LCA Symposium workshop feedback - summarized

16 October 2014

PAVEMENT LCA 2014

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Question 1

- When considering impact categories and impact assessment:
  - How much regionalization is needed to address specific needs?
  - Might impact categories differ for different categories of road within a region?
- What are some regional examples (from your group)?

Q1, G1: The feasibility of implementing regionalization when …

- Regionalization is important, but difficult to implement.
- Implementation is impact category specific, e.g.:
  - GWP and ozone depletion not regional
  - Eutrophication is regionally sensitive
- Need methodology to prioritized the impact categories
- Start with easiest categories or categories that have the most impact, e.g. eutrophication & toxicity, respectively
- Industry average EPDs should possibly be regionalized
- Limited regionalized inventories/factors have already been developed

Q1b, G1 (rephrased): Which impact category should we spend time on to optimize, considering different types of road (high volume highways versus low volume roads) ?

- Spend extra time/energy getting better, available and cost-efficient data

- Include sensitivity analysis

- High level traffic highways are more likely to have greater human and noise impacts

- Low volume traffic roads usually have more impacts on ecosystem

Q1c, G1: Examples of regionalized applications

- Illinois Tollway
- City of Boulder has limited application of LCA
- Regionalized end-of-life impacts, particularly related to toxicity, is helpful, e.g. State of CA

Q1, G2: Localization and Impact Categorization

- Examples
  - Global Warming Potential Versus Air Pollution
  - Global Warming Potential Versus Acidification (SO2)
    - Examples of GHG vs SO2 for increased truck loading (Horvath presentation)
  - Storm Water Runoff can be a regional problem that may have different significance (City of San Jose example)

Q1, G2: Do We Need Different Impact Categories for Different Regions and Roads

- YES!
- City needs can be different than the state needs. GWP may not be as important as air pollution.
- Many of the impacts have different significance in different regions
- Initial sustainability objectives will govern what kind of impact categories are needed
- How will the EPDs be affected by local impact categories?
- Inventory data collection may be affected for local categorization
- How will the system boundaries be affected by local impact categorization or should they be affected?
- Local impact categorization is more of an interpretation problem and LCA should be done transparently following rules and specifications
- For example, the impacts associated with the materials acquisition phase can have different significance regionally than the impacts associated with the construction and use-phase
- Upstream versus downstream separation can help seeing some of the local effects

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Q1, G2: How much regionalization?

- Agency vs state
- State vs city
- Urban vs. rural
- Too specific categories can complicate the data collection and dissemination of results

Question 2

- Considering indicators:
  - Should we move towards IMPACT+ type indicators that divide into global, regional and local impacts, or continue with our current large sets (approximately 10) of mid-point indicators which do not really differentiate where the emissions occur?
  - Are greenhouse gas emissions and energy enough as impact indicators?
  - What do you think are other impact indicators that might be important?
- What kind of guidance would you give to decision makers regarding prioritization / interpretation of impacts / LCA results so they can prioritize?

Q2, G3: Indicators

- Should adopt global, regional, and local indicators

- LCA goals should influence selection of indicators for spatially dynamic LCA studies

- Extended to temporal dynamic studies (now, or later?)

Q2, G3: Are GHG emissions & energy enough as impact indicators?

- GHG and EE indicators are insufficient but may form basis of high level decisions (caveat emptor)
- Even though more impact categories are important, these impacts are more readily summed over a network level vs project level

Q2, G3: Other impact indicators?

- Decision makers should pick from a full menu as per ISO 14044

- More comprehensive normalization and other interpretation techniques to answer the "so what?" question

- Guidance to decision makers (to help *them* prioritize) on uncertainty in network/project level regional/local normalization

- Better communication

Q2a, G4: Should we move towards IMPACT+ type indicators …

- Great idea and we support it
- It is going to take a while to get the life cycle inventory data to support and in getting characterization factors correct

Q2b, G4: Are GHG emissions and energy enough as impact indicators?

