WCTR 2013 RIO

SELECTED PROCEEDINGS

GREEN FREIGHT TRANSPORT – A DYNAMIC TOOL TO IMPROVE ENVIRONMENTAL PERFORMANCE IN THE FREIGHT TRANSPORT INDUSTRY

TOMAS LEVIN, SINTEF, TRONDHEIM, NORWAY
ROAR NORVIK, SINTEF, TRONDHEIM, NORWAY
E-MAIL FOR CORRESPONDENCE: TOMAS.LEVIN@SINTEF.NO

This is an abridged version of the paper presented at the conference. The full version is being submitted elsewhere. Details on the full paper can be obtained from the author.

ISBN: 978-85-285-0232-9

13th World Conference on Transport Research

www.wctr2013rio.com

15-18 JULY 2013
Rio de Janeiro, Brazil

GREEN FREIGHT TRANSPORT – A DYNAMIC TOOL TO IMPROVE ENVIRONMENTAL PERFORMANCE IN THE FREIGHT TRANSPORT INDUSTRY

Tomas Levin, SINTEF, Trondheim, Norway

Roar Norvik, SINTEF, Trondheim, Norway

E-mail for correspondence: tomas.levin@sintef.no

ABSTRACT

This paper reports on a research project that developed a new emission model for freight transport that is to be tightly integrated with the freight transport service providers' production system. A primary intent of developing a new emission model for freight transport was not to provide yet another worrying number, but to report a number that was sensitive to measures under the control of single firms. The idea was to provide freight transport service providers with a tool that will show and document emission changes in a dynamic fashion as results of changes to their production schemes. Implementing an emission model to make it in to a useful tool was challenging and thus the Green Freight Transport project was followed by an implementation project called the Network for Green Freight Transport. A goal for this project is to get the major freight transport operators to implement the same model so that changes in emissions are in fact results of different production schemes and not different assumptions in the emission tools used by the firms.

Keywords: Emissions, Freight, Transport, ICT

INTRODUCTION

"We do not inherit the earth from our ancestors, we borrow it from our children" is a Native American proverb. Our children and their children will be faced with the results and consequences of this and previous generations. This is especially true for environmental issues and more specifically the issue of global warming. In 1994 the United Nations Framework Convention on Climate Change (UNFCCC) entered into force. The UNFCCC is a result of the 1992 Rio convention. The primary goal of the UNFCCC is to reduce the global temperature increase via cooperation. The measures resulting from the UNFCCC are national reporting schemes and willingness to comply with politically negotiated emission reduction targets. Klimaforliket (the climate compromise) from 2008 serves as Norway's political platform for how Norway is to reduce the Norwegian global warming emissions. A challenge with Klimaforliket is that the proposed measures are very high level, for example more funding for research into renewable energy and increased fuel taxes. These measures offer the ordinary man little opportunity to contribute to emission reductions by minor changes to everyday routines.

In 2004 30% of the total Norwegian greenhouse gas emissions were related to the transport sector (Lavutslippsutvalget, 2006). For the EU27 23.6% of the CO_2 emissions where from the transport sector (Agency, 2010). In addition to the climate challenge that transport poses there are issues with local pollution caused by transportation. Locally and regionally polluting emissions are a result of transport and other sources. Emissions from road vehicles have been a concern for a long time. In 1970 the European Economic Community (EEC) adopted regulation to reduce air emissions, directive 70/220/EEC. This was followed by the Euro emission standards for motor vehicles. CO_2 is not regulated by the Euro emission standard as it focuses mainly on locally and regionally polluting emissions. To preserve the planet and local environment for future generations both climate change and local environmental consequences must be kept in mind.

An interesting question arising is: Are there complementary ways to reduce global warming emissions that focus on specific every day chores? This paper looks at a Norwegian Research project Green Freight Transport aimed at enabling single firms to continually monitor their emissions to see effects of implemented measures. The Green Freight Transport project started in January 2008 and finished in March 2011. The idea was to use a state of the art emission model and integrate it with the freight transport companies' production system to create a dynamic emission tools

THE GREEN FREIGHT MODEL IN CONTRAST TO EXISTING TOOLS

There exist several tools that allows user to calculate emissions from freight transport, NTMCalc (Network for Transport and Environment, 2012) and EcoTransIT (Knörr et al., 2010) are two such prominent tools. They allow users to calculate CO_2 and environmental impacts with ease. Freight transport service providers participating in the Green Freight Transport project all had their own tools to calculate emissions. The main challenge with existing tools where that they gave different results for the same calculations. It was believed that the differences observed were caused by assumption not made known to the user of the existing tools (Knudsen, 2007). Two key factors that have a clear impact on emissions where load-factor and how empty returns are accounted for. The EcoTransIT 2010 documentation has clear definitions of load factor and the empty trip factor (Knörr et al., 2010 p. 17). The reason for introducing these factors and estimating values for them is to increase the usability of the tools. But this also makes the tools more static. As changes to load factor and the empty trip factor need not to be estimated for each trip. Two of the partners in the Green

Freight Transport project had consolidated shipping as their preferred business strategy, thus the load factor is vital in emission calculations. Empty returns were also of concern as some of the project partners had 2-way contracts with truckers and thus had an incentive to reduce the amount of empty returns.

