
Case Study

Low Temperature Asphalt



Summary

Low temperature asphalt (LTA) technology has considerable potential for reducing the carbon emissions associated with road construction. The lower temperatures used to manufacture these materials mean that less energy is required to produce them, which drives lower energy costs. The lower emissions create better working conditions and result in a lower impact on the environment. Currently the market share for low temperature asphalts in the UK is very low at under 1% compared to an estimated 21% in the USA which has embraced the benefits of the technology much more rapidly. The US made great strides around low temperature asphalt by creating a technical working group to oversee the implementation of this technology. A large number of trial sections and demonstration projects were completed, leading to wider understanding and deployment. This project, led by Lafarge Tarmac and part funded by Carbon Trust (via the Department of Energy & Climate Change (DECC)) and by the Department for Business Innovation & Skills (BIS) through its Regional Growth Fund, has developed a new approach to low temperature asphalt mixes and demonstrated their in-service performance on public roads as being equivalent to conventional hot asphalt. The project has also broken new ground by developing the first Specification for low temperature asphalt mixtures in the UK, enabling the mixtures to be specified and purchased with greater confidence. As a result of the project there will be increased interest from local authorities and other highway clients who wish to reduce the carbon footprint of their road programmes without compromising performance.

Background

Each year throughout the UK approximately 25 million tonnes of asphalt¹ is produced, the main ingredients of which are aggregates and bitumen. The carbon footprint for asphalt manufacture is estimated at 24 kg CO₂/tonne¹ which, when combined with the embedded carbon in the aggregate and the bitumen, rises to 40 kg/CO₂/tonne². The total UK carbon footprint associated with asphalt manufacture is estimated at 786,000 tonnes of CO₂/year³ which is the equivalent to 5,000 km driven by a million average family cars⁴. Almost all of the asphalt manufactured in the UK is hot asphalt, i.e. mixed and laid at temperatures of 140°C – 190°C.

Lower temperature asphalt has been available for many years, but market uptake remains low and therefore the potential benefits from low temperature asphalts have yet to be realised; these benefits include:

- > reduced emissions during manufacturing and road construction
- > a longer workability window for laying
- > increased incorporation of recycled asphalt (RAP)
- > lower energy consumption during manufacture and lower CO₂ emissions.

¹ MPA Records, 2008.

² TRL Aspect footprint calculator CO₂ footprint of bitumen 190kg CO₂/tonne; 1.3 million tonnes bitumen; 20.7 tonnes aggregate.

³ Carbon Trust, Industrial Energy Efficiency Accelerator, Guide to the asphalt sector

⁴ Assuming the average car emits 150g/CO₂/km

The main barriers to increasing the market share of low temperature asphalts have been identified through this project as;

- > an absence of evidence of their in situ and long term performance,
- > the lack of a national specification and,
- > its affordability.

This low demand has hindered investment in new technologies from the asphalt sector. Unblocking this demand-supply “stand-off” was the main goal for the project and Lafarge Tarmac built a highly skilled and committed team of suppliers, customers and industry experts to deliver it.

The Project

This project, led by Lafarge Tarmac in partnership with Nynas and Atkins and part of the Industrial Energy Efficiency Accelerator Programme funded by the Carbon Trust that helped identify innovations across 14 mid-energy intense sectors, including in the aggregates sector in which SKM Enviro acted as the technical consultant. One of the technologies identified with the largest potential impact on carbon emissions in the aggregates and asphalt sector was lower temperature asphalt and the acceleration of its adoption by the highways authorities, namely Local Authorities and the Highways Agency. In response to this, Lafarge Tarmac, in collaboration with its project partners, worked closely with the Carbon Trust on a project plan to develop the market for low temperature asphalt and overcome the barriers to its adoption.

Lafarge Tarmac deployed this technology on one of its UK sites, developing the new materials and the engineering process changes required to manufacture LTA with a number of partners: Nynas Bitumen provided

the technical expertise in binder and low temperature technology; Atkins the stakeholder engagement with Local Authorities and the Highways Agency; the Transport Research Laboratories (TRL) developed the product specification standards and MIRO provided independent project management.

