WARM MIX ASPHALT IN A CRITICAL PERSEPCTIVE

Alex van de Wall
KWS Infra bv, Vianen, The Netherlands

ABSTRACT

Sustainability is an important issue in the Netherlands. Since 2010 the national government wants to use sustainability criteria in all its tendering and procurement processes. The provincial and local governments have similar aims, but over a longer horizon. To help achieving these goals, so-called sustainability criteria have been formulated for many working fields, including road construction. At the same time there is a strong drive to reduce CO2, following the agreements on a global and European level. Both aspects have become intertwined.

As a result, asphalt produced at a lower temperature has again gained more interest. One can find it prescribed in contracts of indicated as an option. Still, in spite of all the efforts over the last decade, only a relatively small amount of WMA can actually be found on the Dutch Roads. This can not be ascribed to the lack of techniques. Other, non technical factors, play a dominant role including economics, politics etc. By sketching the different aspects involved, a possible explanation is given for its present status. WMA is put in a larger perspective indicating a framework for future developments but also indicating other approaches to sustainable road construction.

Keywords: sustainability, Warm mix aspalt, energy, carbon footprint, CO2

1. PRESENT STATUS

Sustainable Public Procurement is defined as taking into account environmental and social aspects in all phases of any procurement or tendering process financed by public money. With regard to environmental aspects, it concerns the impact on the environment, ranging from energy usage to waste reduction during the production process and using recyclable materials. But also lowering the CO_2 emission levels has become part of the sustainability drive.

With a yearly expenditure of over 50 billion Euros, the Dutch public authorities can give a substantial boost to sustainable products, projects and concepts. As a consequence, sustainable public procurement is one of the priorities of the national government. Since 2010, it wants all of its purchases to be 100% sustainable. Municipal authorities aim at 75%, and the provincial authorities and water boards at 50%. All parties committed themselves to 100% sustainable purchases in 2015.

In this framework, the production of asphalt at lower temperatures could take a prominent place. A lower production temperature implies lower gas consumption and lower CO_2 emissions.

Although a clear objective has been set by de different governmental bodies, it has not yet been accomplished. It might be more accurate to say sustainability is generally considered during the purchasing process. It also has not yet translated into a significant boost for warm mix asphalt (hereafter: WMA).

2. WMA TECHNIQUES

Not only in The Netherlands, but all over the world, many techniques are available to lower the production temperature of asphalt. Table 1 gives a short, non comprehensive list. Almost all concepts are based on changing of the viscosity of the bitumen.

The high production temperature during asphalt production is necessary to lower the viscosity of the bitumen. This results in a workable mix and a good wettability of - and adhesion to the minerals. At lower temperatures this would become much more difficult of not impossible. By changing the viscosity of the with WMA techniques, the workability and wettability can also be improved at lower temperatures. In some cases additives are necessary to secure a durable adhesion.

In the case of foamed bitumen and emulsion, it has been found that a certain amount of moisture should remain in the mix for a proper compaction. This also explains why the temperature can go below 100 °C. Obviously one has to compensate for the negative consequences for the active and passive adhesion.

Table 1: Overview of the most important WMA concepts.

Concept	Product / technique	Production temperature
Additives	wax, zeolith, surface-active chemicals	110 – 150 °C
Foamed bitumen	LT Asphalt	90 – 110 °C
	Shell WAM process	130 °C
Emulsion	KonwEco2	15 °C
	Finfalt (tar free RAP recycling)	80 °C
Process	Partial drying of minerals	80 - 90 °C

A lower production temperature implies a lower fuel consumption en lower emissions. Figure 1 gives a model explaining the energy consumption during the production of asphalt. It should be noted that the continuous line the figure represents the theoretical energy consumption. As the evaporation of water is not limited to 100 °C, the dotted line will be a more realistic representation. Especially as the heat distribution during mixing is not homogeneous. This is an important aspect in discussions on the need to be below or above 100 °C with regard to energy consumption and moisture.

The energy savings can easily be translated into a reduction of CO_2 emissions. But the same accounts for odour and other emissions. Studies by the EAPA show that lowering the production temperature by 10 °C will cut the emission of aerosols in half. In The Netherlands, odour emissions might very well be THE issue regarding asphalt production facilities. This follows directly from the population density and the fact that productions facilities did start away from populated areas, but have slowly been surrounded by the expanding cities.

