Implementation of pavement LCA and future directions

John Harvey

LCA Workshop 2015
Harbin, CHINA
7-8 August, 2015

UCPRC
UNIVERSITY of CALIFORNIA
Davis • Berkeley
PAVEMENT RESEARCH CENTER

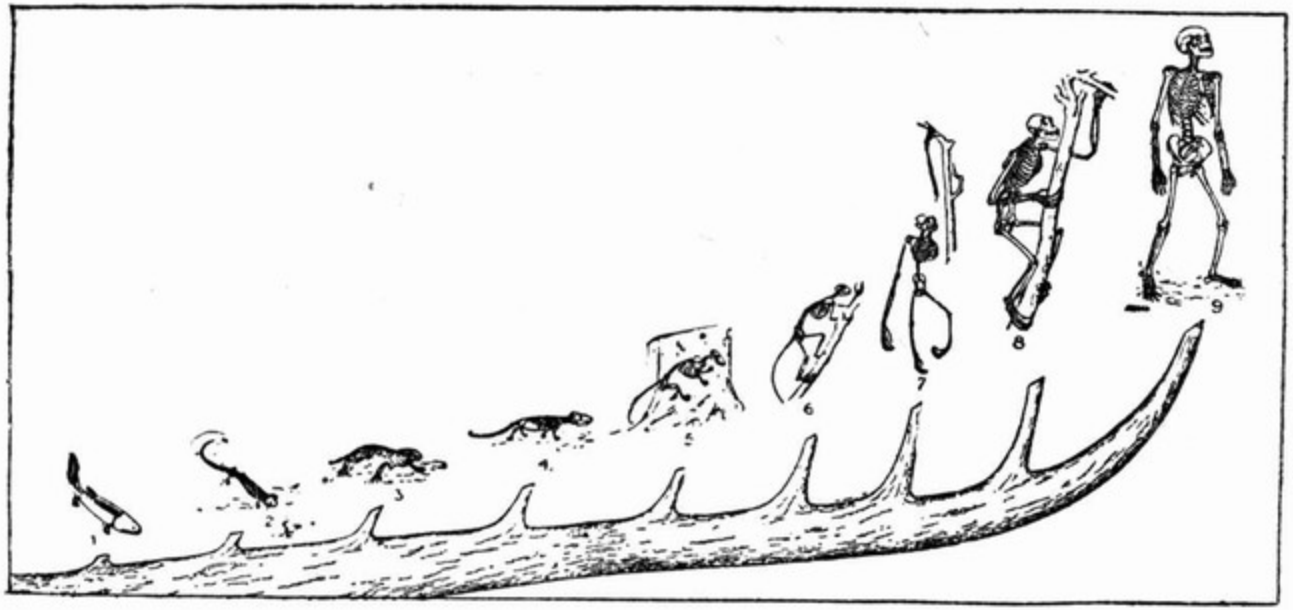
Outline

- Forces driving consideration of environmental impact in pavement
- Current status of pavement LCA
- Implementation of LCA
- Expected future trends

Dutch LCA experience

By Joep Meijer, CEO, The Right Environment

- 1990's
- 2000's
- 2010's



Dutch RWS LCA experience

- 1990's
  - Internal Design Selection: Energy analysis for most environmentally friendly alternative (MMA)
  - Exploration of LCA : optimization of preservation of bridges and material selection for river and coastal defense works
  - External invitation to contractors: what is your sustainability approach as part of the bidding process

Dutch RWS LCA experience

- 2000's
  - LCA for materials becoming available
  - National database NMD established
  - National LCA standard NEN8006:2004 published
  - DuboCalc first version: LCA tool for RWS, internal
  - Innovation programs with pilots, invitation
  - Rise of WMA and WAM foam
  - Rise of RAP

Dutch RWS LCA experience

- 2010's
  - DuboCalc for every design and tender
  - EPD requirement (Dutch MRPI)
  - Contractors and suppliers can provide data, all do through associations, some do individually
  - CO_2-performance for operations of contractors
  - Functional performance specifications
  - Green procurement mandatory
  - Contract term boundaries extend into service life
  - Europe: EPDs EN TC350 WG 6

Policy of the Netherlands

- 20 % CO_2 emission reduction in 2020 compared to 1990
- In 2015 all public authorities must apply green procurement on all purchases; 2012 all state agencies

Joep Meijer The Right Environment

Goal of Green Public Procurement

….is….

to use the procurement process to force (or challenge) suppliers and contractors to deliver added value by delivering sustainable products through sustainable working processes and better materials

