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Using carbon dioxide emissions as a criterion to award road construction projects: a pilot case in Flanders

Joke Anthonissen [a,*], Dirk Van Troyen[b], Johan Braet [c], Wim Van den bergh [a,1]

[a] Faculty of Applied Engineering – Constructions, University of Antwerp, Rodestraat 4, 2000 Antwerp, Belgium

[b] Agency for Roads and Traffic – Road Engineering Department, Flemish Government, Olympiadenlaan 10, 1140 Evere, Belgium, E-mail address: dirk.vantroyen@mow.vlaanderen.be

[c] Departement Engineering Management, Faculty of Applied Economics, University of Antwerp, Prinsstraat 13, 2000 Antwerp, Belgium, E-mail address: johan.braet@uantwerpen.be

*Corresponding author:

Tel.: +32 3 213 79 34

E-mail address: joke.anthonissen@uantwerpen.be

[1] E-mail address: wim.vandenbergh@uantwerpen.be

Abstract

In the last decade, innovative technologies with regard to improved energy and material efficiency of asphalt pavement construction have been implemented by road industries. Two technologies are currently advocated: warm mix asphalt technologies and the increased use of reclaimed asphalt pavement. Unfortunately, these technologies were evaluated only by their technical and economic benefits and in most cases without an environmental impact study for the overall process. For encouraging the endeavour of the industry to implement newer – greener – technologies with focus to environmental benefit, the procuring authorities made an effort to enforce a sustainable approach for road works by the Project Carbon Free-ways. This pilot project included basic environmental parameters in the award criteria for public tenders on road works in Flanders. For this project two calculation tools, called Carbon Counter and Traffic Tool, were developed by the Flemish Agency for Roads and Traffic in order to estimate the carbon dioxide emissions of respectively the construction process and the traffic disturbance caused by the construction. The subject of this first public tender – with an evaluation of both tools – was the reconstruction of an asphalt road pavement in Kontich (Belgium). In this contribution the preliminary study on the methods of the tools and the main conclusions of the project are reported and discussed. The study illustrated that the current tendering process and the tools used, do have some limitations and drawbacks: the tools do not cover the total environmental impact as e.g. LCA do, the data concerning recycling or specific plant-related processes are outdated or missing and the data collection for back calculation of the total emission required too much manual efforts and shortcomings. Nevertheless, this pilot project proved to be a valued attempt to achieve more innovative and sustainable public procurement – as a first step, giving an unambiguous signal to the industry that this type of selection will be part of future tenders.

Keywords

Green public procurement, greenhouse gas emissions, asphalt pavement, road engineering, carbon footprint, traffic

1 Introduction

The compulsory targets to reduce the greenhouse gases, initiated by the Kyoto protocol encouraged a search for innovative techniques. Various technologies have been developed by the road pavement industry in order to reduce the environmental impact: the use of reclaimed asphalt pavement; reducing the asphalt production temperatures; and concepts that prolong the service life of a pavement. According to the annual report Asphalt in Figures (European Asphalt Pavement Association, 2014) the total production of hot mix asphalt (HMA) and warm mix asphalt (WMA) in Belgium in 2013 totalling 5.3 million tons of which 51% contain reclaimed asphalt. In this way 61% of 1.5 million tons available reclaimed asphalt was used in HMA and WMA. According to the Flemish guidelines on best available techniques for asphalt plants (Leyssens, Verstappen, & Huybrechts, 2013), recycling reclaimed asphalt in asphalt is seen as the best solution in Flanders (a region within Belgium) to decrease waste disposal and use of natural materials.

The contracting pavement administrator has an important role by encouraging a more sustainable road infrastructure. Green public procurement (GPP) can be understood as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" (European Commission, 2008). The European Commission (European Commission, 2014) stated that the criteria for GPP used by Member States should be equal to avoid distortion of the market and reduction of EU-wide competition; and to reduce the administrative burden. The EU GPP criteria for road construction (currently under revision) are formulated as guidelines rather than specific quantitative criteria (European Commission, 2010). Three core award criteria for GPP were defined: i) the use of secondary aggregates and recycled materials, ii) the durability and performance characteristics, and iii) the reduction of energy consumption through the life cycle. These three criteria are supplemented with four other, comprehensive GPP award criteria.