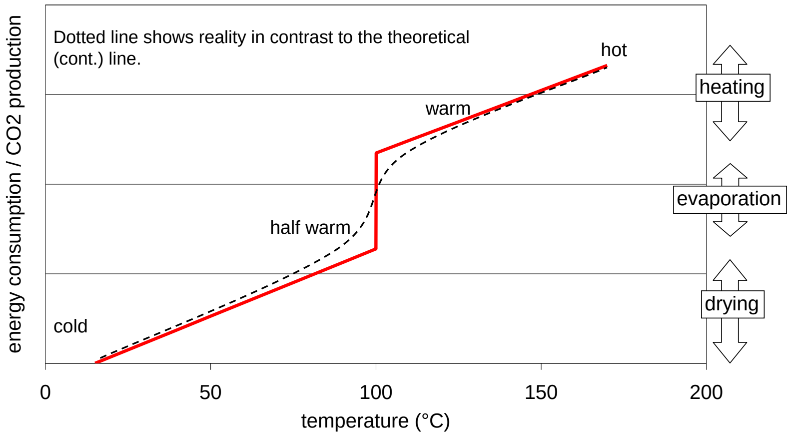


Figure 1: Energy consumption and CO2 emissions during asphalt production.

2.1 Additives

Additives allow the production temperature to go down 20 to 30 °C. One type of additive is wax that melts and thus lowers the viscosity of the binder above a specific temperature. Below their melting point these waxes crystallize, causing a stiffening of the binder. Although a property to be explicitly considered during paving, it is also an additional benefit. The wax could be considered a simple stabiliser. But, because of the crystallization the compaction window becomes actually smaller.

Certain zeoliths contain crystal water that is emitted in the form of steam above a specific temperature. The steam causes the bitumen to foam, resulting in a lower viscosity of the binder. Upon cooling the emission of steam stops. During paving one has to take care not to stop before all steam has been released. Once the job is finished, the zeolith acts as standard filler. Homogeneity of zeolith distribution in the asphalt mix is obviously of vital importance for a successful application of this technique.

Surface active additives do not change the properties of the binder, but influence the interaction between binder and mineral, resulting in a better wettability and workability despite lower temperatures.

The advantage of all these additives is that they can be applied in almost any asphalt plant, without modification. No investments are necessary. In case larger quantities are produced, an additive dosage system can be implemented or an existing system, e.g. the fibre system, can be used.

2.2 Foaming

By adding water and air to hot bitumen, the bitumen temporarily becomes a foam like substance. Although the binder itself (due to loss of energy to the water) becomes more viscous, as a whole it has a relatively low viscosity. This enables it to mix with minerals that have been heated up to 80 – 110 °C. Additives and/or the choice for specific bitumen types ensure the stability of the foam.

In the Netherlands there are two more or less similar concepts, of which KWS Infra has, in collaboration with several other contractors, developed the so-called LT asphalt. This concept has proven itself on amongst others highway A30. At present foamed bitumen can be used in most mixes, including those that contain a certain amount of recycled asphalt. The main question that remains is the (technical) durability of foam-mixes.

Foaming requires a modification of the asphalt plant. Also, a spacious mixing chamber is necessary to get the best results.

2.3 Emulsion

It is possible to produce asphalt mixes at “room” temperature. That is, without adding any heat. The drawback of these emulsion-asphalts is that they do not have the strength of hot-mix asphalt. This has lead to the development of KonwEco2 by KWS Infra. Still under development, this product comprises a cold-mix asphalt with hot-mix properties. The first trial took place in 2010 in collaboration with the province of Gelderland. Lacking the need for heat, the mixture can be prepared without the use of an asphalt plant. Present investigations of the company involve using foam rather than emulsion in order to reduce complexity and costs.

Finfalt is a special form of emulsion based asphalt. It was introduced in the Netherlands in the late eighties by KWS Infra in collaboration with several other contractors. Finfalt combines emulsion asphalt with heating of the minerals up to 80 °C using steam. At the time it aimed at the recycling of tar-containing RAP. As this material is no longer allowed to be recycled, the production technique has disappeared. However, it could also be used for clean RAP, allowing a 100% recycling rate.

