TEXAS ASPHALT PAVEMENT ASSOCIATION

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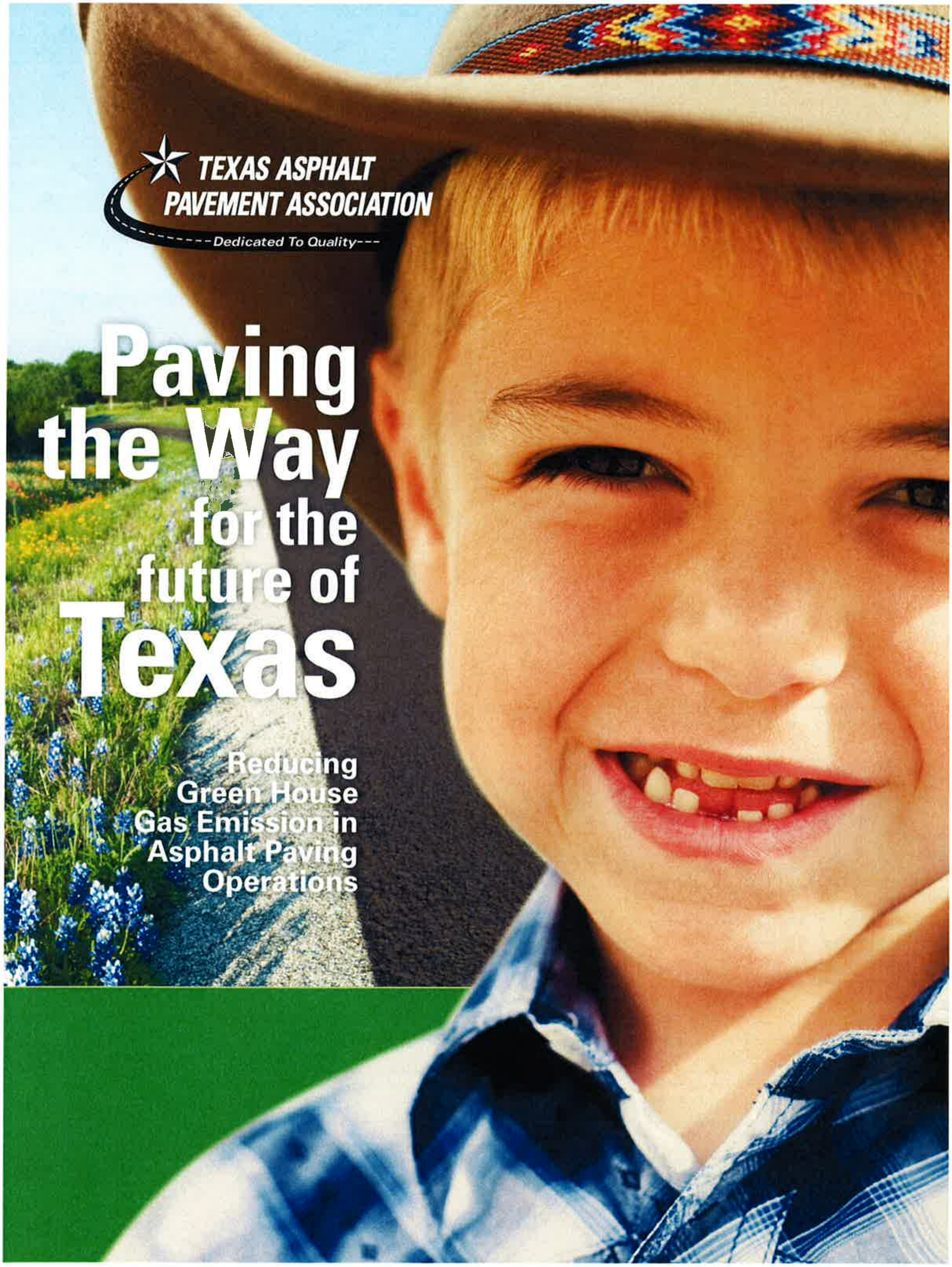
Reducing Green House Gas Emission in Asphalt Paving Operations