In relation to the physics of emissions there were raised questions about the technical qualities of the emission functions used. Some firms used fuel-based emission factors derived from the Euro emission standard. Back in 1998 the first warnings about the effectiveness of the Euro emission standards under real world driving conditions were raised (Kågeson, 1998). Road gradients where also a major cause of concern as (Hassel and Weber, 1997) stated that:

> *"Even in the case of large-scale considerations, however, it cannot be assumed that - for example - the extra emission when travelling uphill is compensated by correspondingly reduced emission when travelling downhill."*

Thus not including gradients in the emission calculations will lead to under estimation of emissions. In tools like NTMCalc and EcoTransIT gradients are included at the national level as correction factors to the final result. Three levels of topography are used: flat, hilly and mountainous (Knörr et al., 2010). Not being able to utilize gradients in emission calculations will reduce the tools usefulness in relation to routing when alternative routes have different topography.

The Green Freight Transport project also looked into rail and sea modes. Both EcoTransIT and NTMCalc offer these modes, but the issues with assumptions are also present for these modes. The Norwegian costal freight fleet is diverse, in 2009 the fleet consisted of 263 ships with an average age of 28 years (Oterhals et al., 2009). The Norwegian rail network also has some traits that make it unusual compared to European rail. The main freight and passenger lines are single track, and priority is given to trains that receive state subsidies. Passenger trains are subsidized while freight trains are not, and thus freight trains have to yield for passing passenger trains.

As a result of the review of the existing models a decision was made to look for emission factors in order to build a new model for freight transport emissions. The MEET (Hickman et al., 1999) project and later the ARTEMIS (Boulter and McCrae, 2007) project are good sources for detailed emission factors for freight transport. The objective of the MEET (Methodology for Calculating Transport Emissions and Energy Consumption) project was to provide basic pan-European procedures to evaluate impacts of transport on air pollution. The ARTEMIS (Assessment and Reliability of Transport Emission Models and Inventory Systems) project extends on this knowledge and the project developed a harmonized emission model for all modes.

The new model was to build on detailed European emission factors and utilize detailed digital infrastructure descriptions as input to the detailed emission factors. The production systems of the freight transport service providers were explored to learn how much data could be extracted from these with little human intervention. The user needs assessment study in the Green Freight Transport project indicated that all firms wanted a tool to calculate environmental consequences, but the cost of operating the tool must be low (Lervåg, 2009). This is also supported by studies conducted by A. McKinnon and reported in the book McKinnon et al. (2010), Environmental sustainability: a new priority for logistics managers, were the studies reported indicate that firms are mostly interested in the marketing gains from being perceived as environmentally friendly rather than being environmentally friendly for the sake of the environment.

The challenge was to build a detailed emission model that could utilize logistic parameters (load factor and empty return factor) and the key factors that influence emissions for each shipment while not increasing the operational cost. But the Green Freight Transport user needs assessment indicated that firms were willing to take the cost of implementing the model into a tool. The distinction between model and tool is intentional as the model only does emission calculations for single vehicles on specific routes. The model is turned into a tool by integrating the model with data from the freight transport service providers production system. This allows for calculating which shipments travelled together in the same vehicle.

MODEL DESCRIPTION

The main idea of the Green Freight Transport project was to create an emission model to be used by the freight transport service providers to understand emissions resulting from their operations in order to find measures to reduce emissions. The model is sensitive to changes at two levels, the transport level and the logistics level. At the transport level, route and equipment changes will have an effect on emissions. At the logistics level changes that have an effect on vehicle utilization and number of empty runs will cause changes to emissions. In laymans terms the idea can be expressed as: make a change, see a change.

The second thought that the project tried to keep in mind was the wish from the freight transport service providers to keep costs and work associated with doing emission calculations low. If the operating cost of doing emission reporting was too high then there is a high likelihood that the freight transport service providers will not use the new model.

