

# Method for understanding where winter maintenance could be more energy efficient

L. Nordin

Department of Earth Sciences, University of Gothenburg, Sweden

e-mail: [lina.nordin@gvc.gu.se](mailto:lina.nordin@gvc.gu.se)

## Abstract

*In road maintenance district Trollhättan in the Midwest of Sweden there is an ongoing PhD-project about how to make winter maintenance of roads more energy efficient. Winter maintenance was compared to slipperiness information from the Road Weather information system – RWIS in order to isolate occasions that had the potential to become more energy efficient. Information about maintenance activities was matched against RWIS information to understand how often the maintenance was actually performed in accordance with slipperiness on the road surface. The Swedish Road Administration (SRA) is very tough on saving money but still the safety is the number one priority. This makes it hard for the contractor managing the maintenance district. In order for them to be compensated for their work the RWIS need to have detected one of several slipperiness criteria. It is hence crucial to find a method to detect occasions of maintenance which might not have been needed according to the weather. The results of this method show that about 15 % of the maintenance occasions were performed when there were no indications of slipperiness from any of the RWIS stations in the region. The method also reveals that in 30% of the occasions there were only some of the RWIS stations in the area indicating slipperiness. This could suggest a potential for savings if parts of the region were maintained differently.*

## Introduction

There have been many improvements in winter road maintenance over the years. Such improvements are for example anti-icing, which has been shown to be the most effective maintenance for slippery roads (Chollar, 1996). New techniques in ploughing or the use of salt solution instead of salt as a solid are yet other improvements. The list is long and continues to grow. The driving force for improvements is often the environment and with that comes the term energy efficiency. It can be seen in many parts of today's society. Industries want to become more efficient to save money and create competitive advantages. In Sweden such ideas have reached winter road maintenance. The Swedish Road Administration (SRA) declares different goals for the transportation sector. These goals are influenced by other large actors in different sectors. The EU-directives about traffic safety and the reduction of greenhouse gases by the year of 2020 have been the main source for these ambitions along with organisational aims of important industries in Sweden such as the transportation solutions company; Volvogroup (SRA, 2008A). The transport political aims proposed by the Swedish government (SG) are to keep the transportation socio-economical and long-term sustainable for the citizens as well as the industry. The proposition also declares that the transportation sector should contribute in keeping the environmental aim *Reduced Climate influence by reducing the use of fossil fuels* a long side with becoming more energy efficient (SG, 2008). Since one quarter of the energy use in Sweden comes from the transportation sector and the road traffic stands for about 94 % (Swedish Energy Agency, 2009) of this it lies in the governmental and public interests as well as in the contractor's to reduce the energy use.

Winter maintenance of the roads is the single most expensive task for operating the roads in Sweden today (SRA, 2009). Most of the winter road maintenance includes transportation as the roads often are chemically treated in winter time.

In road maintenance of Sweden the ambition is to reduce the energy use in terms of transportation. This can of course be done through the use of new less energy prone techniques as well as eco-driving. But even though the personnel are obliged to be educated in this they seem to find it difficult to use this within their every day work. This study focuses on the maintenance district of Trollhättan in the Midwest of Sweden. The ongoing research project is set to evaluate and study other methods and potentials in reducing energy use. Some of the areas in focus are route and vehicle use optimization, decreasing number of vehicles due to new improved maintenance techniques and reduced number of maintenance events due to better forecasts, better knowledge of the road conditions or changed type of maintenance action.

