Update from ISAP APE LCA working group

TRB 2012

Updates

- Michigan Technical University
- Massachusetts Institute of Technology
- FHWA contract on pavement sustainability
- RILEM 2011
- Miriam (U. of California, VIT Sweden, ZAG Slovenia)
- IFSTTAR (M. Kane)
- A few comments

Michigan Technical University

Amlan Mukherjee

Project Emissions Estimator (PE-2) - Inventory

- Web Based Construction Project Inventory
  - Based on 14 highway construction, maintenance & rehab projects that were closely monitored
  - Resources: All materials & equipment used on site
  - Site Information: Layout, operation design
  - Travel Distances: On site and to site travel distances
- Provides: Project emissions calculated using a Life Cycle Assessment method:
  - Footprint in carbon emission equivalents "to gate"
  - Example

PE-2 Estimator Tool

- An online tool to estimate highway project emissions:
  - Empirical estimates based on project inventory
  - Use phase included: MOVES emission estimator used
- Properties:
  - Users can load:
    - Material & equipment use estimates using online estimate tool
    - Expected pavement maintenance schedule
  - Returns annualized emissions over the expected pavement life
  - Can be used as a project level & network level emission estimator

PE-2
Project Emission Estimator

EMISSIONS REPORT FOR PROJECT NUMBER 44043-79776:

Project type: Concrete Reconstruct, 40.56 lane miles
Project location: I-69
Project classification: R1
Number of working days: 350

Brief Project Description

10.14 mi of concrete pavement and shoulder reconstruction; guardrail and drainage improvements; and bridge rehabilitation of 12 bridges on I-69 from east of M-15 easterly to east of M-24; Genesee and Lapeer Counties.

MATERIALS EMISSIONS

Total material emissions were calculated across the following material categories:

Material Category	Tonnage (MT)	Emissions (MT of CO2)
Asphaltic	24428.7	300.03
Concretus	299108	34521.2
Drainage	--	864.85
Earthwork	--	2079.32
Batchplant	--	1402.65
Misc.	--	1544.06
	Total	40712.1

Pavement Metrics

CO2 Equivalent Emissions in MT per 100 MT of pavement material:

Asphaltic: 1.23 MT of CO2/100 MT

Concretic: 11.54 MT of CO2/100 MT

For detailed break up of emissions across divisions:

Query

EQUIPMENT EMISSIONS

Total material emissions were calculated across the following material categories:

Category	Emissions (MT of CO2)
On Site	3367.49
To Site	5.55
Total	3373.04

Equipment Metrics

Emissions per working day: 9.64 MT of CO2 Equiv.

Gallons used per day: 761.31 Gallons

Detailed equipment emissions per equipment category: (Please be patient, this query may take a while)

Query

SUMMARY

TOTAL PROJECT EMISSIONS: 45487.79 MT OF CO2 EQUIVALENTS

Massachusetts Institute of Technology

Methods, Impacts, and Opportunities in the Concrete Pavement Life Cycle

Summary of Findings

Report published December, 2011

Nicholas Santero

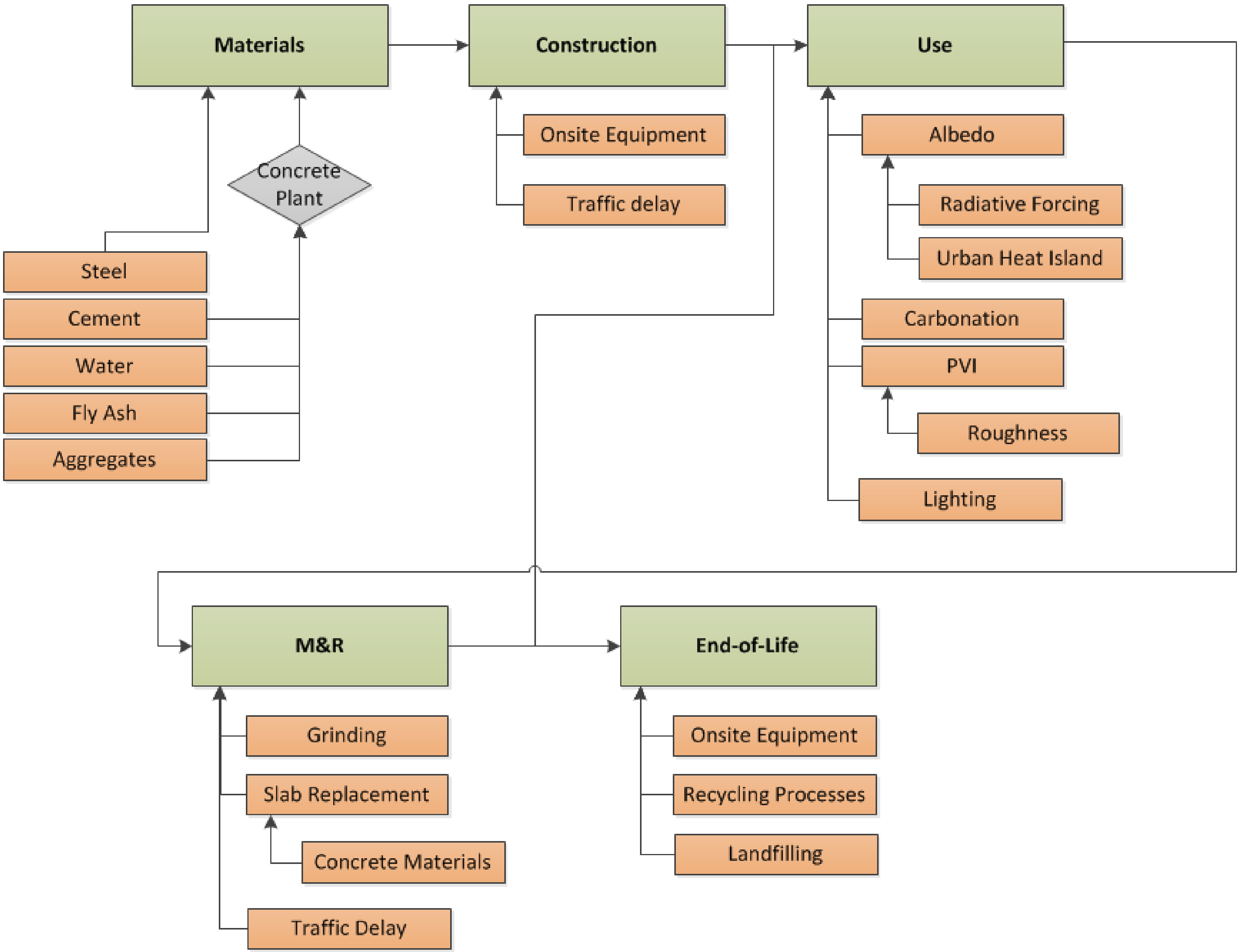
Research Goals

1. Develop a comprehensive methodology that puts forth good-practice concepts for conducting a pavement LCA;

2. Use the developed methodology to quantify GHG emissions for concrete pavements, identify strategic opportunities for reducing emissions, and calculate the cost effectiveness of the reduction strategies;

