GREEN FREIGHT – EVERY PENNY COUNTS

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INTRODUCTION

Businesses in the freight industry are faced with new challenges as a consequence of the increase in climatic awareness. In Norway the politically correct view is that freight should be moved from road to rail or sea. This seems to be founded in the "fact" that rail and sea are better modes for the climate than road. From a research perspective this "fact" that rail and sea are always better is not nuanced enough. Intermodal transports will nearly always have a component of road based transport, so there should be a break even between intermodal and direct transports somewhere. The tools to calculate emissions that are available today are not able to geographically identify where the break even is.

To become greener is the act trying to minimize the negative impacts on the climate and environment at the same time. Customers of the freight industry want to know the climatic impact of moving their goods and are forcing the freight industry to supply them with emission figures for the transports. Not an emission figure for an average transport, but a figure for their freight. As a consequence several actors in the freight industry have teamed up in the Green Freight Transport research project. The Green Freight Transport project is a three-year research project started in 2008 with the aim of developing a decision support system for managing environmental challenges in freight transport.

The search for a "quick fix" to the problem of transport related CO2 emissions seems to have become wild goose chase after publication of the Gallagher Review. In 2009 the Norwegian government decided to remove the tax exemptions on bio-diesel citing "fuel for food" as a major concern. Thus one has to look at small improvements, throughout the freight chain, that single companies can implement. If measures result in better energy efficiency for the whole transport then there should also be an economic gain. Thus every penny counts in the greening of freight transportation.

This paper focuses on the task of building a framework for estimating freight transport emissions from a bottom up approach. Intermodal transports and terminals will also be discussed in the context of building a tool and gathering information to make the tool usable.

Intermodal transportation began in the United States and Europe with the use of containers that could be transferred between ships and railcars. Containerization was ultimately extended to freight transfers among ships, railcars, trucks, and airlines, thereby linking all four major modes of cargo transport.(Rondinelli and Berry, 2000). Transport is one of the strategic fields of interest for the European Union. In its transport policy, the European Union is exerting itself in favor of intermodal transport as an alternative to road transport. The policy makers aim to extend the intermodal network in Europe and to remove barriers for using intermodal transport. The optimal functioning of the transport system requires full integration and interoperability of the individual parts of the network, as well as interconnection between different (modal) networks. Crucial in achieving this result are the nodes, which are the logistics centers of the network and offer connectivity and choice for both freight and passenger transport. Intermodal and transshipment platforms should be promoted and developed where there is a potential for consolidation and optimization of passenger and freight flows. This will typically be the case in areas with a high activity of passengers and freight transport, i.e. in urban areas, and where high-volume corridors are intersecting(Directorate-General for Energy and Transport, 2009).

A key question when it comes to assessing single shipments is when is intermodality the right choice for the climate and environment? And do we have the tools to assess this?

DEVELOPING A BOTTOM UP TOOL FOR FREIGHT EMISSION ESTIMATION

Several tools are available to calculate freight transport emissions. Two of the most prominent are NTMCalc[1] and EcoTransit[2]. Problems with these tools are that they lack an infrastructure description or that the infrastructure description for Norway is incomplete. The existing tools can give quite different results if tested for the same freight transport(Knudsen, 2007). The tools are also quite high level in that they use general factors for road and rail emissions. In the existing tools topography of routes is not taken into consideration. Nor is the location of the terminals in relation to the road and rail infrastructure. Different driving speeds are also known to have an impact on emissions. These two facts alone reduce the usefulness of the existing calculation tools for single firms on specific freight relations.

The main idea for the development of the Green Freight Transport methodology is to use as detailed emissions functions as possible that can be used in conjunction with the existing digital infrastructure description that are available. An extremely detailed emission calculation tool is useful for the research community, but the tool is of no value if it cannot be used by actors in the freight industry. The way to get from detailed calculations to a usable tool can be found by the process of aggregation. Aggregation can be based on assumptions or data mining in the shipment databases of the larger freight companies.

