Reducing Pavement Life Cycle Environmental Impacts Using LCA

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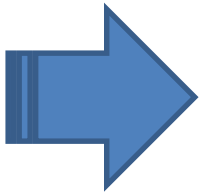
City and County Pavement Improvement Center

Governance:
League of California Cities,
California State Association of Counties

State and federally funded research and development for highways



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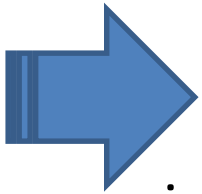

Training, development, implementation, research

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City and County Pavement Improvement Center

ITSBerkeley Institute of Transportation Studies 70

TransGET National Center for Transportation, Green Technologies, and Education

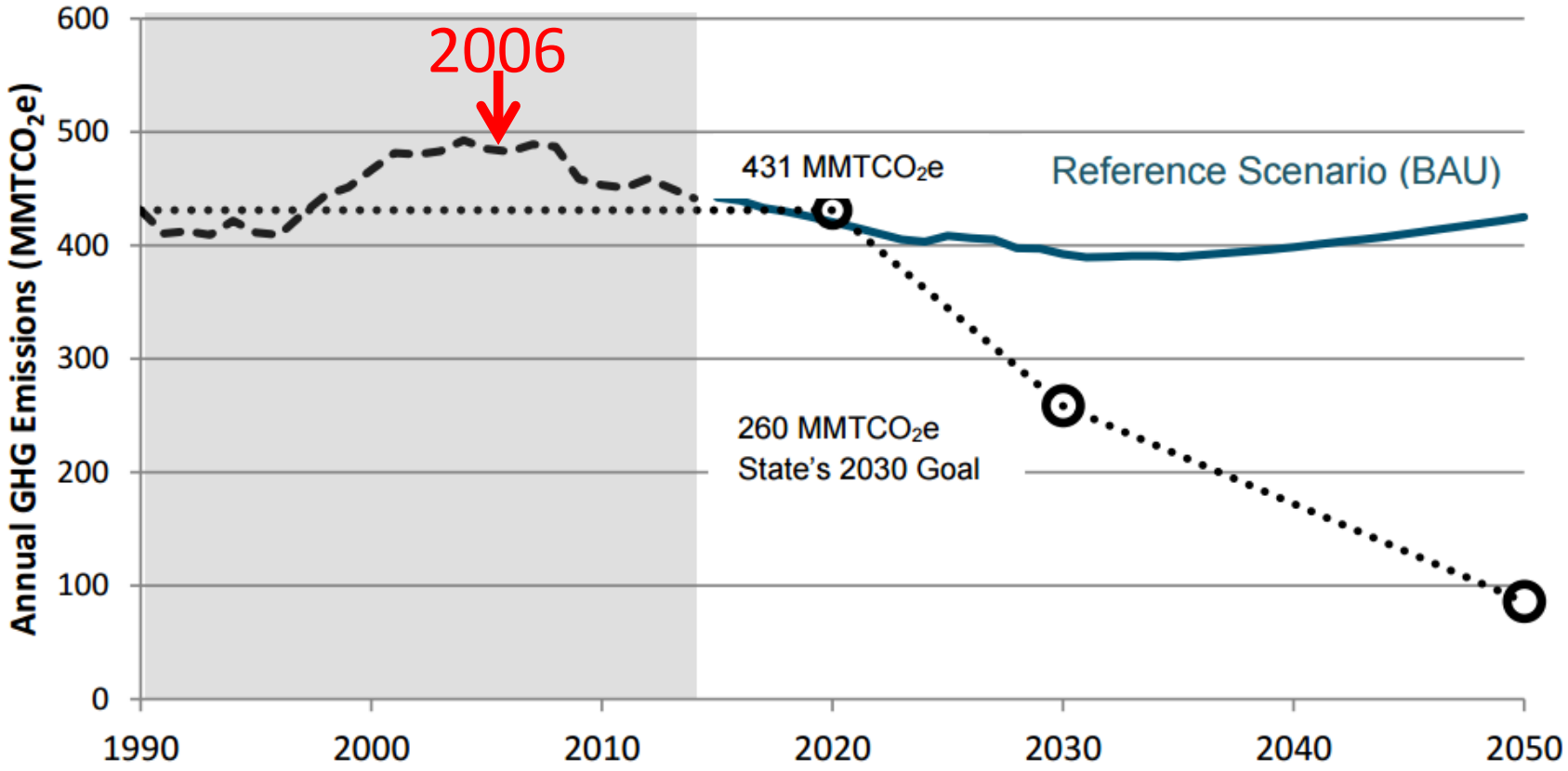
CAL POLY DISCERE FACIENDO

Outline

- Current laws and concerns that LCA can help address
- Quick review of LCA
- Recent results and current UCPRC work on LCA for Caltrans

- Note: views expressed are those of the presenter and NOT necessarily those of any sponsoring agency