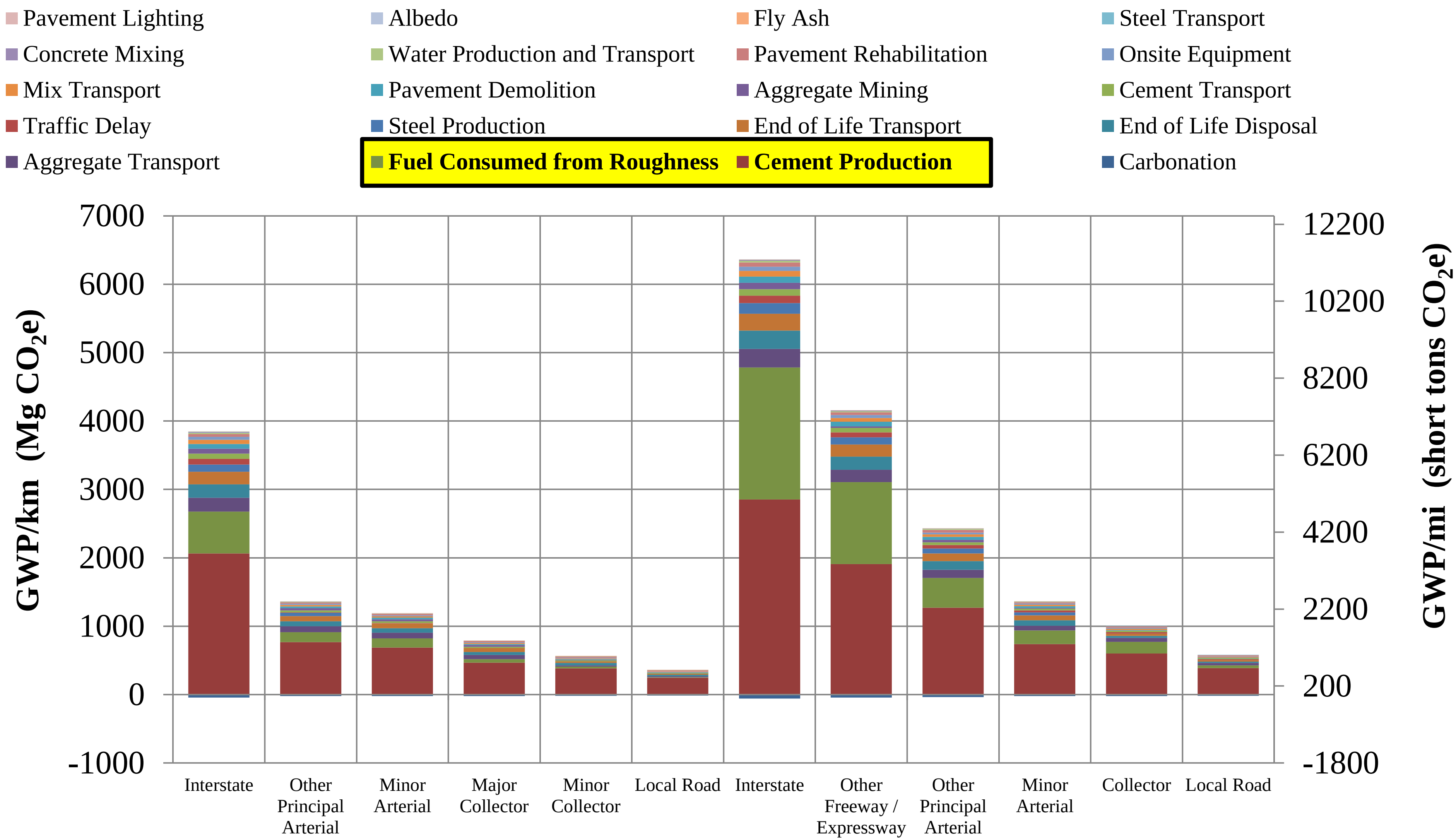
3. *Improve the science which supports pavement LCAs by developing a first-order mechanistic pavement-vehicle interaction (PVI) model that relates fuel consumption to pavement material and structural properties.*

Simplified Flow Chart of the MIT Concrete Pavement LCA Model



LCA Results

Absolute GWP per centerline-kilometer and centerline-mile



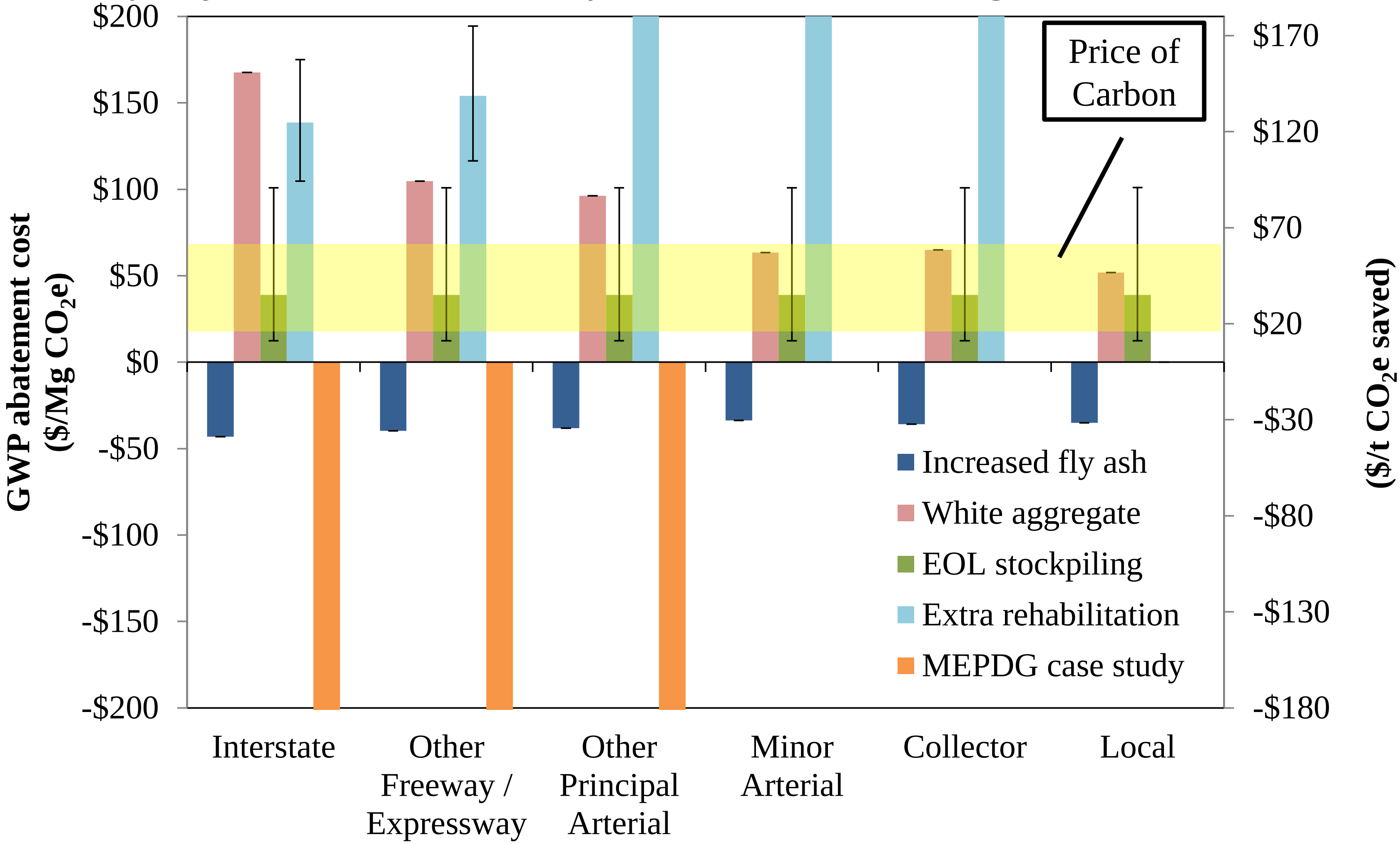
GHG Emission Reduction Opportunities

Categories and Scenarios

- A strength of LCA is helping to identify and compare reduction opportunities
  - Where are the low-hanging fruit for emission reductions?
  - How can transportation agencies and industry achieve emission reduction targets?
- Many opportunities for reductions in the concrete pavement life cycle
  - Quantitatively exploring a subset of possible solutions
  - Establish a framework for evaluating and comparing emissions reduction strategies
- Categories (scenarios) evaluated
  1. Embodied emissions (fly ash replacement, MEPDG case study)
  2. Albedo (white aggregate)
  3. Carbonation (End of Life crushing and exposing)
  4. Fuel consumption (extra rehabilitation)