A Swedish investigation (Varnäs et al., 2009) found that both public and private clients in the construction industry take environmental impacts into consideration in their procurements, however, environmental criteria in tender evaluation are less common and seldom affect the award decisions. This trend is currently also been observed in Belgium, where until 2014 no environmental criterion was implemented in public tenders for road construction. As summarized by (Testa et al., 2014), the main obstacles limiting the uptake of GPP, are the lack of organizational resources for political support, the limited information on the real environmental impact of the products, the difficulties in preparing calls for tenders and purchasing, the absence of guidelines from general authorities and a non-coordination between authorities.

The Dutch Department of Public Works within the Ministry of Infrastructure and the Environment, Rijkswaterstaat (RWS), implements monetised environmental award criteria in their public procurement for road construction by using two different tools (van Geldermalsen, 2013, 2014). DuboCalc converts life cycle environmental impacts in 11 areas (using a life cycle assessment (LCA) database), into an environmental cost indicator (ECI) value. The CO_2 performance ladder is used to assess the efforts of a company to reduce carbon dioxide (CO_2) emissions caused by the project. The supplier chooses a level of

ambition, with each level yielding a 1% reduction of the submission price. The project is awarded to the supplier with the lowest adjusted quoted price.

The Flemish Agency for Roads and Traffic (ART), in collaboration with the Dutch and British Highways Agencies, considered methods that can reduce CO_2 emissions from road works. These agencies agreed on three evaluation criteria for road construction: procurement, street lighting and construction of the road. The Flemish ART started a pilot project called Carbon Free-Ways, where the reduction of CO_2 emission of the road work was an award criterion for the public tender, together with the price.

Since 2013, the European Union Emission Trading System (European Union, 2013a) covers all installations with a net heat excess of 20 MW. For Flanders (Departement Leefmilieu Natuur en Energie, 2014), 220 installations were subjected to the emission trading system in 2013, together emitting approximately 40% of the greenhouse gas emissions. For the asphalt production sector, 13 of the 19 plants are subjected to this system, representing 43,269 tons CO_2 equivalent or 0.13% of the registered CO_2 equivalent emissions in Flanders.

2 Pilot project Carbon Free-Ways: objective and approach

The objective of the pilot project Carbon Free-Ways was to stimulate CO_2 efficient working methods for road construction. The authors want to emphasize that taking into account only CO_2 emissions, will lead to a significant underestimation of the full environmental impact by excluding impact categories such as fossil depletion, land use, human and ecotoxicity, ionising radiation, eutrophication, particulate matter, etc. (European Union, 2013 b). The public tender for this road work, executed in May 2014, included: milling and repaving a test section on a Flemish primary road (N171 in Kontich); applying road markings; providing traffic management; and the maintenance of the work during the three year warranty period. The test section was 1 km long, consisting two lanes and a paved emergency lane in each direction. The work, monitored in the context of the pilot study, included repaving the base (7 cm) and top (3 cm) layer of the test section.

2.1 Operation procedure of the pilot

Presently, for all public works, the tender price is the standard (sole) award criterion. In this pilot project the tender was evaluated by price for 50% and by CO_2 emissions for the other 50%. The score for the price (maximum 50 points) was calculated with equation (1).

$$score\ price = 50 - 25 \times \left(\frac{P - P_{min}}{P_m - P_{min}}\right) \qquad (1)$$

With: *P: project price of the contractor in euro;*
P_{min}: lowest price of all applicants;
P_m: arithmetical average of the prices from all applicants.

Two different tools were developed by the Flemish ART in order to calculate the theoretical CO_2 emissions based on measurable data. All contractors, applying for the public tender, were forced to use

these two tools to calculate the emissions. The Carbon Counter (original Dutch name: '*Koolstofteller*'), accounting for a weight of 30% in the judgment, was used to calculate the emissions from the asphalt production, the transport of materials and the production of the raw components of the asphalt mixture. The score for the Carbon Counter (maximum 30 points) was calculated with equation 2.

$$score\ Carbon\ Counter = 15 + \frac{15}{0.25} \times \left(1 - \frac{CO_{2,kt}}{CO_{2,kt,m}}\right) \qquad (2)$$

