volume on LHT (1 822 080 ton p.a.) as a point of departure for estimating the increases in volumes from the digitization. The logic behind this is that the digitization of the railway likely attracts volumes in relation to its current volumes rather than the total in the RFC. We posit that the increase in volumes due to digitization of the railway should be assessed in relation to the scale of the current utilization of LHT in the railway-system. Thus we argue for what could be called lead-user scale symmetry. Taking SFL being a lead-user as a point of departure is a way to ensure realistic assessments. At any rate, using the current SFL LHT volumes in the ScanMed RFC can be considered a conservative assessment and mitigates any positive biases of the effects of the measure.

#### *Macro-level assessment*

This analysis is the same as for the LHT measure above. Assuming that a digitized railway enables the shift from road to rail we can calculate the effects for shifts at a 10, 30 and 50 % level, respectively. Thus, the results become identical to those in section 6.3.2 Table 6.4 and are not duplicated here.

The main difference is that here we assume the digitization as a prerequisite for the shift to happen. In section 6.3.2 no such assumption was made. Instead we assumed the railway system being able to absorb the volume increases without any measures such as digitization or any other infrastructure investments. This is of course unrealistic, but gives a proxy to what effects that could be expected.

#### 6.3.5 Sensitivity analysis

##### **Info Box: Sensitivity discussion**

Operating electric driven trains inevitably leads to the discussion of electricity origin and its related emissions somewhere else. This specific solution using well utilized long trains leads to a very energy efficient transport solution that in its design is difficult to match with other transport solutions. On this specific rail stretch it operates on green electricity procured by the Swedish Transport Administration. Transforming this specific transport solution into a general performance indicator as CO<sub>2</sub>e wtw [g/tonkm] would lead to the results showed below:

Green electricity (Bra Miljöval):	0.18 g/tonkm
Nordic electricity mix:	2.21 g/tonkm
Average European mix:	9.50 g/tonkm
Coal based electricity mix:	20.00 g/tonkm

Even when operating the train on coal based electricity, the emissions are fairly low per tonkm. For sure this would lower the gains significantly in the case but still be good. We have chosen the alternative Green electricity since that is what SFL buys, but we are well aware of other views on this topic and therefore we leave that to the reader to interpret and evaluate.



## 6.4 Discussion: Core issues from the Railway case

### 6.4.1 HCT Rail

Our scenario-analysis for the ScanMed RFC based on the rail use case shows a potential for GHG-emissions savings, especially when cargo is shifted from road to rail. However, as was stated earlier, any conclusions from this analysis must be made with utmost care. In the following we shall discuss some of the indications that can be identified.

While LHT alone creates no aggregated savings, this measure does create a more environmentally efficient solution as the GHG-emissions per ton cargo transported decreases. This means that the total CO<sub>2</sub>-emissions increase but the CO<sub>2</sub>-emissions *per ton goods transported* decreases (see Table 6.3). However, these decreases are quite small as compared to the effects from this in combination with a shift from road to rail.

In our analysis we analysed many levels of shifts in six scenarios (section 6.3.2 and Table 6.4). Here we shall focus on the effect in terms of the GHG-savings that a shift from road to rail in three scenarios creates: in Scenario 6 with a 10 % shift in volume from road to rail; in Scenario 5 with a 30 % shift and in Scenario 4 with a 50 % shift. See Table 6.6. Again, for now, we disregard any infrastructure issues that this may entail and also from any investments that may be necessary.

**Table 6.6** Annual CO<sub>2</sub>-emission savings with shifts from road to rail in three scenarios

	<i>Unit</i>	<i>Scenario 6: 10 % shift</i>	<i>Scenario 5: 30 % shift</i>	<i>Scenario 4: 50 % shift</i>
Rail	Volume	911 040	2 733 120	4 555 200
	GHG	78	235	391
Road	Volume	8 199 360	6 377 280	34455 200
	GHG	254 221	197 728	141 234
Sum total	Volume	9 110 400	9 110 400	9 110 400
	GHG	254 299	197 963	141 625
Baseline	GHG	282 468	282 468	282 468
<b>Result</b>	<b>GHG-saving</b>	<b>-28 169</b>	<b>-84 505</b>	<b>-140 843</b>

Note: GHG units: ton CO<sub>2</sub>e p.a. Volume units: ton p.a.

The baseline constitutes Scenario 6 in Table 6.4 in which all the added cargo volumes would have been transported by road resulting in a total of GHG-emissions amounting to 282 468 ton annually. This is as a mean of comparison. If this measure has the effects shown in Scenarios 3, 4 and 5 above – the result as compared to the baseline alternative of transporting all the cargo by road is shown at the bottom of table 6.6.



Reading the table from left to right means that one goes from a relatively small shift to a larger with increasing volumes of cargo going from road to rail. As can be seen from Table 6.6 the expected savings are following the amounts of cargo volumes transferred. This is because the relative share of GHG-emissions from rail compared to road is so small, and because the length of the stretch is assumed equal for both road and rail. In this particular case, variation in transport activity becomes dependent on the cargo volumes only since the distance is equal and fixed.