Climate Change: road transport related strategies planning to 2030 and 2050

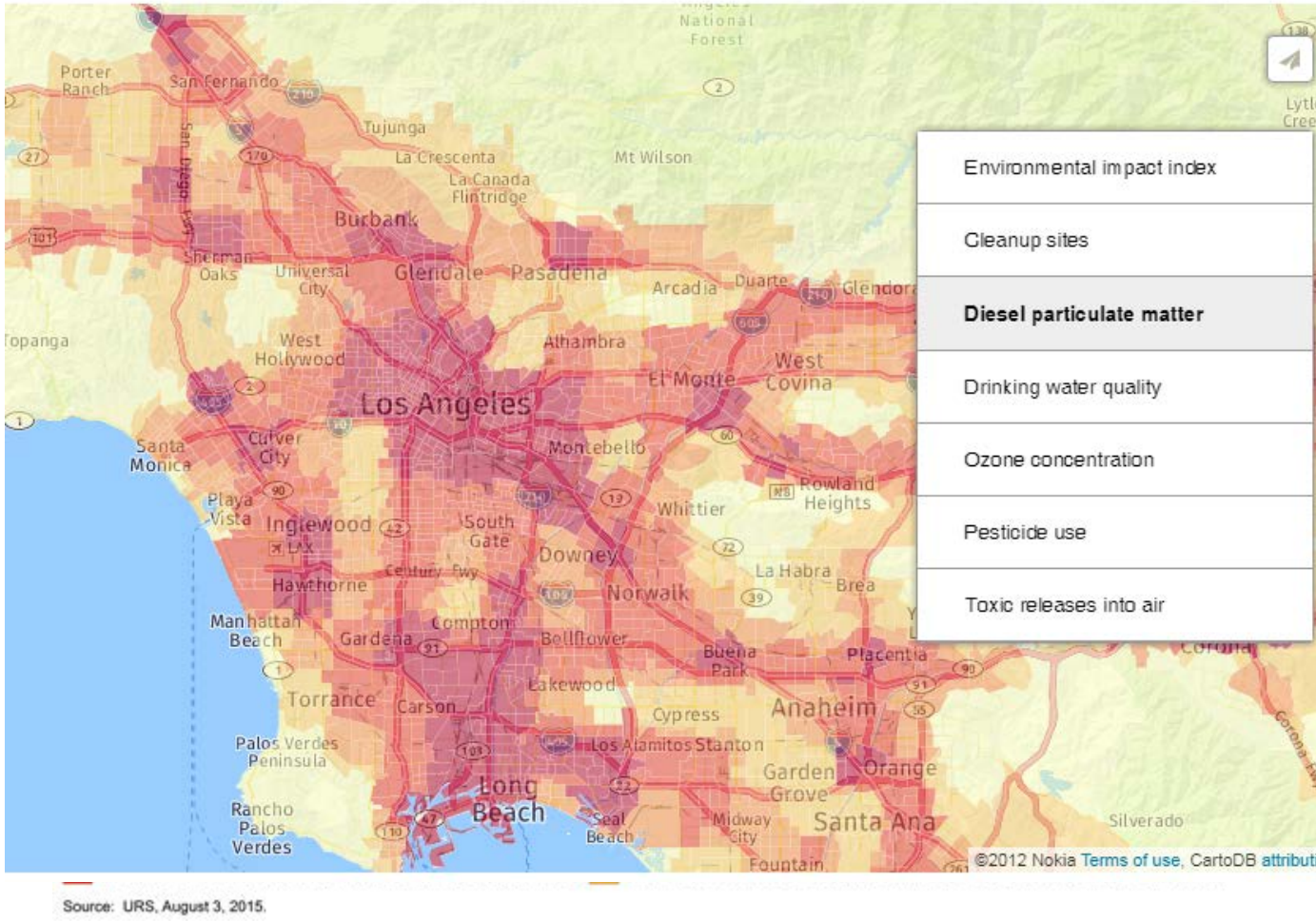


Air Resources Board Climate Scoping Plan

Air Pollution Toxicity

- Transportation related factor of most importance is air pollution, especially diesel trucks