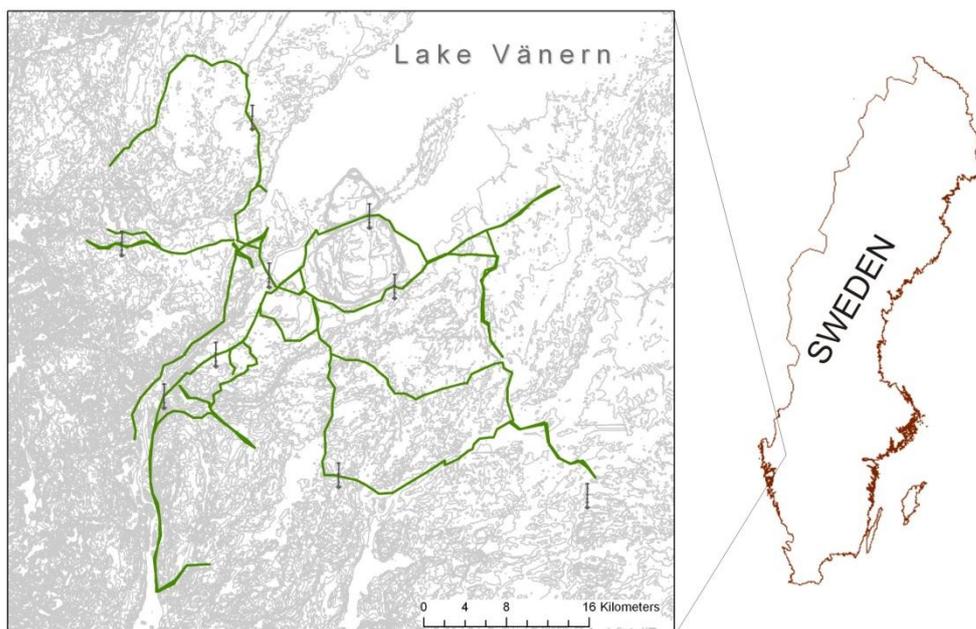


Figure 1, Map over maintenance district Trollhättan. The green lines represent the 5 routes used in the study. The RWIS stations are the vertical lines close to the roads.

## Objective

A first step in making winter maintenance of roads more energy efficient is to investigate where energy is used and to what extent this use is redundant. The different maintenance activities are performed either after a set schedule such as the road construction inspections every third day, or they are set on an *as-it-occurs* basis which is more dynamical. The objective of this study was to create a methodology for understanding the potentials in saving energy by better understanding this *as-it-occurs* type of maintenance. The weather creates such type of maintenance activity since the weather changes in frequency as well as intensity over time.

The hypothesis of this study is that some of the maintenance that is controlled by the weather is done in excess.

## **Data**

Days of slippery occasions were obtained from the Road Weather Information System (RWIS) data in the region. There are nine RWIS stations in the area only five of them were chosen for the study. The selected stations are situated along each of the five maintenance routes in the area. The green lines in figure 1 are the roads that are used in this study. Three of the neglected stations showed unreliable data and was hence excluded from the study. The RWIS in Sweden are run by the Swedish Road Administration (SRA). Temperatures at two metres above ground and on the surface are measured as well as wind speed, wind direction, amount of precipitation and type of precipitation. Each contractor may download information from these stations such as road temperatures or modelled warnings about slipperiness (further on called the slippery weather warning) hence the different slipperiness codes from these data were used in the study to compare the number of maintenance activities to the occurring weather.

The maintenance data used comes from the driver logbooks. In the logbook the maintenance personnel record start and stop times for an activity. Data used is from the winter period (October to April) of 2008-2009.

## **Methodology**

As mentioned the main objective is to create a method to find potentials in saving energy within the winter maintenance activities. In order to do this the weather data was to be matched in time with the maintenance data. This was done by dividing the hours of the day into four sections, from midnight until 06:00 (1), from 06:00 to noon (2), from noon to 18:00 (3) and from 18:00 to midnight (4). The same time span was used for the maintenance data. The starting time for each winter maintenance activity was sorted into one of the four time spans as was the slippery weather warnings. This gives that each maintenance activity was given a number from 1-4 as was the slippery weather warnings from the RWIS. Only warnings that lasted over one hour in time was used since contractors will not get compensated for shorter weather warnings than that. Every time interval where there could have been slippery conditions on the roads was summarized to make a maximum of winter slippery indications. These indications came from that either a maintenance activity was performed or a weather warning was given from the RWIS. The maintenance activity number (1-4) was compared to the weather warning number (1-4) of the RWIS closest to the specific maintenance route mentioned in the data section. A set of questions was then asked to the dataset to understand how well maintenance compared to the weather. The questions and the percentage of winter slippery indication are presented in table 1.