COMBINING WARM MIX ASPHALT WITH 15% RECLAIMED ASPHALT PAVEMENT AND 5% RECLAIMED ASPHALT SHINGLES CAN REDUCE GREEN HOUSE GAS EMISSION IN ASPHALT PAVING OPERATIONS BY NEARLY 25%

Reducing Green House Gas Emission in Asphalt Paving Operations

THE TEXAS DEPARTMENT OF TRANSPORTATION RECOGNIZES THAT IT MUST CONTINUE TO BUILD, REHABILITATE, MAINTAIN AND OPERATE THE HIGHWAY SYSTEM WITH AN EVER-INCREASING AWARENESS OF ITS IMPACTS ON THE ENVIRONMENT.

The Texas Department of Transportation (TxDOT) continues to build, rehabilitate, maintain and operate the backbone of the highway transportation system in the state of Texas. These assets are a very important contributor to the economic well being of the state of Texas and its citizens.

The Department has undertaken major research and development efforts to implement technologies that not only reduce our use of natural resources, including asphalt binders and aggregates, but also reduce the energy consumption associated with the performance of these operations.

These implemented technologies can reduce carbon dioxide (CO2) emissions and lower the production costs of these operations. Materials conservation, energy reduction, CO2 reduction and cost savings are all possible with these technologies—all while providing transportation facilities of equal or improved life cycles.

This briefing document provides information on CO2 emissions associated with the use of asphalt-bound paving materials (asphalt concrete or hot mix asphalt). CO2 is one of the gases that trap heat in the atmosphere—typically referred to as "greenhouse gases." Some of the new technologies that are being implemented statewide by TxDOT to reduce energy consumption and the amount of CO2 emitted by the Department's highway construction activities include the use of reclaimed asphalt pavement (RAP), warm mix asphalt (WMA) and reclaimed asphalt shingles (RAS).

Reclaimed Asphalt Pavement

Rather than disposing of reclaimed asphalt pavement (RAP) in landfills and utilizing RAP on unsurfaced roadways, shoulders and in base course materials, TxDOT specifications allow RAP use as a partial replacement for new or virgin asphalt binder and aggregate in new hot mix and warm mix asphalt.

In addition, technology improvements and new specifications changes now allow higher quantities of RAP in our mixtures. TxDOT contractors, at their own option, are using increased quantities of RAP due to economic incentives based on decreasing materials costs, resource conservation and energy reductions.

Warm Mix Asphalt

TxDOT specification changes also allow contractors to use warm mix asphalt technology, at their option. This relatively new technology reduces the temperature at which hot mix asphalt is produced and placed by 30–75°F and has been quickly adopted by contractors throughout the state and nation.

These lower production temperatures not only reduce CO2 emissions but also reduce energy consumption associated with mixture production and provide an improved environment for workers—both at the mix plant and at the paver. Currently eleven different warm mix asphalt technologies are approved for use by TxDOT.

Reclaimed Asphalt Shingles

Presently, most shingle waste material is discarded in landfills. Reclaimed asphalt shingles are obtained from shingle manufacturing plants as plant waste or re roofing operations commonly known as "tear-offs." Shingles contain relatively large quantities of asphalt binders that can be recycled and used in hot mix asphalt and warm mix asphalt as a replacement for virgin asphalt binder. TxDOT specification changes allow the use of reclaimed asphalt shingles in hot mix and warm mix asphalt paving materials.

Emission Reductions

This briefing presents information defining the potential for CO2 emission reductions associated with the use of RAP, WMA and RAS technologies. These technologies have been a focus of research, development and implementation efforts by TxDOT over the last few years. Information is presented in terms of technology-based reductions and annual TxDOT reductions.

Technology-Based Reductions

Tables 1–3 summarize the CO2eq reduction possible with the use of the use of the various materials and technologies as compared to standard hot mix asphalt. Note that these CO2EQ reductions represent the total reduction possible for the "complete" production operations, including extraction and production of raw materials, production of the paving mixtures, transportation and mixture placement.