With: $CO_{2,kt}$ *: tons of* CO_2 *produced (the Carbon Counter result);*
$CO_{2,kt,m}$*: arithmetical average of the Carbon Counter results from all applicants in ton .*

The Traffic Tool, which counted for 20%, was used to calculate the extra emissions due to the disturbance of the traffic. The score for the Traffic Tool (maximum 20 points) was calculated with equation 3.

$$score\ Traffic\ Tool = 10 + \frac{10}{0.25} \times \left(1 - \frac{CO_{2,tt}}{CO_{2,tt,m}}\right) \qquad (3)$$

With: $CO_{2,tt}$*: tons of* CO_2 *produced by disturbed traffic (the Traffic Tool result);*
$CO_{2,tt,m}$*: arithmetical average of the Traffic Tool results from all applicants in ton.*

$$total\ score = score\ price + score\ Carbon\ Counter + score\ Traffic\ Tool \qquad (4)$$

The contractor was selected based on the application with the highest total score (equation 4).
Measurable and verifiable parameters were reported and used by the contactor as input data for the assessment of the CO_2 emissions: amount of raw materials; transport distances and methods; the energy type and consumption on the asphalt plant; and the working period and traffic management scenario.
The objective of these tools was to compare different execution methods and to select the most CO_2 efficient candidate based on the calculated values rather than accurately estimating the total CO_2 emitted for this work.

After completion of the work, ART used both tools to calculate the emissions based on the verified data, collected during the construction. A positive or negative difference with the emissions declared by the applicant larger than 5% would lead to respectively a penalty or bonus.
Furthermore, after the construction, the longitudinal evenness of the pavement is measured. Unevenness or roughness creates vibrations in tires and suspension (Jackson, Willis, Arnold, & Palmer, 2011). Energy is lost in these vibrations because the shock absorbers absorb this energy and hence the fuel consumption is influenced. Shortwave unevenness is seen as the most important factor in determining fuel consumption. It can cause up to 10% changes in fuel consumption. If the measured unevenness is less than 75% of the maximum allowed unevenness as described by the Flemish road standard SB250 ($VC2,5_{i,max}$ = 40 000 mm²/hm for this test section), this will be rewarded with a financial bonus.

2.2 Carbon Counter

The Carbon Counter, worked out in an Excel® sheet, was developed in order to estimate the emissions from the production and transport of raw materials and asphalt. Table 1 illustrates the layout of the tool, based on a very simple, hypothetical case of 300 ton asphalt mixture.

Table 1: Overview of the Layout of the Carbon Counter for a simple, hypothetical case of 300 ton asphalt

RAW MATERIALS

1. Aggregates	Quantity (m^3)	Density (t/m^3)	Mass (ton)	Emission factor (tCO_2/t)	CO_2 (t)
Coarse aggregates (virgin)	84,00	1,600	134,40	0,00520	0,699
Coarse aggregates (recycled)	38,00	1,600	60,80	0,00260	0,158
Sand (virgin)	28,00	1,600	44,80	0,00510	0,228
Sand (recycled)	26,00	1,600	41,60	0,00255	0,106

2. Binder	Quantity (m^3)	Density (t/m^3)	Mass (ton)	Emission factor (tCO_2/t)	CO_2 (t)
Bitumen (virgin)	11,00	1,030	11,33	0,48000	5,438
Bitumen (recycled)	8,00	1,030	8,24	0,24000	1,978
				Total CO_2 (t)	**8,608**

TRANSPORT

1. Raw material from source to plant	Number of journeys	Distance (km/journey)	Conveyance	Emission (g/km)	Share-factor	Utilisation-coefficient (full = 1,5; empty = 1,0)	CO_2 (t)
	10	75	Trailer (25-30 ton)	822,87	0,75	1,5	0,694

2. Transport asphalt mixture to site and return	Number of journeys	Distance (km/journey)	Conveyance	Emission (g/km)	Share-factor	Utilisation-coefficient (full = 1,5; empty = 1,0)	CO_2 (t)
	20	50	Trailer (25-30 ton)	822,87	1,00	1,5	1,234

3. Transport reclaimed pavement	Number of journeys	Distance (km/journey)	Conveyance	Emission (g/km)	Share-factor	Utilisation-coefficient (full = 1,5; empty = 1,0)	CO_2 (t)
	10	50	Trailer (25-30 ton)	822,87	1,00	1,5	0,617
						Total CO_2 (t)	**2,546**

