eLCAP and PaveM: California's Network and Project Level Quantification Tools

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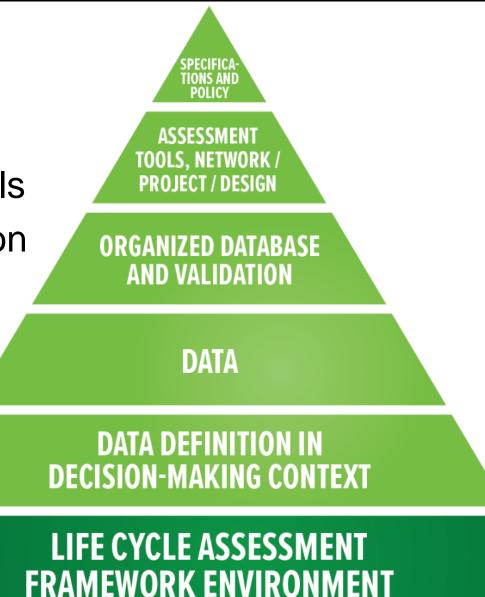
Pavement LCA 2017
Champaign, IL
12 April 2017

The need for pavement LCA tools

- Pavement LCA information awareness and knowledge growing; need to start doing
- Tools are available (examples)
  - Conceptual-level tool for GHG, national data (ICE)
  - Commercial interfaces to databases not specific to pavement (GaBi Envision)
  - Pavement tools with incomplete life cycles (Athena, Roadprint [web based])
  - Web based tools specific to another DOT (PLCA)
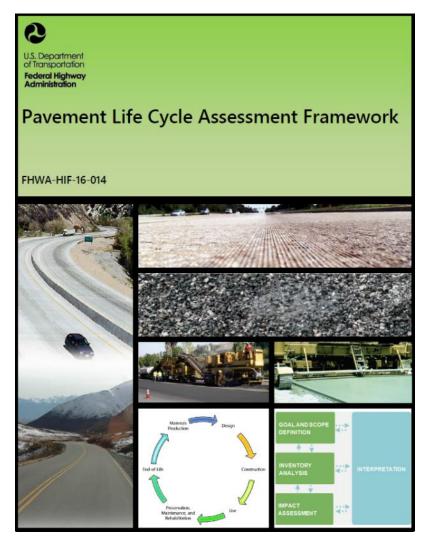 - Strong regional inventory excel tool (Tollway)
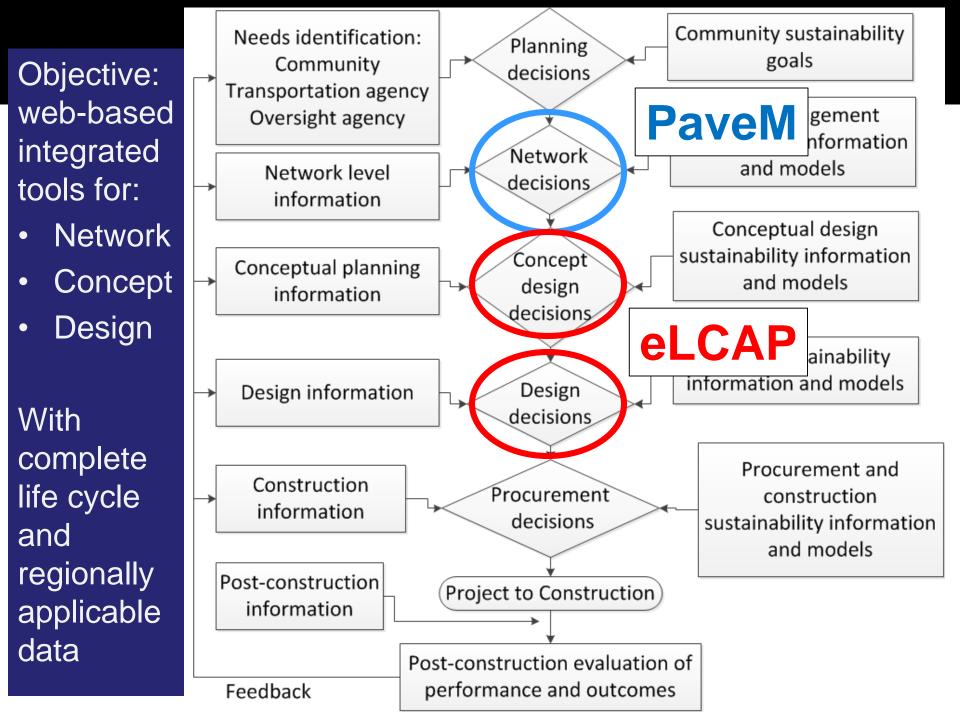
Ready to produce pavement LCA tools?