The total project costs were £687,283 and total grants of £276,815 have been provided through the Carbon Trust and also from the Regional Growth Fund.

The project was ambitious in that it had twin objectives; the first to further develop low temperature materials capable of in situ performance that is comparable with conventional hot asphalts and the second to overcome the key barriers to market growth. These objectives were delivered through the following key areas of research:

Area 1: Technology Development

- i) Review of technologies and benefits from around the world
- ii) the development of low temperature asphalt products with lower carbon footprints
- iii) the demonstration of their performance through site trials on public roads
- iv) the parallel development of engineering solutions to enable existing plants to produce low temperature asphalt

Area 2: Overcoming Market Barriers

- i) stakeholder engagement to fully understand the barriers to the adoption of low temperature asphalts;
- ii) the development and publication of a specification standard for low temperature asphalts to enable them to be purchased consistently and with confidence.

The project's progress was overseen by a working group, made up of the project partners, to ensure that decisions were made on a collaborative basis and focused on its targets. In addition an advisory group was formed made up of senior representatives from the Highways Authorities including Local Authorities, The Highways Agency and Transport Scotland, to act as a dissemination channel for project outcomes. As part of the stakeholder engagement a questionnaire was sent to over 600 potential customers; 84 responses were returned giving a comprehensive insight into the market barriers to specifying low temperature asphalts, the main ones being:

- > knowledge & understanding
- > insufficient evidence of performance
- > absence of a national specification and
- > a risk averse attitude to procurement.

Technology

Low temperature asphalt consists of three types of material classified by the temperature at which they are manufactured:

Classification	Temperature
Warm	Produced and mixed at temperatures of 100°C to 140°C
Semi (or half) warm	Produced with heated aggregates at a mixing temperature (of the mix) of 70°C to 100°C
Cold	Produced with unheated aggregates using bitumen emulsion or foam to an ambient (less than 70°C)

These materials differ from hot asphalt in that the manufacturing procedures of the binder are modified to allow mixing, working and compaction at a lower temperature. This is achieved by the addition of modifiers to the bitumen which changes its viscosity, or by adjusting the manufacturing procedures to allow production using bitumen foam or bitumen emulsion.

This project concentrated on the design of semi-warm and cold mix products using foaming technology for the semi warm and emulsion technology for the cold as these materials offer the greatest potential for CO₂ reduction. Laboratory trials and testing were used to determine the best combination of materials to achieve the required performance. A crucial part of the early research was to optimise the foaming process to ensure that the foamed bitumen fully coated the aggregate and developed a strong bond with it.