It is worth noting though, that as cargo shifts from road to rail, the savings from decreased emissions from road transports are so significant and the increase in emissions from rail so insignificant so that the total GHG-emissions savings equals that of the magnitude of the shift itself. Our results show that a 10 % shift from road to rail renders approximately a 10 % decrease in GHG-emissions, a 30 % shift renders a 30 % decrease, and a 50 % shift renders a 50 % decrease (See Table 6.6).

Although, the distance of 477 km of this part of the corridor is fixed and equal for both road and rail, given the emission data on rail and road transports, using LHT to accelerate a shift creates a potentially substantial CO<sub>2</sub> saving as more and more cargo shifts to rail as is shown in Table 6.6.

#### 6.4.2 Digitization of Rail

The digitization of the railway in itself create little or immeasurable direct effects on GHG-emissions. However, the indirect effects are measureable. Table 6.7 shows the total CO<sub>2</sub>e -savings from the Current SFL and Expanded SFL scenario respectively.

**Table 6.7** GHG-emission savings from the scenarios of a digitized railway

<b>Scenario Option</b>	<b>Rail increase</b> CO <sub>2</sub> e [ton p.a.]	<b>Road decrease</b> CO <sub>2</sub> e [ton p.a.]	<b>Total saving</b> CO <sub>2</sub> e [ton p.a.]
Scenario 1: Current SFL	+3	-1 130	-1 127
Scenario 2: Expanded SFL	+16	-5 649	-5 633

Table 6.7 show that in the current SFL scenario derived from an estimated modest 2 % shift from road to rail, 1 127 tons GHG-emissions would be saved every year. If the shift is 10 % the saving is 5 633 tons annually.

Yet, the main argument for investing in the digitization of the railway is not primarily because its greening effects, neither indirect nor direct, rather it s due to a perceived need to constantly increase the service level of the transport offering to customers. This can be related to the data on transport purchasing behaviour reported on in chapter 3



earlier. Environmental effects are seen as positive, but not prioritized (see Figure 3.2). If a greening effect is created it is to be considered a secondary effect – almost unintended. Still, such measures hold some promise as a way to both prevent volumes from leaving rail as well as attracting new volumes, primarily from road transports, as we have shown in the scenarios used here.

If larger shift occurs as a result from the digitization of the railway, the effects are identical to those reported and discussed in section 6.4.1 above. We shall not replicate them here, but only point out that the consequences are the same as in the previous analysis: if and when cargo shifts from road to rail, the savings from decreased emissions from road transports are so significant and the increase in emissions from rail so insignificant so that the total GHG-emissions savings equals that of the size of the shift itself. These two analyses thus complement each other.





## 7 The Infrastructure Use Case

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### 7.1 Lead user: Swedish Transport Administration

The Swedish Transport Administration (hereafter TrV) is the agency responsible for the overall long-term infrastructure planning of road, rail, sea and air transport in Sweden. TrV also manage and control the construction, operation and maintenance of state roads and railways.

The long-term objective of TrV is to develop an efficient and sustainable transport system through sufficient access of intermodal traffic solutions, hence fulfilling the vision of a transport system in which “everybody arrives smoothly the green and safe way”. (TrV website). Table 7.1 shows some characteristics of TrV.

**Table 7.1** Characteristics of TrV

Total budget in 2014	Approx. 52 600M Sw. kr.
Number of employees 2014	Approx. 6 500
Location of headquarter	Borlänge
Number of offices across Sweden	6

#### 7.1.1 General aspects of traffic tunnels

Tunnels for road and rail are an increasingly essential part of the traffic infrastructure since available land is scarce. Traffic access needs can often only be met by tunnels due to difficult legal processes and criteria's for building surface based infrastructure. Hence tunnels solve environmental aspects of land intrusion, barrier effects and disturbing traffic noise. Tunnels can also solve traffic related topographical challenges as well as ensuring a smooth throughput. Meanwhile tunnels have their advantages their construction and operation has its specific challenges and risks of severe environmental impact. It is therefore an ambition from TrV to carry out a solid preventive environmental work in relation to construction of tunnel infrastructure.

The environmental impact from tunnels can be divided into the following phases:

- Design and Construction
- Operation
- End of life (more on a principle basis as few tunnels cease to be used)

The aim is to design, build and operate tunnels at minimum environmental impact meanwhile its use reduces negative traffic related environmental impact.



According to the Swiftly Green project, a general recommendation is to systematically develop traffic tunnels through the phases of pre-study/design, construction and operation. The activities in each of these phases are shown below:

#### Pre-studies and design:

- Systematic assessment and analysis of other best practices
- Mapping and design for an efficient pathway
- Analysis of geothermal possibilities and challenges<sup>48</sup>
- Design of tunnel for an efficient maintenance
- Analysis of most environmental and climate efficient material
- Analysis of most environmental and climate efficient building process
- Analysis of most environmental and climate efficient building logistics
- Analysis of most environmental and climate efficient handling of residues

#### Construction:

- Consideration of environmental and climate impact from machinery during construction
- Environmental and climate considerations when selecting material integrated in the procurement process
- Environmental and climate considerations in material deliveries and residues transport
- Reuse and recycling of material
- Closed loops for use and scrapping of toxic and environmentally damaging material and products.