- Want to answer questions
- Ready for initial tools
- Inventory information available, reviewed
- Sufficient data and models to start
- Data definitions ready
- FHWA framework

FHWA Pavement LCA Framework Document

- Published January 2016
- Downloadable on FHWA Sustainable Pavements website
- Guidance on uses, overall approach, methodology, system boundaries, and current knowledge gaps
- Specific to pavements
- Includes recommended guidelines for EPDs

Objective: web-based integrated tools for:
- Network
- Concept
- Design

With complete life cycle and regionally applicable data

Needs identification: Community Transportation agency Oversight agency

Network level information

Conceptual planning information

Design information

Construction information

Post-construction information

Planning decisions

Network decisions

Concept design decisions

Design decisions

Procurement decisions

Project to Construction

Post-construction evaluation of performance and outcomes

Feedback

Community sustainability goals

gement nformation and models

Conceptual design sustainability information and models

ainability information and models

Procurement and construction sustainability information and models

PaveM

eLCAP

Considerations for implementation

- Relevancy
  - Address relevant pavement decisions and questions, goals and scopes
  - Flexibility: ability to add new questions, materials, designs, practices, data
  - Regional and temporal relevant data and models

- Trustworthiness
  - Transparency of data, models, processes
  - Follow FHWA Pavement LCA and other appropriate guidelines
  - Critically reviewed inventories and approaches

Considerations for implementation

- Practicality
  - Studies can be completed:
    - In reasonable time
    - With available data
    - With reasonable training
  - User input interface able to:
    - Provide reasonable default data
    - Ability to take more detailed user-defined data, including from EPDs
  - Reporting
    - Targeted to decisions, documentation requirements
    - Easy-to-understand

Traffic Database for PaveM and eLCAP

- Use same traffic data from Caltrans databases

Caltrans Truck Annually published, 3,400 stations CA highways

- Annual Average Daily Traffic (AADT)
- Daily Truck Count (2, 3, 4 and 5+ Axle Counts)
- 1 to 2 year time-lag

PeMS Traffic Real-time/time series DB, 17,600 stations

- Daily and hourly traffic flowrate, speed, lane distribution

TASAS-TSN* Continuous updates in Highway Log, pull as needed

- AADT of segment in Highway Log (Network definition)

Weigh-In-Motion 110 stations

- Axle weight and gross weight, axle spacing, vehicle classification, speed

* TASAS-TSN: Traffic Accident Surveillance and Analysis System – Transportation Systems Network

PaveM approach for network LCA

- Decision trees select Treatment or Do Nothing
- Calculate GHG over analysis period for Treatment and Do Nothing cases for each segment,
  - Simplified equations from eLCAP for GHG from materials, construction for each treatment (default thicknesses)
  - Simplified equations for GHG from vehicle interaction with roughness for each vehicle type x volume x length
- Prioritize segments for treatment on benefit/cost
  - Reduction of GHG vs Do Nothing is benefit
  - Select projects with greatest benefit/cost
- GHG reduction for network over analysis period is summed over selected treated segments

eLCAP approach for conceptual and design level LCA

- Web based, US/SI units, multiple languages
- Cradle to laid or cradle to grave
- Follows FHWA framework (18 impacts, TRACI+)
- Functional unit definition
  - Conceptual: user defined configuration using general treatment type from PaveM, other considerations
  - Design: user defined pavement design, layers, materials
  - User selected traffic
    - State highway data from annually updated database for segments and post-mile
    - User defined for cities and counties