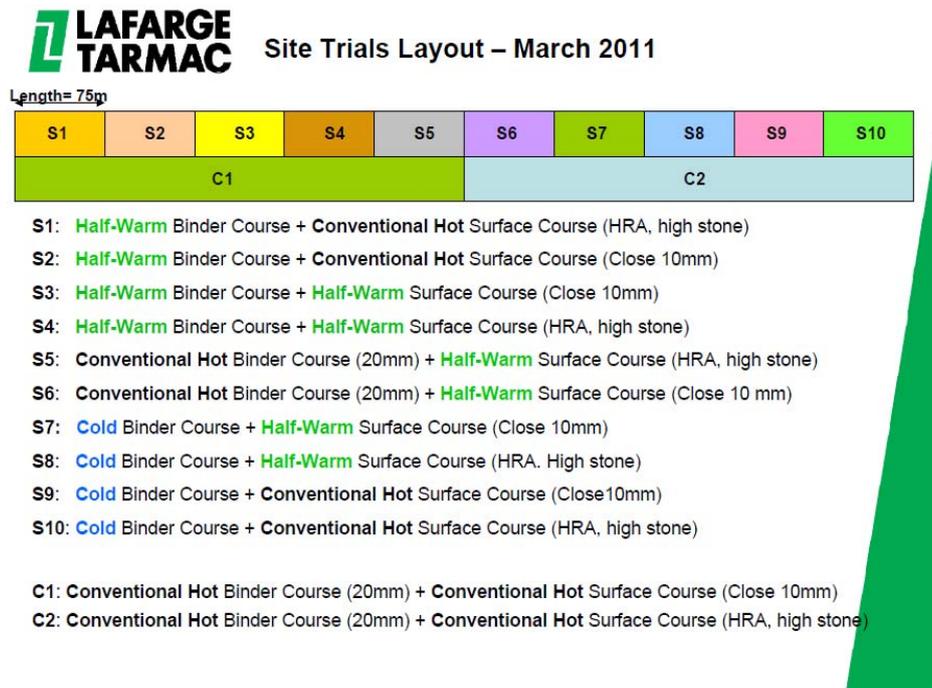
The laboratory trials produced four materials for testing on a larger scale: a cold mix material using bitumen emulsion designed to maximise the incorporation of recycled asphalt plantings (RAP) and three semi-warm mix materials made using virgin aggregates and foamed bitumen. The cold mix material was produced using an existing mobile mixing plant and the semi-warm material was made on a fixed asphalt plant in Derbyshire. Modifications to the manufacturing process were required for the semi-warm mix to enable foam bitumen to be successfully injected into the mixer box and the project faced its first engineering challenge. The challenge was the blocking of in-situ water spray nozzles -- used to produce the bitumen foam -- when switching between hot and semi-warm products.

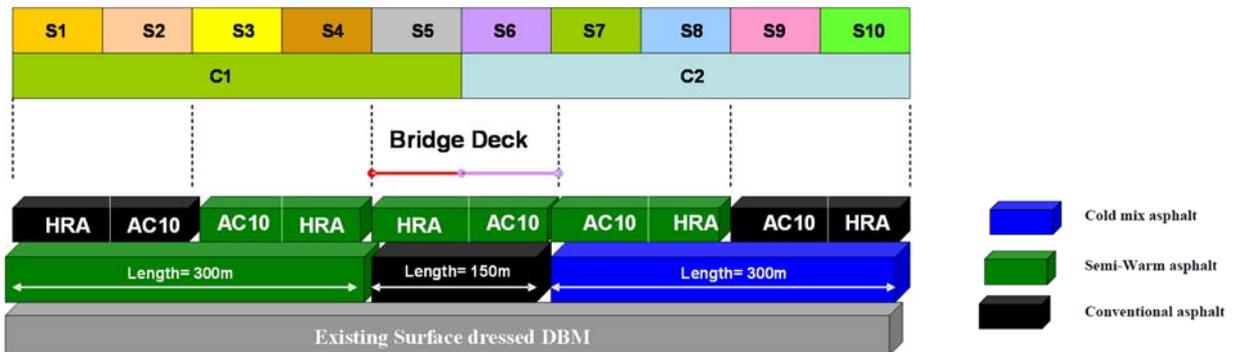
This was solved by introducing already foamed bitumen directly into the mixer as the spray nozzles could be made much larger and were less susceptible to blocking. The cost of this modification to the process amounted to £85,000 and is one that can easily be adopted by other sites as demand increases. Another technical challenge faced on scale up was the mixing regime to ensure that the finished material had the required properties.

The first semi-warm production trials took place in January 2011 and three materials were laid at the asphalt plant consisting of a binder course and two surface courses. The laying of these materials and their in-situ performance gave confidence to carry out a larger scale trial on a public road at

Bringham in Leicestershire at the end of March 2011. The length of the trial was 800m with one side of the road constructed with conventional hot asphalt binder and surface course as a control and the other side with various combinations of hot, semi-warm and cold materials. The single cold material was used only as a binder course whilst the three semi-warm materials were used as binder and surface courses. In total 10 different combinations were constructed for comparison against the conventional hot mix asphalt. The semi-warm materials were made at the modified asphalt plant and the cold mix using a cold mix mobile plant. A schematic showing the layout of each section of the trial is shown in figure 1.