2.4 Process modification

Foaming of the bitumen using special nozzles is one possibility. The use of zeoliths is another. But, if properly controlled, also the moisture in the minerals can be used to \`foam\` the bitumen. By adjusting the production process and optimizing the minerals and RAP, it is possible to produce asphalt at lower temperatures. The main difference with the special foaming systems is that the process is much more complex to control. However, trials in several countries have shown its potential. Looking at the Netherlands, it may be seen as a return to the first days of asphalt recycling, but with a more controlled approach.

In this case, the coarse minerals are heated to approximately 130 °C and mixed with the hot bitumen. Next, the fine minerals and RAP are added without being heated. Depending on the specific situation, part of the fine minerals may be heated together with the coarse minerals. The moisture, present in the cold fraction will cause foaming of the bitumen.

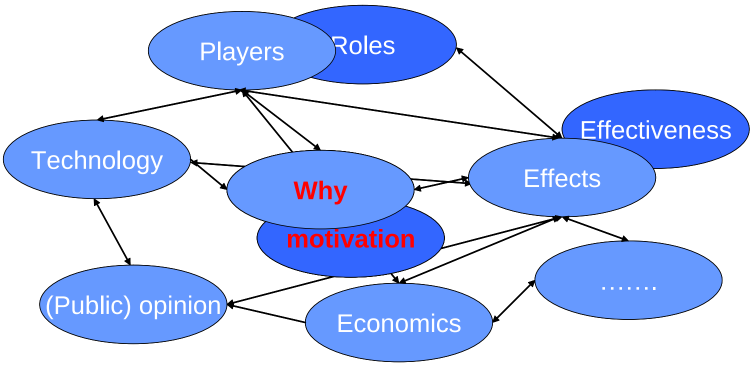
3. UNDERSTANDING THE STATUS OF WARM MIX ASPHALT

Despite all available techniques, only a relatively small amount of Warm mix asphalt can be found on the Dutch roads. If applied, it is often as a pilot project, covering a small surface. This, even though the first trials took place in the last century!

To understand the status of warm mix asphalt in the Netherlands, one has to look at a range of different aspects. As shown in the previous paragraphs, there is no lack of techniques. There are many available, each with its advantages and disadvantages. It should only be a question of choosing the best technique for the specific project in question. The question why warm mix asphalt is chosen should be evaluated with regard to the underlying motivations. Does it follow from an inherent sustainability drive or are there other reasons. There is a big difference between applying WMA because of the advantages of the product itself or if it is chosen to make a statement to stimulating awareness. Is energy saving the issue of CO_2 reduction? On what scale should the effect be evaluated?

Figure 2 displays the different aspects to be considered in order to understand the applicability and added value of warm mix asphalt.

Figure 2: Decision framework WMA



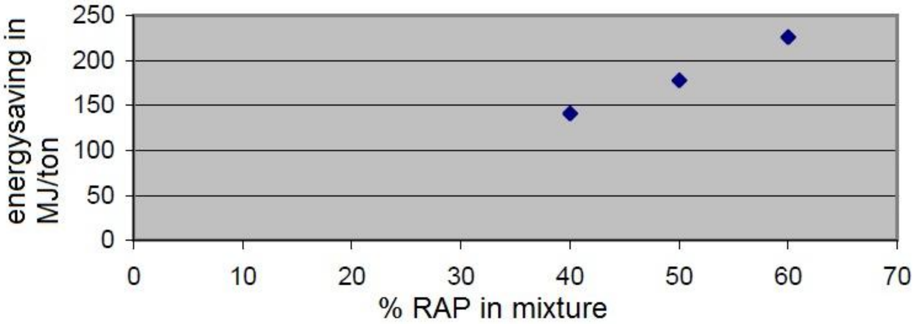
3.1 Energy and CO_2 in the chain

Although a lower gas consumption during production leads to energy savings and fewer emissions, a dilemma arises. This dilemma follows from the need for recycling. Recycling has always been an important issue in The Netherlands. Starting in the seventies, the amount of RAP in asphalt has steadily increased from 10% to 60% in recent years. Even 100% asphalt recycling is now possible. It is obvious that recycling has an immense positive effect with regard to sustainability. It reduces waste, prevents the usage of primary materials such as rock, gravel, sand, oil and therewith reduces the energy consumption in the chain. In The Netherlands, asphalt with 50% to 60% of RAP is generally considered to be of equal quality to asphalt with less or no RAP in the bottom and intermediate asphalt layers. In surface layers the amount of RAP can go up to 30-40%.