#### Operation:

- Efficient energy use (illumination and ventilation)
- Cleaning (dust and particulates)
- Maintenance

## 7.2 The Varberg tunnel project

One of the major railway infrastructure projects in Sweden focuses on increasing the capacity and reliability of the Swedish west coast line from Lund to Gothenburg. The aim of the upgrading of the whole west coast line is to create a quick, efficient and environmentally friendly mean of transportation for both people and freight. The west coast line is an important line in the Swedish railway infrastructure as it connects Malmö/Lund with Gothenburg and the ports in these cities. Currently approximately 85 % of the line is double track.

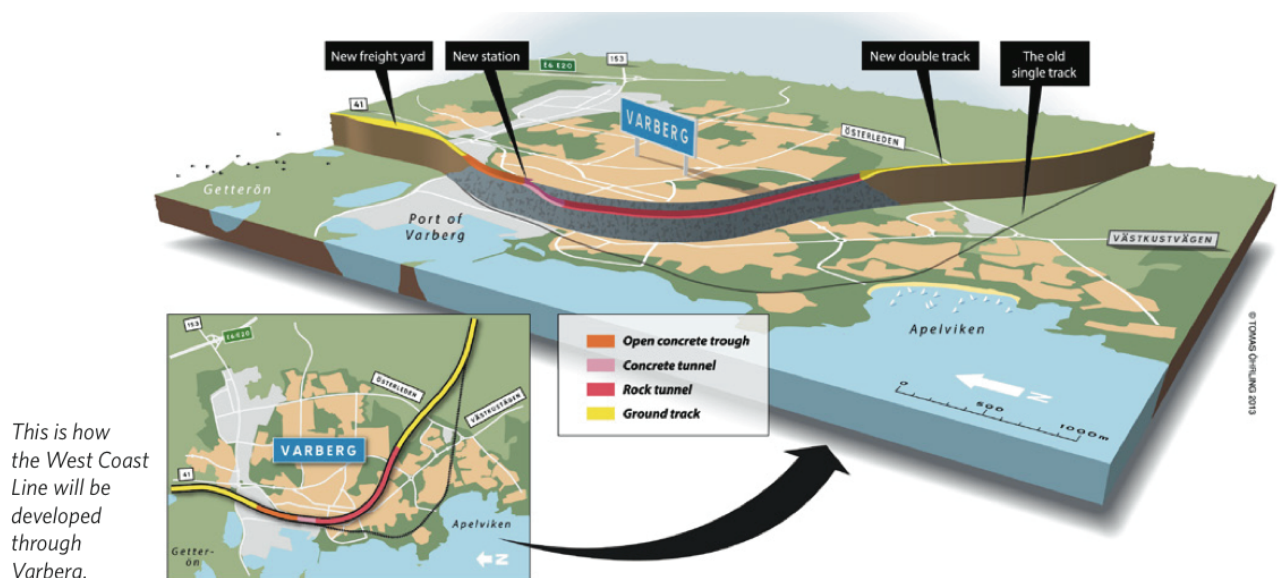
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<sup>48</sup> A nice example of how thermal energy out of the tunnel can be used is the *Tropenhaus Frutigen* tropical greenhouse in Switzerland: <https://www.tropenhaus-frutigen.ch/en/>. Accessed on 2017-02-26.



This stretch includes many separately extensive projects of which the tunnel project through the Hallandsås was the most complicated. This tunnel was opened and inaugurated in December 2015 started its planning process in 1975 and construction 1993. The Varberg tunnel project that is planned for construction in 2019 – 2024 is another big tunnel.

The Varberg tunnel project includes replacement of old single-track railroad through the city of Varberg in Halland to a double track railroad in a tunnel with a slightly different stretch underneath the city. It also includes a new station underneath the central city and a new freight yard. (See Figure 7.1 and Table 7.2).



This is how the West Coast Line will be developed through Varberg.

**Figure 7.1** The Varberg tunnel project.

(Source: TrV, *Expansion of the West Coast Line to double tracks through Varberg*)<sup>49</sup>

Thus the project includes both the construction of the double track and tunnel, as well as a new station and a freight yard. The project is co-financed with TrV as the main financier supported with additional funding from Jernhusen (for the station) and Varberg Municipality and the Region of Halland.

<sup>49</sup> Downloaded 2016-11-28 from: [http://www.trafikverket.se/contentassets/6af3089d6a754fdca375e5c32d34b4ae/expansion\\_of\\_the\\_west-coast-line\\_eng\\_150924.pdf](http://www.trafikverket.se/contentassets/6af3089d6a754fdca375e5c32d34b4ae/expansion_of_the_west-coast-line_eng_150924.pdf).



**Table 7.2** Short facts of the Varberg tunnel project (Source: TrV).

Location	West coast line through Varberg, Halland
Length of double tracks	7,5 km
Rock tunnel	2,8 km
Concrete tunnel	300 m
Open concrete trough	900 m
Planning period	2015 – 2018
Construction period	2019 – 2024 (approx.).
Estimated cost (2009 price level)	3 990M Sw. kr.