Figure 1. Trafficked Road Trial



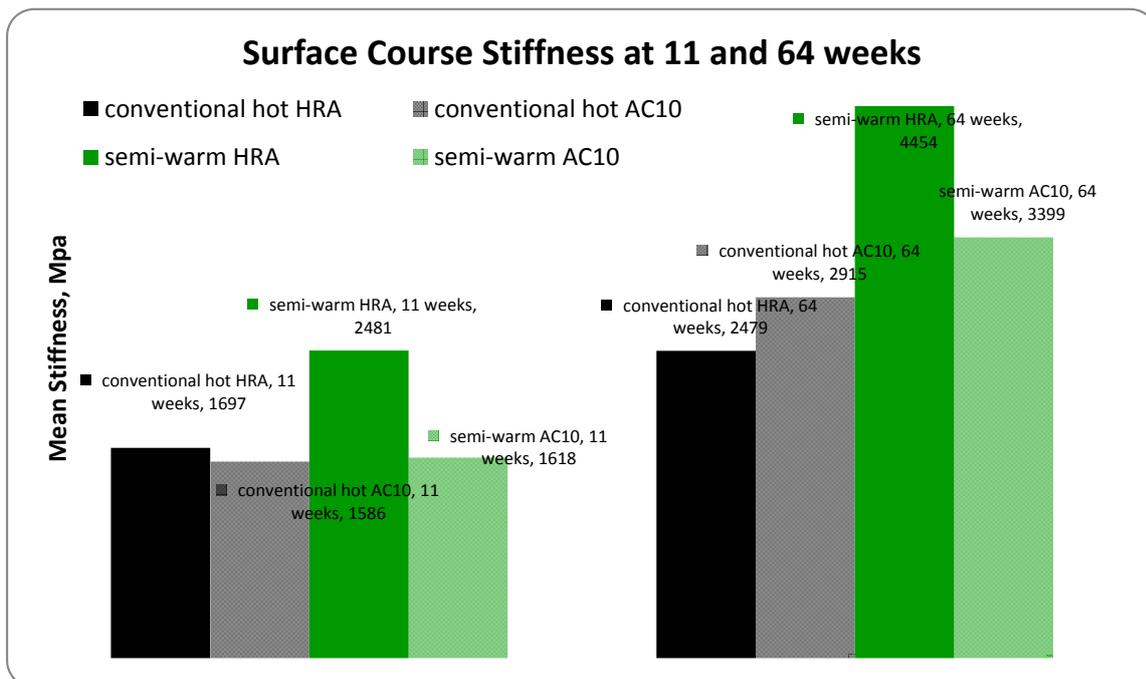


The diagram shows that on one side of the road two different hot asphalt surfaces were laid on top of a common binder course. On the other side of the road 3 binder courses were laid: hot, semi-warm and cold on top of which three surface courses were laid: two semi-warm mixes and one hot mix. No technical problems were reported during the installation of the site trials for any of the sections and a programme of performance testing on the road commenced with cores extracted at 11 weeks and 64 weeks which were

tested for stiffness. The results presented in figures 2 and 3 show excellent performances of all the combinations with comparable stiffness to conventional hot asphalts.