The model scope was set to domestic freight transport in Norway. Emission studies are context sensitive and use of detailed emissions functions require large amounts of input data. Thus there is a challenge in getting hold of the data and computational power required to calculate the emissions. The idea is not to build a single worldwide model, but to create several models that link together. This is in line with the wish for the model to focus on measures that single companies in the freight transport industry can implement. The model should not just produce "Yet Another Worrying Number" (YAWN), but focus on reporting the consequences of measures that single firms make. The main goal of the model is not reporting, but to create a tool that allows single firms to understand the emission impacts of their everyday actions. The new model is designed to be used in a process of continual improvement shown in Figure 1 Triangle of improvement.

The Green Freight Transport emission model has a modular design. A modular design allows for updating and replacement of single modules when changes are made to logistic networks or when new emission functions become available. The modular design also allows for partial use of the model. This is useful in an academic context where only parts of the full model are used. Figure 2 shows the four modules of the Green Freight Transport model. The lightly shaded triangles contain parts that are company specific. The darker shaded triangles are modules that are common for all companies. Having parts of the infrastructure descriptions company specific allows to make it possible to see differences caused by the different logistical networks that the companies utilize. The result management module is also company specific because of differences in the availability of data from the production systems. Some firms may not have all the data needed to perform everyday calculations. For example they may not know the specific vehicle utilized for a trip. Thus they need a routine in their company to create an average fleet and use this fleet for calculations. Data to update this average should be collected periodically and at least annually.

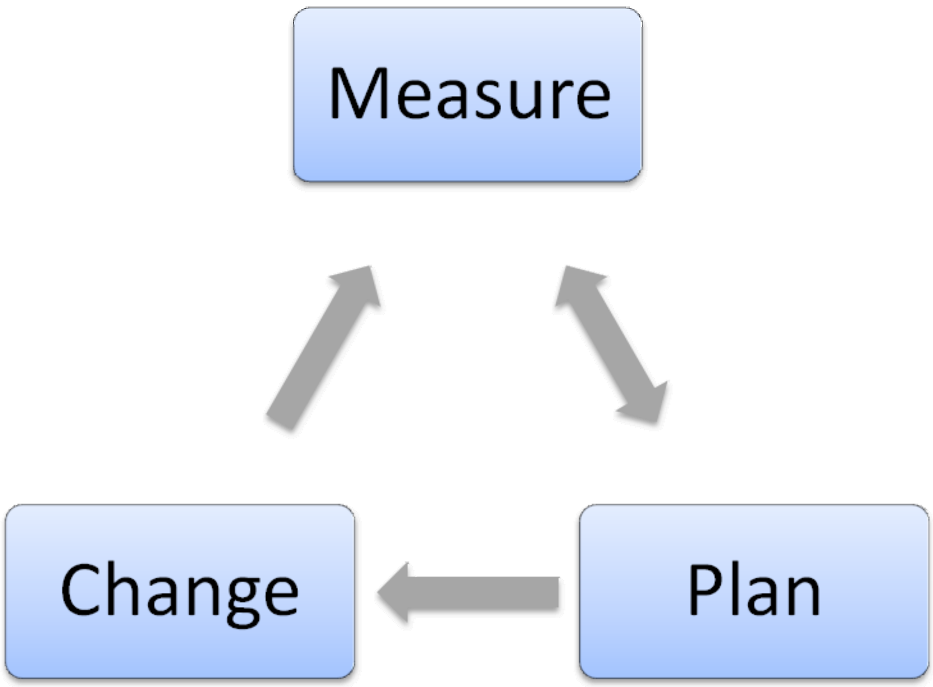

Figure 1 Triangle of improvement (Levin and Sund, 2010)

The first model design choice was to separate emission calculation from allocation. In the traditional tools like NTMCalc and EcoTransit calculation and allocation are combined. This allows the users to make assumptions about average utilization and thus does not have to calculate emissions from single vehicles, but rather focus on tonnes moved. The negative effect of this traditional simplification is that the model is fairly static in relation to vehicle size and utilization. In the new model emissions are calculated for single vehicles, and then the emissions are allocated to the goods moved. The new model is built on the belief that there exists data in the freight transport service providers' production systems that allows for establishing vehicle utilization for every single vehicle. The data typically exists in the databases used for tracking shipments and/or billing systems for subcontractors doing the transports. Those who are not able to calculate the vehicle utilization can use the tool, but they have to assume a vehicle type and its utilization.