One of the benefits of the Varberg tunnel is that the current barriers posed by tracks and yard will be eliminated. The inhabitants will thereby have better access to the shoreline and lowering the tracks into a tunnel releases space for housing and other activities. In addition, the noise emissions from the passing trains will be significantly reduced. While noise emission reduction measures are a specific issue for the railway in general, these reduced noise emissions will be a second order effect of the tunnel project. Where ever railway lines cut through densely populated areas noise pollution and noise emissions are always an annoyance. Hence the elimination of noise adds to the societal net benefit of the project.

### 7.3 Identification of measures from the TrV case

One of the main issues for TrV infrastructure projects is to ensure efficiency and sustainability gains in creative and smart ways where the four-step principle is to be used as a guide (see Info Box below). The Varberg tunnel project is an example of a project at step 4.

#### 7.3.1 A four-step guide for infrastructure projects

All activities within the Swedish Transport Administration must follow a four-step principle guide for infrastructure projects. Each step covers different aspects and phases in the development of traffic infrastructure.

Sustainable transports focus on the first two steps through attitudes on using more sustainable transport solutions.



### **Info Box: The four-step principle**

#### **1 Re-think**

The first step revolves around measures of transport-demand as well as modal choice.

#### **2 Optimize**

The second step focus on measures that make use of existing infrastructure more efficient.

#### **3 Re-build**

If needed the third step means limited reconstruction of existing infrastructure.

#### **4 Build new**

The fourth step is carried out if transport demand cannot be met through the three previous steps. This means new investments and larger upgrading projects.

### 7.3.2 Identifying measures

The whole infrastructure project embraces the upgrading of the west coast line to double tracks for reliable, faster and more efficient passenger and freight transport. There will also be gains to be made locally. In the Varberg tunnel case the magnitude of these gains are dependent on management of the project, technical issues and issues of creating circular flows of resources in the construction process, etc.

Another effect of the Varberg tunnel project relates to noise emissions from the railway. Noise emissions are legally the responsibility of TrV being the infrastructure holder, but noise generation is much related to technicalities of the freight waggons owned by various operators. Of course building tunnels reduces noise emissions, but such measures are in general too expensive to be relevant if the sole purpose is to lower noise emissions. Another alternative is to reduce the highest allowed speed limits at certain lines in order to lower the noise emissions, but such measures also have other drawbacks making it less attractive as a measure.

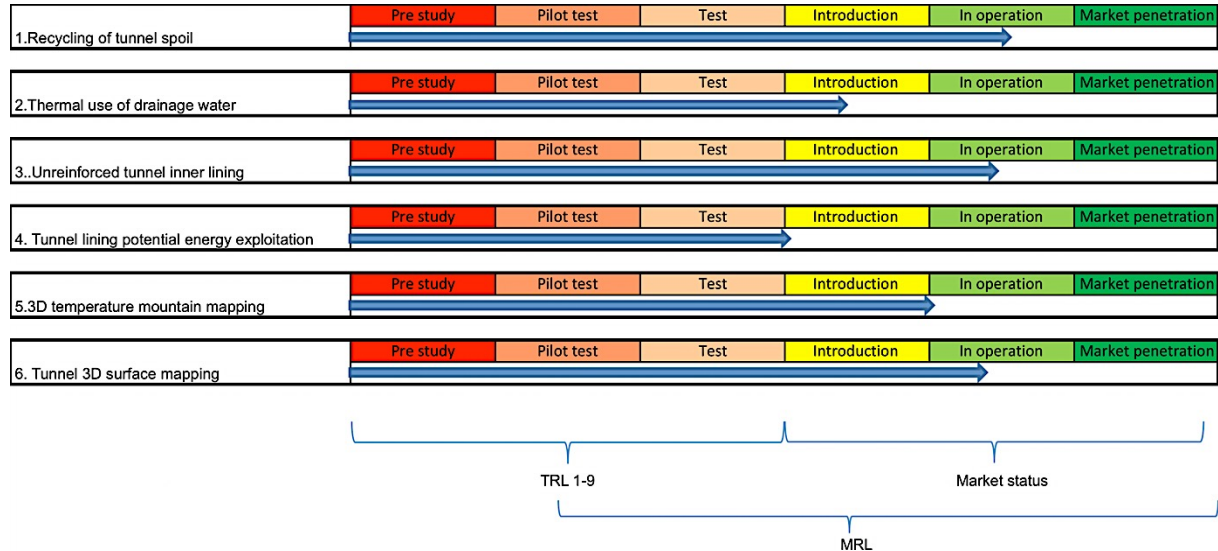
From this rationale we identify the following measures from the Swiftly Green toolbox as relevant or partly relevant for this case:

1. Recycling of tunnel spoil
2. Thermal use of drainage water
3. Unreinforced tunnel inner lining
4. Tunnel lining potential energy exploitation
5. 3D temperature mountain mapping



## 6. Tunnel 3D surface mapping

Measure 1-6 all relates to the issue of infrastructure construction management. These measures have been identified as potentially implementable based on the case. Figure 7.3 shows our assessment of the TRL and MRL of these measures.