✓ Requiring changes in vehicle energy sources, especially trucks

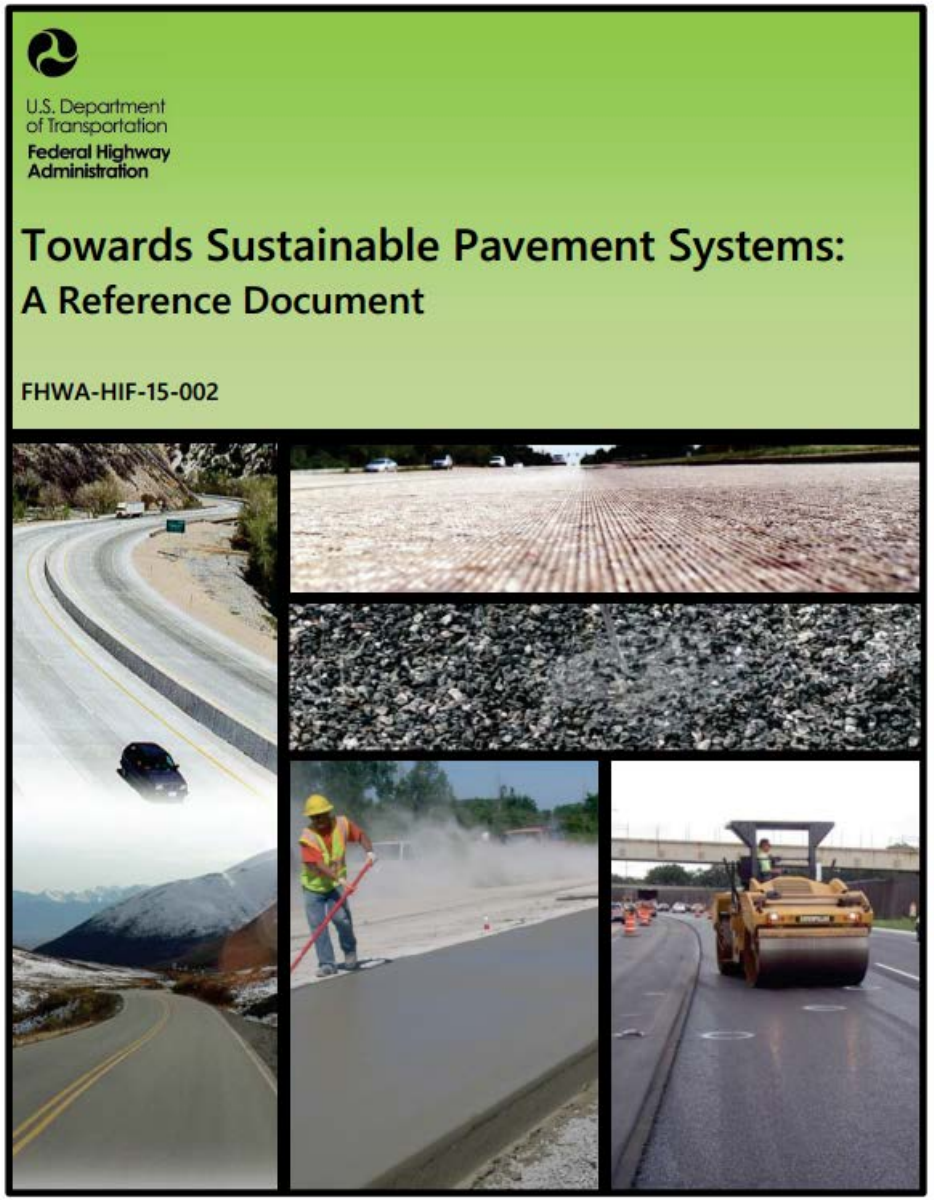


http://graphics.latimes.com/responsivemap-pollution-burdens/

https://www.uschamber.com/issue-brief/ozone-national-ambient-air-quality-standards

So what can be done to make pavements more sustainable?

- FHWA Sustainable Pavements Task Group
  - More sustainable pavement reference document (2015)
  - Covers everything about pavement and sustainability
  - Tech briefs and webinars



http://www.fhwa.dot.gov/pavement/sustainability/ref_doc.cfm

Measuring Sustainability

- Life Cycle Cost Analysis (LCCA)
  - Economic
- Life Cycle Assessment (LCA)
  - Range of environmental impacts, quantitative
- Sustainability Rating Systems (e.g., INVEST)
  - Environmental and social impacts, qualitative