<u>Focus on:</u>

energy, <u>materials</u>, spatial quality

<u>Boundary conditions:</u>

value for money, life cycle approach

All about the contract

1. Functional Specifications (FS)
   - No specific technology solutions prescribed
2. FS works only with D&C and DBFM contracts
3. Designs evaluated and based on LCC and TCO.
4. National minimum sustainability criteria (types of applications/materials)
5. Award Most Economically Advantageous Tender (MEAT)
6. Monetized MEAT criteria for sustainability:
   - $C0_2$ Performance ladder
   - DuboCalc

Most Economically Advantageous Tender

Selection based on a combination of <u>bidding price and quality</u>

Procurement procedure:

- the tenderer provides :
  - a) the functional specifications
  - b) a description of the to be assessed quality aspects
  - c) the assessment criteria for the **quality** aspects (SMART)
  - d) the calculation procedure to monetize the quality aspects

- the provider submits an offer with:
  - a) a description of the solution (e.g. a civil engineering design)
  - b) the bidding price
  - c) a description of the quality that he promises

- the tenderer
  - a) assesses the quality and monetizes the proposed quality
  - b) selects the winner by <u>comparing bidding prices minus the monetized quality</u>

monetizing of environmental impacts

Two criteria for the environmental quality of offers will be assessed and monetized:

Performance	**of**	**assessed with**
CO_2 emissions ----------→	working <u>processes</u>	CO_2 performance ladder
Environmental impact----→	the <u>product</u>	DuboCalc

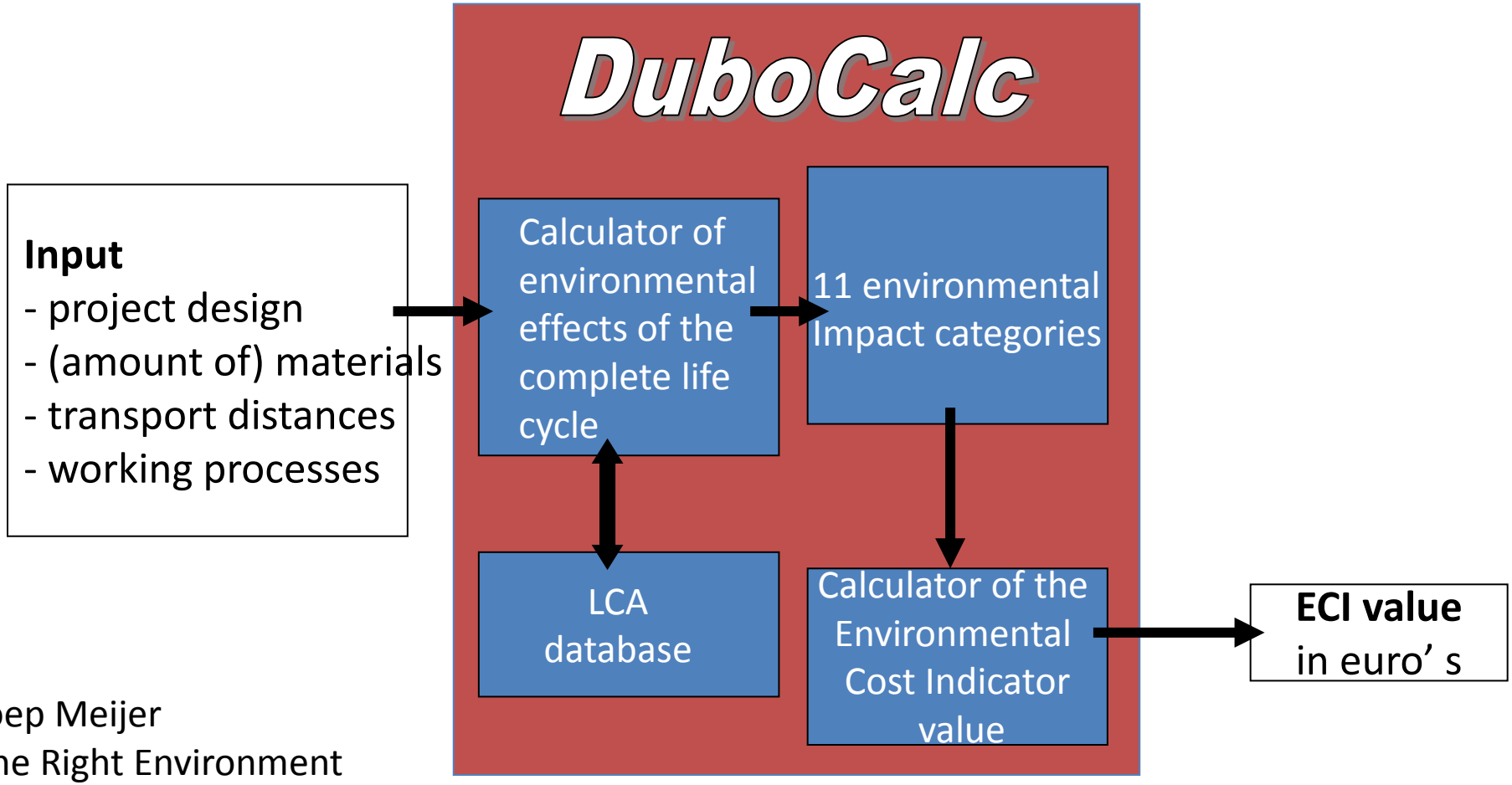
The CO_2 performance ladder is a tool to assess the efforts of a company to reduce CO_2 emissions caused by the company's activities and processes and grants a rung in ascending order as the efforts are larger.