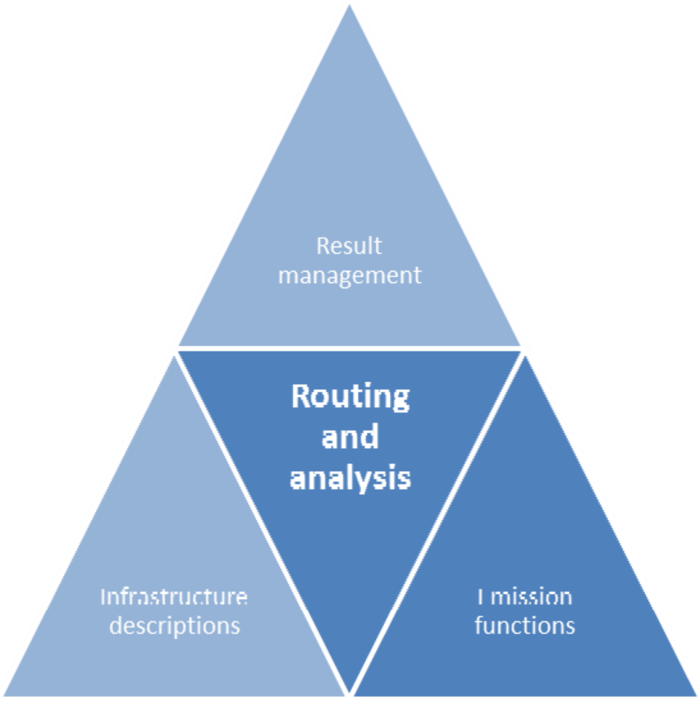

Figure 2 The four modules of the Green Freight Transport model

The second design choice relates to level of detail in the emission functions. The project was to use the most detailed emission functions available in order to make emission studies sensitive to actions of the freight transport service providers. To incorporate the detailed factors a detailed network was built using data from the national road and rail databank and official descriptions of nautical fairways. Thus the model was built on top of a geographic information system (GIS) to find routes between origin and destination.

The most challenging design issue was how to make the model useful for freight transport service providers. The core routines of the emission tool are dependent on GIS for route calculations. The freight transport service providers' production systems are centered databases and the GIS application developed in the Green Freight Transport was built on top of a desktop GIS. Thus a final stage, the result management stage, was added to the Green Freight Transport model. The result management stage produced a database of pre-calculated emission functions between all postcodes in Norway. The database contains different vehicle types and an emission function for the specific relation that only needs vehicle utilization as an input. The database contains emission functions for the regulated emissions and CO_2, but also energy and fuel consumption are stored in the database. The database is quite large, 100 Gigabytes including indices. Lookup speed on off the shelf hardware is unproblematic, less than one tenth of a second. The key to successful implementation is integration with the freight transport service provider's production systems. A schematic illustration of this integration is presented in Figure 3.