[1] http://www.ntmcalc.com
[2] http://www.ecotransit.org/

Accessing the needs of the freight industry

A needs assessment was conducted early on in the Green Freight Project (Lervåg, 2009). A key finding in this assessment is that the driving force in the quest for more and better information on climatic and environmental impacts are large private companies whom buy freight transport services. Concerns over economic issues are highly ranked, but it is still seen as beneficial for actors in the freight industry to be able to market one self as environmentally friendly. The freight companies listed several measures that are believed to reduce the negative impacts of freight transport. No one seemed to believe in “a dramatic change” that would make freight transport green over night. The suggestions were of the type: Do what we due, but due it incrementally better. In general it seems that measures that can have a positive economic impact are most likely to be implemented.

In order to implement measures to reduce the negative impacts several obstacles where identified. Capacity and punctuality issues for the Norwegian rail freight network was reported as an obstacle for moving more freight from road to rail. The firms also reported that there was a lack of tools to evaluate and measure climatic and environmental consequences of measures. This was expected and it can be seen as justification for developing a new emission estimation tool.

The Green Freight Transport project is a user driven innovation project. In this type of research project the partners that will be using the results are supposed to steer the project in a direction they want. Thus practical usage questions are having a significant impact on the design of the tool.

Designing the emission calculation tool as a framework

Early on in the process it became clear that the tool would not be a simple excel spreadsheet. Digital infrastructure descriptions, state of the art emission functions and freight transport data have to be combined in such a way that it becomes a useful tool for the common man. In order to make the tool useful a process of detailed calculations followed by aggregation was developed. Figure 1 gives and overview of the process.

The idea was to divide the process of calculation into small separate parts that each performs a single operation. An example of such an operation could be to calculate emissions from diesel-electric freight train on a specific stretch of railway. The main argument for doing things this way is that the emission functions are technology specific. New transport technologies are continuously evolving so to improve the expected lifetime of the tool on has to be able to incorporate new calculation routines in an efficient way. Regenerative breaking for diesel electric trains may become viable with the developments in battery technology. The tool developed in the Green Freight project solves this by having the ability to plug in new calculation routines at the appropriate stage when they become available.

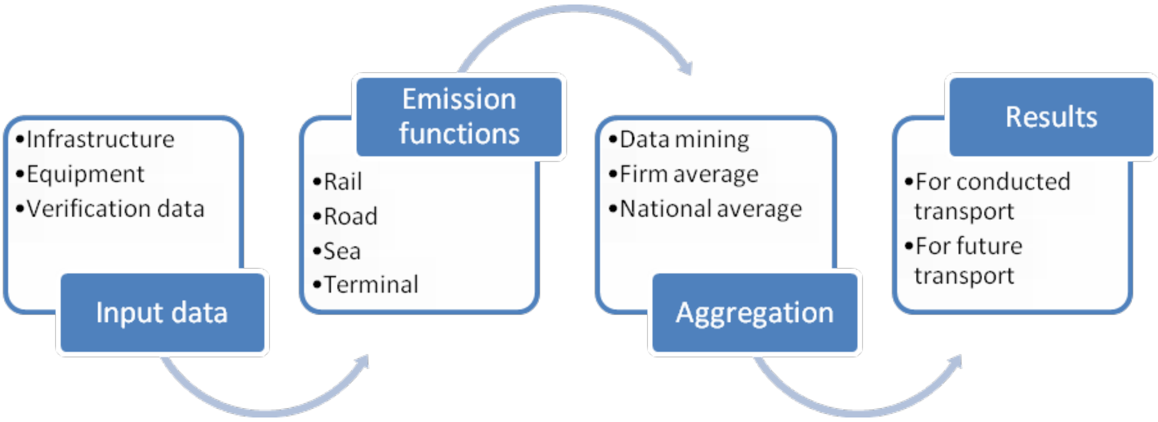

Figure 1 the 4-stages for a bottom-up emission calculation

Input data

Digital descriptions of the available infrastructure for a specific shipment are needed if one is to employ detailed emission functions. National databanks of the rail and road network exists in Norway. The costal administration also has a digital description of the sailing routes. Infrastructure descriptions for each mode have been available, but quality has been an issue. The main problem has been that the transport networks have been used for something that they are seldom used for and that is to create nationwide topologically correct networks. Algorithms for error identification and mitigation have been of primary concern. Manual error checking and correcting is not cost effective due to scale, as the road network consists of 578 000 links. The development of algorithms for error finding and mitigation also solves the task of updating the networks. An updated network can be extracted from the national databanks, error corrected and stitched together in an automated process. This allows for rapid updating of digital network descriptions.