TABLE 1 RECYCLED MATERIALS STRATEGIES

PAVING STRATEGY	LB. OF CO2EQ / TON OF MIX	% REDUCTION FROM HMA
HMA	108.6	--
HMA 10% RAP	104.2	4.1
HMA 20% RAP	99.4	8.5
HMA 40% RAP	90.4	16.8
HMA 3% RAS	102.8	5.3
HMA 5% RAS	100.8	7.2

RECYCLED MATERIALS STRATEGIES

Table 1 shows CO2eq emission data (lb. of CO2eq per ton of mixture) for standard hot mix asphalt and hot mix asphalt containing RAP and RAS. Note the table shows a percent reduction in CO2eq relative to hot mix asphalt as the base material. A reduction in CO2eq of 8.5% is possible with the use of 20% RAP; a reduction of 7.2% is possible with the use of 5% RAS.

TABLE 2 WARM MIX ASPHALT STRATEGIES

PAVING STRATEGY	LB. OF CO2EQ / TON OF MIX	% REDUCTION FROM HMA
HMA	108.6	--
WMA – Additive	98.6	9.2
WMA – Foam H2O	97.6	10.1

WARM MIX ASPHALT STRATEGIES

Table 2 shows representative values for CO2eq emission data for warm mix asphalt technologies (WMA) and percent reductions from standard hot mix asphalt. TxDOT currently approves the use of eleven different WMA technologies, categorized as either additives (chemical or organic) or plant modifications for water injection (foaming).

The chemical additives as a group show slightly lower percentage of CO2eq reductions as compared to the foaming techniques due to the manufacture and distribution of the chemical additives. It should be noted, however, that in general larger reductions in temperatures can be achieved with the use of additives as compared to the foaming systems. Production facility optimization is a critical factor for energy and CO2 emission reductions.

COMBINED STRATEGIES

Table 3 indicates that larger reductions in emissions are possible when a combination of these technologies is utilized. For example, a combination of 20% RAP utilization with WMA technology can reduce CO2eq by nearly 20% as compared to conventional hot mix asphalt. An aggressive use of WMA technology with 15% RAP and 5% RAS can result in a reduction of nearly 25% as compared to conventional hot mix asphalt.

TABLE 3
COMBINED STRATEGIES

PAVING STRATEGY	LB. OF CO2EQ / TON OF MIX	% REDUCTION FROM HMA
HMA	108.6	--
WMA 20% RAP	87.4	19.5
WMA 15% RAP 5% RAS	83.0	23.6

USE OF WARM MIX ASPHALT CAN REDUCE CARBON EMISSIONS BY ABOUT 10%

Annual Texas Department of Transportation Reductions

TxDOT research, development and implementation programs have resulted in an increased utilization of RAP and WMA over the last several years. Table 4 and Figure 1 contain historic data that indicates the utilization of RAP, WMA and RAS since 2005 and estimates the quantities for 2010 and 2015.

Note that Table 4 contains a column of information identified as All Mixes – HMA equivalent. This is the total tonnage of asphalt mixture produced for the year shown, but also the amount of hot mix asphalt that would be produced in that year if RAP, WMA and RAS were not utilized. RAP and RAS replace the use of virgin or new asphalt binder and aggregate in hot mix asphalt and WMA is produced at a lower temperature than hot mix asphalt. So the total of hot mix asphalt, RAP, WMA and RAS will be the All Mixes – HMA equivalent column shown on Table 4.