Reasons to Measure

Decision support

Establish baselines for process improvement

Reporting for public, industry and government

Four Key Stages of Life Cycle Assessment

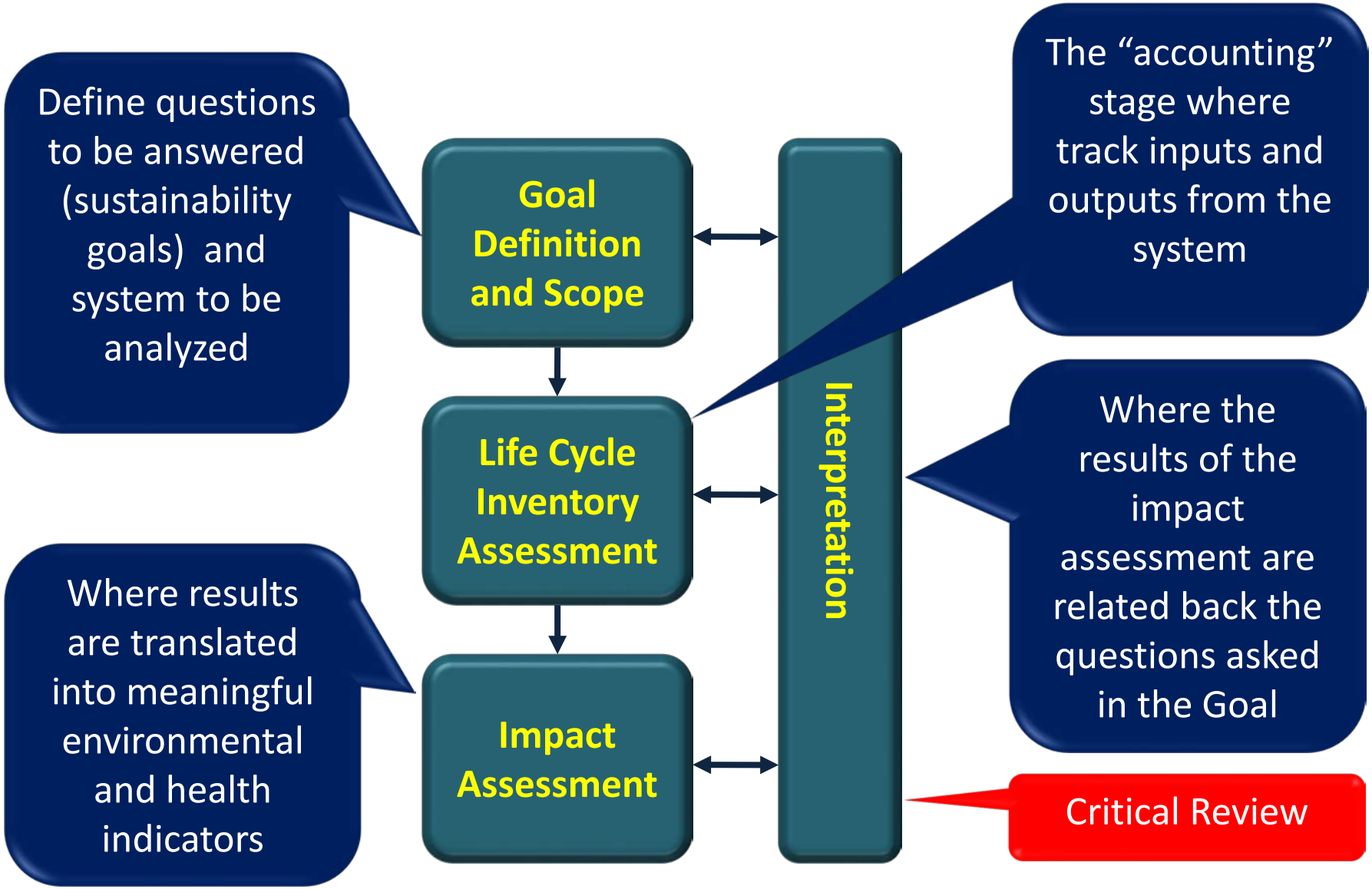


Figure based on ISO 14040, adopted from Kendall

US EPA Impact Assessment Categories

(TRACI – Tool for the Reduction and Assessment of Chemical and other environmental Impacts)

- Global warming
- Stratospheric ozone depletion
- Acidification
- Eutrophication
- Photochemical smog
- Terrestrial toxicity
- Aquatic toxicity
- Human health
- Abiotic resource depletion
- Land use
- Water use

