Implementing Weigh-In-Motion for Generation of Carbon Offset Credits in Canada

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Paper prepared for presentation at the
ITS Canada 2011AGM
Vancouver, BC
ABSTRACT

In 2002, Canada ratified the Kyoto Protocol and committed to reducing its greenhouse gas (GHG) emissions by six percent from 1990 levels by 2012. Currently Canada is struggling to meet this target. Canada remains committed to working towards reducing GHG emissions and has developed an Offset System to encourage industry to develop methods of reducing GHGs. This Offset System requires specific procedures for quantification, data management and verification by a third party that must be followed and maintained to qualify for the compliance market for carbon credits.

Weigh-in-motion (WIM) and other intelligent transportation systems (ITS) have been shown to improve efficiencies in trucking while still enforcing weight and dimension legislation to protect roadway infrastructure. With the implementation of these technologies the amount of GHG emissions generated from trucking enforcement requirements may be reduced. This paper reviews how specific WIM and ITS technologies can be implemented to meet the carbon emission reduction quantification, data management, verification of data and reporting procedures that are required to be maintained and reported under Canada’s Offset System for Greenhouse Gases.

The case study presented reviews two scenarios of implementing ramp and mainline WIM sorting systems integrated with various ITS technologies compared to the use of traditional static scales. The findings of this case study show that with the implementation of various WIM and ITS technologies, there is a significant decrease in the delays trucks experience which results in the generation of potential carbon credits that may be sold for revenue by an agency.

1.0 INTRODUCTION AND BACKGROUND

Canada ratified the Kyoto Protocol in 2002 and committed to a six percent reduction in GHG emissions from 1990 levels between 2008 and 2012 (1). Recently Canada has committed to the Copenhagen Accord agreeing to a 17% reduction of GHG emissions from 2005 levels by 2020 (2). Canada faces a great challenge to reduce these GHG emission levels as in March 2010 it was reported that GHG emissions were at levels 25% greater than those in 1990, resulting in being 32% above the Kyoto Target (2). It is also estimated that if Canada does not take action the
emission levels could reach 940 Mt by 2020, this is 58% higher than the 1990 emission levels (3).

As Canada works towards reducing the amount of GHG emissions generated it has set up various programs and incentives to encourage citizens and industries to reduce their emissions. Some of the initiatives in the past for the transportation industry have included the One-Tonne Challenge, Freight Efficiency and Technology Initiative and the amending of the sulphur in diesel fuel regulations (4). The development of Canada’s Offset System for Greenhouse Gases is an initiative by the Government of Canada to reduce the overall amount of GHG emissions in Canada by encouraging the development of cost-effective solutions to the reduction of carbon emissions (5). This system can be applied to any type of industry, allowing carbon credits to be generated by parties where carbon reductions are easily and economically achieved and then these carbon credits can be purchased by those parties that may have a more difficult time reducing carbon generation.

A carbon credit offset is: “a reduction in GHG emissions created by one party that can be purchased and used to balance emissions of another party” (6). A number of carbon credit markets have been introduced around the world. These markets may be categorized into either the Voluntary Carbon Market or into the Compliance Carbon Market (7). The Voluntary Carbon Markets are generally used by parties who voluntarily choose to purchase carbon offsets. The quality of the credits that may be purchased within the voluntary system may be questionable. Prior to purchasing any credits from a voluntary system the quality of the credit should be reviewed. The Compliance Carbon Market is used by parties that are regulated in government programs as government programs require strict review processes to be in place to verify that the carbon offsets that are being purchased are real (7). The requirements outlined in Canada’s Offset System for Greenhouse Gases places the system within the Compliance Carbon Market.

The World Resources Institute reports that globally the transportation sector is responsible for 14% of GHG emissions of which 72% is generated from travel on roadways (6). In 2007, the transportation sector in Canada was identified as the second largest source for GHG emissions by sector in Canada at 27% (9). From 2000 to 2007 the emissions from transportation increased
from 187 to 200 Mt, a rate of 1.6% per year while the total overall emissions for Canada grew at a rate of 0.6% per year (9). While the fuel efficiencies of vehicles has improved over these years, overall emission increases can be attributed to the increased movement activity of freight and passengers, the shift of transportation modes to ones that are more fuel intensive and the fact that most fuels are carbon based (9).