TABLE 4
HISTORIC AND FUTURE ESTIMATED QUANTITIES (TONS)

YEAR	HMA	WMA	RAP	RAS	ALL MIXES – HMA EQUIVALENT[1]
FY 2005	10,369,259	--	309,158	--	10,678,417
FY 2006	12,366,568	--	440,958	--	12,807,525
FY 2007	11,465,803	1,200	488,261	--	11,955,263
FY 2008	10,044,956	166,660	466,755	--	10,678,371
FY 2009	8,162,198	497,410	534,827	--	9,194,435
2010	8,370,000	900,000	700,000	30,000	10,000,000
2015	3,300,000	5,000,000	1,500,000	200,000	10,000,000

[1] "All Mixes – HMA equivalent" is the sum of the values for HMA, WMA, RAP and RAS. If WMA, RAP and RAS were not utilized the value of "All Mixes – HMA equivalent" represents the total HMA placed for the year.

FIGURE 1
EFFECT OF TECHNOLOGIES ON HOT MIX ASPHALT USED, PERCENT

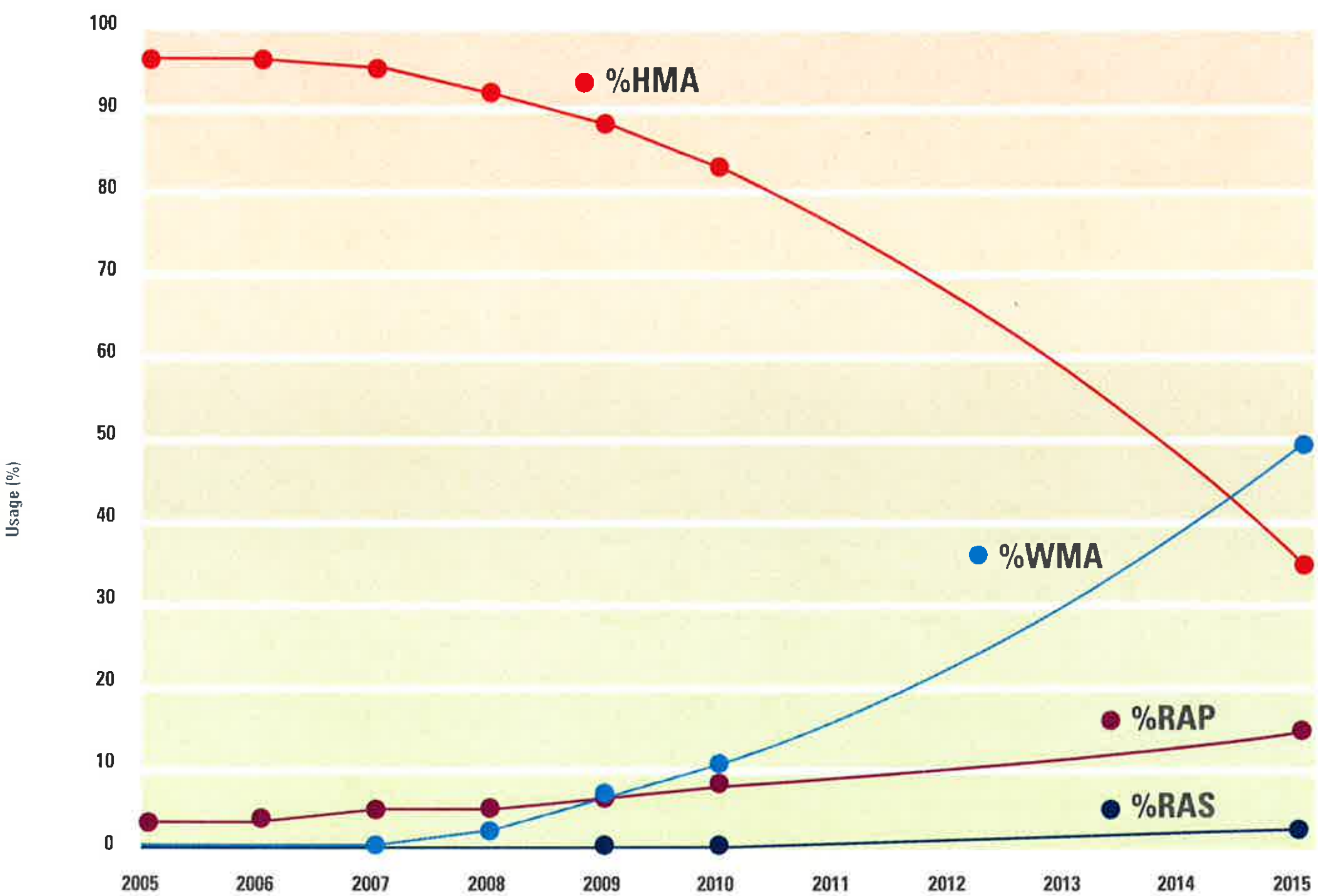