Cost-Effectiveness Analysis

Example for urban roadways, with discounting (0%, 2.3%, 5%)



Key Findings: Concrete Pavement LCA

- Comprehensive approach
  - Quantified GWP for all FHWA roadway classifications, from urban interstates to rural local roads
  - All relevant phases of the life cycle (materials → end of life)

- Potential for significant GWP reductions
  - Reductions over 50% possible
  - Many other opportunities exist and should be evaluated, for example:
    - Slag
    - Two-lift pavements
    - Increase processing efficiency

- Many strategies are (or can be) cost effective
  - Reducing natural resources lowers emissions and costs
  - Other strategies are competitive with carbon prices, but need to be evaluated on a project scale.
  - Framework is established – needs to be expanded to additional strategies

WELCOME

to

UNIVERSITY OF LIVERPOOL

RILEM Technical Committee SIB

Advanced Testing and Characterization of Sustainable & Innovative Bituminous Materials

and

RILEM Technical Commitee MCD

Mechanisms of Cracking and Debonding in Asphalt and Composite Pavements

- <u>State of the Art Report – Discussion & Approval</u>
- <u>TG2 "Mixture Design and Compaction"</u>
- Chairman: Hussain Bahia
- Heterogenous nature of mixes and mechanical properties
- <u>TG3 "Mechanical Testing of Mixtures"</u>
- Chairman: Hervé Di Benedetto
- Three dimensional visco-elastic modeling
- <u>TG4 "Pavement Multilayer System Testing"</u>
- Chairman: Francesco Canestrari
- <u>TG6 "Cold Recycling"</u>
- Chairman: Tebaldi Gabriele
- Webinar
- <u>TG1 "Bituminous Binders"</u>
- Chairman: Darius Sybilski
- Test methods, additives, binder-aggregate interaction, specifications
- <u>TG5 "Recycling"</u>
- Chairman: Paul Marsac
- Hot mix recycling

FHWA Sustainability Contract

- **FHWA's Sustainable Pavements Program**
- **Project/Task Order 1 Kick-Off Meeting**
- **31 January, 2011**
- **First task order to establish Technical Working Group**
- **Highway agencies, local government, academia, industry organizations (asphalt and concrete), contractors, suppliers**

Meetings

- Organizing meeting for group in Chicago, May 2011
- Working meeting Atlanta, November, 2011
  – Presentations on reducing emissions from asphalt and concrete mixes
  – Review of sustainability ratings tools
  – Implementation of new strategies
  – Breakout sessions on definitions
- Next meeting April, 2012
  – Presentations on LCA work
  – Presentation on sustainability ratings systems
  – Rest of agenda being developed

Miriam SP3 Update

University of California
VTI Sweden
ZAG Slovenia

Rolling Resistance effects on
Greenhouse Gases

Miriam Update

- SP1 (VTI, Belgian, Polish, German devices) measurements of rolling resistance at Nantes, France, October, 2011
- LCA models independently developed by UCPRC and VTI, similar approaches
- Workshop to compare and discuss elements of models held in Sweden in November, 2011

Anneleen Bergiers BRRC
Luc Goubert, BRRC
Fabienne Anfosso-Lédée, IFSTTAR
Niels Dujardin, DRI
Jerzy A. Ejsmont, TUG
Ulf Sandberg, VTI
Marek Zöller, BASt


SAXAS
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SCHMITZ

Miriam LCA case studies

- Case studies and reports/papers completed:
  - UCPRC on pavement rehabilitation versus do nothing for asphalt and concrete rehabilitation with high and medium volume traffic
  - VTI on pavement reconstruction alternatives for low volume roads
- White paper on rolling resistance being prepared
- Miriam Phase I summary: TRB session 265, Shoreham Palladium, Monday 13.30 hrs

Factorial for LCA for California State and Local Networks

Factorials	Possible Value
Road type	Rural road; urban road
Road grades	Flat road; mountainous road
Road access type	Restricted access; unrestricted access
Traffic level	Different levels of AADT and AADTT, categorized
Pavement surface type	Asphalt pavement; cement concrete pavement
Pavement surface characteristics	Different levels of IRI and MPD, categorized
Treatment	Different pavement treatment options

Case Study 1 (KER-5): Asphalt overlay on rural/flat freeway

10 mile (16 km) segment in need of rehab
- Rural freeway
- 2 lanes, southbound
- AADT: 34,000; ~35% trucks

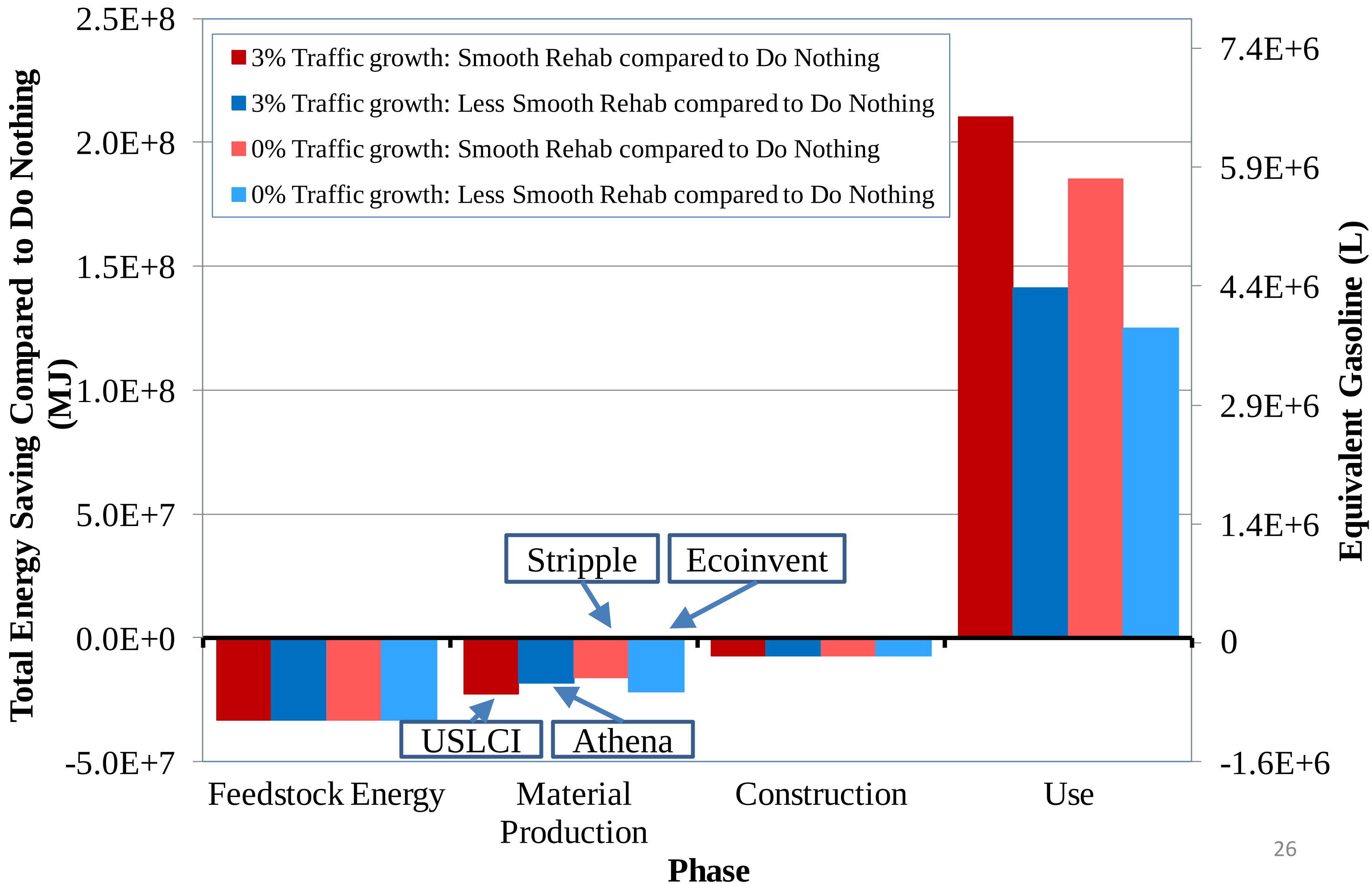
	Passenger	Trucks
Inner Lane	77%	9%
Outer Lane	23%	91%