The transportation network is critical not only to the Canadian / North American economy but also to the standard of living that Canadian’s have become accustomed to (10). In 2004, there was just over 1.4 million equivalent two lane kilometres of roadways consisting of freeways, highways and local roadways in Canada (10). Almost everything that is purchased including food, building materials and vehicles are transported by truck (11). In 2005 the trucking industry in Canada employed 171,000 people, contributed $14.2 billion dollars to the Canadian economy and comprised 28.8% of the transportation and warehousing Gross Domestic Product (GDP)(11). For-hire trucking companies in 2004, hauled 65.9 million shipments, weighing 604.3 million tonnes on Canadian roadways (11). From 1989 to 2006 the goods carried by the for-hire trucks in Canada increased by 59% (10). The tonne-kilometre increased by 144% because of the concept of just-in-time delivery resulting in more trucks being on the road (10).

With the Canadian economy so dependent upon the transportation network and the cost of operating a truck is estimated at approximately $2/min, many companies ensure that trucks are loaded as much as possible (12). It has been shown that vehicles that are over the allowable weight will cause damage to the roadways (13). To regulate and enforce weight and dimension legislation static weigh stations have been constructed throughout North America. However, with growing truck traffic traditional static weigh stations may have trucks queue on the roadway as the capacity of the weigh station is not sufficient. Weigh station queues may grow onto the highway causing safety issues and congestion for all vehicles. Trucks called into a static scale weigh station must wait for their turn to be weighed resulting in not only a long wait time, but additional emissions being generated from stopping and idling (13). The implementation of Intelligent Transportation Systems (ITS) such as weigh-in-motion (WIM), automatic vehicle identification (AVI) and vehicle tracking have been implemented to address the issues related to traditional static weigh stations (13).
2.0 STUDY OBJECTIVE AND SCOPE
The objective of this project is to investigate and model the requirements for implementing Canada’s Offset System for Greenhouse Gases to a project and to review how the implementation of WIM and other ITS technologies can be utilized for emission reduction quantification, data management, verification of data and reporting procedures that are required.

3.0 OVERVIEW OF CANADA’S OFFSET SYSTEM FOR GREENHOUSE GASES
Canada’s Offset System for Carbon Credits has been established to encourage cost-effective methods of GHG reduction that are not covered by other federal incentives or regulations for reduction (5). The system is regulated through Environment Canada under the Environmental Protection Act 1999, section 322 as a voluntary program (5). This is the proposed market where carbon credits may be sold at a national level (5). This system has been developed base on five principles which are (5):

- That there are net environmental benefits with GHG reduction,
- GHG reductions are in Canada,
- Maximize the scope of the system to cover many project types over various sectors,
- Maintain a simple administrative system that is cost-effective and practical to minimize the burden of the participant but to ensure the integrity of the system is maintained, and
- To build on experience of previous projects.

For a project to receive offset credits, Proponents must complete the five steps as summarized in Figure 1.

Step 1: Creation of a Quantification Protocol

Step 2: Registration of the Project

Step 3: Implementation of the Registered Project and Monitoring of Data

Step 4: Reporting and Verification of Reductions from the Registered Project

Step 5: Certification of Reductions and Issuance of Offset Credits

Figure 1: Steps for Achieving Canada’s Offset Credits (5)
3.1 Step 1 – Creation of a Quantification Protocol
The first step is to develop the Quantification Protocol which details the approach that the Proponent will use to implement procedures, calculate offset credits and monitor and manage data collected for a project. In some cases for specific project types, protocols have been already developed and an applicant may fast track an application (14). The protocol that is developed is reviewed based on the international standard ISO 14064-2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements. Six principles are presented in this standard including Relevance, Completeness, Consistency, Accuracy, Transparency and Conservativeness (5).