- No
- However, it is a good start

Q2c, G4: What do you think are other impact indicators …

- At this point it is premature to rule out particular indicators because we do not know which ones are the most significant

- We can test significance using normalization and assessment of how well suited characterization factors are to a particular location

# Q2d, G4: What kind of guidance would you give to decision-makers …

- LCA experts should inform policy-makers of the kinds of things that can be calculated because policy-makers are unlikely to know this

- Then policy-makers can use the information to make informed decisions

Question 3

- How important is international and national collaboration on development and standardization of pavement LCA?
  - Is more or less needed or it is about right?
  - Why?

- How does global trade and the internationalization of product procurement and services play a role?

Q3, G5

- Categories of Collaboration
  - Information sharing
  - Collaboration
  - Harmonizing
- Levels of Collaboration
  - National, International
  - Interdisciplinary
  - Interdepartmental/Inter-agency
  - Stakeholders/Industry/Users

I — **International**

IC — **National**

IHC — **Local**
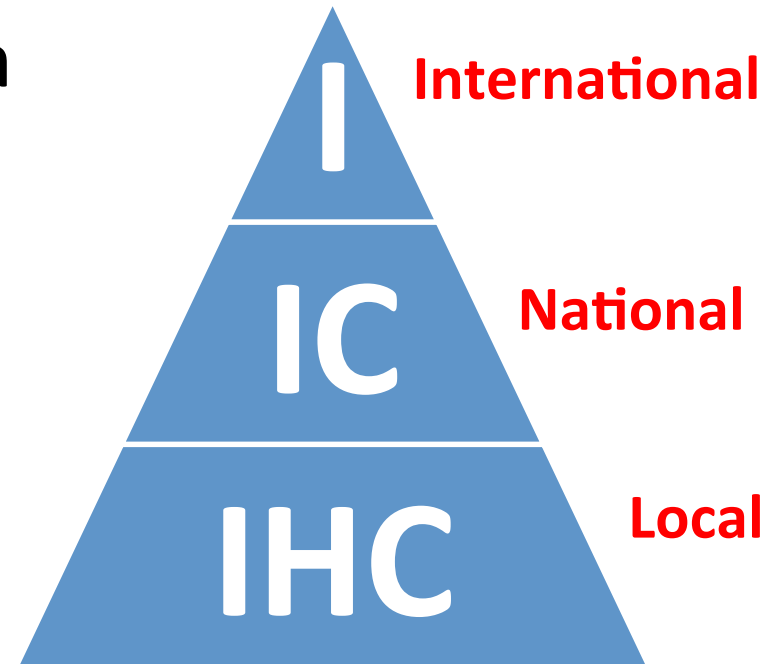
Q3, G5

- Appropriateness of Data Sharing
  - Depends on project level
  - Consistent data format
- Consistent system boundaries

Q3, G6: International and National Standards & Collaboration

- Two issues: Standardization & Collaboration

- Impacts Pavement LCI as much as LCA

- "Flow" of an LCA should be understood and LCI requirements set accordingly

- Let regulators (e.g. EPA, FHWA) frame rules on contentious issues

Q3, G6: Collaboration

- More the merrier – avoid repetition, encourage use

- Allows discussion in a globalized world - important to talk

- Talk to stakeholders (engineers, industry, urban planners, government) for a wide perspective

Q3, G6: Standardization

- Global standard is difficult – global, flexible framework with regional standards

- Reasonably accurate, fair and consistent local models with tools for contractors

- Code of ethics for engineers on sustainability

- Transparency in EPDs
  - As much data as possible
  - Use a checklist to inform stakeholders

Question 4

- Is it possible to provide a $-value to environmental damage in the US? What are the methods to balance cost vs GHG (GHG calculators for network level; Policies for management; What decisions are we ready for)?

Q4, G7: Monetize impacts?

PROS: practical tool for decision makers
- Incentives aligned with objectives
- Can provide incentives toward tangible environmental goals
- Reduces learning curve
- Tangible measurement for all (simple)

CONS
- Virtual, 'not real money', 'not real value'
- Can use clear policy to mandate goals, why $?
- Can be manipulated
- Oversimplifies complex problems

NEXT STEP?
Conceptually, we recognize potential value in monetization but acknowledge that it will always have limitations and/or unintended consequences.