Damage (€) per parameter

Environmental parameter	Equivalent unit	Amount [€/unit]	Price [€]	Costs
• Climate change	CO_2 eq	5,8 eq	€ 0,05	€ 0,29
• Ozonlaagaantasting	CFK-11 eq	etc	€ 30,--	etc
• Humane toxiciteit	1,4-DCB eq		€ 0,09	
• Ecotoxiciteit, aquatisch (zoetwater)	1,4-DCB eq		€ 0,03	
• Ecotoxiciteit, aquatisch (zoutwater)	1,4-DCB eq		€ 0,0001	
• Ecotoxiciteit, terrestrisch	1,4-DCB eq		€ 0,06	
• Fotochemische oxidantvorming (smog)	C_2H_2 eq		€ 2,--	
• Verzuring	SO_2 eq	€ 4,--		
• Vermesting	PO_4 eq	€ 9,--		
• Uitputting van abiotische grondstoffen	Sb eq		€ 0,16	
• Uitputting van fossiele energiedragers	Sb eq		€ 0,16	
Total ECI value			sum	

DuboCalc: what is it?

DuboCalc is a tool to assess and monetize environmental impacts of a product/design based on life cycle analysis



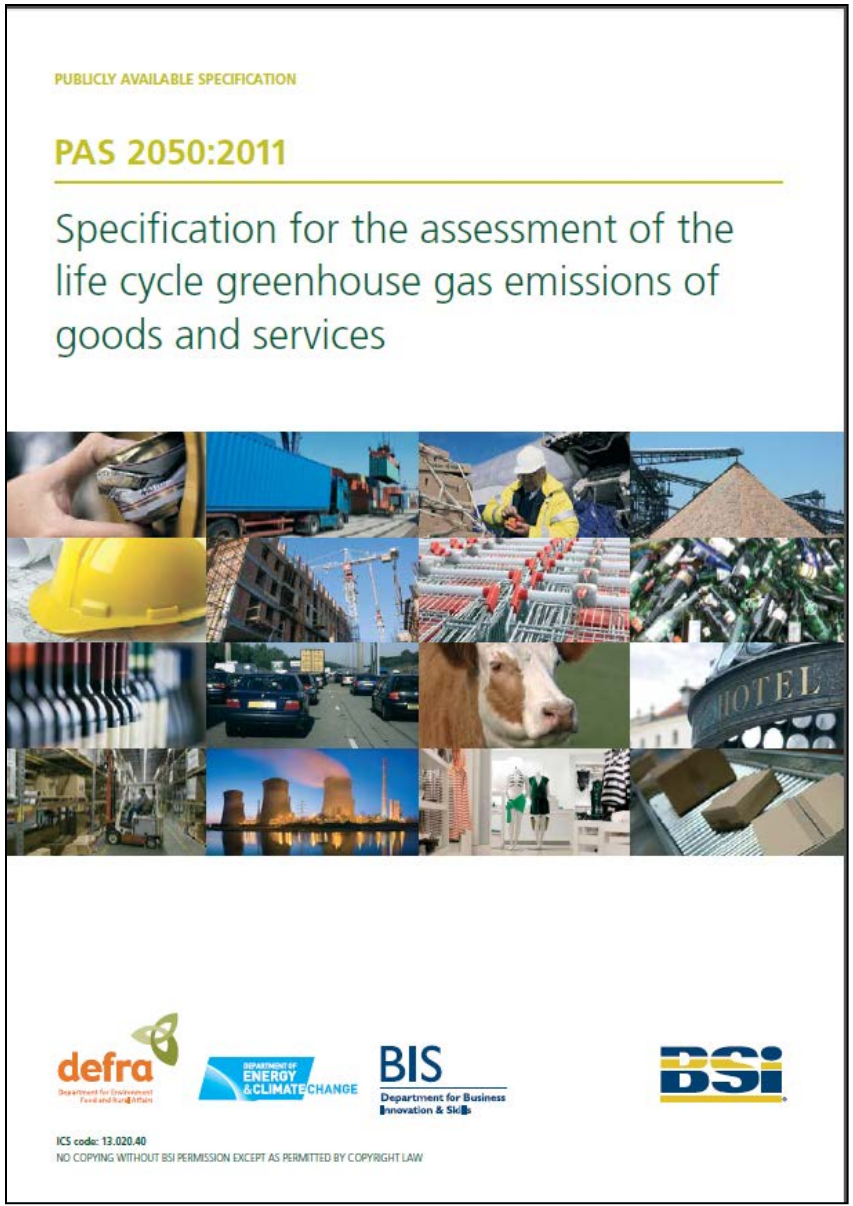
Joep Meijer
The Right Environment

Other Countries in Europe

- France
  - National LCA software developed for proposal preparation for Design-Build-Maintain projects
  - Contractor selected based on LCCA + LCA
  - Software: Ecorce (government), Seve (industry)
- Sweden and UK currently developing similar system for likely implementation within two years
- Various EU projects to share LCA tools, data and knowledge

LCA Standards for Europe

- ISO standards
- EN 15804:2012+A1 (2012 and update)
  - Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products
- National standards in France for building materials
- UK has new LCA standards for all products



PUBLICLY AVAILABLE SPECIFICATION

PAS 2050:2011

Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

defra

DEPARTMENT OF ENERGY & CLIMATE CHANGE

BIS Department for Business Innovation & Skills

BSI

ICS code: 13.020.40

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USA
National, State, Local, International and Industry Developments

MAP-21 federal road funding legislation and performance measures

- The cornerstone of MAP-21's highway program transformation is the transition to a performance and outcome-based program.
- Pavement Performance Related Goals
  - Infrastructure condition—To maintain the highway infrastructure asset system in a state of good repair.
    - Quantified through state reporting of ride quality (IRI)
  - Environmental sustainability—To enhance the performance of the transportation system while protecting and enhancing the natural environment.
    - Method of quantification not yet established

http://www.fhwa.dot.gov/map21/summaryinfo.cfm