## **Results and discussion**

The questions asked to the dataset gave a total number of slippery indications which was used in the percentage calculations. As presented in table 1, the maintenance activities in the district agreed with all the RWIS in the area during 27 % of the total indications and 30% agreed with some of the stations in the area. This indicated that about 60% of the maintenance was done in accordance with the weather. However, during the 30 % of the slippery occasions that only some RWIS indicated slipperiness there could be a potential for energy savings if the different maintenance routes in the area were performed differently depending on local climatological aspects. It seems that such an approach could be possible since there in this study sporadically are such occasions were only some

maintenance is performed. Such occasions are signified by the last two rows of table 1 where some RWIS indicate slipperiness, 11 %, and 5 % where no RWIS indicated slipperiness.

*Table 1, Presentation of questions and distribution in percentage of winter maintenance and weather match.*

Questions	Abbreviation	Part of winter slippery indication (%)
All Maintenance agrees with All RWIS in district	AMAR	27
All Maintenance agrees with Some RWIS in district	AMSR	30
All Maintenance does Not agree with any RWIS	AMNR	15
No Maintenance but All RWIS in the district	NMAR	3
No Maintenance even though Some RWIS	NMSR	9
Some Maintenance agree with Some RWIS	SMSR	11
Some Maintenance but No RWIS	SMNR	5

During 3 % of the indications there were no maintenance performed yet all the RWIS in the area measured slippery conditions. During another 9% of the time there were no maintenance yet some RWIS in the area registered slippery conditions. This is also interesting and could be because the RWIS indicated something that was not true. It could be that there was still salt on the roads and that the freezing point hence was lower than what was indicated in the weather warnings. It could also be because the maintenance personnel misjudged the situation, or that the few stations that showed slipperiness was erroneous. Perhaps there was just a slight slipperiness which occurred during a time of the day when there was little traffic and hence no maintenance was performed.

The 15 % maintenance performed without any indications from the RWIS could indicate potentials for energy savings if performed maintenance was proven to be unnecessary. 15% of the about 200 events that maintenance was performed in the maintenance district with 425 km of roads, gives a potential decrease of 30 events which is about 12750 driven kilometres per winter.

Assumed that the fuel consumption is 3,5 l/10 km. For each round that can be left out about  $3,5 * 42,5 = 149$  litres of fuel can be saved. Assuming that each of the 30 events was unnecessary would give 4462,5 litres of fuel saved in a winter in the district. A calculation of the energy use for those 30 events will be 120 000 MJ according to calculations done by NTMCALC (NTM,2009). This would prove the hypothesis of the study to be true.

But it is important to know that it is probably not as simple as that, the RWIS could be missing something crucial on the road surface. The safety of the roads is the main issue for the contractor. A system which predicted road surface temperatures along the roads such as the XRWIS (Thornes and Chapman, 2008) or a Maintenance decision support system (MDSS) (Mahoney and Myers, 2003) could possibly give a more energy efficient winter maintenance, but in order to do so the contractor would have to fully rely on the system.

## Conclusions

The study resulted in a method to understand where and when maintenance was done in accordance to the occurring weather. The method called **Winter Maintenance Weather Match**

**(WIMWEM)** was used to investigate the potentials for energy efficiency in the part of winter maintenance that is determined by the weather.

One interesting result was that not all maintenance routes in the district of Trollhättan were maintained every time which indicated that it might be possible to optimize maintenance according to different climatic areas.

About 60% of the slippery weather indications were maintained in accordance with the outcome of the weather. This implies that it must be really difficult for maintenance personnel to decide upon when or where maintenance should be performed, since the SRA only compensates for those slippery events that are indicated by the RWIS. The contractor should hence be striving for only maintaining when absolutely necessary or they might run at a loss. This is not an easy task since unmaintained roads increases the risks for the road users.

One way of making the winter maintenance more energy efficient is hence to get better and more sufficient decision making tools and to get the maintenance personnel to trust in the outcome of these tools.

What energy savings could be made? A quick calculation showed that the maintenance district of Trollhättan might be able to reduce the number of maintenance activities by 30 events which equals a reduction of 12750 driven kilometres or 120 000 MJ of energy every winter.

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