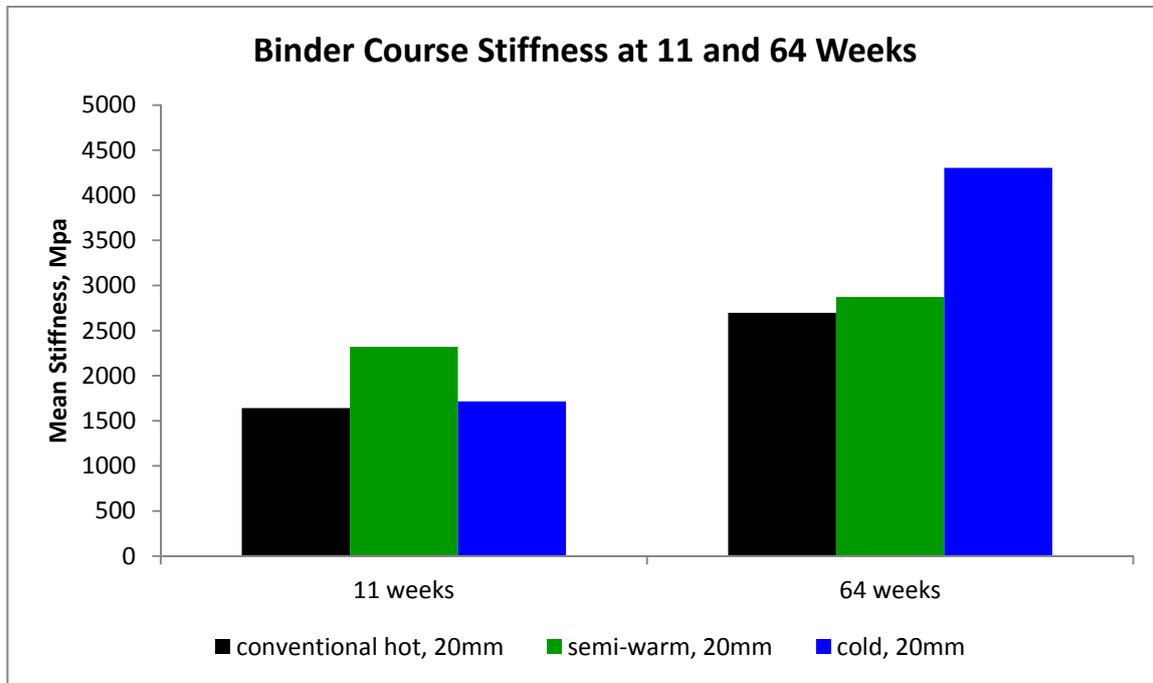
The road remains an example of how low temperature asphalt in-situ performance can match that of conventional hot mix. Monitoring of this road surface by Lafarge Tarmac and the Midlands Highway Alliance that supported the trial will continue.