**Figure 7.3** Assessment of TRL and MRL of the six measures described in the tunnel infrastructure case.

## 7.4 Analysis and performance assessments

In order to verify the relevance of the toolbox measures related to tunnel based traffic infrastructure, in depth interviews with the Varberg project manager was carried out. In the interviews it became obvious that specific measures, being relevant at some places may not be equally relevant for other tunnels. Hence this section presents the approach from the Varberg tunnel project and thereafter we comment on these solutions and processes in relation to the suggested toolbox measures. It should be emphasized that our empirical data is based on limited empirical data, hence concluding remarks and analysis should therefore be considered as fairly shallow.

Major traffic infrastructure projects are in general initiated by political decisions being the pre requisite for building new traffic infrastructure. Thereafter various alternative routes are investigated in relation to the overall aim and other considerations. For rail traffic infrastructure this phase means development of the railway investigation (järnvägsutredningen) that in its next phase becomes the railway plan (implementation). Prior to starting building a rail tunnel many diverse and additional interests also arises locally. In Varberg one such example was a political condition that the railway station must be placed underneath the central part of the city. This is not the best location from a pure rail optimum perspective but considered crucial by the city of Varberg.



During the process of planning tunnel projects tend to become more expensive, partly based on an incentive to keep costs low in order to motivate a tunnel project. Costs are kept low during planning in order to arrive at a calculated profitable project on a 120 year writing off period (for tunnels). In Varberg this meant no lining and the construction of one main tunnel and one service tunnel. The solution with two railway tunnels and one service tunnel would have been better for future maintenance, but as it was more expensive and added complexity to the railway switches in both ends of the tunnel it was not selected as the final solution.

Systematic feedback of experiences from previous tunnel projects is not fully in place. There is however a requirement on a final environmental report. At the moment there are no stringent format requirements on this report that would make feedback more accessible. There are in other words still risks that previously made mistakes could be repeated. Another issue is that local conditions are hugely different. In one region or municipality there may be requirements that are not valid in the neighboring municipality and so on. There are also differences among the individual staff within municipalities where their opinions differ on various matters.

Based on the railway investigation and the railway plan the environmental consequences of the new tunnel have been assessed influencing the conditions that need to be fulfilled by the construction. On top of local and regional requirements the national railway requirements is another major constraint that must be fulfilled. There is also a requirement to carry out a climate analysis of rail tunnel projects. The climate analysis is however evaluated after the project is finalized, assessing deviations from initial estimated gains and is therefore hard to use as a control and management tool. Consequently the role of the climate analysis seems to be downplayed at times. In addition, technical issues such as functional requirements related to speed requires a specific minimum track radius that cannot be deviated from.

A major driver for environmental concern regarding all new Swedish rail tunnels is the previously built tunnel through the Hallandsås. This project had huge environmental problems related to lowering ground water levels and use of toxic chemicals (Rhoca Gil). The project became an environmental scandal and took some 23 years to finalize. The effect of the construction failures of the tunnel through the Hallandsås is a range of improvements in the construction process such as requirements on handling of chemicals, list of approved chemicals and a chemical advisory board. Environmental requirements are continuously increasing linked to new legal requirements as well as based on the ambition to be on the forefront. This is materialized through:

- Checklists
- Environmental enhancement plans
- Processes for permits
- Site requirements
- Protective measures related to environmental consequences assessment



- Environmental construction enhancement
- Regular environmental controls

The selection of material is in the end a trade-off between cost and environmental impact. The supplier will choose the cheapest alternative if there are no specific requirements.

Still, construction of tunnels does not always include specifications on all materials used. Previously it was possible to build tunnels that severely influenced some species living conditions negatively but today's regulation on protecting species such activities need to be compensated elsewhere. Environmental regulations are in general fulfilled without margins but for some larger projects more resources are spent on developing proactive measures, exceeding legal demands. There are extensive supporting guidelines on supplier evaluation at TrV, but the magnitude of the project often determines the level of ambition with regard to supplier evaluation. At TrV an exogenous factor for successful environmental construction is the commitment from suppliers. If they are environmentally committed the outcome is in general much better. Regarding construction for a more efficient operation of the tunnel this is an area that can be improved, although there are improvements done already today.

Later maintenance aspects are part of the process through the:

- Planning
- Investments in large projects
- Operation and maintenance affects the planning process

In the process of procurement of material and construction processes there is a general concern to not exceed regulations linked to public procurement regulations. There is an anxiety to establish conditions that may cause competitive distortion that can be appealed. In general this seems to be an area that can be improved.

The tunnel in Varberg is the second large tunnel project (after the tunnel of the Hallandsås) on the west coast railway line which will be followed by one additional tunnel before this stretch is updated as a whole according to the plan.

A summarizing reflection is that the process is good but construction seems to be traditional and highly dependent on individuals and their skills and experiences. To accomplish world-class performance does not seem to be the vision. There are international benchmarking on how comparable traffic infrastructure projects are carried out and how specific requirements have been solved. Still it seems that this is not done fully systematically.

## 7.5 Discussion: Core issues from the Infrastructure case

The main general difference between the toolbox measures and the actual process of the Varberg tunnel is its practical implementation. In reality the process is much impacted





from economical and technical realities that in practice lead to the final solution. Another factor that deviates is the high dependence on practical experiences in reality.