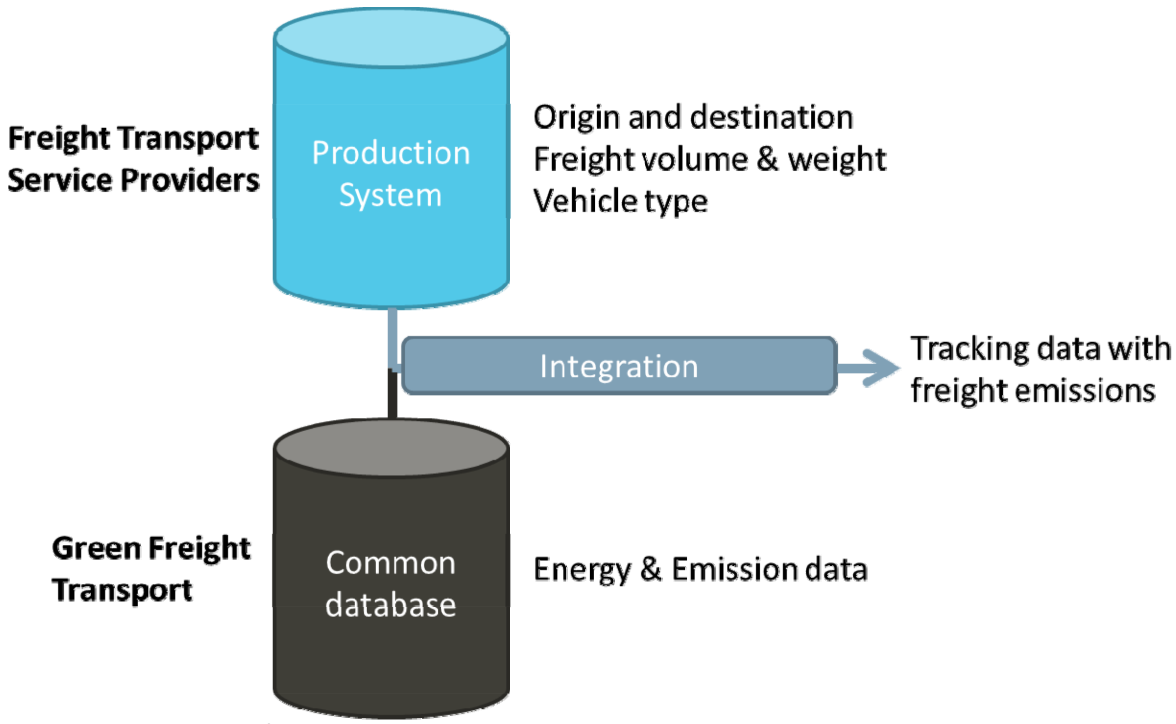

Figure 3 Implementation of the model as a tool

IMPLEMENTATION OF THE MODEL AS A TOOL

To make the Green Freight Transport model useful for firms in the freight transport industry the model has to be implemented as a tool. After the Green Freight Transport project ended a Network for Green Freight Transport was established. The purpose of this project was to support other firms than the pilot firm to implement the Green Freight Transport model as a tool. The implementation has to functions; the first is to find the data to use the model in the company's internal production systems. The second is to document the implementation with relation to firm specific issues.

Finding the data to use the Green Freight Transport model is challenging. Each firm had to look in to their systems to find the information required to use the new emission model.
The following data had to be extracted from the IT systems:

- Location information – origin and destination for each leg of the transport
- Weight of the goods moved
- Volume of the goods moved
- Total weight of goods on the specific vehicle
- Total volume onboard the specific vehicle
- Vehicle type (truck, train or boat, including subtypes)

The route from origin to destination has to be decomposed into separate legs for emission calculation. The reason for this decomposition is that it is important to find out which pieces of goods traveled in each vehicle to get the correct loading and utilization of the vehicle. Weight of the goods is used to calculate emissions while a combination of weight and volume is used to allocate the resulting emissions to the freight in the vehicle. The Green Freight Transport project encouraged freight transport companies to use the same key for allocating emissions as they use for allocating costs. Distribution and collection routes are more complex than long-haul as the amount of goods in the vehicle changes between each stop. Companies that have complete knowledge about pickups and deliveries have the ability to implement a package sequence methodology for calculating emissions from the pickup and delivery route. A package sequence requires the freight transport company to further decompose the pickup and collection routes into individual segments between each stop. For each segment total weight and volume will be calculated and emissions are allocated for each segment. At the end of a trip emissions on all segments are aggregated for each packet.

Emissions caused by empty vehicle trips are summed up and allocated to all packages according to the key chosen for allocating emissions. But the empty runs are split into two categories, one for long-haul and one for distribution and collection. It is believed that this scheme where the emission consequences are explicitly reported could cause increased awareness among customers and the freight transport service provider. The freight transport service provider can then try different distribution and collection strategies in order to reduce emissions and to document if the specific measure had the anticipated effect. The freight transport companies that do not have a digital trace of their delivery/collection routes will have to use a direct route package emission estimation routine. To use the direct route routine the freight transport company has to estimate the average vehicle utilization and define a vehicle type used for the transports. Both vehicle type and average utilization should be reevaluated and documented every year. The evaluation should be built on data collected periodically, once a month or at least annually. Emissions will be calculated for each package going from the terminal and back again and allocated according to the average utilization.

Information on the vehicle type used for the transport is important as the different vehicles have different emission functions and loading characteristics. For road vehicles the Green Freight Transport model has 14 vehicle types and 6 Euro-classes for each vehicle type. It was found that many of the Norwegian freight transport companies that had outsourced transport to external companies used the vehicle registration as an identifier for financial and tracking purposes. The Norwegian Public Roads Administration gave access to the national vehicle databank so that companies could extract the necessary vehicle characteristics from the database to be used in the calculation.

Presentation of emission data to customers of the freight transport providers is also an issue. Some companies have sophisticated tracking systems that provide the customers with data on shipments. This is a good match for presenting the emission data as the emission data is also connected with the tracking data in the calculation process. A tight integration with the tracking system opens up the possibility to testing scenarios. If a freight transport service provider decides to open up a new train route then the emissions effect of this decision could be simulated beforehand by using for example last year's tracking data modified for the new train route. Thus environmental schemes could be tested, before they are implemented, to see if they have the expected effect.

Implementing the Green Freight Transport emission model requires access to the freight transport service providers IT systems and thus company IT departments play a vital role in the quest to reduce emissions from freight transport. In order to create a dynamic tool that shows the consequences of measures to reduce emissions there is a need to extract a large amount of data from the company's production systems.