Emission functions

In order to make use of the digital infrastructure descriptions one has to have emission functions that can utilize the data. A primary source of emission functions has been the ARTEMIS project(Paul Boulter and McCrae, 2007). The ARTEMIS project has aggregated and made available a large amount of emission functions for the modes used in the Green Freight Transport project. Both documentation and the underlying data from the ARTEMIS project are freely available from INTRETS web pages[3]. For road transport the average speed functions are utilized. For rail transport a modified version of the rail calculation method described in (Lindgreen and Sorenson, 2005b, Lindgreen and Sorenson, 2005a) is used. For sea born transport an ARTEMIS module has been adopted. The ARTEMIS emission functions for ships are very general. They are so general that the Green Freight Transport steering committee requested alternative emission functions that are per ship and not per ship category. The Norwegian Coastal Administration is currently working on an emission

[3] http://www.inrets.fr/ur/lte/publi-autresactions/fichesresultats/ficheartemis/artemis.html

accounting scheme that utilizes AIS positioning information with international databases for ship characteristics. For the prototype developed in the Green Freight Transport project a data for a specific ship will be used.

Creating emission factors for terminals is challenging due to the heterogeneity of terminals. Equipment used, type of goods, scale and administrative functions are factors that make each terminal unique. The emissions from terminals are said to be small compared with the total emissions of a transport. The Green Freight project has made a point of finding small but, valuable contributions to reducing green house gas emissions. A study of terminals has given valuable insight into energy usage at the terminals. Results of this analysis are presented later in the paper.

Aggregation

The Green Freight Transport project is a user directed research project, it was a clear demand that the tools should be usable for all actors involved in freight transport. The main problem was that a very detailed approach was needed to be able to calculate the impact of measures under the control of single companies, while the user requirements where to be highly moderate if the tool is to be a success. Figure 2 shows the relationship between explanatory capabilities and ease of use in relation to how one describes a transport.