Conveyance	Emission-factor
4-axled truck (16-20 ton)	638,05
Trailer (25-30 ton)	822,87
Barge (per unit of 30 ton)	261,21
Sea-vessel (per unit of 30 ton	206,52
Train (per railroad car)	633,60

ASPHALT PRODUCTION

	Energy source	Quantity (kWh for electricity or m^3 for other)	CO_2 (t)
Drying aggregates	Diesel	0	**0,00**
	Refinergy gas	1500	**3,05**
Warming bitumen	Electricity	30	**0,02**
	Refinergy gas	0	**0,00**
		Total CO_2 (t)	**3,06**

Energy source	Emission factor	Unit
Diesel	3,162661	tCO_2/m^3
Fuel oil	2,90	tCO_2/m^3
Heavy fuel oil	3,1411	tCO_2/m^3
Lignite	2,04	tCO_2/m^3
Refinergy gas	0,002031	tCO_2/m^3
Electricity	0,0005	$tCO_2/kWhe$

The emissions from the production of raw materials (Table 1) are determined by multiplying the mass with a default emission conversion factor in ton CO_2 per ton material, derived from the Inventory of Carbon & Energy (ICE) version 2.0 (Hammond & Jones, 2011). Only the main components of an asphalt mixture are included: coarse aggregates, sand and bitumen. A recycled variant for each material can be selected and is associated with a 50% reduced emission factor. This is a stimulus for the applicant to use recycled materials.
In Flanders, using additives in asphalt is not a common practice and currently no standard emission factors could be found for filler materials. Therefore, emissions from filler and additives are not included in the tool. Nevertheless, different types of filler are on the market, from pure lime stone till biomass filler, and, moreover, the use of both industrial filler and baghouse dust is allowed. One should consider in future the impact of the type of filler in the calculation.

The transport part in Table 1 contains three trajectories: the transport of raw materials to the asphalt plant (supply single way); the transport of the asphalt mixture from the plant to the work site (including the return empty state); and the transport of the milled, old pavement from the worksite to the asphalt plant (the return of the empty truck to site). The user of the tool must select the appropriate means of transport for the three trajectories: truck, barge, sea ship or train. Similar to the materials, each transport method has a fixed emission factor in gram per kilometre, derived from ICE v.2.0 (Hammond & Jones, 2011). For each trajectory, the distance in kilometres, the share factor[1], the utilisation coefficient[2] and the number of identical journeys must be specified in the Carbon Counter. The multiplication of all these factors, added up for all different trajectories is the total CO_2 emission related to transport.

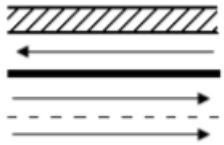
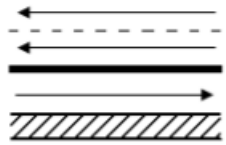
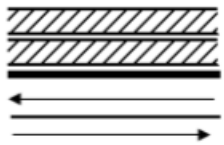
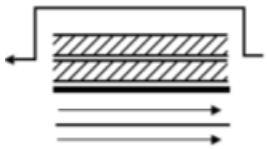
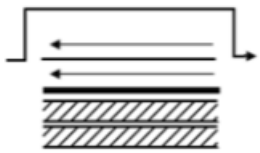
The asphalt production part (Table 1) accounts for the energy consumption for drying and heating aggregates and for the hot storage of the binder in the tank. Likewise the other parts, the six energy types available in the tool have a fixed emission factor in t CO_2/m^3 for diesel, fuel oil, lignite and gas or in t CO_2/kWh for electricity, derived from ICE v.2.0 (Hammond & Jones, 2011). The quantity of each energy type is multiplied by its emission factor. The use of warm mix asphalt, the insulation of the bitumen tanks and the dry storage of granulates result in reduced fuel consumption and are hence encouraged in this part of the tool.

2.3 Traffic Tool

The Traffic Tool, worked out in Excel®, calculates the additional amount of CO_2 emitted by road users of the considered road section and traffic diversions during road works. Three different traffic management scenarios (see Table 2) have been specified for this particular case. The user of the tool must choose one scenario for the total project period.