3.2 Step 2 – Registration of the Project
If a project is registered (Step 2) this indicates to the Proponent that if the project is implemented as detailed in the Quantification Protocol that it will most likely generate offset credits (5). For a project to be registered under the offset system six eligibility criteria must be met. Many of these eligibility criteria are addressed during the development of the Quantification Protocol. These criteria are (5):

1. Scope – The project must take place in Canada and reduce one or more of the six GHGs.
2. Real – After accounting for all of the GHG sources, sinks and reservoirs within a project, the Proponent must show specific and identifiable action for which the reduction occurs.
3. Incremental – Any credits that are applied for must be in addition to the regulatory requirements and other climate change incentives.
4. Quantifiable – GHGs must be able to be quantified.
5. Verifiable – A third party verifier must review the GHG reduction claims of the project.
6. Unique – The GHG reduction can only be used once for offset credits.

3.3 Step 3 - Implementation of the Registered Project and Monitoring of Data
The third step is for the Proponent to implement the project as detailed in the Quantification Protocol. Once the project has been implemented the Proponent must monitor the data that is being collected.
3.4 Step 4 - Reporting and Verification of Reductions from the Registered Project
The fourth step involves the reporting and verification of the carbon reductions and is critical to the offset system as it ensures that the environmental integrity is maintained. To qualify for earning offset credits the Proponent must show that a third party verifier, who is accredited by the Standards Council of Canada, has reviewed how the data has been collected and managed and if it has been done as detailed in the Quantification Protocol (5). The outcome from the review will be a positive, qualified or adverse conclusion. A positive conclusion indicates that there are no major discrepancies with the quantification system. A qualified conclusion indicates that the reviewer found issues with the system however they were beyond the control of the Proponent. An adverse conclusion indicates that the review has found discrepancies within the system (5).

3.5 Step 5 – Certification of Reductions and Issuance of Offset Credits
The final step to receive certification for the reduction and carbon offset credits involves a final review to ensure that all the requirements needed are met. This process ensures that the integrity of the Offset System is maintained (5). Once this final check is completed the credits are placed in an account with a serial number and they now may be traded, banked or used for compliance purposes. All information collected during the establishment of the credits must be retained for eight years as audits may be completed at a later date. If a party is found to be in noncompliance, action by the government may be taken (5).

4.0 WIM AND ITS IMPLEMENTATION
Agencies have implemented WIM to protect their roadway infrastructure and to enforce weight and dimension legislation. With the implementation of this system great savings can be achieved by the trucking agencies by reducing the wait time for trucks and reducing the amount of fuel that is consumed (13).

The general operation of a dynamic weigh scale involves a number of systems in addition to the WIM system that is implemented. WIM technologies that are available for implementation include piezoelectric sensors, quartz sensors, bending plates and load cells. The implementation of a specific WIM system will depend on the needs of an agency. The most accurate system is
the load cell followed by the bending plate, quartz sensors and then the piezoelectric sensor (15). The costs of these WIM systems increase with increased accuracy (15). Depending on the configuration of a dynamic scale various other technologies will be required to fully operate the scale. The number and variety of additional technologies will depend on the information that is being collected and the purpose of the station.

The information that is created by the vehicle travelling across the WIM technology must be translated with the use of software to a useable form of information. This software also allows for communication and calibration from an in-house computer to be utilized as needed to ensure that all of the systems are running properly. These systems also allow for reports to be completed based on the information that has been collected (15).

With the use of the WIM technologies that are already in place a framework for the calculation of carbon offset credits was developed as shown in Figure 2. With this framework only those trucks that are not required to stop would qualify to generate offset credits. As each truck that passes a static weigh station is unique, to accurately determine the amount of carbon emissions that are reduced, specific information about each truck will be required to be collected. The case study presented in section 5.0 will detail how this can be achieved. If all of the information that is required from the truck for the calculations is received, then carbon credits may be generated. To protect the integrity of the carbon credit system if any information about the truck is missing no carbon credits will be generated.
5.0 CASE STUDY

This case study will review how various ITS technologies can be used to meet the requirements for quantification, data monitoring, verification and reporting for implementing Canada’s Offset System for Greenhouse Gases. The case study also reviews the application of these systems to ramp and mainline WIM truck sorting systems to quantify the amount of carbon that can be
reduced and as a result carbon credits generated. A review to determine if implementing WIM at static scales to reduce the amount of GHG emissions generated can qualify for offset credits under Canada’s Offset System was completed. The findings were that all of the requirements set out in Steps 1 and 2 of the Offset System can be met and as a result the implementation of WIM is anticipated to qualify for generation of carbon credit offsets in Canada (16).