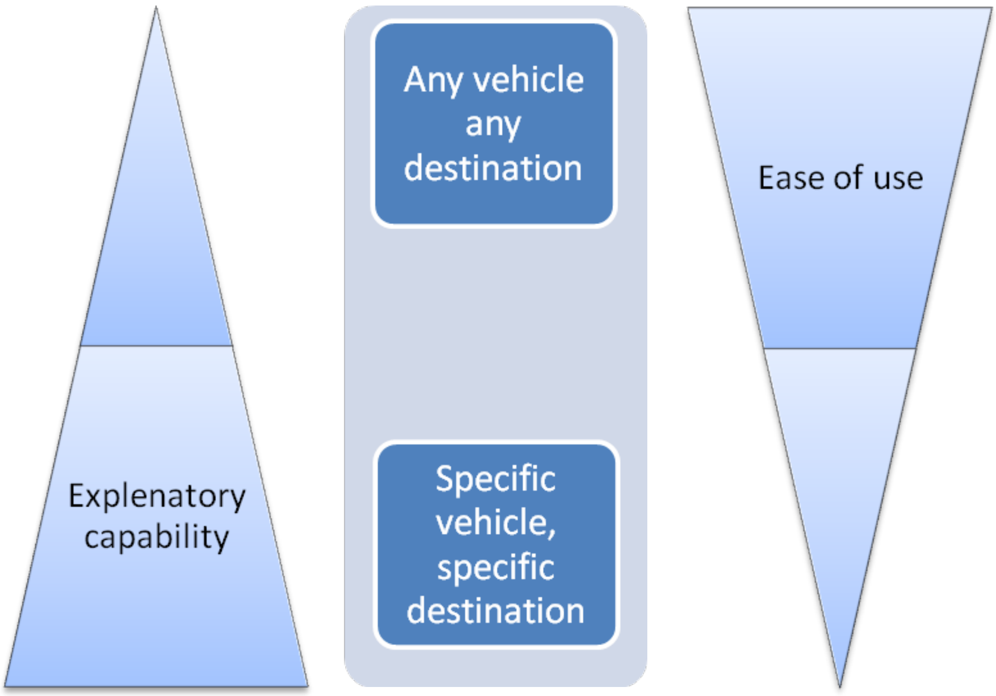

Figure 2 Emission models, explanatory capabilities and user requirements

For the prototype developed in the project the idea is to employ a scheme of aggregation of needed input data. This aggregation process is not visible to the end user performing the emission calculations. In the prototype we will make use of the freight forwarders database that contains details of each shipment for tracking purposes. From this database the route taken and vehicles and modes utilized can be extracted. Freight transport is to some extent like public transport in that the goods share a vehicle and thus emissions have to be distributed. To distribute emissions among freight that traveled together one needs to know which parcels traveled together. For a rail transport that has freight from several companies onboard the train one needs to know the company's share of the total train load. The total train weight exist in the train operator database or in the Norwegian National Rail Administration database for energy billing, at least for the parts of the railroad that are electrified. This data will be used to find company emissions and then distribute these emissions among the freight from that company.

In some cases we are not able to harvest data from the company databases then average values have to be used. Documentation of the averages and how to compute them has to exist within the company.

Results

The Green Freight Transport project does not have a single goal of reporting freight emissions, but also to contribute to continual improvement at company level. The idea is that the tool is to be used in the decision making processes so that economic, climatic and environmental impacts can be assessed together. The Green Freight Transport project does not seek to answer the question of how economic, climatic and environmental issues should be weighed together. That is a topic for further research. In this round the focus has been on getting reliable emission figures. Figure 3 shows the triangle of improvement, where the key concept is to measure. One thing is to measure actual change, the other is to measure impacts of planned changes.

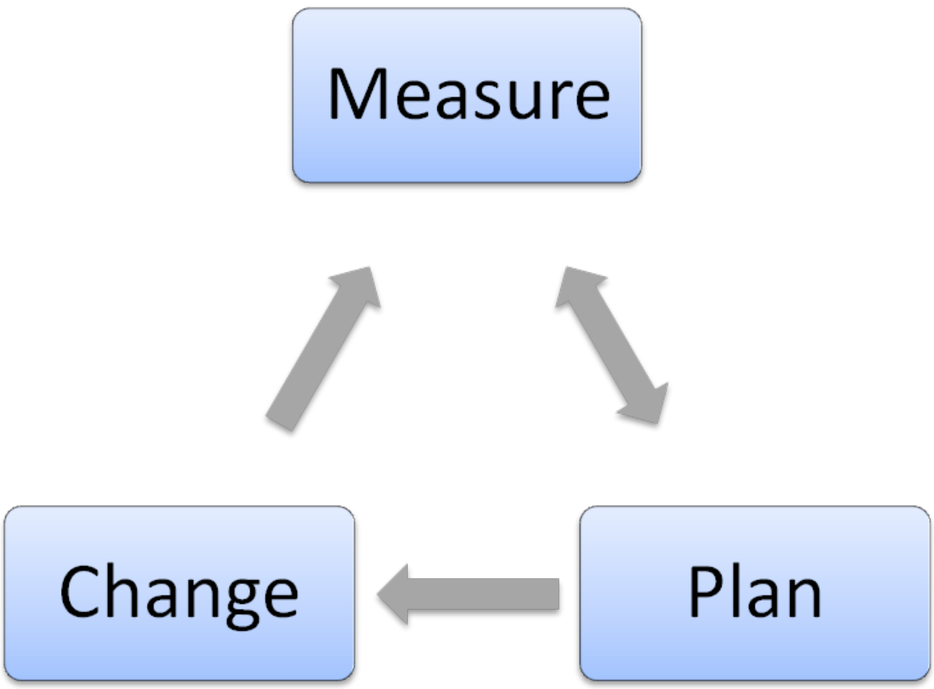

Figure 3 Triangle of improvement

To implement the triangle of improvement one does not only have to be able to calculated emissions from transports that have been conducted, but also calculate emissions for planed transports of planed changes in transport schemes. Thus measurement can also be the task of calculating the effect of planned schemes. The tool is not supposed to give general figures for large scale changes, but for changes in shipments or shipment agreements for specific firms. The tool can be used to calculate large scale infrastructure improvements, but then one need to have data available to aggregate up to this level.