Compare:
- Do Nothing
-10 year rehab
-HMA, RHMA

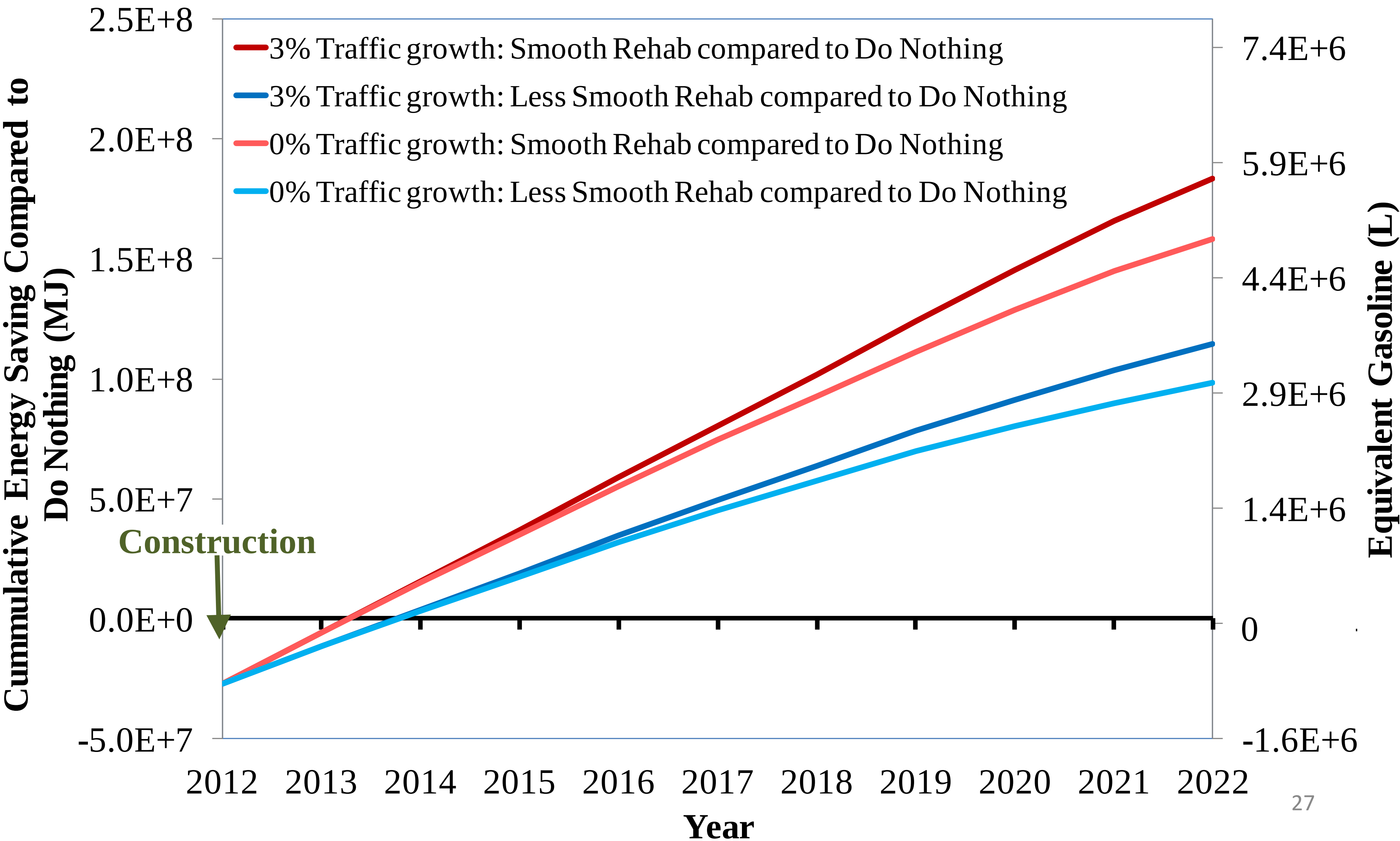
Construction Scenarios: KER-5

HMA Type	Design life	Treatment	Cross Section	Smoothness
HMA	10 Years	Mill & Overlay	45 mm (0.15') Mill + 75 mm (0.25') HMA with 15% RAP	Smooth Rehab
				Less smooth Rehab
RHMA	10 years	Mill & Overlay	30 mm (0.1') Mill + 45 mm (0.15') RHMA	Smooth Rehab
				Less smooth Rehab

KER-5 (HMA): 10-year life cycle energy savings compared to “Do Nothing”



KER-5 (HMA): Cumulative life cycle energy savings compared to "Do Nothing"



Case Study 3 (BUT-70): Asphalt overlay on rural/flat highway

5 mile (8 km) segment in need of rehab

- Rural highway
- 2 lanes, westbound
- AADT: 3,200; ~15% trucks

	Cars	**Trucks**	**IRI**
Lane 1 (Inner)	61%	8%	3.8
Lane 2	39%	92%	3

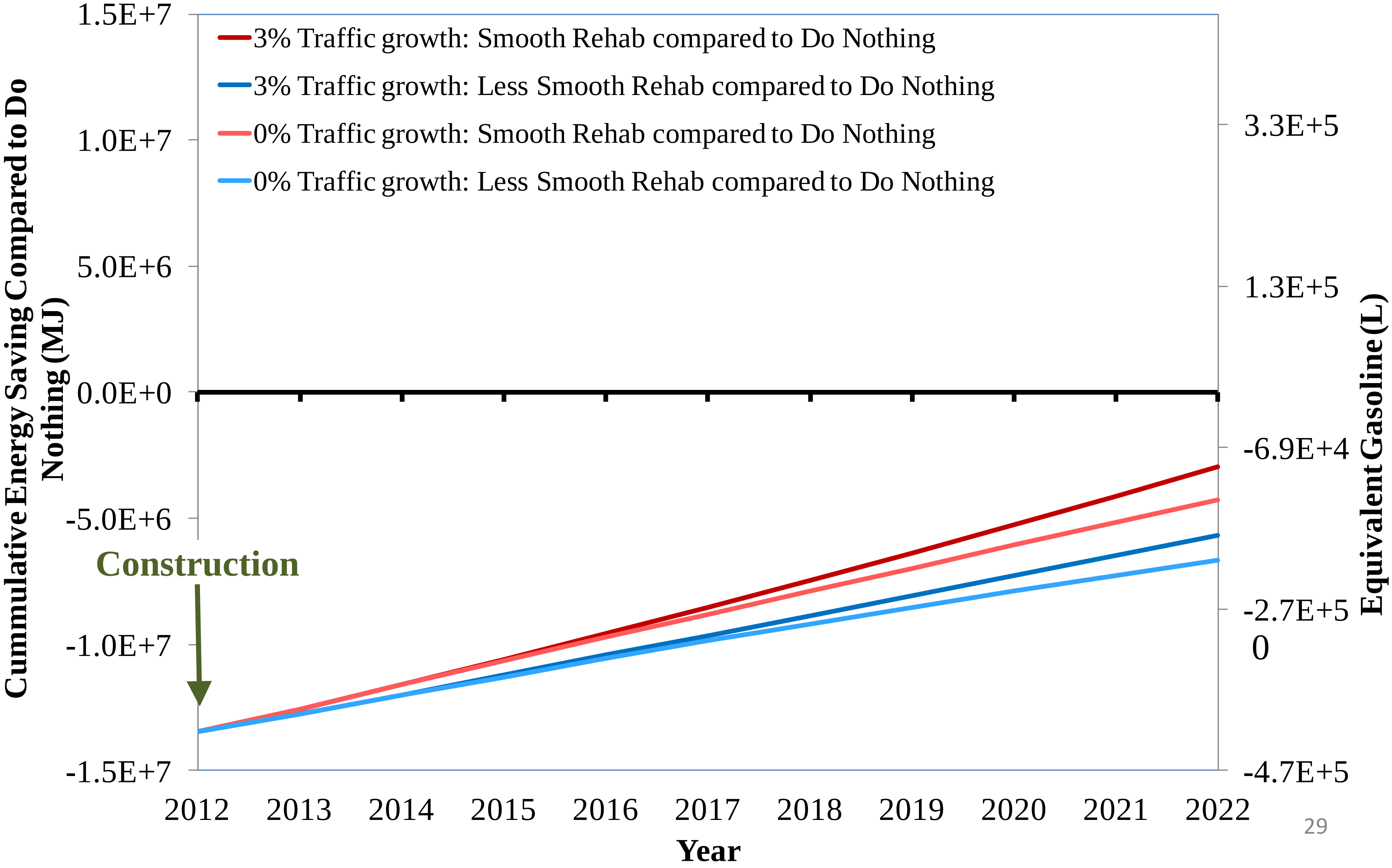
Compare:

- Do Nothing

-10 year rehab

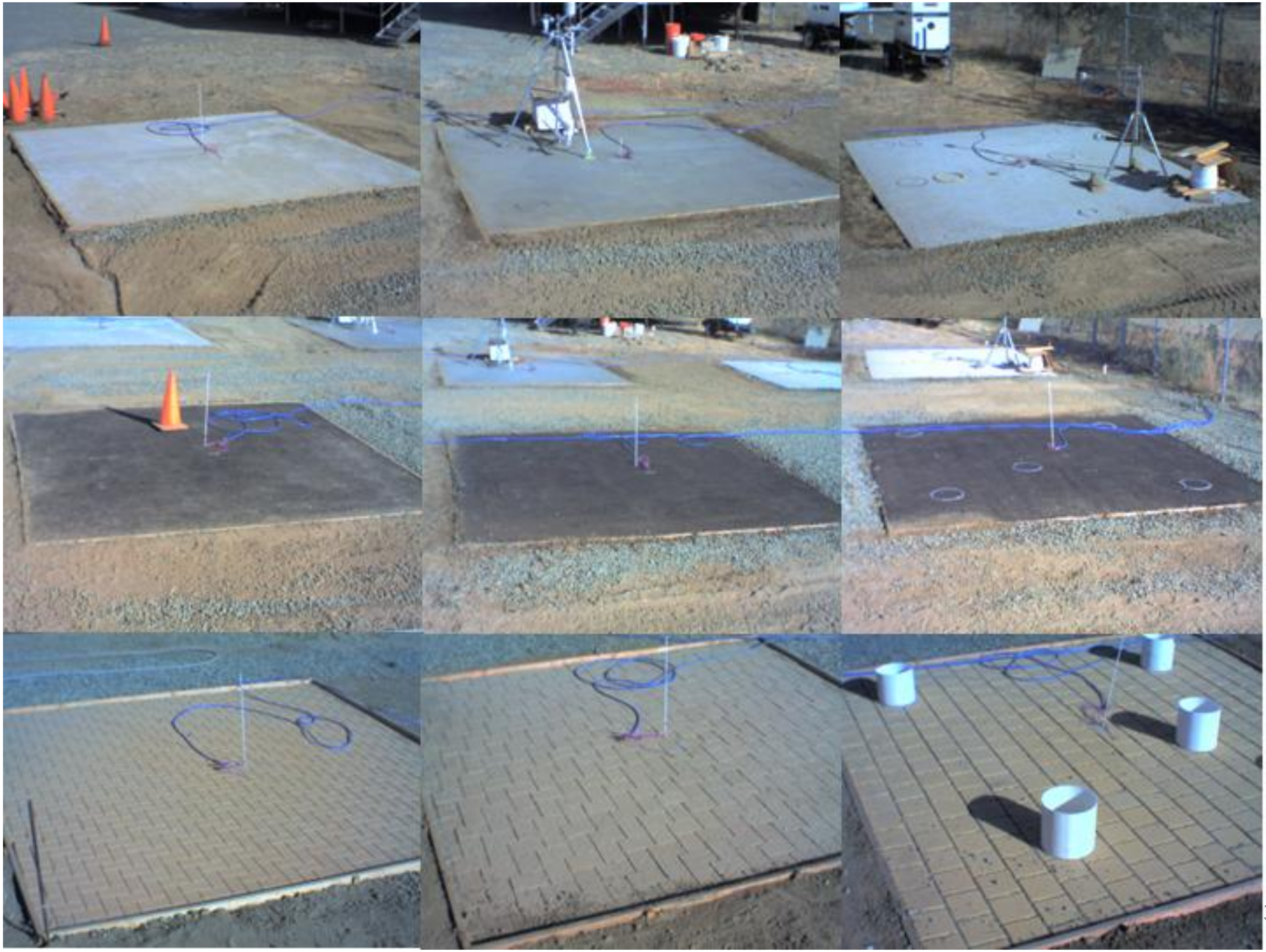
-HMA, RHMA

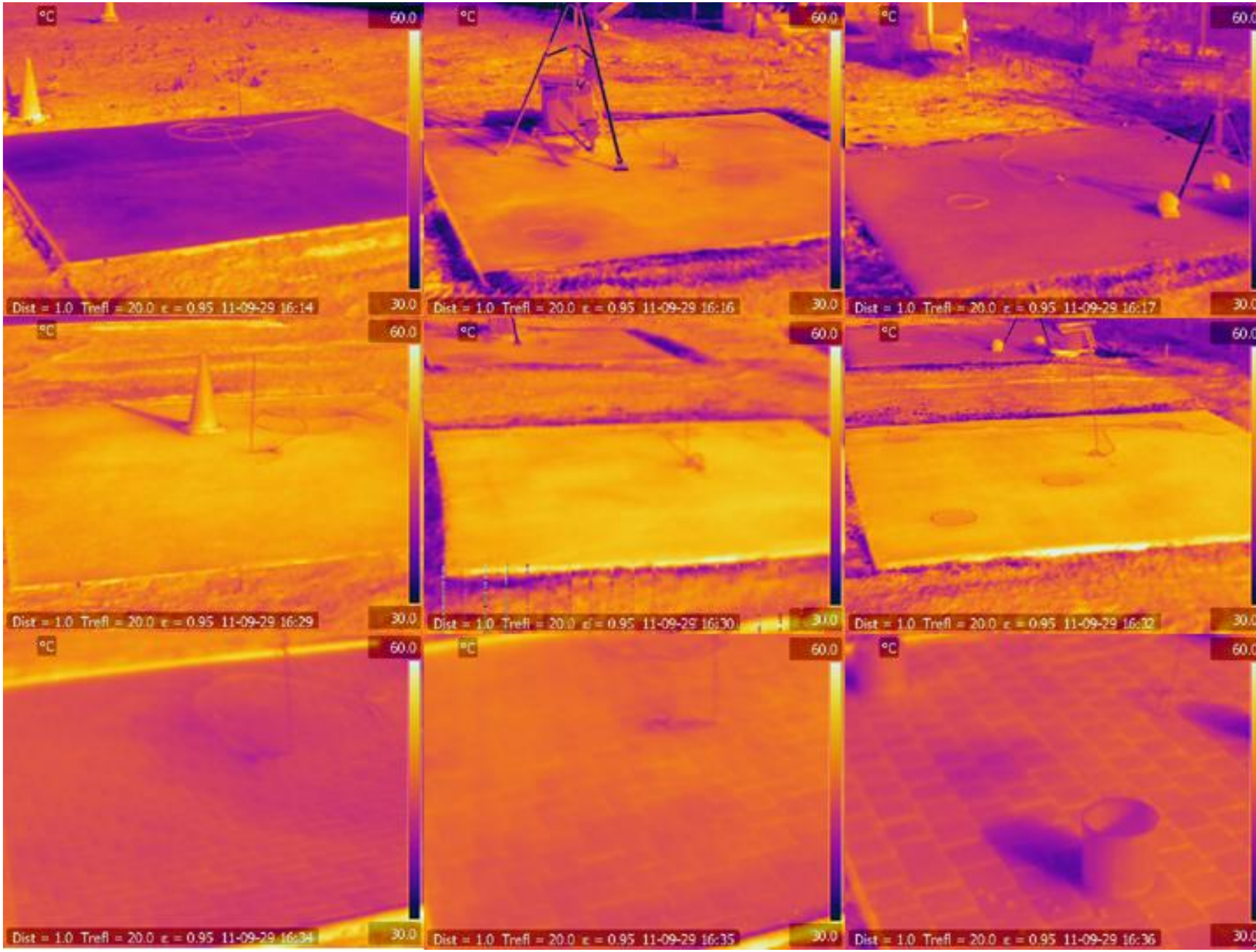
BUT-70 (HMA): Cumulative life cycle energy savings compared to “Do Nothing”