Federal Highway Administration

Federal Highway Administration

Office of Asset Management
1200 New Jersey Avenue, SE
Washington, DC 20590

- Sustainable Pavements Technical Working Group, March 2011
- Semi-annual meetings
  - Introduction of LCA, April 2012
  - Introduction to PCRs, EPDs, June 2013
- Reference Document: Towards Sustainable Pavement Systems, based on LCA, January, 2015
- Pavement Life Cycle Assessment Framework, January, 2016

Review of California legislation and LCA

- AB 32 (2007):
  - by 2010, reduce GHG emissions to 2000 levels
  - by 2020, reduce GHG emissions to 1990 levels
- and subsequent Executive Order by Governor Schwarzenegger
  - by 2050, reduce GHG emissions to 80 percent below 1990 levels
  - Requires substantial changes in technology to get more than 60 percent reduction
  - Pavements and all other sectors of economy being examined
  - Transportation still largest source of GWP

California Pavement/Environmental Legislation and Initiatives

- Other state Legislation affecting pavement and the environment
  - AB 338 Rubber tire recycling (2005)
  - AB 812 Recycling of asphalt pavement (2012)
  - AB 296 Cool Pavements (2012)
- LCA being used to determine whether AB 338, 813 and 296 actually increase GWP
  - UCPRC using LCA to check AB 296

Illinois Tollway Authority

- December 2013: ITA signed a three-year agreement with the Univ. of Illinois to develop life cycle assessment tools
- Completion in 2015 with implementation to follow
- A major initiative of this LCA project is to develop regional life cycle inventories for all pavement products for inclusion in LCA tool (currently underway)
- ITA may begin using LCCA and LCA together to select contractors in the future (Design/Build)

(http://www.cptechcenter.org/events/archive/IL_Tollway_docs/Tab%205%20Research%20and%20Reference%20Materials/5%20Illinois%20Tollway%20Sustainability%20Initiative.pdf)

LEEDv4 (2013)

- Major non-governmental organization setting standards for building "sustainability"
  - Particularly strong for building industry
  - Many governmental agencies now required LEED certified buildings
- Previously awarded points on an arbitrary basis
  - Heavy criticism
- LEEDv4 requires use of LCA for whole building and EPD for differentiating building products, leading many pavement materials producers to move towards PCR/EPD

Radical Industrialists

4 ways LEED v4 will change business

Mikhail Davis and Melissa Vernon
Friday, October 18, 2013 - 2:15am

Who is Doing LCAs?