Tool availability

This emission calculation tool can only be seen as useful if it will be used in everyday operations by the freight industry. One key aspect here is usability in a production environment. And as a part of the needs assessment firms said that they were willing to cooperate with competing firms as in order to reach their environmental goals(Lervåg, 2009). This gave room for an open source solution when it came to calculation routines. Open source development has 2 key benefits for this project. The first is openness, giving out the source will enable every one to see how the calculations are done. The hope is that full insight into the calculation routines can make calculations more trustworthy. This is in line with the academic ideal of publication and verification. The second reason is the freight forwarders expressed interest in a tool that they can integrate into their production system. An open source tools is simpler to integrate into existing proprietary systems because they have access to the source code and therefore can port it to the required language or platform. The tool developed in the Green Freight uses the Python computer language. Python is a computer language that has batteries included strategy. The standard library shipped with python has very wide scope, thus you need very few lines of code to solve everyday problems. And the language has the ability to integrate with other applications, most importantly the ESRI GIS package which is used for managing digital network descriptions and analysis. Python is also available on a wide variety of platforms, Microsoft Windows, UNIX and Linux. Once the tool is finalized it will be made available to the general public.

ENVISAGED TOOL USAGE

There is a dualism of the core tool that is developed. The partners in the green freight project want a tool that can be used in a production environment with a minimum of extra work. And from a scientific view point there is a need to look at established truths. Especially the political view that: intermodal freight transport the right choice for the climate? The tool should cater for both these needs.

Everyday use in firms

As mentioned in the introduction firms are looking for ways to reduce their environmental impact by changing factors under their control. The typical question is: what is the best way to move goods from A to B? The answer depends on a lot of factors, from our point of view there is not one general answer for this question. A generalists approach defeats the meaning of the whole Green Freight Transport project because we want to focus on each shipment and what that specific firm is able to with respect to the logistic network it has available.

A common objection to this is that you need so much specific knowledge to do this that it will become very cumbersome for the firms. Mainly because you have to enter a lot of input data just to get one emission figure. Advocates of this view seem to lack an understanding of the value of the shipment information available in the freight forwarders databases. The Green Freight tool will not reach its full potential until it is integrated with the databases managing everyday operations. For large freight forwarders the tool is planed for emission accounting and finding ways to move freight in a greener fashion. The core tool is to be built into the database systems and most input data is to be collected from the database. There is also a hope that the core tool can give emission inputs to the optimization tools used in the firms.

Usefulness for very small firms

The Norwegian Hauliers' Association, whom are a member of the steering committee, wanted the tool to be useful for single truck owners also. We are looking at a solution where we use the same core calculation routines to educate the drivers about the effects of driving conditions and topography. This can enable them to find greener ways of solving their everyday tasks. Fuel accounting is seen as a viable way for the truck drivers to measure their performance. This is again the same principle that primarily focuses on the factors that also give economic gains such as reducing fuel expenditure. For example topography has quite an influence for a truck driver that collects milk. One idea here to become greener is route ordering so that the truck starts off empty at the highest point then works its way down, the rout might not be the shortest, but I can be the most fuel efficient. Especially if the equipment that is used has an extra trailer that can be parked so that is only towed when needed. Put in the right hands the tool can be used calculate the effect of this measure. Put in the right hands is a key point, because as earlier stated the core routines of the tool will be available free of charge in a hope that they will be used by others and included their own production tools. This is not unlike the idea that the British government had when giving free access to public data. The quote below is from the British website that gives access to public data[4].

> We're very aware that there are more people like you outside of government who have the skills and abilities to make wonderful things out of public data. These are our first steps in building a collaborative relationship with you.

As researcher we have to see our limitations, and it may bee to the greater good for the climate that creative minds outside the scientific community take our core tools and make

[4] http://www.data.gov.uk/

them more usable in new and exciting ways. The example of the milk truck is not the result of research, but that of a creative truck owner in the middle of Norway.