[1] The share factor charges the percentage of the haulage that could be assigned to the investigated project e.g., if a fully loaded barge supplies 350 ton virgin aggregates to the asphalt plant, but only 70 ton is used in the project under research, the share factor for this supply is 0.2.
[2] The utilization coefficient charges the load of the conveyance i.e., value 1 if empty or 1.5 if fully loaded conveyance.

Table 2: Three traffic management scenarios in the Traffic Tool

		working direction ←	working direction →	explanation
scenario	1			Alternately one lane is closed in the working direction to repave, while two lanes in the opposite direction remain open
	2			Both lanes in the working direction are closed to repave, while each lane of the other site of the road is used by the traffic in a different direction.
	3			Both lanes in the working direction are closed. The traffic in this direction is redirected with a detour. Both lanes in th eopposite direction remain open.

The Traffic Tool associated with a particular scenario looks like a time schedule with 1 h intervals (see Figure 1). Every time slot has a corresponding CO_2 emission value, depending on the scenario chosen, the day of the week and the hour of the day. These emission factors have been determined by the Agency on beforehand by simulating the influence of the measures on traffic congestion for the different scenarios.

	0h-1h	1h-2h	2h-3h	3h-4h	4h-5h	5h-6h	6h-7h	7h-8h	8h-9h	9h-10h	10h-11h	11h-12h	12h-13h	13h-14h	14h-15h	15h-16h	16h-17h	17h-18h	18h-19h	19h-20h	20h-21h	21h-22h	22h-23h	23h-24h
Mo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tu	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
We	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Th	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Sa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Su	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tu	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
We	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Th	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sa	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Su	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
We	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Th	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Su	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
We	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Th	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Su	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 1: Completed Traffic Tool for traffic management scenario 2 with the indication of the periods with road works

Based on traffic counts during 10 days in September 2010 on the specific field track in Kontich, average intensities per day of the week and per hour of the day were calculated.

The theoretical capacity of the road depends on the width of the road and the design speed (90 km/h). The maximum capacity per day per lane is 20,000 passenger car equivalents (pce) in the original situation (Agency for Roads and Traffic n.d.) or 833 pce per hour per lane. In the direction of the road works the speed limit is reduced to 50 km/h, associated with a maximum capacity of 10,000 pce per day per lane (Agency for Roads and Traffic n.d.) or 417 pce per hour per lane. In this specific road work situation,

correction factors are included to reflect the reduced capacity due to turning traffic at the T-junction at one end of the field case. These correction factors are 0.85 and 0.95 respectively for right and left turning traffic (CROW kennisplatform, 2014). Therefore, the corrected theoretical capacity is calculated by multiplying 417 pce per hour per lane with both correction factors resulting in 337 pce per hour per lane during the road works. In scenario 3, an additional correction factor of 0.93 should be applied in order to take into account the lane width of the detour track (CROW kennisplatform, 2014) resulting in a theoretical capacity of 313 pce per hour per lane.

If the actual traffic volume is lower than the theoretical capacity, free flowing traffic is assumed corresponding to an emission factor of 152 g CO_2/km (den Boer et al., 2008). However, if the traffic volume is higher than the capacity, congested traffic is supposed with an emission factor of 228 g CO_2/km (den Boer et al., 2008). In this model, there is no situation between both extremes.
The emission schedule of the original situation was calculated by multiplying the intensity per hour by the CO_2 emission factor for free flowing traffic (152 g CO_2/km) and the length of the test section for each time slot (see example equation 5). Free flowing traffic was assumed because no traffic congestion was observed during the traffic counts (before the road works).

$$32\ \frac{pce}{h} \times 152\ \frac{g\ CO_2}{pce\ \times\ km} \times 1\ km\ = 4{,}864\ \frac{g\ CO_2}{h}\ = 5\ \frac{kg\ CO_2}{h} \qquad (5)$$

Equation 6 is the calculation of the corrected theoretical capacity in one direction of the detour scenario 3 (313 pce/h lane) and a comparison with the measured intensity in this direction for a specific time slot (626 pce/h). Equation 7 is the calculation of the emissions for that time slot in that direction (analogue to equation 5). These calculations were repeated for the three scenarios and for each working direction (see table 2) using the corresponding intensities, capacities, emission factor (free flowing or congested traffic), correction factors and section length which resulted in a schedule with the CO_2 emissions per hour.