Table 5 and Figure 2 show the CO2eq reductions associated with the use of these technologies anticipated in the 2010 and 2015 construction seasons. Estimated tonnages are shown for each technology as well as the combination of all technologies. For example, in 2010 an overall reduction in CO2eq resulting from these technologies is expected to be 20,647 tons, or 3.8%, as compared to the use of conventional hot mix asphalt.

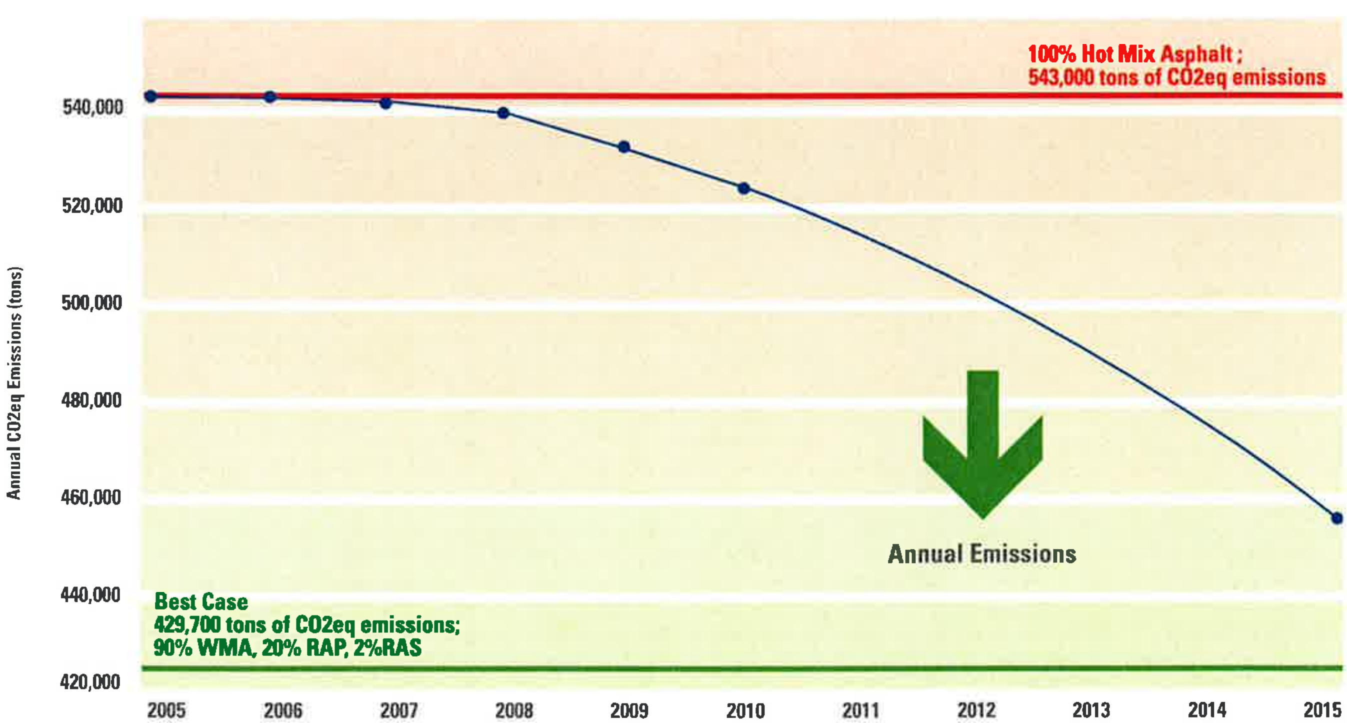
Figure 2 shows the annual CO2eq emissions and the overall reduction by the increased use of RAP, WMA and RAS. This trend is expected to continue, as the estimated tonnages for 2010 and 2015 shown in Table 4 provide an even greater reduction in CO2eq emissions. A best case scenario shown in Figure 2 estimates 429,700 tons of emissions—a reduction of 113,300 tons, or 20.9%— and utilizes 90% WMA, 20% RAP and 2% RAS.