From a scientific viewpoint

The Norwegian national transport plan for 2010 – 2019(Samferdselsdepartementet, 2009) stated that more goods should be moved by rail and sea rather then road. This is a clear statement that intermodal freight transport is more climate friendly than road based transport. This is a very general statement, intermodal freight transports are usually more energy efficient than road transport(Thune-Larsen et al., 1997). For intermodal transportation networks to be effective it is required that the main goods flows are routed through centralized nodes where the goods are efficiently transshipped to another carrying unit. Thus, the terminal is the key to achieve competitiveness in intermodal networks. It is at the terminal that the “inter”-aspect of intermodality is realized (Netland, 2009)

But to be able to consolidate goods to increase utilization one needs collection and distribution services. Thus even if rail is a lot more energy efficient than road there could be a break in economic and environmental terms. From an economic point of view intermodal transport suffers from a number of problems that restrict its competitiveness. (van Klink and van den Berg, 1998) cite a minimum distance of 500 km in Europe for intermodality to compete. But what is the distance if one focuses on emissions? And does the terminal handling needed for intermodal transport effect this break even?

The terminal

The partners in the Green Freight tool wanted a tool to access which travel mode was the most green. To do this one has to look at every stage in the logistics chain and figure out the emissions at each of these stages. A lot of work has been done on emission factors for each mode. The ARTEMIS project has looked at all modes and tried to give emission figures under normal operating conditions(Paul Boulter and McCrae, 2007). Other emission calculation tools also cover each mode, EcoTransit(Knörr and Reuter, 2005) and NTM calc(Nätverket för Transporter och Miljön, 2009), but the terminal is often left out of the calculation. The terminal might not be a major contributor to emission when one looks at the whole transport chain, but there are certainly emissions at terminals since they consume quite a lot of energy.

In order to include energy consumption at terminals and resulting emissions into the calculation a small study of terminals was conducted. The emission if compared to the whole transport can be small, but the total consumption of energy at a terminal can be quite big. The Green Freight Transport project hoped to develop emission factors for terminals that could be used for emission calculation. But in order to estimate emission functions data on activities and energy consumption was needed. The project partners said that they had measures of activity; typically twenty-foot equivalent units (TEU) were used. But when it came to energy consumption we were surprised by the lack of knowledge about terminal energy usage. We were also surprised that there existed rental contracts were energy consumed (electric) was included. Thus terminal operators had no economic incentives to reduce energy consumption. The other key observation was concerning the equipment used at the terminals. Fuel consumed by trucks was measured in liters fuel burned per engine hour. This has a nasty side effect of promoting idling, and is therefore not a key performance index that promotes the environment. That being said operators still have reasons for reducing engine idling time. Maintenance and rental fees are usually billed on the basis of engine hours.

Since most of Norway's electric energy comes from hydro electric power emissions from electric trains are said to be close to zero(ANDERSSON and LUKASZEWICZ, 2006). Even if we use 100% pure hydroelectric power there will be emissions from freight train operations. Diesel powered yard shifters are used in the terminals because one cannot have overhanging electric wiring where the trucks for loading and unloading the trains operate. Thus there will be a component of direct emissions from terminals. Once again key performance indexes exists, but for liters fuel burned per hour.

Terminal energy consumption data was collected for a freight forwarders terminal network (28 terminals) and from a rail terminal operator (12 terminals).