Q4, G8: Is it possible to provided a $-value to environmental damage …

- Possible but cost is completely arbitrary because there is no method to accurately capture costs of environmental damages

- We do not understand systemic impacts of these environmental emissions

- Uncertainty in current LCA tools makes it unfair to charge industry/individuals based on estimated emissions/impacts

Q4, G8: What are the methods to balance cost vs. Environmental Impact

- Context Sensitive
- Compare alternatives
- Low to start, simple, such that it gets incorporated in policy
- Actual cost of impact is less important than finding prices that drive emergent behaviors

Question 5

- When evaluating materials, technologies and practices that are intended to be more sustainable in terms of the specifications/ regulations, and contractor incentives:
    - What are the pros and cons of each?
    - What is the role of LCA in each?
    - What are the motivators for industry (how, who, when, incentivizing, innovation)?
    - If using incentives instead of prescriptive mandates, specifications, and regulations:
        - What are some ideas for how to set that up and what would be the role of LCA?
        - What is needed in LCA to make that work?
- How would that work in a Design/bid/build (low-bid) delivery system versus a Design/build or Design/build/maintain delivery system?

Q5, G1. Pros and cons of regulations when evaluating materials, technologies and practices that are intended to be more sustainable

Pros	Cons
• Easy to implement	• Some regulations may favor larger companies
• Easy to apply quality assurance	• Unintended consequences (problem shifting), e.g. anti-strip or sub-optimization of other categories
• Establish clear thresholds	• May not be performance-based
• Uniformity and consistency in results	• Limit innovations
• Right thing to do	• Potential of contradictory regulation, e.g. water & low carbon fuel
	• Scare tactic

Q5b, G1. The role of LCA in the regulations and contractor incentives

Regulations	Incentives
• Provide guidelines to enhance sustainability	• Allow contractors to present their best performance
• Quantify the impacts	• Increase competitiveness
• Identify the hot spots	• Potential for better outcome and cost-saving
• Provide measuring metrics	• Long-term benefits
• Create a demand for environmental information	
• Create better environmental performance	
• Increase environmental awareness	

Q5c, G1: The motivators for industry (how, who, when, incentivizing, innovation)

- Threat of regulation
- Public relation (industry image)
- Competitiveness edge
- Potential economic advantage

Q5d, G1: If using incentives instead of prescriptive mandates, specifications, and regulation:
i. What are some ideas for how to set that up and what would be the role of LCA?
ii. What is needed in LCA to make that work?
iii. How would that work in a DBB delivery system vs. a DB/DBM delivery system?

- Monetize environmental impacts

- Bid preference based on environmental priorities

- Development of LCA contract-friendly

- Having LCA set up in the DBB allows introducing the maintenance phase in LCA, and allows the contractors to foresee the future impacts on pavements

Q5, G2

- When evaluating materials, technologies and practices that are intended to be more sustainable in terms of the specifications/regulations, and contractor incentives, there are some conditions need to be evaluated:
  - It depends on the status of the technology (If the technology is largely available/implementable) – i.e. WMA technology 20 years ago and now
  - Major question in determining which option is better depends on who is going to carry the risk
  - Alternatives should be made available to the contractors if incentive approach is chosen
  - The answer to this question depends on the size of the contractor to take on new technologies (industry is carrying a risk by developing and investing on new technology and business failures can happen)

Q5, G2

Specification		Contractor Incentive	
Pros	Cons	Pros	Cons
Meet the target	Agency risk	Motivates innovation	Ensuring the future performance of the technology and quality of the final product
Introducing new technologies	Suppress innovation		
Easier selection bw/ bids and contractor			

Q5, G2

- Role of LCA:
  - Allows baseline comparison with a condition that agency needs to provide baseline data analysis
  - Evaluates agencies ability to assess sustainability performance
  - Allows prioritizing needs (reducing congestion, construction emissions or thinking long terms with use-phase considerations)
  - Impact of each phase can be captured (material production, construction, or use phase) so agency can interpret the outcome of LCA relative to their objectives
- Motivators for industry
  - Industry are already taking the lead
  - Cost saving
  - Market share gain
  - Can be part of their public relation (PR) efforts