$$10{,}000\ \frac{pce}{day\ \times lane} \times \frac{1}{24}\ \frac{day}{h} \times 0.85\ \times 0.95\ \times 0.93 = 313\ \frac{pce}{h\ \times lane} < 626\ \frac{pce}{h} \qquad (6)$$

$$626\ \frac{pce}{h} \times 228\ \frac{g\ CO_2}{pce\ \times km} \times 1.6\ km\ = 228{,}365\ \frac{g\ CO_2}{h}\ = 228\ \frac{kg\ CO_2}{h} \qquad (7)$$

As the additional emissions from traffic as a consequence of the road works are searched, the next step included the calculation of the difference of the emissions in the three scenarios compared to the emissions in the basic situation. These differences are the basis for the final calculations with the Traffic Tool.

The user of the Traffic Tool has to specify the time intervals when the road works will take place by entering a “1-value”. A “0-value” is placed in the time slots when there is no road work activity. The sum of the emission factors in the time slots with a “1-value” gives the final result of the Traffic Tool (expressed in kg CO_2).

It can be seen from the tool (see Figure 1) that working on a Monday morning from 7:00 a.m. till 8:00 a.m. will yield higher emissions than working from 7:00 a.m. till 8:00 a.m. on a Saturday morning. Hence, the contractor is stimulated to minimise the working period and traffic disturbances.

An important note for this Traffic Tool is that the effect on the surrounding roads was not taken into account because it was assumed that only a small number of vehicles would use other routes. Furthermore, it is clear that if this tool should be used for other road projects, the method can be used, but specific traffic counts, speed limits and correction factors will be necessary.

After the construction, ART will fill out the Traffic Tool again and re-calculate the total CO_2 emission, based upon the actual working times.

3 Verifications during the execution of the work

In Belgium, COPRO (an impartial institute for control and testing) performs quality and conformity controls on construction products and on its on-site integration. During the pilot project in Kontich, COPRO performed a large number of measurements and verifications of the asphalt plant and road works. At the asphalt plant, COPRO verified i) the delivery of raw materials: the weight of the materials, the transport distance and method from the suppliers to the asphalt plant, and the origin of the materials; ii) the energy consumption for the hot storage of bitumen and for drying and heating aggregates in both the white and parallel drums; iii) various temperatures: external temperature, bitumen tank, and asphalt in the mixer; and iv) the moisture content of the aggregates in the stockpile was measured. Furthermore, all transport between the plant and the work site was monitored for truck load, origin and destination.
At the work site, COPRO examined the asphalt mixture temperatures (before and after compaction).
In addition the Belgian Road Research Centre has performed tests on the compaction (gamma probe and cores) and ART measured the evenness of the road pavement.

Lastly, researchers from the research group EMIB from the Faculty of Applied Engineering at the University of Antwerp monitored the project to collect data for environmental assessment with the inclusion of various LCA impact categories.

4 Winning tender

In this section, the approach chosen by the selected candidate is discussed based on the two tools. Compared to other contractors, the selected candidate had better scores for price as well as carbon counter and traffic tool. Due to confidentially, the proposed approaches of other contractors cannot be discussed.

4.1 Carbon Counter

The tender specified the use of split mastic asphalt for the wearing course and an asphalt concrete with performance requirements for the base course. According to the Flemish road standard (SB250 v2.2) the

use of reclaimed asphalt is not allowed in surface layers. For the base layer, 50% reclaimed asphalt was added in the mixture, yielding a significant CO_2 reduction due to material use. For base layers with a mixture with performance requirements, the SB250 v2.2 does not limit the percentage of reclaimed asphalt.
In order to reduce the emissions from the transport, the delivery of all raw materials to the asphalt plant was done by ship.
To reduce the impact from asphalt production, both produced asphalt mixtures were chosen to be WMA based on foaming technology. According to the tender, a WMA has a temperature between 100 and 130 °C after the mixing process. The asphalt plant is equipped with a natural gas burner emitting less CO_2 than e.g., fuel oil.

4.2 Traffic tool

The emissions from the disrupted traffic have been limited by choosing the scenario with the lowest emissions, scenario 1 (see Table 2) and to working the weekends instead of the week.