Selected Impact Categories and Inventories	Material Production	Material as Cons
Acidification	1.7178E-03	93
Ecotoxicity (recommended)	6.4297E-01	92
Eutrophication	5.5258E-05	89
Global Warming Air, excl. biogenic carbon	3.3580E-01	94
Global Warming Air, incl. biogenic carbon	3.3581E-01	94
Human Health Particulate Air	1.4940E-04	96
Human toxity, cancer (recommended)	2.2114E-10	97
Human toxity, non-cancer (recommended)	5.2534E-08	94
Ozone Depletion	1.1043E-09	99
Resources, Fossil fuels	5.5400E-01	93
Smog Air	2.4085E-02	88
Primary Energy Demand used as raw materials (Feedstock Energy)	2.4120E+00	100
Primary energy demand from ren. and non ren. resources (gross cal. value)	5.1562E+00	94
Primary energy demand from ren. and non ren. resources (net cal. value)	4.8278E+00	94
Primary energy from non renewable resources (gross cal. value)	5.0339E+00	94
Primary energy from non renewable resources (net cal. value)	4.7055E+00	94
Primary energy from renewable resources (gross cal. value)	1.2232E-01	100
Primary energy from renewable resources (net cal. value)	1.2232E-01	100

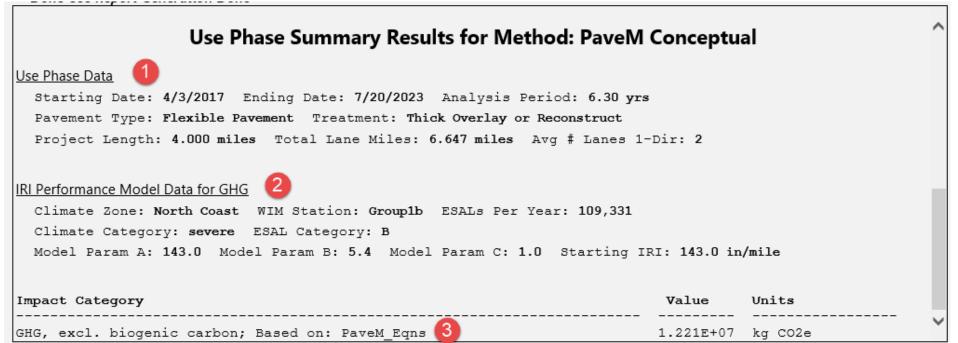# eLCAP approach for conceptual and design level LCA

- Materials, transport, construction models
  - Models
    - Built by UCPRC using models, GaBi, other data for materials and construction processes
    - GaBi data updated annually and then kept constant (thinkstep agreement)
  - Default materials design for each type
  - User capability to adjust materials designs or input impacts from EPDs
  - User defined transport distances and modes
  - Construction equipment operation tied to material and quantity, default or user defined
- Repeat for subsequent M&R

eLCAP approach for conceptual and design level LCA

- Use stage
  - Excess fuel consumption from vehicle roughness interaction difference (Wang et al) vs "ideal" 40 in/mile
  - Uses PaveM IRI models
  - To be added soon:
    - Texture models vs ideal 0.5 mm MPD or MTD
    - Calibrated structural response models vs ideal no response, considering hourly traffic flow, speed and temperature across years
- EOL
  - Stops at reconstruction or land fill
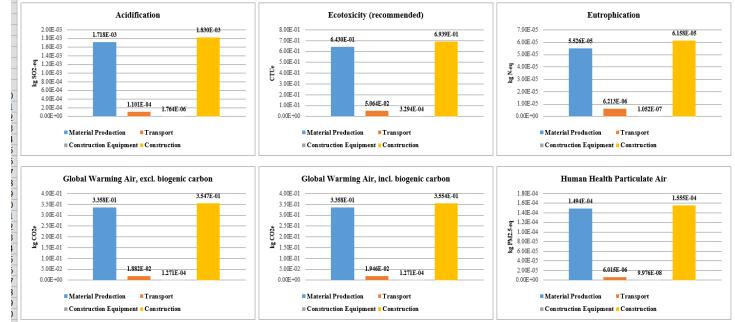 - If no real EOL, follows FHWA framework

IRI models

- Simple IRI models used in PaveM and eLCAP
  - Continuous models from PMS data
  - Simplified: Average_IRI (inches/mile) = a+b*Age^c
    a, b, c depend on treatment, ESAL/yr, climate category
  - Future:
    - Use continuous models for design level eLCAP

Use Phase Summary Results for Method: PaveM Conceptual

Use Phase Data ①
  Starting Date: **4/3/2017** Ending Date: **7/20/2023** Analysis Period: **6.30 yrs**
  Pavement Type: **Flexible Pavement** Treatment: **Thick Overlay or Reconstruct**
  Project Length: **4.000 miles** Total Lane Miles: **6.647 miles** Avg # Lanes 1-Dir: **2**