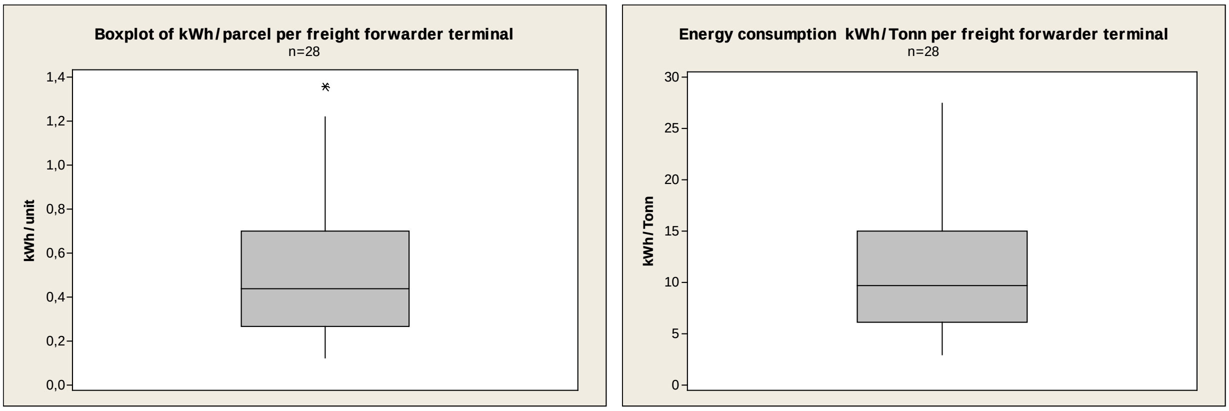

Figure 4 Consumption of electricity at freight forwarding terminals

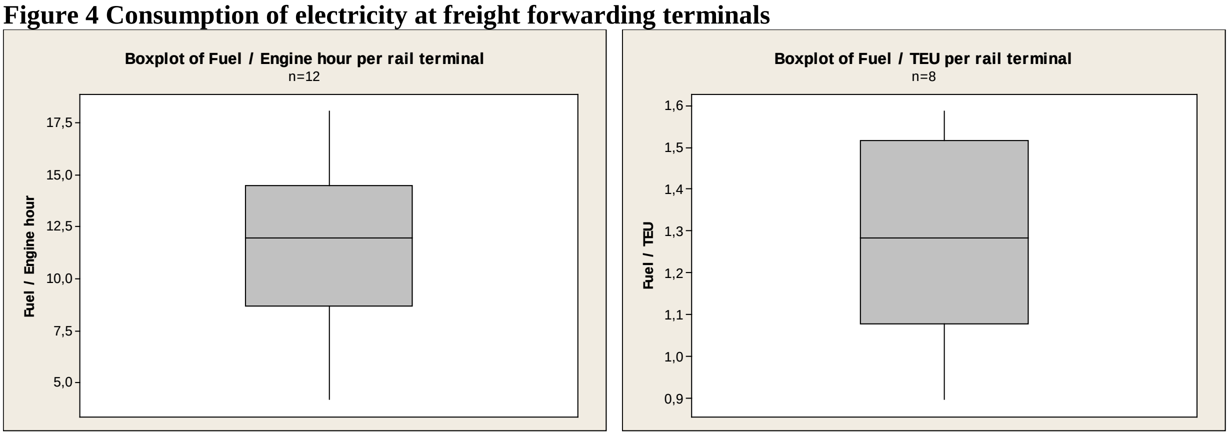

Figure 5 Consumption of fuel at rail terminals

Figure 4 shows box plots of electrical energy consumption for a terminals run by a freight forwarder. Data for the number of parcels and weight was available and thus an index that is linked to productivity could be produced. There is quite a lot of variability in the energy consumptions at the terminals. From the box plot in Figure 4 one can see that the difference between the most efficient and the most inefficient is about six times. This should warrant further investigations at the terminals to why this is so. It is also an indication that there is a potential for energy optimization.

Data was also collected for Norway's rail terminals; the 12 terminals that move intermodal freight were selected. The typical index was fuel burned per engine hour, but for 8 terminals freight volume in TEU's was available. Box plots of fuel usage per engine hour and fuel usage per TEU are shown in Figure 5. The fuel consumption per engine hour shows quite a difference, about a threefold. The difference drops to about 50% if TEU's are used as an index. The fuel consumption is for trucks only, fuel consumption by yard locomotives are not included.

The figure per TEU might seem small, but for a terminal with 100 000 TEU's annually a change from 1.5 liters to 1.1 liters per TEU is 40 000 liters of fuel saved annually. With a fuel price of 6 NOK per liter about 240 000 NOK can be saved annually. In environmental terms 40 000 liters of diesel equals 106.4 tonnes of CO2.

The Green Freight Transport project might not succeed in including a quantitative model for emissions at terminals. Further studies of the differences seen in Figure 4 and Figure 5 need to be undertaken. But the project is thinking in line of creating a qualitative statement for terminals. The key idea behind this is to raise awareness of the environmental impact that the terminal can have. The idea is to promote registration of consumption and relate it to the primary freight moving activities. This will in time enable us to estimate terminal emission functions. Terminal operators will be able to measure their energy efficiency performance. Due to the diversity among terminals it is possible that a factor has to be estimated for each terminal. A factor specific for each terminal will also be inline with the detailed focus in core calculation routines of the Green Freight Transport project.