Big Issue in US: Cool pavements

Permeable, impermeable pavement heat island test sections, Davis, CA

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IFSTTAR

"Environmental Assessment of Roads construction and maintenance
The French Experience"

22th january 2012 Washington ISAP meeting

Dr Agnès Jullien
Presented by Dr Malal Kane
Research Unit EASE
Department Infrastructures et mobilité IFSTTAR (LCPC before)

Our experience with LCA : 2001-2011

- contracts mixing experimental measurements and LCA
  - Environmental evaluations of reclaimed asphalt pavements
    - *Resources, Conservation & Recycling 47, pp356-374, 2006.*
    - *J. Road Material and Pavement Design, Vol.9, pp. 319-338, 2008.*
  - Environmental comparison of and hot and warm mix processes
    - *Transport research Board, Washington, January 2008*
    - *Routes roads publication, 2011*

- Environmental assessment of earthworks
- *New Delhi /PIARC meeting , february 2011*

- Ph.D thesis
  - *Tung Hoang, 2005 Rural roads assessment LCI*
  - *http://media.lcpc.fr/ext/pdf/theses/rou/tung_hoang.pdf*
  - *Régis Paranhos, 2007 topic : hot mix asphalt assessment*
  - *Shahinaz Sayagh, 2007 Urban roads assessment using BFs LCA*
  - *http://media.lcpc.fr/ext/pdf/theses/rou/these_sayagh.pdf*
  - *Thomas Martaud, 2008 topic: natural aggregates assessment*
  - *Cong Chen , 2009 Topic : concrete assessment*
  - *Adrien Capony, since 2010 topic : road equipment emissions earthworks*

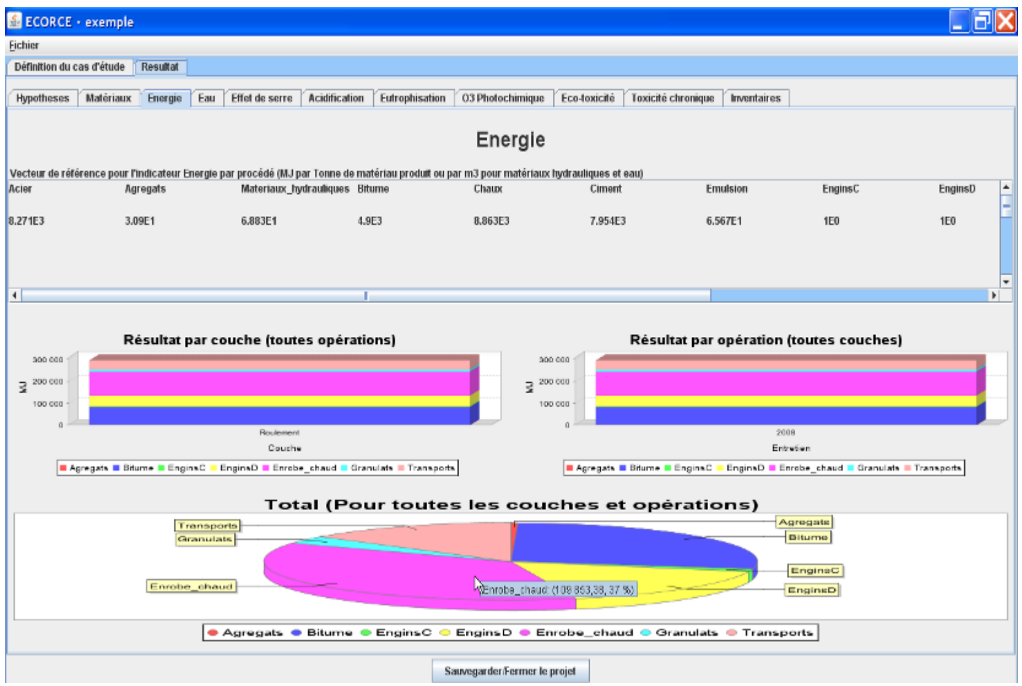
- # 1 configurable tool

  ## ECORCE (ECOcomparator for Road and their Maintenance)

  [ECORCE 1.1 ECO comparateur Routes, Construction et Entretien(2010)]

  A book edited by Ifsttar : Ventura A. , Dauvergne, M., Tamagny P, Jullien A., Feeser A., Goyer S., Baudelot L., Odeon H., Odie L., « L'outil logiciel ECORCE Eco-comparateur Routes construction Entretien, Cadre méthodologique et contexte scientifique, Ed LCPC, CR 55 collection ERLPC, Routes et sécurité routière, 159p.

  \+ Examples for pavement LCA

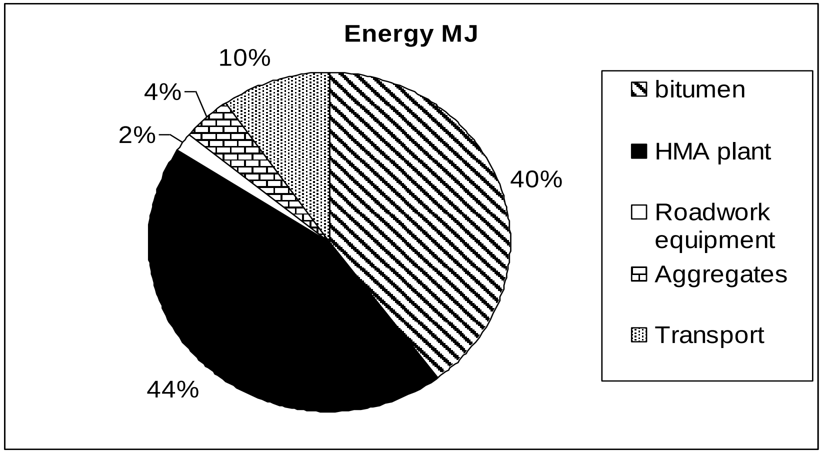


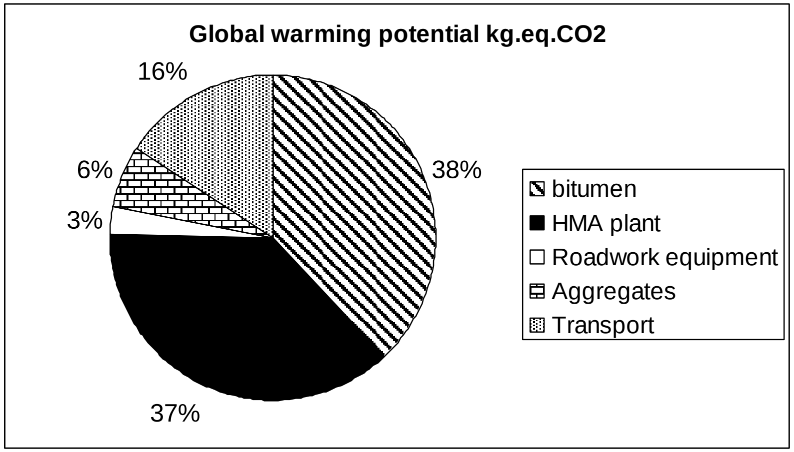
ECORCE 2 (2011) : A new version, with a better ergonomy which allows for pavement and earthworks assessment