For small companies that do not have a production system a simplified tools has been developed. Figure 4 shows the user interface to the calculator. The calculator uses the same database as the freight transport service providers use. But the users of the simplified tool have to manually enter origin, destination, vehicle type and weight of goods in the vehicle.

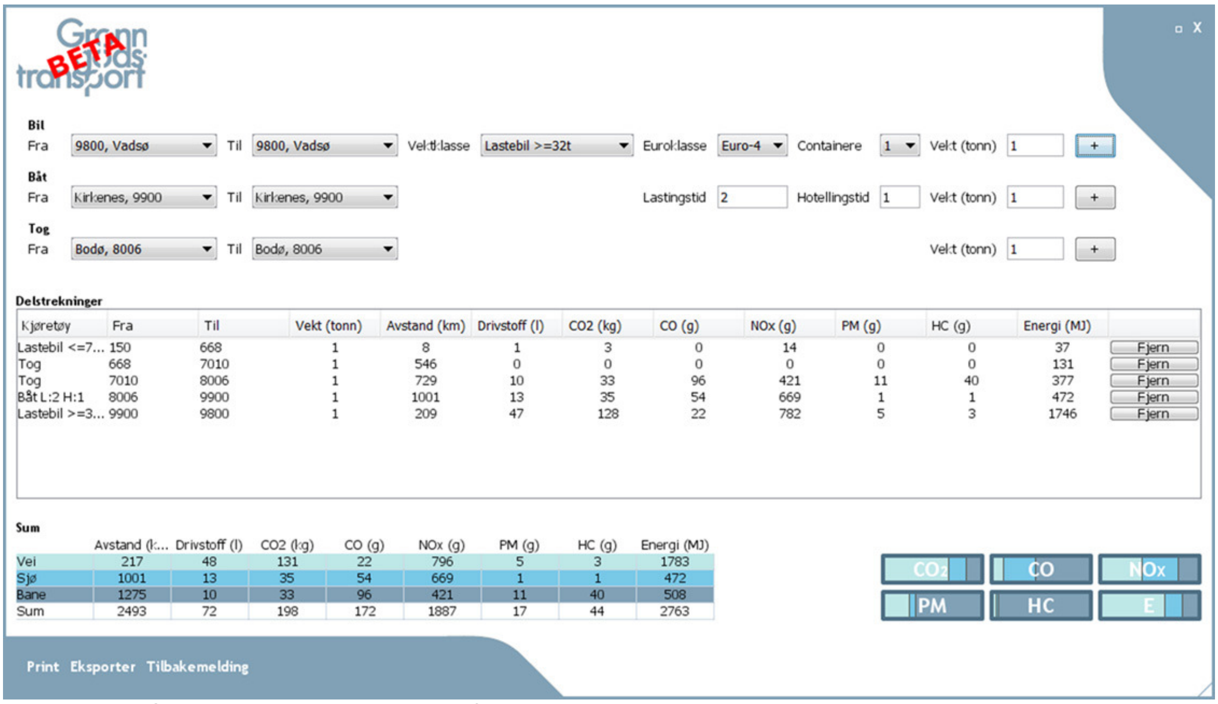

Figure 4 The Green Freight Transport simplified calculator

The simplified calculator was developed by the Network for Green Freight Transport project and is open source and free to use for all. Developing the model and the simplified tool as open source is important as it allows for peer review of the model and example code that could be used for implementing the model as a tool.

Fuel and energy consumption figures were included to enable freight transport service providers to assess the quality of the calculations. Many freight transport service providers monitor average fuel consumption per vehicle for financial purposes. The Green Freight Transport emission model fuel calculations were tested fuel logs from a fleet management system. The fleet management system reported accumulated fuel usage every 10 minutes of driving time along with the location. The locations from the fleet management system along with vehicle type and cargo weight were used in the emission and energy calculations. Thus it was possible to compare calculated fuel usage with actual fuel usage for 10 minute long segments of the trips.