IRI Performance Model Data for GHG ②
  Climate Zone: **North Coast** WIM Station: **Group1b** ESALs Per Year: **109,331**
  Climate Category: **severe** ESAL Category: **B**
  Model Param A: **143.0** Model Param B: **5.4** Model Param C: **1.0** Starting IRI: **143.0 in/mile**

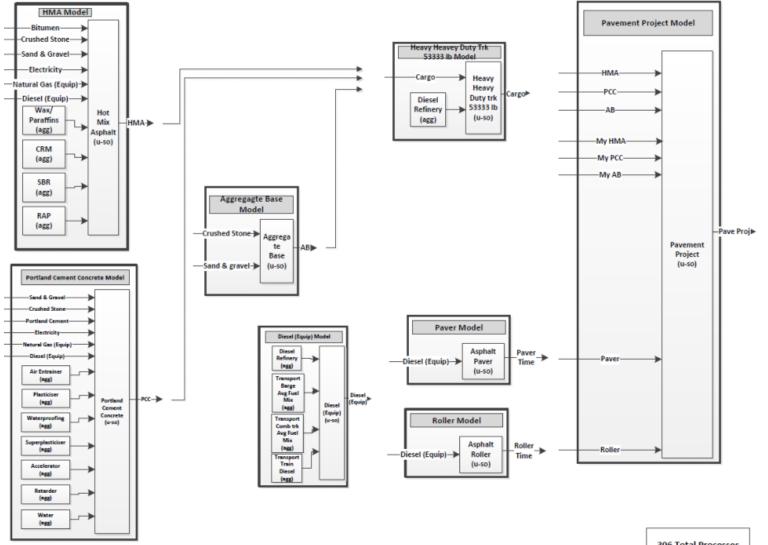| Impact Category	Value	Units
GHG, excl. biogenic carbon; Based on: PaveM_Eqns ③	1.221E+07	kg CO2e

Reporting

- Impacts can be broken down by:
  - Each impact category
  - Life cycle stage
  - Elements (material types, material components, construction, transport) within stage
- Tables, bar charts and pie charts

Documentation of all data, models and assumptions, necessary for critical review
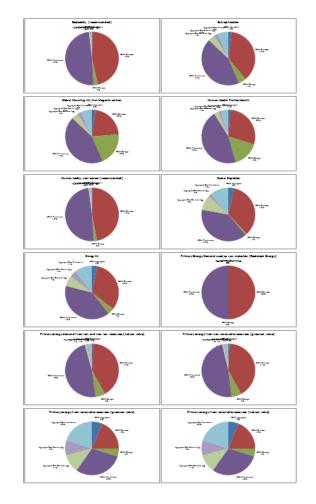
Critical review

- Initial eLCAP main inventory for materials and construction data reviewed by outside critical review team in 2016
  - Benchmarked against other data
  - Review of data quality assessment
- Annual updates to eLCAP LCI and processes will be similarly critically reviewed by independent outside team

Advances with these tools

- Builds on progress of other tools
- Integration between network-, conceptual- and design-level LCA
  - Data, models
  - Assumptions, impacts, reporting
- Integration with LCCA
  - Traffic data, performance models, treatments
- Web-based, complete life cycle, flexibility of data, critical review

Future developments

- Future developments in next year
  - Continuous IRI models for design use
  - Excess fuel use from structural response and texture
  - Tie materials to item codes, expanded use of EPDs
  - Better construction work zone traffic impacts model
  - Post-construction evaluation tied to pay items
- Annual updates
  - LCI data from GaBi to update impacts
  - Update models for new materials and processes
- Tri-annual updates
  - Performance models in PaveM, eLCAP, RealCost-CA

Thoughts on future development of tools

- Training, support, transparency, trustworthiness
- Keeping tools practical within time, data availability, cost constraints of users
- Use of EPDs, regional data, better models for everything, licensing of proprietary data
- Customized user interfaces and data
- Platforms
  - Web-based for more complex tools
    - Updates are easy
  - Python for simpler tools
    - Avoids problems with VB updating, good interfaces
    - Example is LBNL heat island LCA tool

Questions

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