Q5, G2

- What needs to be done for incentive method:
  - Give breathing room to contractors and be more flexible with them when they are implementing new technologies
  - Staged implementation (monitor performance, incentivize for a period of time and then mandate)
  - Pilot studies to trigger innovation
  - Analogy to performance based specifications: smoothness and density specifications work well and similar concepts can be used to try and implement alternative technologies with contractor incentive method
- What needs to be done in LCA:
  - LCA should answer uncertainty considerations especially for the use-phase models and allow agencies to make informed decisions for short- long-term planning and risk planning

Q5, G2

- How would that work in a design/bid/build (low-bid) delivery system versus a Design/build or Design/build/maintain delivery system?
  - Low-bid: limited chance of implementation and can only allow incremental changes
    - If we can build bonuses in to the contract (like a separate incentive item in contract), then low-bid can also work
  - Design/build/maintain can be the more appropriate (example of agencies owns toll roads)

Question 6

- What uses do you see for the kind of "thick mapping" of data for urban areas, such as detailed electrical energy and water use, remote sensing of carbon dioxide emissions, traffic patterns, income, age demographics, etc.?
  - Can this data be used for validation for pavement LCA models?
  - Can this data be considered input data for use phase models involving vehicles using predictive data for future traffic patterns?
  - Are there any other potential uses for this data?
- Is this approach maybe not so useful?

Q6, G3: Thick Mapping

- Limited use for pavement LCA in dense urban areas because of confounding factors, but possible in more rural areas for pre-post study

- Can contribute to development planning - for instance in consequential LCA

- Potential use in use-phase traffic flow models requires traffic forecasting to be solved before useful for pavement LCA

- Other data of this type, such as vehicle accelerations (e.g. from smartphone apps) is more useful

Q6, G3: Thick Mapping

- Could be useful for interpretation, through local normalization (also local health issues)
- Other uses: environmental justice, insurance company information, use phase emissions, e.g. in non-attainment areas

Question 7

- Regarding allocation rules for "waste" materials coming into pavements from other industries:
  - Should all of the impact of producing the material be assigned to the upstream product, or should it be split between the pavement application and the upstream product? (e.g. slag cement in concrete and tire rubber in asphalt)?
  - Is it possible and feasible to "expand" the system and determine what virgin pavement materials are not used because of the use of the recycled material?
  - Who should be the authority when there are conflicts in allocation between PCRs from different industries? Do the conflicts need to be resolved?
- How should conflicting PCRs be dealt with, especially when having conflicts with secondary materials?

Q7, G4:

- ISO type "waste" definition based allocation is problematic for pavements because economic conditions that guide definition change frequently

- Goals of allocation rules are:
  - 1. Transparence in execution; 2. Outcome actually reduces environmental impact;
  - Cutoff (no upstream allocation) appears to potentially meet goals
  - 50-50 might be plausible or attractive

- Need to fill gaps
  - Study of a comprehensive set of pavement recycling sceneries with cutoff and 50/50 to check impacts and economic incentives
  - similar study of co-product allocation rules based mass, economic value and substitution alternatives
  - Both studies should be probabilistic, involve economists

- For pavement PCRs and EPDs should review upstream EPD allocation rules, report where used cutoff in pavement EPD

- Recommend that need a PCR review authority to minimize inconsistencies between upstream and downstream. Same problems occurred with California Low Carbon Fuel Standard. Who? (ISO, States, US EPA, CalEPA ?)

Question 8

- Regarding explicit consideration of uncertainty through reporting of impacts as probability distributions:
  - Is this important?
  - What are the pros and cons?
  - What are the difficulties envisaged with this approach?
- Should variability be included in EPDs – particularly for averages?

Q8, G5

- Yes, uncertainty is critical
- Advantages
  - Risk management, analysis is possible
  - Additional confidence in results
  - Assisting motivation to invest in more data to increase data accuracy
  - Better comparative analysis
  - Sensitivity analysis
  - Supports collaborative discussion (international, national, local, interdisciplinary, etc.)