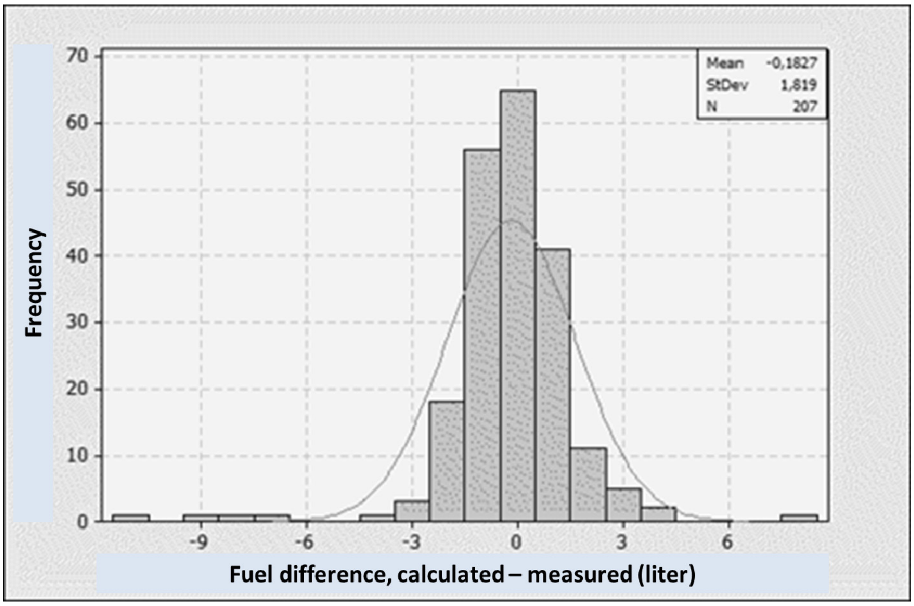

Figure 5 Difference between calculated and measured fuel usage

Figure 5 shows a histogram of the difference between calculated fuel usage and measured fuel usage on each of the 207 10 minute long segments. The vehicles were fully loaded articulated truck departing from a firm located on the Norwegian west coast and going to several large cities in Norway (Oslo, Trondheim, Bergen, Stavanger and Hamar). The payload ranged from 25.9 to 28.3 tonnes and the vehicles were Volvo FH 13 trucks. The result showed that the Green Freight Transport emission tool is capable of calculating fuel and energy usage with high accuracy when compared with data from vehicle. There are a few large discrepancies; some can be explained by the fact that idling is not included in the model, the large negative values seen in Figure 5. The large positive value is believed to be caused by an erroneous gradient in the road network.

DISCUSSION

The Green Freight Transport emission model was designed to complement national efforts in relation to reducing air emissions from freight transport. The model is complementary in the sense that it is sensitive to measures that are under the control of single firms. Vehicle utilization lay out of the logistic network and vehicle definitions are taken from the production systems. The new model provides a more dynamic tool than the traditional tools used that utilized average factors for utilization and were independent of routes. The challenge with a dynamic tool is that it requires dynamic input data, thus the link to the freight transport service providers' tracking systems is vital. Companies that have control over their data and are able to interact directly with the tracking databases to create the data types needed for the model have an advantage. For companies that do not have full control over their data the Green Freight Transport methodology allows for simplified solutions. This also makes the Green Freight Transport model flexible in terms of how it can be implemented. Average values for the different parameters can be used, but they have to be updated at least annually and the average should not be a "guestimate", but based on data collected. One important lesson from the test implementation of the model in the Green Freight Transport project was that specific cases will arise when implementing the model as a tool. Thus the Network for Green Freight Transport was established to provide companies that wanted to implement the model with scientific support. The purpose of this support was to design workarounds where companies where missing data and find methods for the companies to develop average factors that used other data found in their systems to update their average factors. The methods where designed so that the updates should at least be done annually. Three of Norway's largest Freight Transport Service Providers are implementing the Green Freight Transport model as a tool.

Providing detailed dynamic emission data is not without its challenges. Tools that rely on average utilization or load factors will consistently produce the same emission figures on the same route for each shipment. A dynamic tool will take utilization into account and thus the emission figures are dependent the actual vehicle utilization for the specific trip.

Environmental concerned customers may also be surprised by the emission result of decisions that were taught to can be environmentally friendly. One such decision could be to move to an off-peak train departure. Using the Green Freight Transport emission model the firm that shifted to the off-peak train departure will get an increased emission as the train has a lower utilization. Another customer might be moved from road to the attractive train departure and this customer will get a large environmental benefit. The problem is that what is best for freight transport service provider might is not always best for the individual customers. The example above might seem artificial, but it is typical for the freight being moved along the main railway lines in Norway. This example shows that it is not straight forward to use detailed emission calculations and communicate the results to the customers.

The above example was also part of the reason for starting the Network for Green Freight Transport as more work is needed regarding emission allocation. It is also believed that having a forum for discussing emission related topic such as emission functions and allocation schemes is positive as it increased the environmental awareness and put emission reductions on the agenda.

By including energy and fuel consumption in the emission calculator makes it possible to compare calculated values with values measured by the vehicle. This is especially useful for road vehicles where fleet management systems can extract fuel consumption information in a standardized way using the FMS-gateway in the truck. The FMS-gateway is a standard for extracting information from the internal communication network in the vehicle; the standard was created by the biggest truck manufacturers.