TABLE 5
CARBON DIOXIDE REDUCTIONS

YEAR	MATERIALS							
	HMA (tons)	WMA (tons)	RAP (tons)	RAS (tons)	TOTALS			
					Mix (tons)	CO2eq (tons)	Reduction (tons)[1]	Reduction (%)[1]
Baseline	10,000,000	0	0	0	10,000,000	543,000	--	--
2010	8,370,000	900,000	700,000	30,000	10,000,000	522,353	20,647	3.8
2015	3,300,000	5,000,000	1,500,000	200,000	10,000,000	468,830	74,170	13.7

[1] From Baseline—based on 10,000,000 tons of hot mix asphalt or 100% hot mix asphalt

FIGURE 2
EFFECT OF TECHNOLOGIES ON ANNUAL CO2EQ EMISSIONS



USING 20% RECLAIMED ASPHALT PAVEMENT IN HOT MIX ASPHALT REDUCES CARBON EMISSIONS BY ABOUT 8.5%

Looking even further ahead, while availability may limit the use of RAP and RAS, the potential of WMA use could drastically increase over the next decade. We can convert the amount of CO2eq reduction associated with the use of these technologies in highway construction, rehabilitation and maintenance into equivalent savings for commonly used consumer identifiable items such as gallons of gasoline, barrels of crude oil, electricity used in homes and coal used to fire power plants. Table 6 shows these conversions. For example, the savings in CO2eq expected in 2010 is equivalent to saving 2,106,934 gallons of fuel, which would be transported by 250 trucks. These savings also amount to 43,560 barrels of crude oil or 97.8 railcars of coal. These savings are also equivalent to the electricity supplied to 2,433 homes for one year.