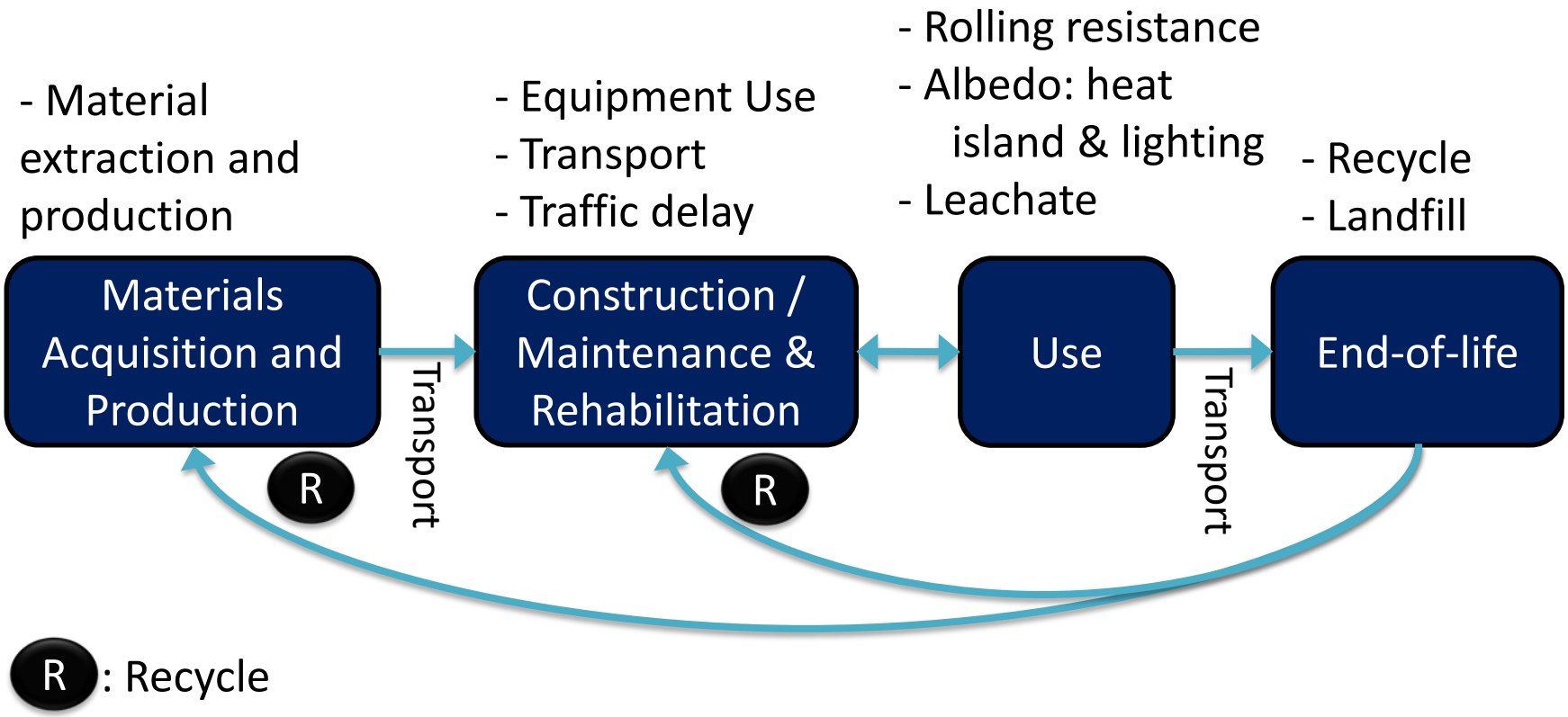
Impacts to people

Impacts to ecosystems

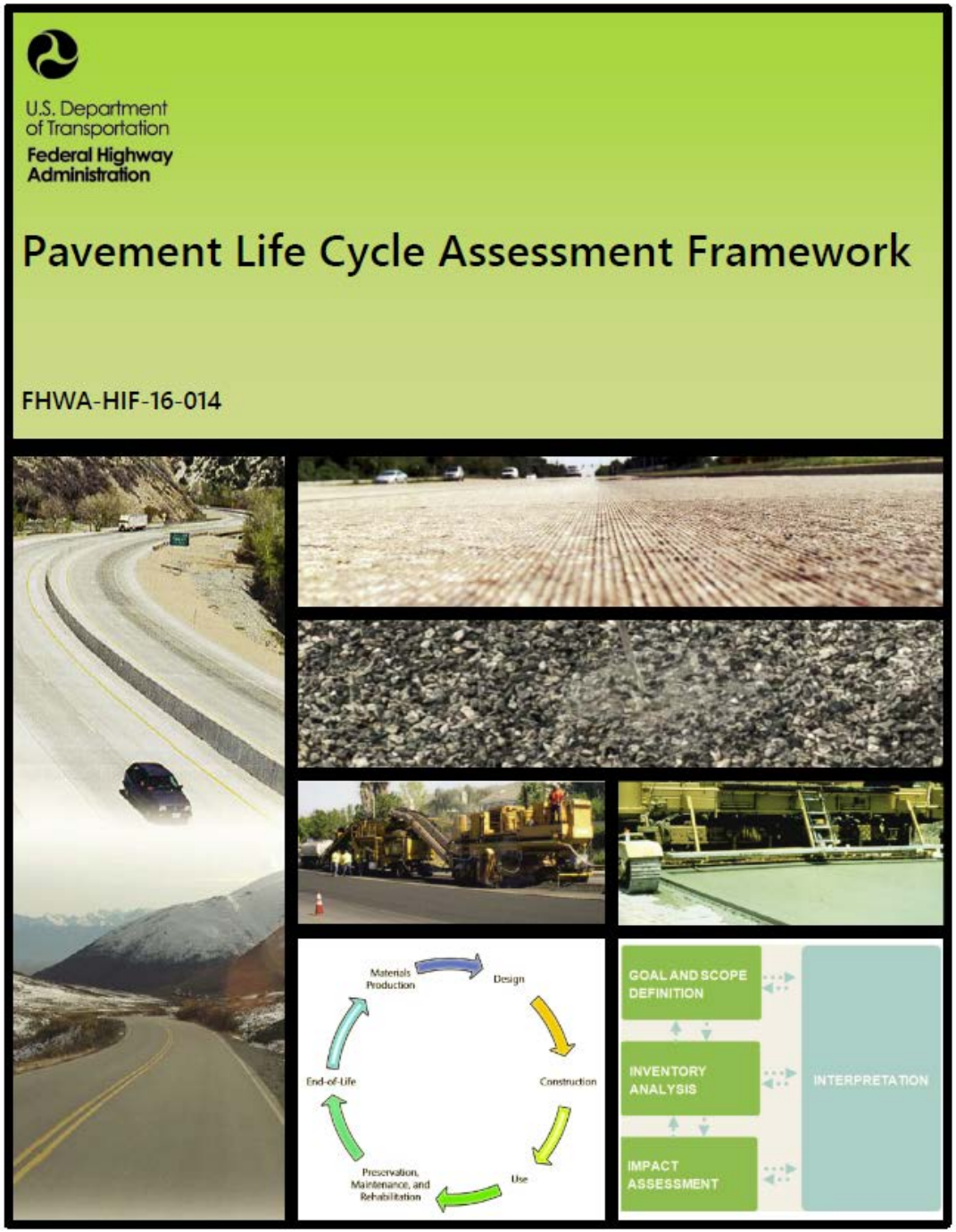
Depletion of resources

From Saboori Image sources: Google

Pavement Life Cycle Assessment



From: Kendall et al., *2010*



FHWA pavement LCA framework 2016

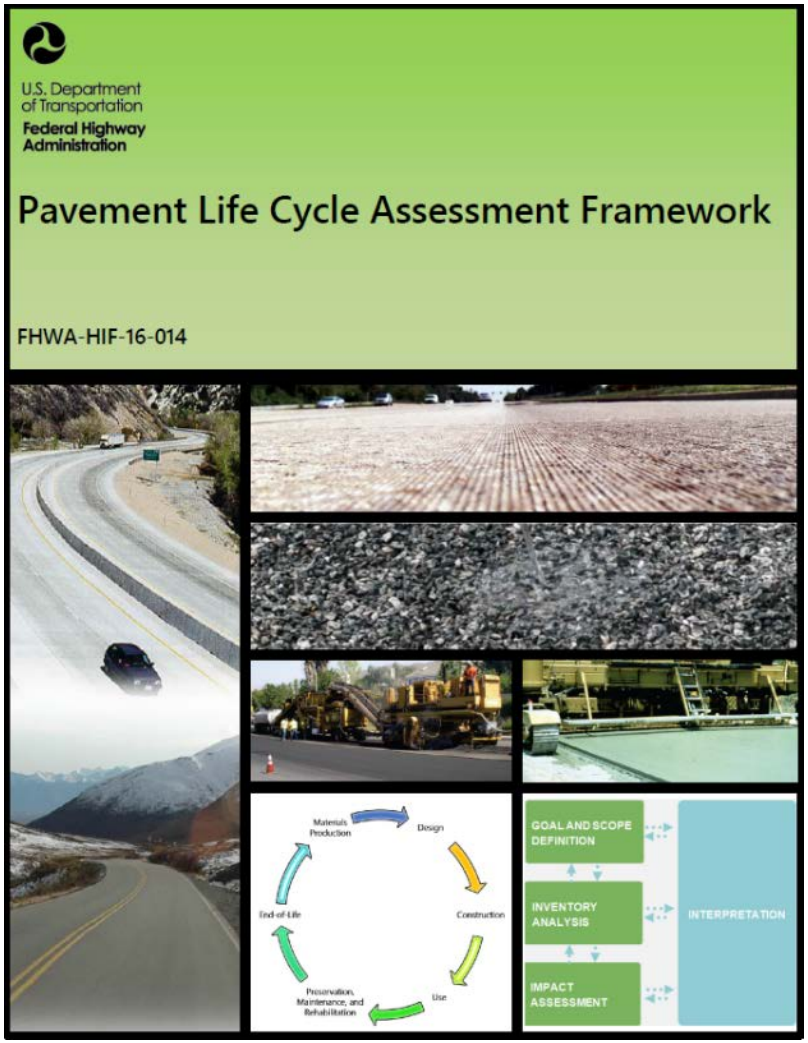
http://www.fhwa.dot.gov/pavement/sustainability/

Why use LCA for evaluating environmental performance?

- Quantifies outcomes:
  - GHG, energy, pollutants, finite resources
- Uses project-specific inputs:
  - materials, transport, construction, traffic levels, re-use
- Requires explicit prioritization of outcomes for decision-making
- Can account for regional and time variability, and other uncertainties in data sets and analysis

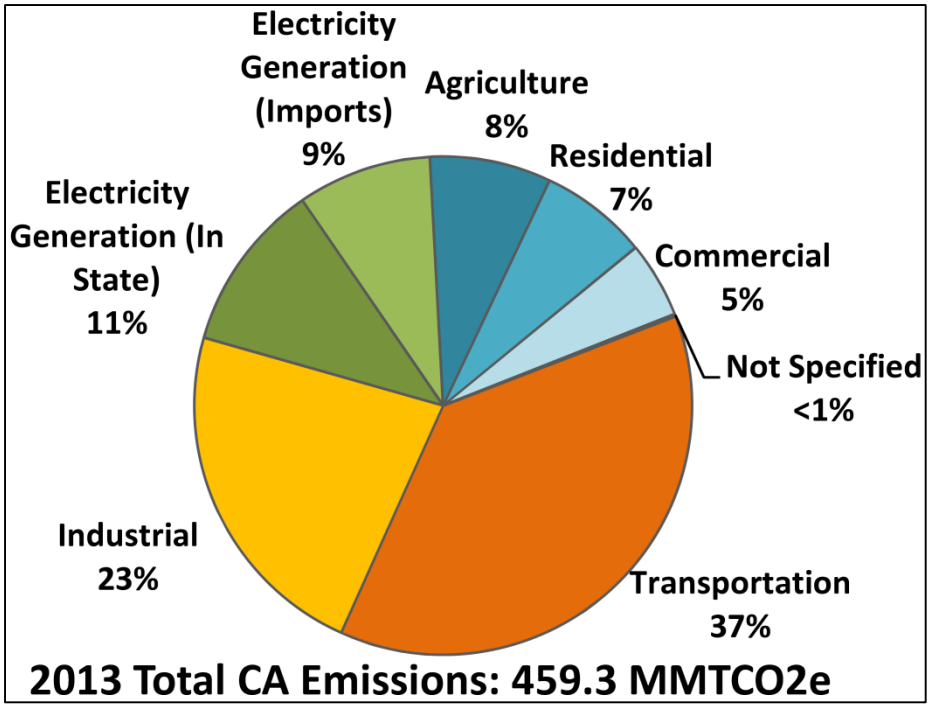
ISO Standards and FHWA Pavement LCA Framework Document

- International Standards Organization (ISO) standards for LCA are generic for all materials
- FHWA guidance specific to pavements published in 2016



How do Pavements Contribute to California GHG Emissions?