As a direct consequence of the energy usage survey at the terminals some of the actors started to change their routines so that they themselves could get a better overview of energy usage on their terminal. Raising environmental awareness at every level in the freight transport chain is one of the keys to success in the greenification of freight transport.

The increasing importance of multimodal infrastructure and intermodal services will intensify the environmental impacts of transportation activities in the future. Identifying major transportation activities with impacts on natural resources is an essential first step in effective environmental management. Three sets of activities associated with transportation — vehicle operations, equipment maintenance, and facilities operations — can have negative impacts on the environment. In addition, transportation infrastructure construction and expansion often generate pollutants or endanger natural resources(Rondinelli and Berry, 2000).

Why does every penny count?

In light of the shortcomings of the UN COP15 meeting in Copenhagen it seems clearer than ever that political solution to the climate problem can be summed up as “NATO” (No Action Talk Only). The Gallagher review challenged the bio-fuel quick fix, and voiced concern over food for fuel issues(Gallagher, 2008). Thus the quick fix to freight transport’s carbon addiction seems diminishing. Climate apathy can arise from frustrations with the politician’s inability to act. One way to fight this apathy could be to enable every actor in the freight chain to see how his or her actions can affect greenhouse gas emissions. The idea behind tools developed in the Green Freight Transport project is to give companies in the freight industry the ability to assess their own environmental performance. There is a link between energy consumption and greenhouse gas emissions. Since energy usage is also connected to cost then there should be an opportunity for economic and environmental gains. The gains per unit moved might be small but annual figures are much larger.

In today’s modern logistic networks it is no longer adequate to find out which mode is better. One has to look at the whole freight chain and include activities that are necessary for the transport of goods. The Green Freight Transport project has looked into terminals and emissions. Terminal emission for one transport might be small, but when summing up each shipment passing through a terminal the sum is rather big. One indication of that there are gains to be made from looking at the terminal is that knowledge about terminal energy usage in relation to terminal production is low. A key to getting terminal operators to look at how they can become greener is to present them with the link between energy expenses and emission reductions.

Until the politicians are willing to make deals that can adversely effect their country’s economic growth or its citizen’s standard of living then one has to focus on the contributions that individuals or single firms can make. Each single contribution might be small, but the total for the freight industry might be big. Choosing the most energy efficient transport solution can be a win–win situation for the wallet and the climate. But to save money and the climate one needs to know where to look and calculate how much can be saved.

CONCLUSION

The increasing focus on climate has forced the freight industry to look for ways to greenify their image. The freight industry is responsible for a large amount of CO2 emissions. There seems to be no quick fix to reduce CO2 emissions, thus one has to look for the small contributions. For the freight in industry it makes sense to ship the same amounts, but in a more energy efficient way. What the Freight industry has been lacking is a tool for calculating freight transport emissions for the whole freight chain. The Green Freight Transport project has developed a tool and methodology for calculating freight transport emissions that is sensitive to measures under the control of single firms. Data quality is essential for creating good estimates at a very detailed level. Input data has to have a quality that matches state of the art emission functions. Freight companies need to have detailed knowledge of their activities so that needed input data can be aggregated and extracted from company databases. Aggregated data is needed for making detailed emission calculations a part of everyday operations. Emission functions do exist and detailed digital infrastructure descriptions also exists. But data quality issues with the digital infrastructure descriptions has been challenging. Routines and algorithms for automatic error identification and error correction have been developed as part of the Green Freight Transport project.

A very important incentive to use the tools developed is the link between energy cost and emissions from energy usage. There seems to be the possibility to save money while behaving in a greener fashion. The gain from improving one operation might be small, but when summed up for the total production volume the gain can be quite large. Looking at the terminal data there is quite a big difference in terminal energy usage. For a mid-size Norwegian rail terminal there can be a potential to save 240 000 NOK and reduce emissions by 106.4 tones CO2 annually.

Focus on energy usage and performance indicators that are linked to freight production is essential to reducing freight transport emissions. Single firms can have economic incentives to becoming greener. The opportunities to cash-in on these savings lies in tools that are able identify these small savings. The tool developed in the Green Freight project has the potential to make every penny count.

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