It seems to be a large number of control mechanisms and procedures in order to avoid a similar environmental disaster as for the tunnel through the Hallandsås. Maybe less would be more in these processes with more stringent guidelines. Something that was obvious is that measures in the toolbox were never considered in this process.



## 8 Discussion

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Implementing improvement measures always entail costs in order to accomplish service improvements or savings with regard to emissions or operational costs. In transport logistics they often, but not always come together. One issue to manage in these circumstances is *who will bear the cost for a given measure*. This is a generic issue and is valid regardless of modality, measure or context.

At a general level, it is a question of how costs, benefits, responsibilities, ownership, maintenance and investments are distributed among a set of heterogeneous actors in a complex socio-technical-economic matrix. In this context it is linked to the traffic and transport systems where initiatives, measures and attempts aim to make these systems more sustainable. If we can overcome economical and regulatory barriers our results indicate considerable emission savings potential.

Our results indicate that by systematically and persistently implementing two or three measures from the toolbox it is possible to reach the ambitious transport related GHG targets prior to 2045 set by the Swedish government.

Combining HCT-road measures such as longer trucks to allow for 32m vehicles fuelled by HVO with long and heavy 730m-trains (LHT) on the core relation Malmö – Hallsberg of the ScanMed corridor creates reductions in GHG-emissions on a scale that fully implemented would enable the transport sector to reach its emission targets.

This leads us to conclude that there are relatively few technical obstacles to reach the targets if we assume that there are sufficient amounts of biomass available. However, scaling up the use of biofuels to meet current and future growing needs in the global traffic system is impossible. We therefore need to also implement measures on demand management, energy efficiency and introduce a massive electrification effort. Still we would need to add enormous biofuels production capacity that at a very large scale may conflict with food production. What we refer to in this study is the transport industry's ability to adopt these solutions.

Apart from resource limitations, obstacles that exist are of legal, regulative, organisational and economic character. To fully harness the potential identified in this report, issues such as EU-regulation concerning HCT-road, the development of open business models, neglected infrastructure maintenance and investments, and the harmonizing of railway regulations and control must be dealt with.



- **We recommend** that *TrV* take a leading role in ensuring maintenance and infrastructure investments to enable more HCT-road as well as LHT. Road and rail are not opposing parties in a zero-sum game in this, but complementary towards a greener transport system.
- **We recommend business actors** in the sector to work on developing more open business models that enables cooperation and more systematic synchronization and coordination of cargo flows.
- **We recommend policy institutions and regulators** to create long-term systematic regulations that ensures that the rules of the game are coherent, stable and geared towards creating a fossil free transportation system in 2045. This also requires international alignment.

Another important reflection that we make concerning the toolbox and the corridor is that the latter could be utilized as a test bed for measures in the former. For example, for road transports, we suggest utilizing the corridor as a platform/infrastructure to test and develop solutions for the implementation of renewable fuels. Development and design of new infrastructures to produce and distribute novel fuels are required for such measures to be successful on a larger scale, and the ScanMed corridor should be the natural location for such development projects and tests. It could similarly be used in this way for railway transports where, for example, the utilization of renewable electricity could be evaluated along longer sections of the corridor to assess its potential. Our sensitivity analyses suggest that there is room for improvement in this area.

In order to avoid sub optimization, a general conclusion in the sustainability transformation of the traffic and transport system is to always consider scarcity of resources. The SFL railway case indicates that if there is scarcity of, for example, train slots, they should primarily be used for inland heavy goods as the alternative by road is significantly worse. Light and volume goods on medium distances should not compete for these train slots (if there is a scarcity). They can advantageously use the HCT alternative.

As infrastructure cost in general is high and there is long term needs to improve the railway system, sea transport along the coast should be developed as an alternative since over use of the railway track will decrease its reliability. The sea modality can complement road and rail in this way.

Renewable fuels should primarily be used for heavy vehicles at medium distance, as electrification of these vehicles is significantly more difficult than of cars that in general operate locally.



These few examples aims to describe a need to enhance a credible and solid road map towards a climate neutral traffic and transport system where each measure should be supported by a performance indicator on their cost per kg CO<sub>2e</sub> saved. This would give a good priority list starting off with activities that give the most “bang for the buck”.

### 8.1 Implications for the road use case

Making road transport more efficient through larger capacity means larger vehicles that may conflict with traffic infrastructure capability, modal competition and in total a less energy and climate efficient transport system. On the other hand the road case through the duo-trailer shows significant potential of GHG-emission savings. The rope trick is therefore to promote long distance transport by rail whereby very efficient road transport is carried out for pick-up and delivery by duo-trailers if possible. If rail service offers insufficient long distance service, the duo-trailer-based road transport using renewable fuel is a very good alternative. In combination this would take us far in our ambitions to reduce GHG-emissions. Based on our examples it is obvious that we need intelligent policies that ensure significant reductions of transport related GHG-emissions in total (effect) and in relative terms (efficiency). If it is possible to overcome pre-assumptions on right and wrong with regard to modal choice and instead focus on results it is very likely that we can reduce transport related emissions by 85 % before the present target year 2045.