5.1 Implementation of ITS Technologies

As part of the Quantification Protocol that is developed, the specific calculations that are used to determine the amount of carbon reductions that are achieved must be indicated. Couraud constructed a truck emissions model at the University Saskatchewan and identified a number of independent and dependent variables that must be considered including various vehicle, fuel and field properties (17). To be able to accurately determine the amount of emissions that are reduced by the implementation of dynamic scales, the specific information from each truck is required. This information can be gathered using various ITS technologies including transponders, imaging and automatic vehicle identification (AVI).

Information from a truck can be received by a weigh station in two ways. The first is to use vehicle imaging and AVI. By implementing these technologies this will allow a weight station to identify a vehicle based on a specific number on the side of the truck or a license plate and then refer that identification value to a different data base where information on the truck is stored. However, a truck must be registered for this information to be collected. The second method would be to collect the information through transponders that are on the truck.

When a truck approaches a weigh station it will cross a WIM scale measuring the weight of the vehicle. If the vehicle is in compliance with the dimension and weight restrictions then the vehicle may continue. If the vehicle is in non-compliance then it will be indicated to pull into the station by a variable message board. With the truck required to enter the weigh station no carbon credits will be generated based on the framework shown in Figure 2. Some agencies have built a large network of weigh stations that share information on trucks and work together to protect the roadway infrastructure while minimizing the stopping time for trucks on the roadway. In these instances, weigh stations can be integrated electronically to work together to pre-clear trucks so
that once they are cleared at the first station and as long as they reach the station within the allowed time they will be cleared at the other stations. With pre-clearing, the information of the truck will be contained within the shared computer system and with each station that is passed the reduced emissions can be calculated.

The information that is collected in both systems is translated by software from the field to the office. This collected information can be used to meet the data requirements that are needed in the Quantification Protocol. The data that may be collected on site includes site identification, time and date of vehicle passing, the lane number, vehicle speed and classification, weight, invalid measurements and other information. All of this information can be collected without any communication from the truck. Reports from the information collected can also be generated based on various types of formats (15). These formats can be set up to meet the reporting requirements for the Offset System.

A program can be set up that utilizes the information collected from the WIM application and combined with the information collected about the truck to conduct the calculations that are needed to determine the amount of carbon emissions that are reduced. Reports can then be generated which include any information that is required to meet the reporting requirements of the Offset System.

Carbon credits will only be generated for those trucks that are allowed to bypass a weigh station and where all of the information that is required to conduct the calculation for the amount of emissions reduced as shown in Figure 2. If all of the vehicle information is not available for a specific truck it should not be included in the carbon credit amount to protect the integrity of the Offset System over the long term. As a result the type of WIM technology that is implemented will not impact the result if carbon credits that can be generated but rather it will only depend if the vehicle is required to stop or not.

Two types of WIM sorting systems, ramp and mainline sorting are reviewed in this case study. Each of these systems are shown in Figure 3 and 4 below. The key difference between these systems is that for the ramp sorting system the trucks must slow down and exit the mainline
roadway and go through a portion of the station whereas with the mainline sorting system no stopping or reduction of speed is required by the truck unless they must enter the station. By allowing trucks to continue travelling at highway speeds the amount of GHG emissions that are generated are further reduced compared to the ramp sorting system.