TABLE 6 CARBON DIOXIDE EQUIVALENCIES

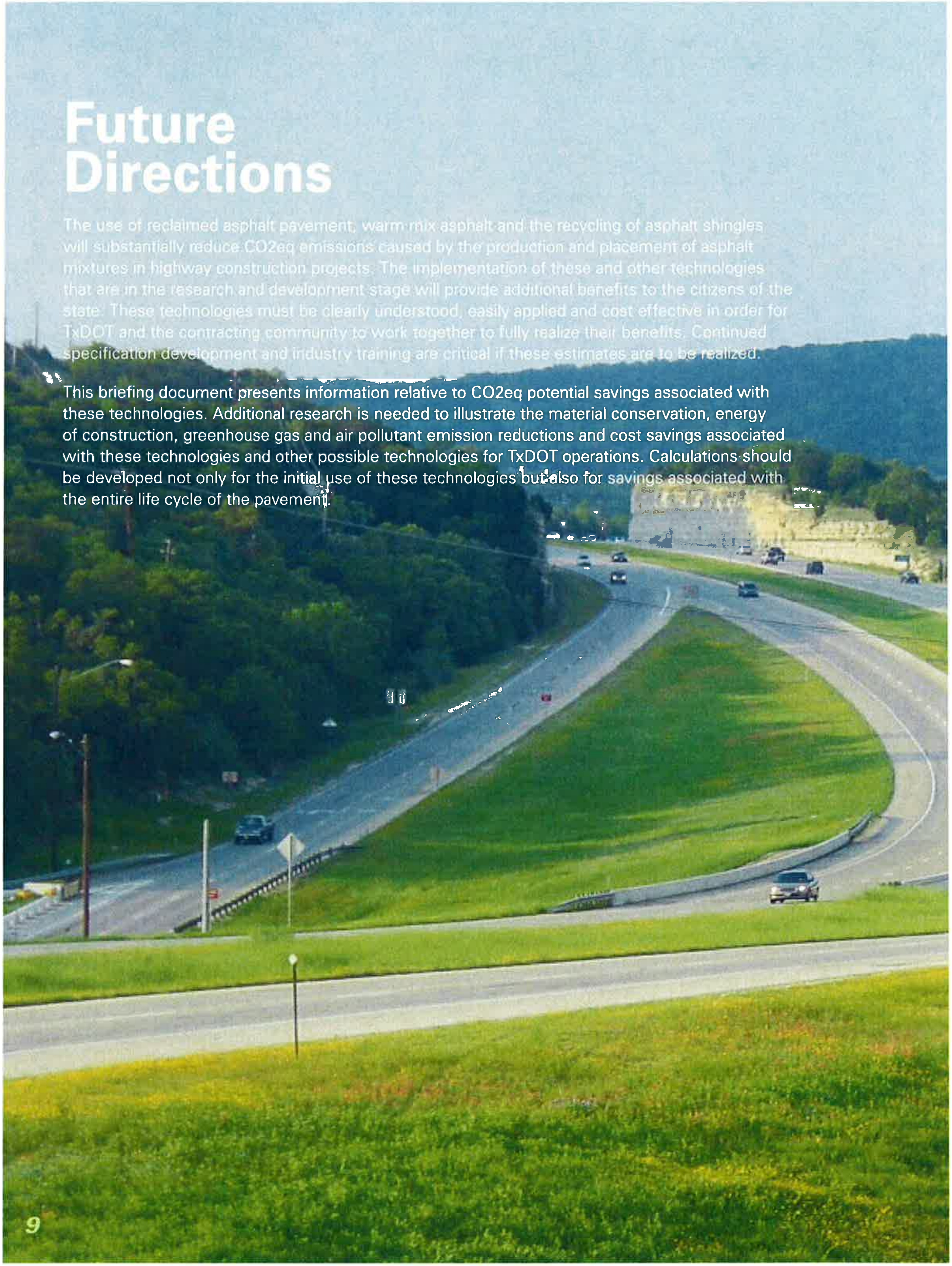
YEAR	REDUCED CO2EQ (TONS)[1]	EQUIVALENT REDUCTIONS					
		Vehicles Removed from Roadway for One Year	Gallons of Gas Consumed	Barrels of Oil Consumed	Homes Supplied with Electricity for One Year	Railcars of Coal Consumed	Tanker Trucks of Gas Consumed
2010	20,647	3,581	2,106,934	43,560	2,433	97.8	250
2015	74,170	12,865	7,568,716	156,479	8,738	351	898

[1] From Baseline—based on 10,000,000 tons of hot mix asphalt

Future Directions

The use of reclaimed asphalt pavement, warm mix asphalt and the recycling of asphalt shingles will substantially reduce CO_2eq emissions caused by the production and placement of asphalt mixtures in highway construction projects. The implementation of these and other technologies that are in the research and development stage will provide additional benefits to the citizens of the state. These technologies must be clearly understood, easily applied and cost effective in order for TxDOT and the contracting community to work together to fully realize their benefits. Continued specification development and industry training are critical if these estimates are to be realized.

This briefing document presents information relative to CO_2eq potential savings associated with these technologies. Additional research is needed to illustrate the material conservation, energy of construction, greenhouse gas and air pollutant emission reductions and cost savings associated with these technologies and other possible technologies for TxDOT operations. Calculations should be developed not only for the initial use of these technologies but also for savings associated with the entire life cycle of the pavement.



Industry Voices

Asphalt is *the* sustainable pavement type. From the production of the mix, to its placement on the roadway, to its rehabilitation through RAP — America's most recycled product—asphalt pavements minimize the impact on the environment.