### 8.2 Implications for the rail use case

Our results show that as cargo shifts from road to rail in the Swedish part of the ScanMed corridor, the savings from decreased emissions from road transports are very large in relation to the increase in emissions from rail, which are very small. As a result, the total GHG-emissions savings nearly equals that of the size of the shift itself. This speaks for an acceleration of the implementation of LHT in the ScanMed RFC. However, there are obstacles to be overcome in order to do so.

Since the railway transportation system is a highly complex socio-technical system comprised of a network of many different actors – the question of investments and cost absorption for implementation of measures is one obstacle. For example, when it comes to LHT investments on rolling stock a question for the owners and users of the wagons is that the investments in infrastructure is the responsibility of TrV (and equivalent bodies in other countries) and the investments in using longer trains is a question for 4PL-actors such as SFL and/or operators such as Hector Rail and/or wagon owners such as TWA.

Organizationally the freight wagons are usually owned by one actor who rent them to other actors who uses them on infrastructure in many countries, pulled by many actors over various stretches, and loaded with freight from actors in many completely different industry sectors. Who bears the costs for investments in GHG-reduction measures of the rolling stock in this situation? This issue is emphasized in the digitization issue in which



wagons must be equipped with technology that requires investments and where detection equipment must be installed along the railway tracks, etc. Both measures require investments and emphasizes the issue concerning who will bear the costs for these investments.

Another critical issue has to do with the coordination and synchronization of infrastructure across nation states. The ScanMed corridor is seen and managed as a unity from the EU-perspective, however in practice this is not quite the case. The ScanMed RFC Corridor-One Stop Shop cannot be utilized to its full extent due to physical infrastructure restrictions at the marshalling yard in Malmö, similar to the ones at the marshalling yard in Hallsberg. Here the development and investments in physical infrastructure and the organizational development are decoupled and non-coordinated. Nevertheless, the 6 billion Sw. kr. investment that TrV have announced<sup>50</sup> in infrastructure facilities in Malmö, Hallsberg and Sävenäs in order to upgrade them would, in the light of the results from this project, seem like a good step in the right direction.

### 8.3 Implications for TrV

For an actor such as TrV, finding mechanisms to distribute costs and rewards in such a complex system as the Swedish traffic infrastructure is one important task that needs to be resolved in order to be able to really take a step ahead in greening the transport system in Sweden. For TrV, this is particularly emphasized as they have the role as both a controlling agent but also as the agent responsible for maintaining and building the Swedish traffic infrastructure. Understanding the network of actors and roles and how costs and revenues are distributed among them is a key issue. Simply put, understanding the business cases is crucial in order to be able to mobilize support and commitment enough to implement measures to green the transportation system, whether these measures comes from the Swiftly Green toolbox or not.

The traditional solution has been to regulate through the infrastructure administrator and through market-based measures and tax reductions. Hence TrV can impose regulation – for example, based on a measure from the toolbox. This means that the network of actors utilizing the infrastructure in question is forced to absorb the cost for investing in GHG-reductions, and that the distribution of costs and benefits from that is managed by the networks.

Usually, this means that the weaker actors carry the most of the investment burdens which is not always to the benefit of the network in total because it tend to weaken the already weak and channel wealth and resources to the already strong<sup>51</sup>. It means that the network is being tightened and successively denser so as to eventually comprise

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<sup>50</sup> March 2017.

<sup>51</sup> Olsen, Prenkert, Hoholm, & Harrison (2014).



only a smaller number of consolidated and powerful actors. These actors usually aim to conserve status quo and resist change and innovation. This is usually what happens in these types of complex network structures – it produces Fat Cats. We conclude that the Fat Cat-problem is a trait of the Swedish transportation system in general.

Unfortunately, there are no readily available antidotes in research yet, but learning to manage and understand the dynamics of complex socio-technical industrial networks is crucial for any involved actor, and especially for those set to regulate such industries<sup>52</sup>.

If no regulation is imposed on the network, the minimum amount of resources required will be spent on investments in infrastructure, commons and collective utility<sup>53</sup>. This is known as the ‘tragedy of the commons’ in the research literature. Some regulation is therefore necessary, but how and of what type is a difficult and pertinent question.

Drawing on the rail use case in this report, it is important to understand the function and behaviour of the industrial networks around, for example, a railway infrastructure – otherwise this infrastructure – this common resource – will eventually erode as a result of the tragedy of the commons. Unfortunately, the lack of maintenance and current problems of technical quality is a manifestation of this begun erosion of the Swedish railway infrastructure.

A systematic and coherent strategy for investments and maintenance of railway infrastructure is a core issue for TrV in this circumstance. This report shows that investments that enable a shift from road to rail and the acceleration of LHT are measures that provide substantial greening effects.

#### 8.4 Implications for the Swedish part of the ScanMed corridor

Drawing on the methodology used in this report, assessing the necessary level of adaptation and change to an already existing socio-economic-technological context for any given measure seem to be of crucial importance for any success in its implementation. These assessments include assessments of the network readiness to adapt to newly introduced measures. Such network accommodation is resource demanding and requires substantial amounts of effort in mobilizing support from other actors.

One implication from this is that the TRL and MRL might benefit from being complemented with a Network Readiness Level (NRL) assessment. This would entail adopting an interactive view on the relationship between science-technology and business and developing some measures of the readiness level of a measure in relation to some important network dimensions. While such a development task is beyond the

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<sup>52</sup> Håkansson (2006).