Nick Santero ThinkStep

Who is Moving to PCR or LCIs in Europe/N. America Pavement Industry

eurobitume

NRMCA™

CSHub MIT CONCRETE SUSTAINABILITY HUB

concawe
ENVIRONMENTAL SCIENCE FOR THE EUROPEAN REFINING INDUSTRY

PCA
Portland Cement Association

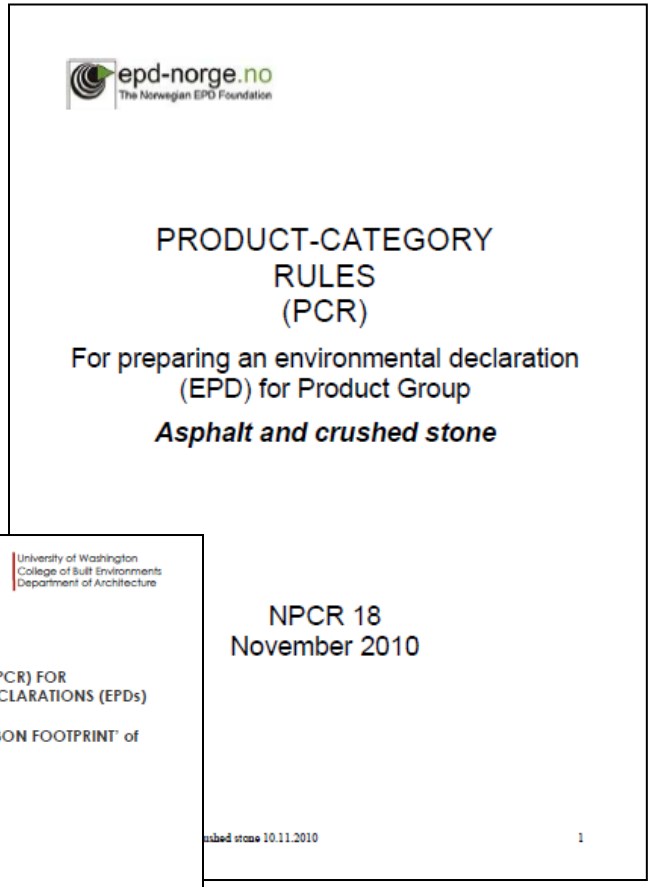
NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

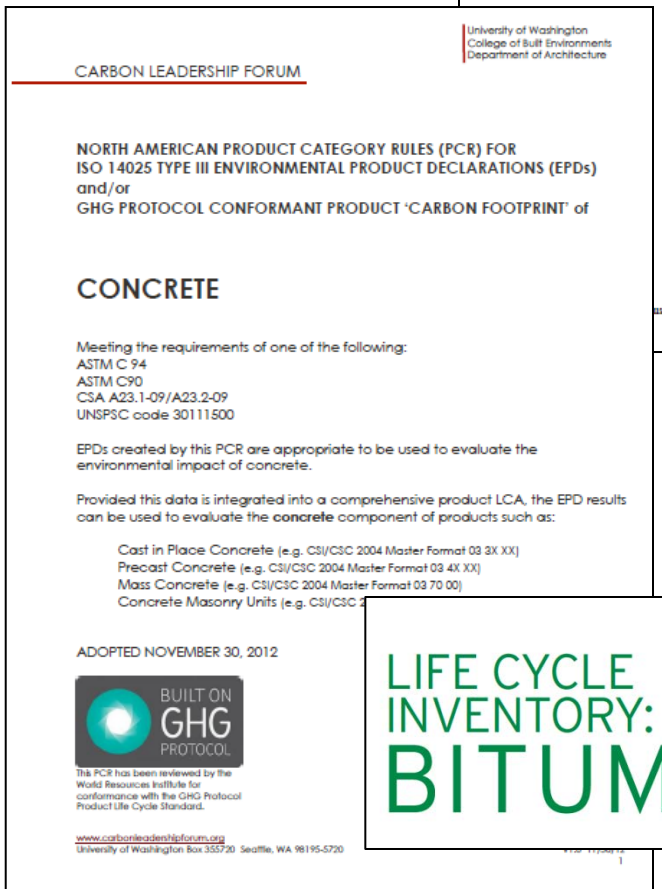
asphalt institute

Types of PCRs

Material Focused

- **Material-Focused PCRs**
  - **Specific to a material**
  - Typically cradle-to-gate (i.e., excludes use and/or end-of-life)
- **Materials-Focused PCRs are prevalent**
  - PCRs (and EPDs) are available for many basic materials
  - Few North American PCRs available
  - Credits for EPDs in LEED v4