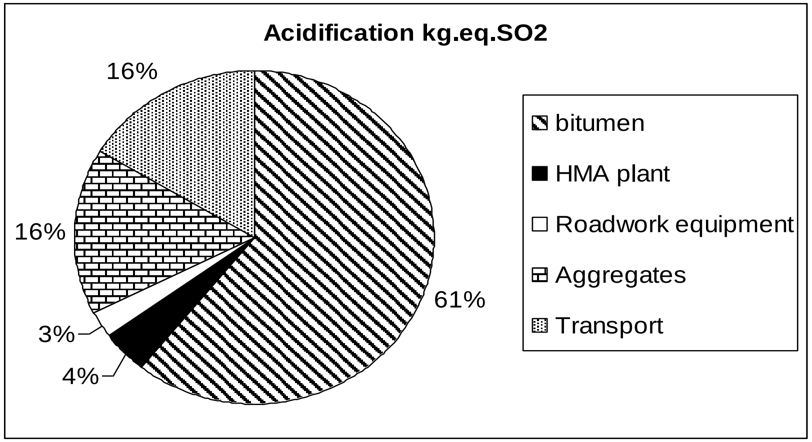
1) Modelling a classical HMA case study

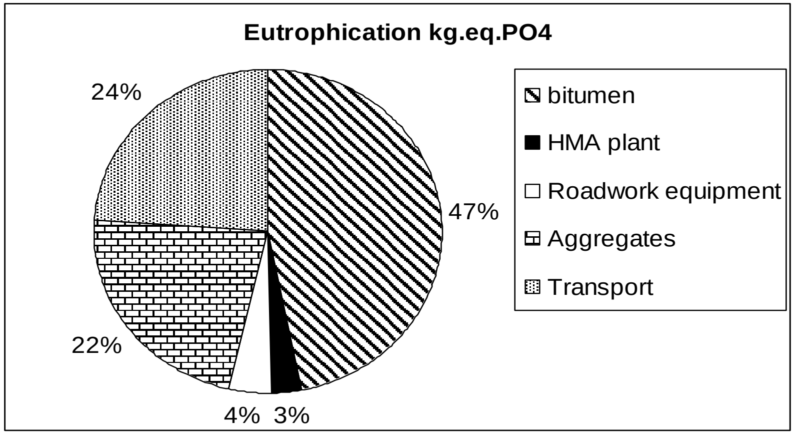
parameters for pavement construction

Layer	Thickness	HMA (plant)	Transport (km)
Wearing course (t)	6 cm	987	20
Subbase (t)	13 cm	2093	20
Surface (m2)	7000		