- Out of 459 MMT CO2e in 2013
  - On road vehicles 155 MMT
    - Optimizing smoothness, texture, deflection energy on state network reduces by 1% of this
  - Refineries 29 MMT
    - Paving asphalt about 1 % of refinery production
  - Cement plants 7 MMT
    - Paving cement about 5 % of cement plant production
  - Commercial gas use 13 MMT
    - Very small amounts for asphalt mixing plants
  - Mining 0.2 MMT
    - Large portion for aggregate mining



Possible Pavement Reductions	MMT/year
Rolling resist to optimum	1.5
Cement use 50%	0.2
Asphalt use 50%	0.7
Demo, oil, stone haul 10%	0.6
TOTAL	**2.9**

http://www.arb.ca.gov/cc/inventory/data/data.htm

Quick review of recent and current Caltrans/UCPRC work on developing and using LCA

Sustainability

- Environmental Life Cycle Assessment Updates and Applications
  - Previous work:
    - Developed LCA approach
    - Initial analyses for Caltrans
      - Network level IRI optimization
      - Project level case studies for asphalt and concrete
      - Urban heat island
      -
  - This Project:
    - Further updates to capabilities

Caltrans Network: roughness trigger for maintenance by traffic group optimization for GHG

Daily PCE of lane-segments range	Total lane-miles	Percentile of lane-mile	Optimal IRI triggering value m/km, (inch/mile)	Annual CO_2-e reductions (MMT)	Modified total cost-effectiveness ($/t$CO_2$-e)
<2,517	12,068	<25	-----	0	N/A
2,517 to 11,704	12,068	25-50	2.8 (177)	0.141	1,169
11,704 to 19,108	4,827	50-60	2.0 (127)	0.096	857
19,108 to 33,908	4,827	60-70	2.0 (127)	0.128	503
33,908 to 64,656	4,827	70-80	1.6 (101)	0.264	516
64,656 to 95,184	4,827	80-90	1.6 (101)	0.297	259
>95,184	4,827	90-100	1.6 (101)	0.45	104
			TOTAL:	**1.38**	**416**

Wang et al 2014

Sustainability

- Environmental Life Cycle Assessment Tool for Project-Level Use
  - Previous work:
    - Inclusion of simplified LCA including roughness effects on fuel use in PaveM web-based pavement management software
    - Performance models for IRI
  - This project:
    - Deliver a project and conceptual level tool: *eLCAP*
    - Web-based
    - Will use
      - Updated, critically reviewed database of treatment LCIs
      - Updated performance models
      - Also being updated in PaveM

Caltrans Pavement Engineering and Database/Software Interactions

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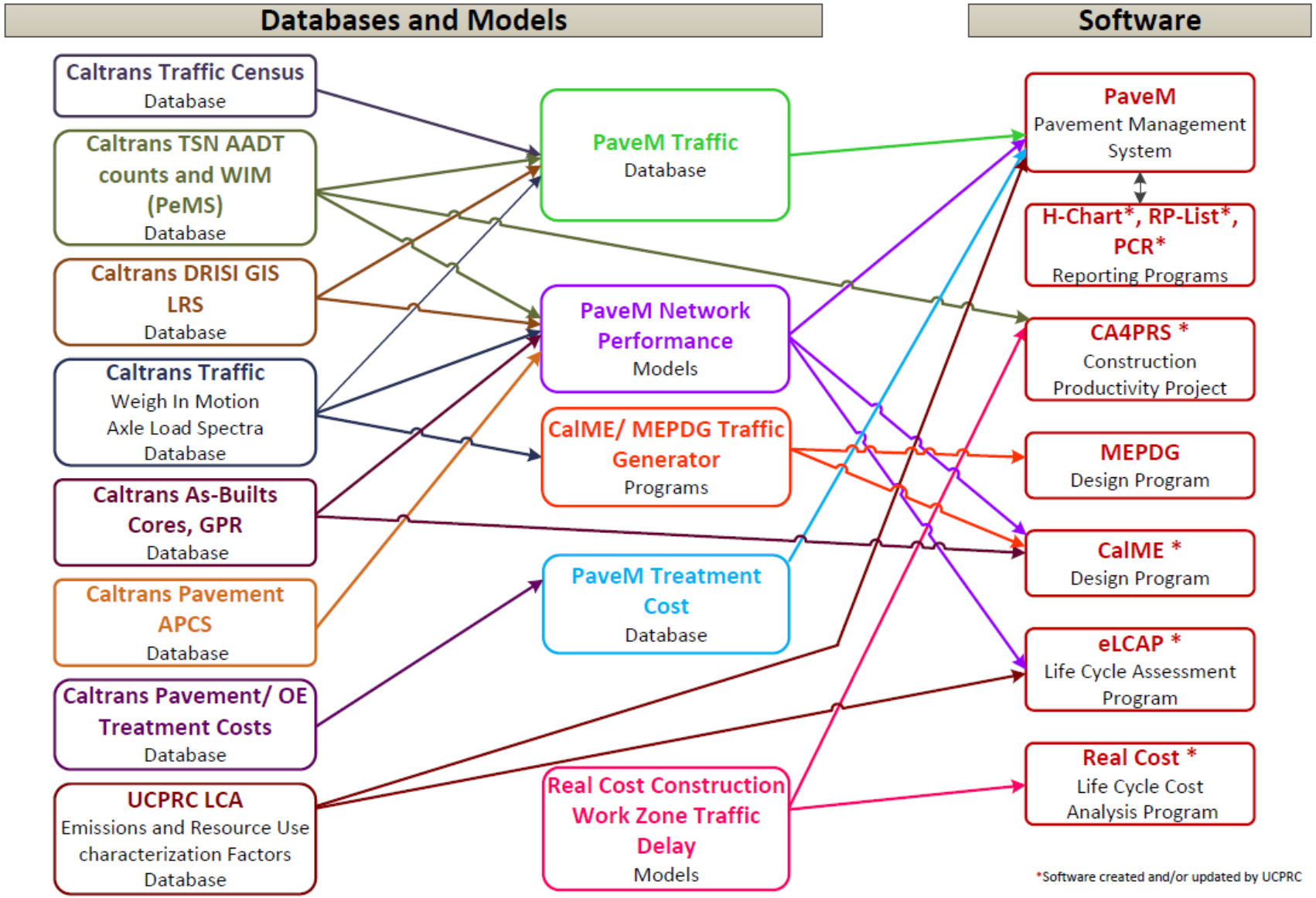