<sup>53</sup> Ostrom (2002).



scope of this report, relating the measures in question to a specific user context functioned as a proxy to this. Adopting this methodology and complementing the TRL and MRL assessments with an NRL assessment (if done properly) would likely yield significantly more potent selections of measures that have more realistic potentials to be successfully implemented. Such measures would also, by definition be industry relevant and have significant consequences for actors involved in the user contexts from which they originate.

In addition, extending the Swiftly Green toolbox with new measures identified by a systematic application of this methodology on a wide range of use cases would benefit the greening ambitions of the transportation sector.

## 8.5 Recommendations

Based on our analysis of the three use cases and calculations of effects on select measures from the Swiftly Green toolbox, we can identify a number of recommendations. First we list those directed to TrV as the infrastructure holder. Then we list those directed to other actors in the sector.

### 8.5.1 Recommendations for TrV as the infrastructure owner

- Secure competence and knowledge on what mechanisms that can be used to distribute benefits and responsibilities and use these strategically to green the transport system
- Prioritize investments in rail infrastructure to enable an acceleration of the utilization of LHT
- Prioritize investments in rail infrastructure that enables a further and smoother shift from road to rail transports – for example by making Hallsberg shunting yard a state-of-the-art node in Scandinavia and Sävenäs shunting yard in Gothenburg an ocean gate, and Malmö shunting yard capable of managing LHT from the continent.
- Use the methodology from this report to identify potential measures and assess their TRL and MRL.

### 8.5.2 Recommendation to shippers and service providers in the sector

- Learn how to become an efficient network actor in the Swedish transportation sector
- Learn how to open up your business model to other actors in the sector, without unacceptable increases of business risk
- Ensure that your business model is aligned with the development towards greener transport systems
- Ensure that you are an important actor for others – for example by enhancing your business model or through strategic collaboration



- Cooperate and collaborate with other actors in order to realize potentials and revenues that are otherwise inaccessible
- Become a wizard at understanding the mechanisms by which rewards and responsibilities are distributed among actors in your particular network
- Learn how to leverage the sustainability-aspects of your role in the transport system

## 8.6 Post Script

Reflecting on the measures of the Swiftly Green toolbox, one problem in is that they are of a kind that places them in a no man's land. Either they are extremely specific concerning a detailed issue on – for example – tunnel lining techniques. Or they are way too general, almost generic so as to lose any relevance in practical application, such as – for example – the idea of mega-hubs for multimodal solutions. This makes the measures hard to use and implement.

One way to deal with this is to continue working with the toolbox and add specificity to measures that are too generic as well as context to those that are too specific, so as to make the toolbox more balanced in the future.

Another problem with the toolbox is that it is unbalanced in relation to the transport modalities. Rail is overrepresented among measures when compared to road, and especially to sea. There are no sea-related measures at all in the toolbox if one disregards the ones relating to ports. This is a problem, as the ScanMed corridor arguably also comprises stretches across sea. It would thus be reasonable to include also seaway transports in the toolbox.

In addition, domestic sea freight is an alternative that might provide opportunities for additional greening of the transportation system, showing a growing interest and potential. Inland and coastal sea freight complement road and rail transports as we progress towards a sustainable transport system.

Overall there is also the problem of updating a database of this kind. Much effort were put into the toolbox during the project Swiftly Green but no examples have been put in the toolbox since the project ended. Most likely, for a toolbox like Swiftly Green to be used and to be more *useful* for many, it would require additional work as well as continuous updates and maintenance.





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# Appendix A: Summary of the Swiftly Green project

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SWIFTLY Green (Sweden-Italy Freight Transport and Logistics Green Corridor) is a European Commission (TEN-T) funded project with a mission to support “greening”, development of green logistics and transport, in the entire TEN-T network. The SWIFTLY Green project has 13 partners from six countries). The project started 1 October and ended in December 2015 and was coordinated by CLOSER, Lindholmen Science Park.

The overall question to be answered is:

“How can we foster a greening of transport – and can we turn policy aims into practice?”

Source: Report, Final Conference Report, Webinar 2015-11-26.

[http://www.swiftlygreen.eu/sites/default/files/content/final\\_conference\\_report\\_26\\_no\\_v\\_2015\\_2.pdf](http://www.swiftlygreen.eu/sites/default/files/content/final_conference_report_26_no_v_2015_2.pdf). Accessed 2017-03-24.

How does Swiftly Green meet the political priorities?

By developing:

- A set of measures for greening the transport corridor based on solutions implemented both at Member States and European Level.
- A delivery of a methodology to assess the performance of the implemented measures.
- A tool-box consisting of a set of guidelines and recommendations for actions to be implemented in order to enhance TEN-T corridors
- An establishment of greening corridor development plan.

Source:

[http://www.swiftlygreen.eu/sites/default/files/content/1\\_sofia.papantoniadou\\_swiftly\\_green.pdf](http://www.swiftlygreen.eu/sites/default/files/content/1_sofia.papantoniadou_swiftly_green.pdf). Accessed 2017-03-24.

For more information, turn to the Swiftly Green website:

<http://www.swiftlygreen.eu/en/reports-material>