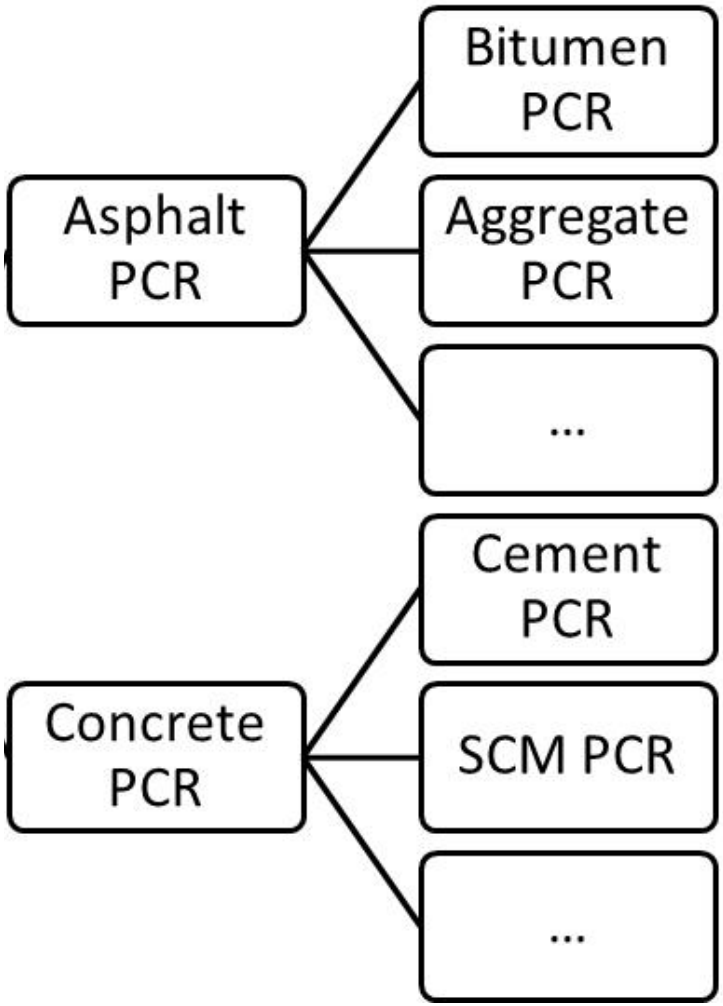




Types of PCRs

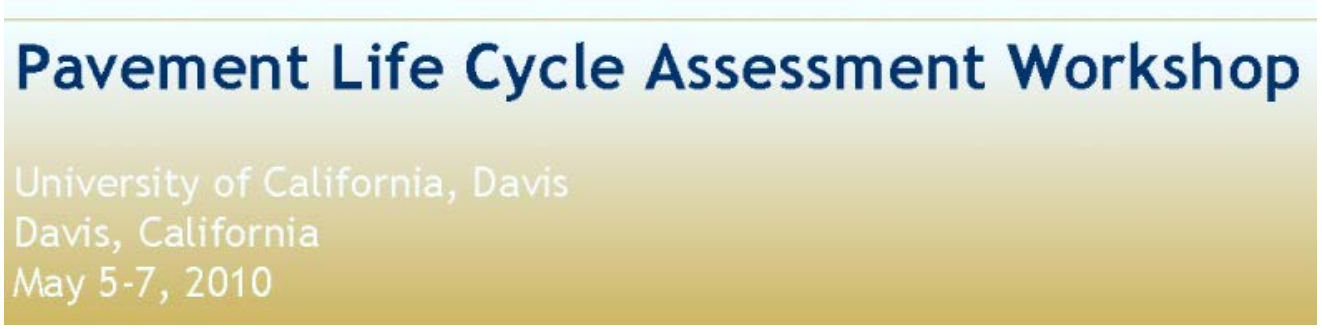
Systems

- **Component Product PCRs**
  - Cement
  - Bitumen
  - Additives
  - Aggregate
  - Polymer
- **Composite Materials PCRs**
  - More complicated than product-focused
  - Build on PCRs of component materials



Standardization Efforts for North America

Development of consensus on practice of Pavement LCA



Next:

- Workshops in Aug 2015
  - China 🙂
  - South Africa
- 4th Symposium in 2016 in Chicago

2010 Workshop Summary Document: Pavement LCA Tech Memo

- LCA framework for pavements
- Summary of system boundaries, assumptions
- Assessment of models/data for each phase
- Transparency Document: Requirements for pavement LCA studies sufficient to permit comparison between studies.