Figure 2: Stiffness of Surface Course at 11 and 64 weeks



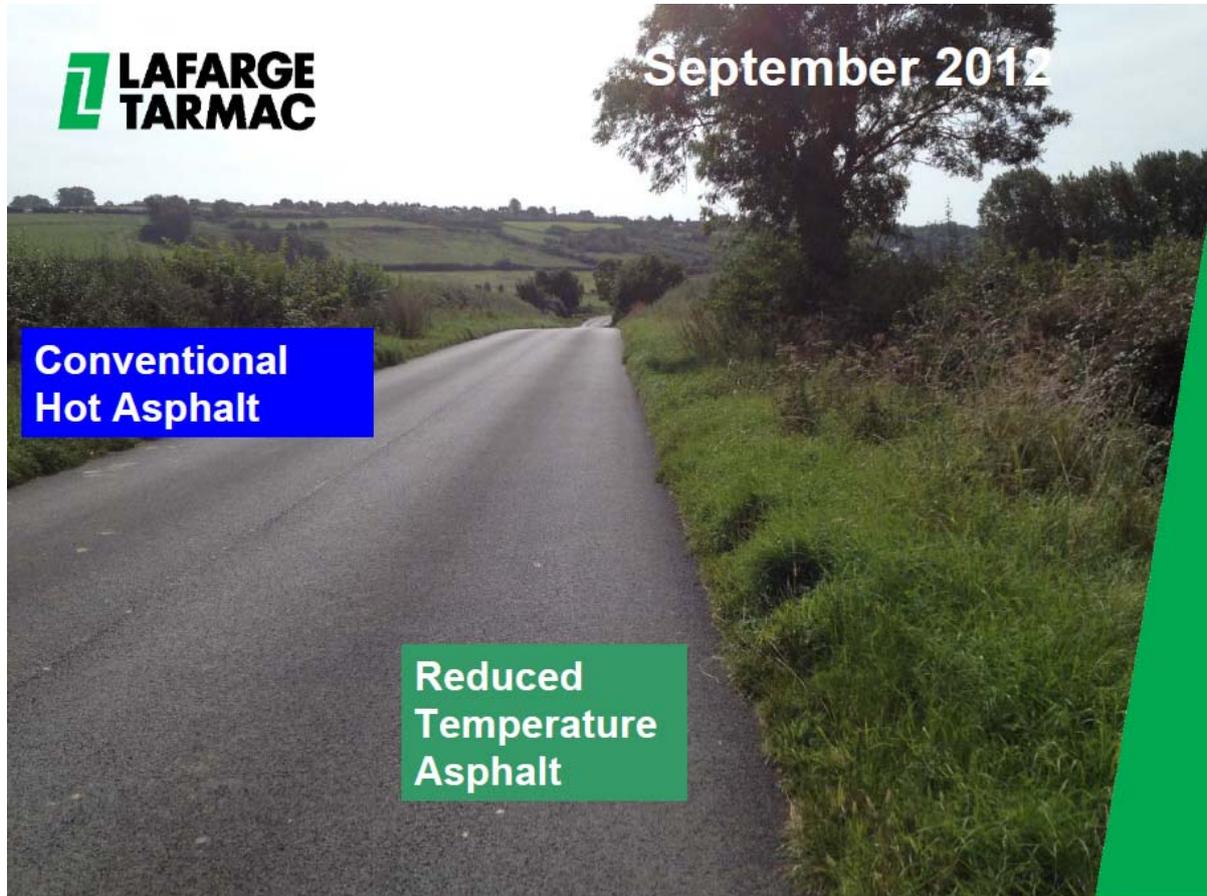
	Mean Stiffness, MPa					Binder Course Mean Stiffness, MPa		
	conventional hot		semi-warm			conventional hot, 20mm	semi-warm, 20mm	cold, 20mm
	HRA	AC10	HRA	AC10				
11 weeks	1697	1586	2481	1618	11 weeks	1641	2320	1715
64 weeks	2479	2915	4454	3399	64 weeks	2697	2873	4304

Figure 3: Stiffness of Binder Course at 11 and 64 weeks



The road is in good condition and demonstrates equivalent in-situ performance of low temperature asphalt compared to conventional hot mix. An image of the road condition after 18 months in service is given in figure 4 below.

Figure 4. Road Trial at 18 Months after Installation



Addressing Market Barriers

The engagement Atkins made on behalf of the project made with Highways Authorities including Local Authorities, The Highways Agency and Transport Scotland gave clear evidence that whilst they are very interested in using lower temperature asphalts they faced major barriers in increasing the amount they currently specify. A lack of documented evidence of their durability was one of the barriers and the absence of a national specification standard for the products was another. With the proving trials seeking to overcome the first of these barriers Lafarge Tarmac commissioned TRL to overcome the second and develop a national specification for low temperature asphalts.

TRL joined the project team and developed a specification for low temperature asphalts based on the European standards for hot asphalts and the findings from this project. The new document PPR666, "Specification for Low Temperature Asphalt Mixtures", will assist designers and procurement teams to specify low temperature asphalts with greater confidence. The publication and launch of the new specification by the project team on 20th June 2013 was a crucial step in the market advancement of low temperature asphalts.

Impact

CO₂: The CO₂ emissions associated with the production of the asphalts from the Bringhurst Site Trials are summarised in the table below. This data shows the considerable reduction in CO₂ emissions that can be made, particularly where cold asphalts are used.