Q8, G5

- Disadvantages
  - Cost of more data
  - Added complexity in correctly understanding the results

- Education is necessary

Q8, G5

- EPDs
  - Industry-wide distributions can be useful that includes a wide range
  - Individual products can be compared to these
    - User determines need
    - Can be an interval improvement process for manufacturer

Q8a, G6: Is this important?

- Yes
- Uncertainty creates a metric for risk analysis
- It needs to be tied in with sensitivity analysis to find out important parameters and phases in uncertainty
- Uncertainty is needed for decision making under comparative assessment

Q8b, G6: What are pros and cons?

- Pro: Helps with making reliable decisions
  - Preserves information detail
- Con: Hard to understand and adds a level of complexity
- Could lead to an expensive study

Q8c, G6: What are difficulties envisaged with this approach?

- Research on determining uncertainty in LCI data of major LCA parameters: use a range in processes and inputs as a surrogate for uncertainty

  – Rating of data quality: Do it nominally, as a score

  – Look at separability of result distributions rather than just the confidence bounds (ie. 95th percentile)

Q8d, G6: Should variability be included in EPDs? Particularly for averages?

- Yes. Can be simplified through scoring matrix as metric for reliability of data

- Do literature review of statistical techniques in handling uncertainty without having detailed input data

Question 9

- Considering LCI information:
  - How should routine updating of information on LCIs be done and how often should this be done? Is this a requirement?
  - What are the alternative methods for developing LCI data? Should it include questionnaires / industry associations / other means?
  - What role should regionality play in this?
- How should LCI input be structured in a LCA tool to fit contractor type data? Maybe tied to a pay item?

Q9, G7

- Updating LCIs
  - Function of change in technology, energy mix, material inputs, etc.
  - Recommend 5-year update cycle → complies with EPD requirements and general LCA best practices
- LCI development suggestions
  - Manufacturer should understand value of process
  - LCA practitioner should understand technology and manufacturing process
  - Data collection scope should be "socially negotiated"
  - Maximize data already available (e.g., emissions reporting)

Q9, G7

- Regionality
  - Generally, regionally-specific information is good
  - Potential conflict between regional-specific data and consistent data → which should be prioritized?
  - Standardized methodologies and databases are important considerations
- LCI input for pavement LCA tools
  - LCI data should be tied to pay items for reporting purposes
  - Sufficient information should be reported to enable LCA tools to function (i.e., material quantities)

Question 10

- Considering LCA model assumptions:
  - How comfortable is your group with modeling assumptions in LCA, especially in light of major differences in impact predictions from different impact indicator models?
  - Should there be an effort for validation of models?
- Should there be an effort for auditing LCA predictions made by a contractor once the job has begun?

Q10, G8

- Generally uncomfortable
- For LCA tools, the decisions made by the tool developers may dictate the outcome
- Sensitivity and uncertainty analysis are LCA tools to deal with assumption comfort level
- With different impact indicator models, there is need to also report life-cycle inventory

- Yes

Question 11

- When faced with a backlog of deferred maintenance and rehabilitation, what are approaches that a road owning agency can take to consider environmental impacts?
  - How much of a conflict is there?
- What are potential synergies?

Q11, G1: Approaches a road owning agency can take to consider environmental impacts when faced with a backlog of deferred maintenance and rehab

- Optimize sustainability and performance
  - Warm mix with RAP
  - Fly ash in concrete
- Evaluate the financial/environmental impact of an action: including doing nothing

Q11, G2

- Group generally thinks that this is a very difficult situation

- Several alternatives discussed as an approach:
  - To make options available for agencies
  - Performing network level assessment and multi criteria decision making process to prioritize needs and facilitate system wide planning

Q11, G2

- Conflict between accessibility, mobility, and sustainability

  – Proper assessment tools are needed for an agency to make a decision to solve this dilemma

- Maintaining an average acceptable level of service becomes a critical question for the agency

  – Societal impacts can also be included in analysis and planning

Question 12

- What are the next steps for PCR / EPD and how should it be used? What are next steps for EcoLabel type labeling and how should it be used?