2010 LCA Workshop Documents at

www.ucprc.ucdavis.edu/p-lca

2012 Symposium Proceedings

- Topics:
  - Life Cycle Inventory data: validation, aggregation, uncertainties
  - Methods for buildings
  - Decision and management
  - LCA case studies for buildings and infrastructures
  - Dynamic Life Cycle Assessment, service life and indicators
  - Methods for construction materials
  - End of Life, waste and allocation

2012 LCA Symposium Proceedings at http://lca-construction2012.ifsttar.fr/

Topics

http://www.ucprc.ucdavis.edu/p-lca2014

- Application of Pavement LCA in Northern Europe
- Current status and future of standardizing LCA in US
- Approach for developing regional LCI dataset
- Integration of LCA into pavement management systems
- Integration into new design methods
- Use of LCA in different infrastructure delivery methods
- Panel discussion: Implementation of LCA by different organizations: state DOT, FHWA, industry perspectives
- Sponsors: TRB, FHWA, Caltrans, Int. Soc. for Asphalt Pavements, Int. Soc. For Concrete Pavements

Takeaways

- Environmental considerations measured by LCA will increase as market drivers, considering all life cycle phases
- New materials and structures are beginning to be benchmarked on their environmental impact with LCA

The Future?

Use of LCA in Different Project Delivery Methods

- Design/Bid/Build (Low Bid) in US
  - Can implementation of LCCA in US be a model for use of LCA?
  - How much incentive for reducing environmental impact through innovation?
  - Scope of LCA? Materials and construction and end of life? Use phase?
- Design/Build and Design/Build/Maintain in Europe
  - Confidence in proposer supplied LCA? Same software? Auditing?
  - Extent to which assumptions of LCA can be verified in actual delivery?
  - Scope of LCA?

World-wide Benchmarking and Standardization

- Growing world use of LCA for pavement
- Standardization of approaches
- Comparison across methods and data
- Localization of
  - Life cycle inventories
  - Calculation of impacts

From generic to local specificity

Global Warming
Ozone Layer depletion

Global Impacts, independent from emission site

Aquatic and terrestrial acidification
Photochemical ozone formation
Aquatic and terrestrial Eutrophication