Material	Carbon Footprint, Kg CO ₂ /tonne ⁵	Carbon Footprint, Kg CO ₂ /m ²	Saving over equivalent hot product, %
Surface Course, HRA			
Hot	52.0	5.1	0%
Semi-Warm	47.7	4.7	7.8%
Surface Course, AC10			
Hot	55.0	5.4	0%
Semi-Warm	50.7	5.0	7.4%
Binder Course			
Hot	45.1	6.6	0%
Semi	41.9	6.0	9.1%
Cold	27.0	4.0	39.4%

The following calculation shows an example of the savings that could be achieved if the market for low temperature asphalt in the UK rose to 21% (in line with the current proportion in the USA).

If the low temperature asphalt (LTA), composed of both surface course (all assumed to be semi-warm) and binder course (50% cold and 50% semi-warm), gradually rose to a total of 21% in volume in the next 10 years, then the CO₂ saving would be 259,000 tonnes of CO₂ over 10 years.

MPA Records 2008	Volume [Tonne]	LTA market share after 10 years
Binder	12,000,000	30%
Surface	8,000,000	20%
Base	5,000,000	0%
Total UK asphalt market	25,000,000	21%

In the following table, carbon savings are calculated assuming that both semi-warm and cold binders will reach 15% of binders' market share in 10 years (hence, low temperature binders accounting for 30%) and that semi-warm AC10 surface course will reach 20% of surface course's market share in 10 years.

Year	Replacement [%]		Manufacture (Energy) Carbon Savings		
	Binder Course	Surface Course	Semi-warm BC	Cold BC	Semi-warm SC
2014	2%	2%	544 t CO _{2e}	3,493 t CO _{2e}	670 t CO _{2e}
2015	3%	4%	1,089 t CO _{2e}	6,986 t CO _{2e}	1,340 t CO _{2e}
2016	5%	6%	1,633 t CO _{2e}	10,479 t CO _{2e}	2,010 t CO _{2e}
2017	6%	8%	2,177 t CO _{2e}	13,972 t CO _{2e}	2,680 t CO _{2e}
2018	8%	10%	2,721 t CO _{2e}	17,465 t CO _{2e}	3,349 t CO _{2e}
2019	9%	12%	3,266 t CO _{2e}	20,958 t CO _{2e}	4,019 t CO _{2e}
2020	11%	14%	3,810 t CO _{2e}	24,451 t CO _{2e}	4,689 t CO _{2e}
2021	12%	16%	4,354 t CO _{2e}	27,944 t CO _{2e}	5,359 t CO _{2e}
2022	14%	18%	4,898 t CO _{2e}	31,437 t CO _{2e}	6,029 t CO _{2e}
2023	15%	20%	5,443 t CO _{2e}	34,930 t CO _{2e}	6,699 t CO _{2e}
10 Years Total			29,935 t CO _{2e}	192,115 t CO _{2e}	36,844 t CO _{2e}
Overall			258,894 t CO _{2e}		

Cost of Material: In the early stages of the technology engineering costs associated with manufacturing Low Temperature Asphalts are expected to make material costs slightly higher than conventional asphalts but as demand increases and economies of scale become a factor, prices should be similar or slightly lower.

Next Steps for the Technology

The recently published Specification for Low Temperature Asphalt Mixtures produced by the Transport Research Laboratory will help manufacturers, contractors and customers design and specify these new materials with the right performance requirements.

As more authorities begin to use low temperature asphalts and the data on their long term performance increases, demand will further increase and more suppliers will develop processes to manufacture the new materials thus making them more available across the UK.

Low Temperature Asphalt will be promoted to the highways authorities who are keen to reduce the carbon footprint associated with new road construction and existing road

maintenance through discussions with local authorities to explain the project and benefits and through wider dissemination work to industry at conferences. As demand increases nationally suppliers will modify plants locally to ensure haulage distances are kept to a practical minimum.

Recent activities

Since September 2013, 14 local authorities within the West Midlands have signed up to build roads that contain at least 20% low temperature asphalt by 2015.

The Carbon Trust and the project partners have contributed to the dissemination at a number of industry events and continue to do so.

Acknowledgement

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Further information

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To download a copy of TRL's Specification for Low Temperature Asphalt Mixtures (PPR666) visit their web site: <http://trl.co.uk/>

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