However, recycling comes at a price. These high recycling percentages combined with a `guaranteed` quality in the accepted mix formulations cannot be achieved using cold recycling concepts. All asphalt plants in The Netherlands (45 plants with a total production of 10 million tonnes) are using either parallel recycling drums, allowing the RAP to be heated up to 120 °C or drum mixers in which the virgin material is heated up to more than 250 °C. With two drying drums the energy consumption of the asphalt plant will be higher than in the case of a single drum. Also drum mixers will need more energy. The energy and CO_2 reduction is thus not achieved in the asphalt plant, but in the rest of the chain.

Based on independent studies [e.g. 2, 3], the energy savings following from the use of RAP have been established. Figure 3 shows that an increase in recycling rate of 10% results in the energy saving of 20% in the chain from mineral production to road reconstruction. These figures are now used in national regulations concerning the obligatory energy plans for asphalt plant.

Figure 3: The relation between energy savings and amount of RAP in asphalt.



The question therefore must be answered whether to invest in energy savings and lower emission at the asphalt plant or to consider the larger picture. This is especially important as it can easily be seen that increasing the amount of RAP will, certainly in practice, have much more effect than lowering the production temperature. Obviously the combination of both would be very interesting.

It is also possible to look at CO_2 compensation using Biobinders. These are binders based on vegetable oils. The source vegetation needs CO_2 to grow. In contrast to biofuels, a biobinder is not burned. The CO_2, stored in the plant, is therefore permanently extracted from the atmosphere. In the Netherlands biobinder are available that contain a certain percentage of vegetable oil. In the end, the quantity of CO_2 stored in the binder necessary to produce a ton of asphalt is approximately the same as the amount emitted by the asphalt plant to produce this asphalt. This implies a permanently CO_2 neutral production process without significantly reducing the production temperature. Recently a project has been realised involving such a biobinder in, known to be critical, thin porous asphalt layers.

3.2 Quality

Many studies and (pilot) projects have taken place over the recent years. The general conclusion is that it is possible to get a similar quality of asphalt from low-temperature concepts as from traditional asphalt when looking at regular mix formulations in non critical situations. But, at the same time it is easily understood that at present one can only expect to reach the same quality. For most of the techniques it is a matter of adjusting the mixture or adding for example adhesion promoters to compensate (possible) loss of quality in certain areas. Even though the lower temperature does result in less ageing of the binder. Possibly, the future will prove the added value in a technical respect, but for now most efforts are directed at proving the same quality. Especially when considering the long term (mechanical) durability. After all, the tendency is to ask longer life spans and less maintenance efforts from asphalt mixes and constructions. In other words, we are working simultaneously at higher quality asphalt and asphalt that can be produced at lower temperatures without losing quality…

3.3 Economy

For the Netherlands it holds that the reduction of the production temperature implies an increase of the total cost with € 1,50 to € 3,00 per ton of asphalt. These additional costs come from the cost of additives, investments in de installation, additional (manual) labour etc. Although one saves fuel this is economically a very small amount. Saving 2 to 3 m^3 of gas (implying an energy reduction of 25-30%) equals les than € 0,50.

In other words, there is no immediate economical drive to use WMA. This might change with the introduction of the CO_2 emission trading system. In contrast to many other countries in Europe, the Dutch Government includes asphalt production facilities in the trading system. If this happens, the economical benefits might come from reducing the amount of carbon credits that have to be purchased.

Because of the lower production and finishing temperatures, the binder in de asphalt mix is less likely to age. The ageing of the binder during this process may have a significant impact on the (technical) durability of the asphalt. Because this has not yet been proven in practice, one cannot translate this into a financial benefit.