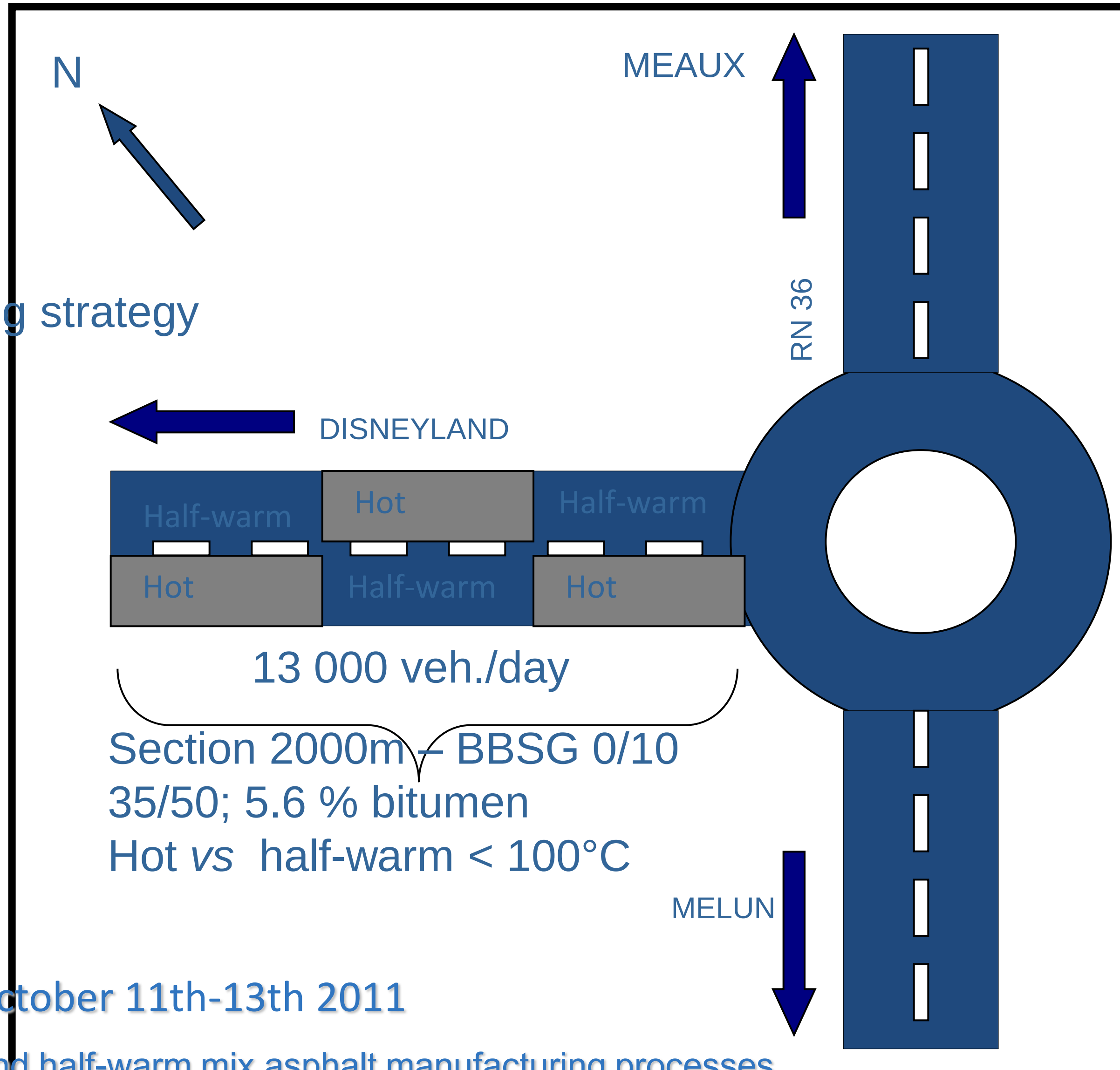




2) Comparing a classical HMA and half-warm – a heavy trafic case study

Assessment

Laying strategy



Wearing course

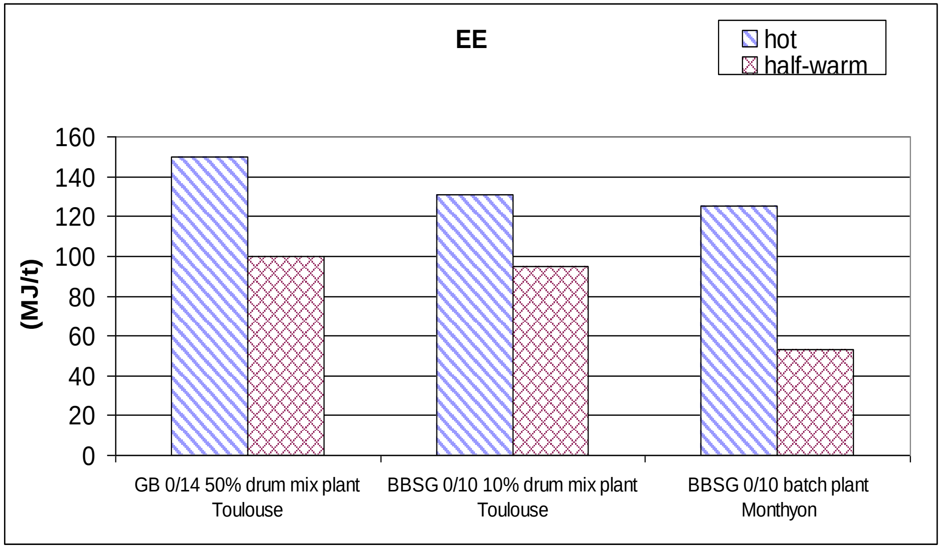
FU : 560 t , 3750 m2
1000 m one side

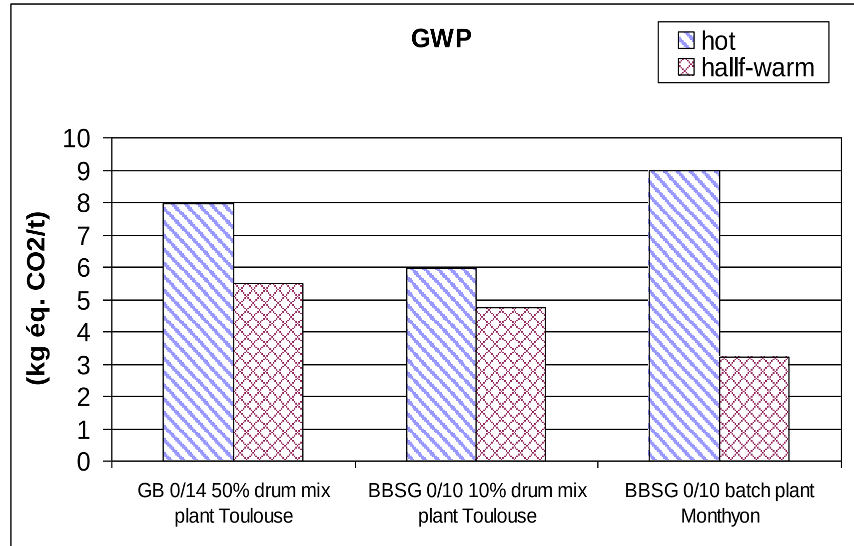
Warm Mix Asphalt St. Louis, October 11th-13th 2011

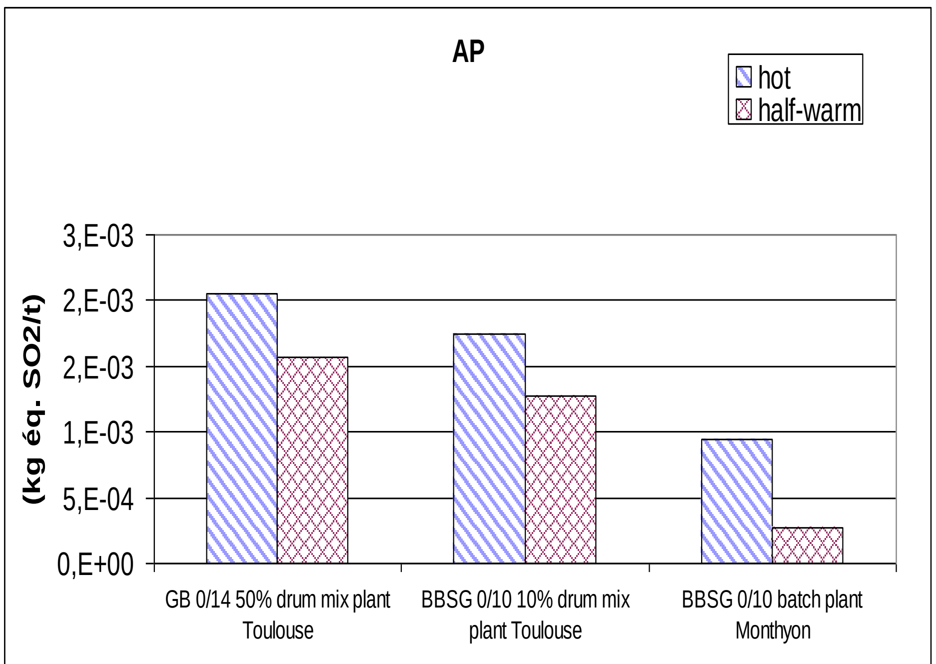
Environmental assessment of two hot and half-warm mix asphalt manufacturing processes

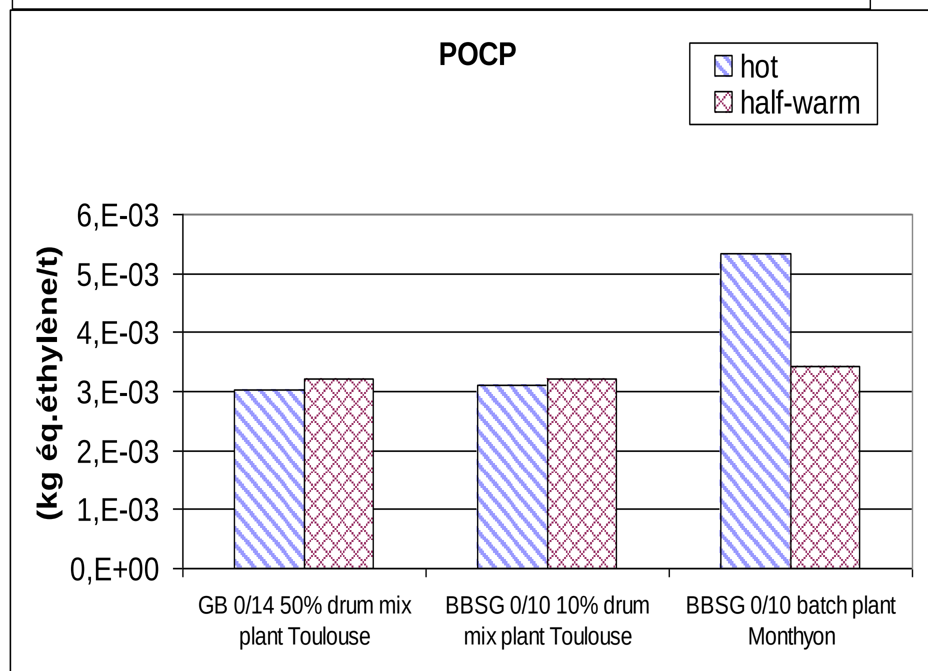
- *Co-authors :* François Olard *,Agnès Jullien, Yvan Baudru, Anne Ventura, Philippe Tamagny,*

LCA impacts indicators ;several asphalt plants technologies and %RAP









International Symposium

Life Cycle Assessment and Construction

Civil engineering and buildings

Lca & construction 2012

10-12 July 2012

Web Site :

http://lca-construction2012.ifsttar.fr

A few comments

- LCA for pavements is beginning to mature:
  - Standardization of systems and approaches
  - Better inventories (materials production, construction)
  - Measurements of rolling resistance
- Outstanding issues
  - Modeling of pavement rolling resistance for congested traffic
  - Improved modeling of rolling resistance
    - Roughness/vehicle, mactrotexture/tire, pavement deflection (viscoelastic energy dissipation)
    - Empirical validation of Use Phase energy use, emissions
  - Regionally specific data for inventories
  - End-of-life approach
  - Sensitivity analyses
  - Definition of appropriate questions