Figure 3: Ramp WIM Sorter (18)

Figure 4: Mainline WIM Sorter (18)
5.2 Model for Case Study

Based on the model that was constructed by Couraud, a case study was completed to model the amount of CO\textsubscript{2} emission reductions that would occur with the implementation of a ramp WIM sorter and mainline WIM sorter compared to a static scale (17). The model was based on 150,000 trucks ranging from 32,500 to 50,000 kg travelling 1000 km in one day for 250 day/year with three stops a day for weight enforcement purposes. When only considering idling of a truck at a weigh station the results of the model indicated a reduction of 228,000 tonnes of CO\textsubscript{2} is expected with the implementation of WIM compared to a static scale (17). This reduction of 228,000 tonnes of CO\textsubscript{2} may be applied to the implementation of a ramp WIM sorter. To compare the CO\textsubscript{2} emission reductions of the mainline sorting system the additional emissions that are generated through the deceleration and acceleration for the truck must be determined.

Based on the work that Couraud completed and a number of assumptions, the emissions generated per truck per entrance is 900 g and per exit is 960 g (17). The assumptions that are made to calculate these values include:

- 300m acceleration and deceleration length for a ramp WIM sorting system,
- average total horse power requirement of 500 HP for the truck,
- 75% efficiency rate for the truck for acceleration compared to operating values, and
- 80% efficiency rate for the truck for deceleration compared to operating values.

Based on the case study parameters developed by Couraud this is equal to a total of 209,250 tonnes of CO\textsubscript{2} per year. By implementing a mainline WIM sorter the total reduction of CO\textsubscript{2} emissions that are expected to be reduced with the elimination of idling and the acceleration and deceleration that is required with the ramp WIM sorter is 437,250 tonnes compared to a traditional static scale. The comparison of the CO\textsubscript{2} reductions for the ramp and mainline WIM sorters is shown in Figure 5.
Based on these reductions for the implementation of ramp and mainline sorting systems a total of 228,000 and 437,250 carbon offset credits may be generated for the implementation of the each respective system. Couraud reviewed the world wide price of carbon credits which ranged from $0.26 to $233.26 per tonne in 2004 dollars (17). Couraud determined that the base value per tonne of carbon was $41.69. By using the base value for carbon credits the amount of revenues that an agency could generate by implementing a ramp sorting system is approximately $9.5 million and $18.2 million for implementation of a mainline WIM sorting system. This is shown in Figure 6.
6.0 SUMMARY AND CONCLUSIONS

Canada and the world are facing a great challenge to reduce the amount of GHG emissions that are being created. Canada ratified the Kyoto Protocol committing to a six percent reduction in GHG emissions from 1990 between 2008 and 2012 however, it does not appear that this target will be met (1, 2). To encourage the development of alternative technologies that can reduce GHGs Canada has developed an Offset System for Greenhouse Gases.

Canadians are very dependent upon the trucking industry to deliver goods to various markets. Within Canada, the transportation industry is the second largest contributor to GHG emission at 27% (9). With the cost for hauling of goods increasing due to labour and fuel, trucking companies want to haul as many goods as possible at one time. Roadway agencies have observed that when vehicles are heavily loaded, significant damage will be caused to the roadways (13). As a result weigh stations have been constructed by agencies to enforce weight and dimension legislation. Static scales were first implemented however, long weight times for trucks were often observed.

WIM technologies were introduced which protect an agency’s roadway infrastructure without requiring trucks to stop. With the implementation of this technology not only are the wait times reduced but the amount of emissions that are released are also reduced as trucks no longer are required to start, stop and idle as they wait in line.

With Canada’s Offset System for Greenhouse Gases, requirements must be met for quantification, data management and verification procedures. This paper reviews the technology that is implemented for WIM and shows that the technology to collect the information required is currently available. Some modifications or additions to information that is collected and software that is used need to be coordinated to implement the tracking of GHG reductions.

Despite the Offset System currently in draft form, the quantification of GHG reductions could move forward and may be considered under other markets until the Canadian system is officially running. The revenues that could be earned by agency’s implementing WIM at static stations could be used to offset funds lost from fuel taxes due to the improved efficiency of trucks or the
money could go back into the maintenance, rehabilitation and construction of the roadway infrastructure.
7.0 REFERENCES