CONCLUSION

The Green Freight Transport project finished in March 2011 and delivered a new detailed emission model for implementation in freight transport service providers' productions systems. The new model is open source software and licensed in a way that allows all to make their own implementations. Anybody can also create products for sale that uses the code and data from the Green Freight Transport project. The most significant difference between this model and other existing tools is that it is more dynamic, as it requires integration with the freight transport service providers' production systems to get access to the needed input data. The freight transport services providers have to develop internal routines to calculate utilization and weight of the goods in single vehicles for the emissions calculations. This makes the tool more dynamic as changes in production will affect the emissions calculated. This enables the freight transport service providers to test different schemes and see if they result in emission reductions.

The model was tested against real transports of specific vehicles on specific routes with very good results for fuel and energy calculations. The inclusion of energy and fuel consumption figures is believed to beneficial as it is possible for the freight transport service providers to assess these figures against other sources that they have available.

The implementation of the model into a working tool is a challenging task. Data that freight transport companies thought they had do not exist. Calculations can become too cumbersome and slow down vital servers, and the quality of the data that is not up to the mark are all familiar problems encountered in the implementation phase. The Network for Green Freight Transport was set up to provide scientific support during the implementation phase for freight transport service providers that wanted to implement the Green Freight Transport model. At present the four largest freight transport companies in Norway have joined the network. In addition to supporting the implementation of the model in each company the network also serves as an arena for discussing emission calculation and allocation. The goal of the network has become to promote a common tool for emission calculation and allocation of emissions that is responsive to measures that single companies can make.

ACKNOWLEDGEMENTS

The research reported here was part of the Green Freight Transport project and the Network for Green Freight Transport project. These projects have been funded by the Research Council of Norway, TRANSNOVA, the Public Roads and Railways administrations and several partners from the transport industry in Norway. The authors would like to thank Tollpost Globe for being a pilot in the implementation process.

REFERENCES

AGENCY, E. E. 2010. *EEA greenhouse gas - data viewer* [Online]. Available: http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer [Accessed October 10th 2012].

BOULTER, P. & MCCRAE, I. 2007. ARTEMIS: Assessment and reliability of transport emission models and inventory systems: final report. TRL.

HASSEL, D. & WEBER, F.-J. 1997. Gradient influence on emission and consumption behaviour of light and heavy-duty vehicles. *MEET Project deliverable.* TÜV Rheinland.

HICKMAN, J., HASSEL, D., JOUMARD, R., SAMARAS, Z. & SORENSON, S. 1999. Methodology for calculating transport emissions and energy consumption. MEET Project deliverable 22: TRL.

KNUDSEN, T. 2007. Godstransport og transportmidlenes miljømessige egenskaper (Freight transport and the modes environmental attributes). *SINTEF Rapport STF A2476.* Trondheim: SINTEF.

KNÖRR, W., SEUM, S., SCHMIED, M., KUTZNER, F. & ANTES, R. 2010. Ecological Transport Information Tool for Worldwide Transports - Methodology and Data 2nd Draft Report. Berlin – Hannover - Heidelberg: IFEU Heidelberg, Öko-Institut, IVE / RMCON.

KÅGESON, P. 1998. Cycle-Beating and the EU Test Cycle for Cars. *In:* ENVIRONMENT, E. F. F. T. A. (ed.) *T&E 98/3.* Brussels: European Federation for Transport and Environment.

LAVUTSLIPPSUTVALGET 2006. Et klimavennlig Norge *In:* MILJØVERNDEPARTEMENTET (ed.). Oslo: NOU 2006:18 Miljøverndepartementet, Oslo.

LERVÅG, L.-E. 2009. Grønn godstransport: Miljøtyring i transportbedrifter Behovsundersøkelse (Green Freight Transport: User needs assessment). *SINTEF rapport A11626.* Trondheim: SINTEF.

LEVIN, T. & SUND, A. B. 2010. Green Freight - Every penny counts. *Selected Proceedings of the 12th World Conference on Transport Research Society.* Lisbon.

MCKINNON, A. C. 2010. Environmental sustainability. *In:* MCKINNON, A., CULLINANE, S., BROWNE, M. & WHITEING, A. (eds.) *Green logistics : improving the environmental sustainability of logistics.* London ; Philadelphia: Kogan Page.

NETWORK FOR TRANSPORT AND ENVIRONMENT. 2012. *NTMCalc* [Online]. Available: http://www.ntmcalc.org/index.html [Accessed October 10th 2012].

OTERHALS, O., DUGNAS, K. & NETTER, J. E. N. 2009. NyFrakt. Analyse av kystfrakteflåten. (Analysis of the costal freight fleet). Molde: Møreforsking Molde AS