4.3 Environment versus costs

Some of the measures to reduce the environmental impact, might induce extra costs e.g., the supply of raw materials to the asphalt plant by ship and working during weekends. The contractor is free to decide whether he bears those cost himself or to charge those to the procuring authorities. The contractor with the highest total score (see §2.1) is awarded the contract and hence each contractor might try to find an optimal balance between costs and impact on environment.

5 Results and discussion

It was seen during the construction that, compared to standard procedures, some specific adjustments were implemented by the contractor in order to reduce the environmental impact associated with the pilot project. Some examples are listed in table 3.

Table 3: Measures during the execution of the works in order to reduce CO_2 emissions

Raw materials	
	using RAP-mixtures with high coarse aggregates and bitumen content
Transport	
	delivering raw materials to the asphalt plant by barge avoiding empty journeys between plant and work site
Asphalt production	
	using most energy efficient bitumen tanks delivering of bitumen to the asphalt plant shortly before asphalt production

Interviewing workers at the road work site, told us that the mechanical compaction of the WMA pavement seemed visually as good as a HMA pavement. Nevertheless, imperfections after the paver were difficult to correct e.g., little bumps, wells or footprints in the paved material. Hence, a

conscientious manufacturing process is recommended while using WMA. Results of the gamma probe showed a good compaction of the base layer. The compaction of the split mastic asphalt in the wearing course is difficult to assess. The evenness of the road surface was remarkably good. This work also showed the good workability of WMA.

Although, the additional work for the contracting authority due to the pilot project was considered: development of both calculation tools (reusable for other projects) and execution of traffic counts. An intensive follow up on the asphalt plant and the road work site during the execution of the works was also required. Most of this surveillance was accomplished by COPRO, while the costs were incurred by the contracting authority. This surveillance in practice is time consuming and it would not be feasible to do this for all future public road works.

It can be argued that the warranty for 3 years is too short in order to encourage the contractor to construct a durable pavement and hence avoid costs and environmental impact from maintenance interventions. Decisions were made in favour of the environmental impact yielding suboptimal results to the performances and the durability of the pavement. In this case the width of the road in each direction was divided in two and paved during two consecutive days. Therefore, the joint between the two sections could not be compacted when both materials were warm. The working method was chosen in order to avoid higher emissions from the disrupted traffic, but the quality of the road pavement might have decreased because of this.

Analyzing the approach for the public procurement, it is seen that the Carbon Free-Ways takes into account the three proposed core award criteria as described by the European Commission (see §1): the use of secondary or recycled materials, the reduction of the energy consumption throughout the life cycle (raw material production to paving) and the durability and performance characteristics of materials. The latter was taken into account by the fact that all bituminous mixtures used for public road works should comply with the Flemish road standard SB250. Additionally, one out of four comprehensive GPP criteria was included by assessing the evenness after the pavement construction: reduce fuel consumption of vehicles travelling on the road and hence reduce emissions to the environment during the use phase of the road.

As described before, this study examined only CO_2 emissions, which is an incomplete environmental assessment. (European Commission, 2010) stated that the greatest environmental impact from road construction is from the combustion of fossil fuels, specifically the emission of CO_2 and nitrogen dioxides (NO_2) by normal traffic. Hence, despite the incomplete environmental assessment, one of the key environmental impacts is covered in the pilot project.
The European Commission recommends for GPP a contribution of all environmental award criteria together for at least 10 to 15% of the total points. The Flemish pilot project uses a 50% rate for both the environmental part and the acceptation price. This ratio was applied to maximise the effect of the CO_2 emissions and not in the light of a general application in the future.
Since the inclusion of environmental parameters in the public procurement was a novelty, some points for improvement were found. Some processes were excluded from the assessment e.g., filler production

and transport, transport of machines to work site, machines operation on site, etc. This is due to the lack of appropriate data and the extent of the project. Besides, it is remarked that data source (den Boer et al., 2008) is slightly outdated with regard to the significant difference in emission caused by new and old vehicles. This is due to the fact that the project was initiated and the tools were developed in 2010 while the execution of the works was in May 2014. Hence, for future projects, the tools used should be updated. Another point of discussion related to the data sources is the default reduction of 50% for emission factors for recycled materials.