Dr. Jon Epps, Ph.D., P.E.
TTI Executive Associate Director

Meeting budgets is important, quality is important and the environment is important. WMA, RAP, RAS and other asphalt paving technologies fit the bill on all three. I see TxDOT and TxAPA working closely for years to come to continue what we have underway.

— David Casteel, P.E., TxDOT Assistant Executive Director for Field and District Operations

The combined use of RAP, RAS and WMA is where we see the most potential to reduce green-house gases in our industry. Our goal is to be an environmentally responsible agency pro-actively implementing these types of technologies without sacrificing safety or the quality of our highways.

— Robert Lee, P.E., TxDOT Senior Materials Engineer

The use of RAP, RAS and warm mix is just the right thing to do. We should continue to be leaders in this area as opposed to being directed down this path. Being proactive with this technology is the appropriate direction for the environment, the citizens of Texas and our industry.

—Chuck Fuller, President, Ramming Paving Company, Ltd.

The asphalt paving industry in Texas is eagerly addressing the sustainable needs of the traveling public and our partners in quality. Through emerging and proven technology such as RAP, RAS and WMA we are able to deliver high quality asphalt pavements that are sustainable and cost effective. When you analyze the true facts it is clearly evident that asphalt pavement is the leader when it comes to environmental sustainability in the construction industry.

—Harold Mullen, Executive Vice President, Texas Asphalt Pavement Association

Partners in Paving the Way

Source of Emission Data

In this briefing document, three primary references form the basis for CO2 emission data from the production and placement of various paving materials (1–3). Colas, an international construction materials company, has published the most complete summary available on CO2 emissions from paving operations (1). The Canadian government developed a document defining methodologies to reduce energy associated with highway construction and maintenance operations (2). The third reference was developed by Granite Construction, a U.S. based transportation Construction Company (3). Granite's report was recently presented at the Transportation Research Board Annual Meeting. The calculations contained in this briefing document are based on representative values for CO2 generation from these three sources.

Information on quantities of materials produced and utilized for TxDOT projects was obtained from the Department's SiteManager project database (4) and from the Construction Division's Flexible Pavements Branch (5).

Basis of Calculations

Carbon dioxide equivalent (CO2eq) is the most commonly used parameter to indicate the warming potential of various greenhouse gases as compared to CO2. A U.S. Environmental Protection Agency mathematical model was used to calculate CO2eq (6). The gases included in this model are CO2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.

References 1–3 were used to define the gases associated with various construction, rehabilitation and maintenance operations. The data in these references are based on the "complete" production operations, including extraction and production of raw materials and production of the paving mixtures as shown below:

1. Extraction and production of asphalt binders and additives
2. Extraction and production of aggregates
3. Haul of asphalt binder, additives and aggregates from production source to asphalt mixing plant
4. Production of asphalt bound mixtures
5. Transportation of mixture to the placement site on the highway
6. Placement and compaction of the mixture

For a full discussion on this topic, see Reducing Green House Gas Emission in Asphalt Paving Operations by Robert E. Lee, P.E., Construction Division, Materials & Pavements Section, TxDOT and Dr. Jon A. Epps, P.E., Executive Associate Director, Materials & Pavements Division, Texas Transportation Institute. February 2010.

References

[1] Chappat, M. and Julian Bilal, "The Environmental Road of the Future, Life Cycle Analysis", Colas Group, 2003.

[2] "Road Rehabilitation Energy Reduction Guide for Canadian Road Builders", Natural Resources Canada in collaboration with the Canadian Construction Association, 2005.

[3] Robinette, Christopher and Jon A. Epps, "Energy, Emissions, Material Conservation and Prices Associated with Construction, Rehabilitation and Material Alternatives for Flexible Pavement", to be published by the Transportation Research Board (presented at the 2010 Annual Meeting of the Transportation Research Board, 2010).

[4] Site Manager Reference

[5] Flexible Pavements CST Reference

[6] "Green House Gas Equivalencies Calculator", United States Environmental Protection Agency, (http://www.epa.gov/cleanenergy/energy-resources/calculator.html)

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