Regional and local impacts with strong dependency on emission site

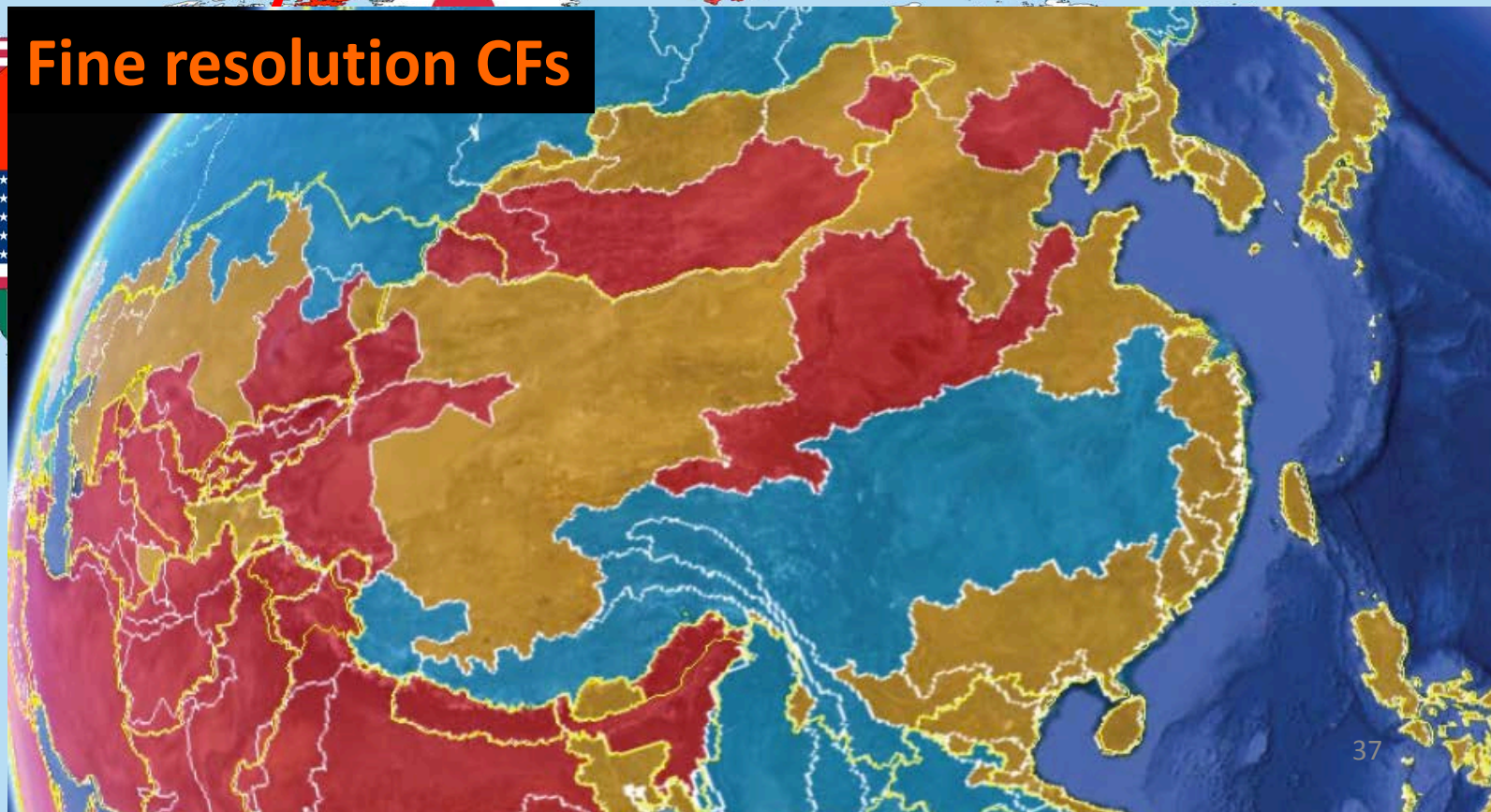
Human toxicity
Ecotoxicity

Land Use
Water Use
Biotic and abiotic resources use

IMPACT World+ the first regionalised LCIA method

Global default Method : IMPACT World +

Continental versions of the method :



Ralph Rosenbaum Pavement LCA 2014

IMPACT World+: a new LCIA method

- Covers the whole world
- Accounts for regional specificity
- Provides explicit estimates of uncertainty and spatial variability
- Includes water use impacts
- Allows for “extraction” of footprint information
- …

Gaps – Technical Issues

- Life Cycle Inventory data for much of world is sparse:
  - Proprietary sources of data that may be high quality, but costly
  - Not regionally applicable, especially for materials production, construction, recycling treatments
  - May not be up to date, especially for warm mix asphalt, concrete additives, and asphalt production
- Use phase modeling gaps:
  - Deflection energy dissipation model validation
  - Urban Heat Island modeling confirmation
- End of Life approach
  - Environmental impact accounting can vary based on allocation approach

Photo: D. Jones

Gaps – Implementation Issues

- Project delivery environment may affect LCA implementation
  - Europe: Design-Build or Design-Build-Maintain
  - US: Design-Bid-Build (low-bid)
- Decisions regarding what LCA should be used for
  - Policy development
  - Guidance
    - Design guidance (project-level)
    - Project management guidance (network-level)
  - Design selection like Life Cycle Cost Analysis (LCCA)
  - Part of procurement (like Netherlands, France)

Recommendations

- Use LCA to evaluate benefits and unintended consequences of pavement policy decisions before implementation
- Integrate LCA principles and calculations into pavement design, procurement policies and pavement management systems (PMS)
- Encourage and facilitate an active and comprehensive market for LCA data
  - PCRs and widespread creation of EPDs
  - Support and incentivize use and improvement of public LCI databases
  - Need for an authority and guidelines to resolve conflicts in PCRs between industries

Recommendations

- Current gaps should be addressed to make pavement LCA more useful to decision-makers
  - Improved models for pavement-vehicle interaction
  - Additional tools and data (EPDs, and development of other data)
- Develop an approach for incorporating pavement LCA with LCCA into the design-bid-build project delivery process

Questions?

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