Finally, expanding such analyses from single project based to continuous plant based assessment might be interesting in order to encourage continuous environmentally friendly asphalt production as part of the optimisation of projects.

6 Conclusions

The inclusion of environmental award criteria in a public tender is new for Flanders. In spite of the obstacles which make the application of GPP for road works difficult, the pilot project is a good first attempt to detect significant and insignificant parameters and data. Furthermore, with the elaboration of the methods and the development of the tools, the basis is laid for GPP in this sector.
There are limitations in the pilot project to keep the tool workable in this first attempt: the number of parameters (and hence, verifications) used in the Carbon Counter and the Traffic Tool are limited by applying a number of assumptions. As a result, the emissions from a number of processes are left out and only one environmental issue (global warming potential) is analysed, which results in a very incomplete environmental impact assessment.
In a future phase, the calculation tools might be extended in order to include more processes (e.g. production and transport of filler and additives, transport and use of equipment on the work site, etc.) and various environmental impacts. In addition, focussing both on the sustainability and on the durability of the road pavement is recommended.
At least ART gave an unambiguous signal to the road industry that neglecting the environmental impact from road works is no longer an option for public works and it might become a fixed selection criterion for tender in the long run.

7 References

Agency for Roads and Traffic, Traffic Load *(Verkeersbelasting)*. Available at: http://awv.wegenenverkeer.be/bouwklasse/belasting [Accessed 09.11.2014].

Den Boer, L.C., Brouwer, F.P.E., van Essen, H.P., 2008. Study on Transport Emissions from all Modalities *(STREAM Studie naar Transport Emissies van Alle Modaliteiten)*. Delft.

CROW kennisplatform, 2014. Manual traffic light regulations *(Handboek verkeerslichtenregelingen)*, second ed. CROW Media, Ede. ISBN: 978 90 6628 643 6

Departement Leefmilieu Natuur en Energie, 2014. Carbon Credit *(Emissiehandel)*. Available at: http://www.lne.be/themas/klimaatverandering/co2-emissiehandel/vaste-installaties-1 [Accessed 19.05.2014].

European Asphalt Pavement Association, 2014. Asphalt in Figures 2013.

European Commission, 2008. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Brussels, Public Procurement for a Better Environment, COM (2008), vol. 400/2. Brussels.

European Commission, 2010. Road Construction and Traffic Signs – Green Public Procurement Product Sheet. Brussels.

European Commission, 2014. GPP Criteria – Background and approach. Available at: http://ec.europa.eu/environment/gpp/gpp_criteria_en.htm [Accessed 20.11.2014].

European Union, 2013 a. The EU Emissions Trading System (EU ETS). doi:10.2834/55480

European Union, 2013 b. Commission Recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations. Official Journal of the European Union, vol. 56.

Hammond, G., Jones, C., 2011. Inventory of Carbon & Energy (ICE) version 2.0, Bath.

Jackson, R. L., Willis, J. R., Arnold, M., Palmer, C., 2011. Synthesis of the Effects of Pavement Properties on Tire Rolling Resistance. Auburn.

Leyssens, D., Verstappen, B., Huybrechts, D., 2013. Best available techniques for asphalt plants *(Beste Beschikbare Technieken voor asfaltcentrales)*. BBT-kenniscentrum VITO, Mol.

Testa, F., et al., Drawbacks and opportunities of green public procurement: an effective tool for sustainable production, J. Clean. Prod. (2014), http://dx.doi.org/10.1016/j.jclepro.2014.09.092

Van Geldermalsen, L., 2013. GPP In practice: Using LCA and CO_2 performance to assess bidders. European Commission. Available at: http://ec.europa.eu/environment/gpp/index_en.htm [Accessed 19.11.2014].

Van Geldermalsen, L., 2014. Green Public Procurement: the Rijkswaterstaat Approach. In *Ecoprocura*. Ghent. Available at: http://www.ecoprocura.eu/ghent2014/

Varnäs, A., Balfors, B., Faith-Ell, C., 2009. Environmental consideration in procurement of construction contracts: current practice, problems and opportunities in green procurement in the Swedish construction industry. J. Clean. Prod. 17, 1214-1222. doi:10.1016/j.jclepro.2009.04.001