3.4 Public Opinion

The behaviour of Governmental institutions is significantly influenced by the public opinion. This is directly related to the fact that most of the decision makers are elected to their office. Also, these institutions have other responsibilities and duties than private companies. As they work with public money, a different decision-making process has to be followed. It is, for example difficult for a municipality to invest money in a project of which the effectiveness has not yet been validated.

Also, the question is whether the local population will accept an improvement of the environment on a larger scale over an improvement on a local scale. Even if the latter is less effective in the long run.

3.5 Effect and effectiveness, the larger picture

The effect of most WMA techniques can be shown on theoretical grounds, in the laboratory as well as in practice. Most techniques will, in the end, result in an energy saving at the asphalt plant of 10 - 40%. Also with techniques that result in mix temperatures below 100 °C, a energy reduction of 40% is probably the maximum that can be achieved. One reason is that the theoretical energy consumption is an idealised model (see figure 1). But, what happens if only 10% of the production of an asphalt plant consists of WMA?. Probably the plant is completely warmed by other mixes productions. As a result, the lower temperature is only a theoretical issue. In other words, to become a “real” option, large productions over prolonged periods are necessary.

Another aspect to consider is the impact of the production on the energy consumption in the total chain. Several institutions have studied and analysed the energy consumption in the asphalt chain. Based on these studies, a.o. by Intron SGS, the energy consumption, excluding the service life of the road, looks roughly as follows:

- Pre-production (mineral extraction, transport, refining of oil): 40%
- Production: 25%
- Hauling & finishing: 16%
- Removal of pavement: 19%

The exact figures may vary a little, depending on the scope of the analyses and where boundaries are set. The figures put the effectiveness of WMA in perspective. If 25% of the produces asphalt consists of a WMA having a reduction potential of 30%, the energy saving of the asphalt plant would be 7,5% ,and the savings over the chain less than 2%. In view of this, increasing the percentage of recycled asphalt and removing the limitations set on this percentage in the regulations, looks more effective !

Even more effective is a re-evaluation of the way road constructions are designed. Fewer tons of asphalt will always be the most effective. Not only by rethinking traffic management, but also on a more basic level. For example: In the Netherlands, road design is based on the traffic load that occurs on the most intensely used lane. This design applied to the whole width of the road. The obvious advantage is that future changes in lane-usage are not limited. However, one has to wonder how often it will occur that the fast lanes will be heavily trafficked by trucks for very prolonged periods. Another option is to rethink bitumen formulations and asphalt mixes such that thinner asphalt layers or more durable asphalt constructions are possible. If regulations are open to such innovations (at present this is not really the case in The Netherlands) huge savings are possible.

There are more considerations. In the Netherlands there is a clear tendency for road works to take place during night periods. Also, winter damage, asks for immediate action. The national government has launched pilots that make it possible to reconstruct highways under winter conditions. This implies that the production conditions asks for a higher energy consumption both in the asphalt plant as well as during finishing.

4. CONCLUSIONS

It is clear that more than one technique is available that to reduce the energy consumption of that asphalt production and reduce associated CO_2 emissions. Despite many studies and pilots, the use of WMA remains at a relatively low level in the Netherlands, but also the rest of Europe.

Considering the different aspects of the use WMA and the framework of this development one has to conclude that WMA cannot be seen as THE answer to sustainable development.

This does not mean one should not invest in WMA. Also KWS Infra has studied several options to lower asphalt temperatures and implemented several of them. However, it is clear that the decisions regarding energy and CO_2 should be based on a sound, transparent, evaluation of the goals to be achieved in each individual project and the options to get to the best result. This asks for open communication with the contract partners.

If this approach is followed WMA should get its proper place in the whole menu of possibilities available for sustainable road construction. At the same time, efforts should be put in rethinking road engineering and planning in order to make more steps towards a more sustainable world. This is only possible if also regulation by and communication with the authorities is put on the discussion table.

5. CONCLUSIONS

[1] EAPA website: www.eapa.org
[2] SenternOvem: www.agentschapnl.nl
[3] Berk, M. van den (2004), SGS Intron. Berekening energiebesparing door recycling van asfalt.
[4] Gesprächskreis Bitumen Temperaturabgesenkte Asphalte (2009), www.asphalt.de
[5] Temperaturabgesenkte Asphalte (2009), www.asphalt.de