Q12, G3: PCR / EPD

- Issues:
  - Use biotic and abiotic resource use descriptions (not non-renewable)
  - Transparency needs to be within competition requirements
  - Need to move from LEED point-chasing
  - Needs to be 'politically' acceptable
- PCRs
  - Will require averages – we are using natural (variable) materials
  - Review against progress with building sector PCR
- EPDs
  - Generic EPDs OK for benchmarking and design studies
  - Companies may publish specific product EPDs if there is perceived advantage

Q12, G3: EcoLabels

- Follow Federal advice on what makes a good EcoLabel
- Big potential for unintended consequences
- Not much use for materials that are not consumer products but could have a role for pavements
- Could be good for promoting benefits to public/legislators but be careful not to sacrifice science

- EPDs and EcoLabels – don't relax when we have them – need continuous improvement – labels are not final goal

Question 13

- What are the ways to handle proprietary data collation in LCI? How should LCI data be protected / incentivized / validated?

Q13, G4

- Need to protect proprietary data depends on data collection methods, different in each phase of life cycle
- Materials and End of life
  - No problems if EPD industry average, EPD Company specific, Other surveys need confidentiality agreements
- Construction (including M&R)
  - Same as materials. Can also use published equipment info for power, etc
- Use phase
  - Fuel economy: currently can only do controlled experiment. Public information regarding pavement condition, but hard to get.
  - Albedo effects: mix of information including building stock information, climate models, electical use
  - Vehicle operating costs: large truck fleets confidential, personal vehicles is private information, but both exist, need agreements
  - Lighting: public information
- The Future
  - Tie to existing business tracking systems, truck fleets, construction companies
  - Telematics in personal vehicles, others in transportation research doing this
  - Ability to audit materials and construction LCAs with later performance data?

Question 14

- Are there alternatives for roughness triggers (i.e. smoothness construction alternatives)? How should LCA results and LCCA be combined?

Q14, G5: Alternatives for Roughness Triggers & LCCA/LCA

- Two types of situations for triggers:
  - Design
    - Use available & appropriate models
  - Maintenance
    - PSD (vehicle-independent measure)
    - Sub-triggers can be considered

Q14, G5: Alternatives for Roughness Triggers & LCCA/LCA

- Separately conducted LCCA first, LCA second for verification

- The weight for each evaluation may be different depending on the situation

- Innovation of design tools to incorporate LCA aspects

- Boundaries in LCCA and LCA must be established to avoid double-counting

Question 15

- What are the system boundaries for LCA – should changes in trucking routes and goods damage be included?

Q15, G6

- For an LCI, boundaries can be extended to freight damage and vehicle operating costs
- As a simple accounting procedure, bigger boundaries can give more information
- For decision making, avoid double-counting with other sectorial LCAs (e.g. tomatoes)
- Goods damage and routes belong to other LCAs and can be considered there
- Pavement LCA vs. Roadway LCAs: includes those components that interact with pavement directly e.g., not roadway grade

Question 16

- What will truckers do when they have models for fuel economy as a function of smoothness and structural response? Is it possible to obtain fuel economy data from trucks and cars and what are the possible data privacy issues? Dispersed data collection mid-point?

Q16, G7

- How will trucking industry respond to PVI models?
  - Optimize tires, speed, and/or routes to reduce costs
  - Could become political priority
- Data collection feasibility
  - Technologically possible (i.e., instantaneous fuel consumption meter + GPS location)

Q16, G7

- Privacy issues?
  - Either mandate data reporting, or…
  - Demonstrate value to trucking industry
- What about cars?
  - Lower priority, but potentially significant due to total VMT of cars
  - Need to establish incentives
  - May require cultural shift
- Collaboration between tire and pavement experts

Question 17

- How important do you think it is to develop social impact indicators? What might be some social impact indicators that might be used along with environmental and economic indicators?

Q17, G8

- Important with caveats - Social indicators often show up too late and should be involved earlier in project stage
- For transportation projects, equitable distribution of mobility and accessibility to good and services can inform project selection
- Safety
- Aesthetics
- Noise
- Vulnerable populations to emissions – Health Impacts