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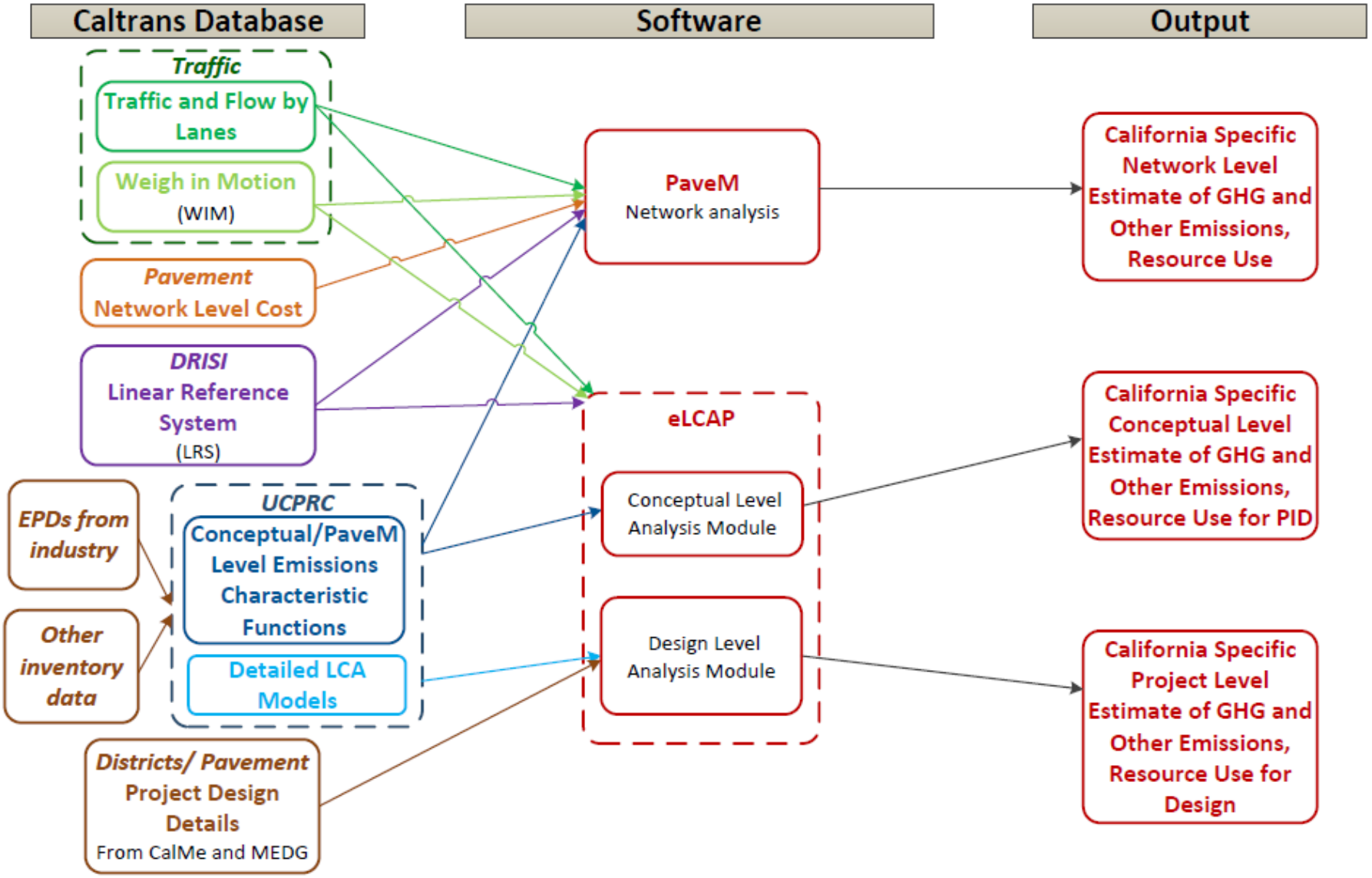
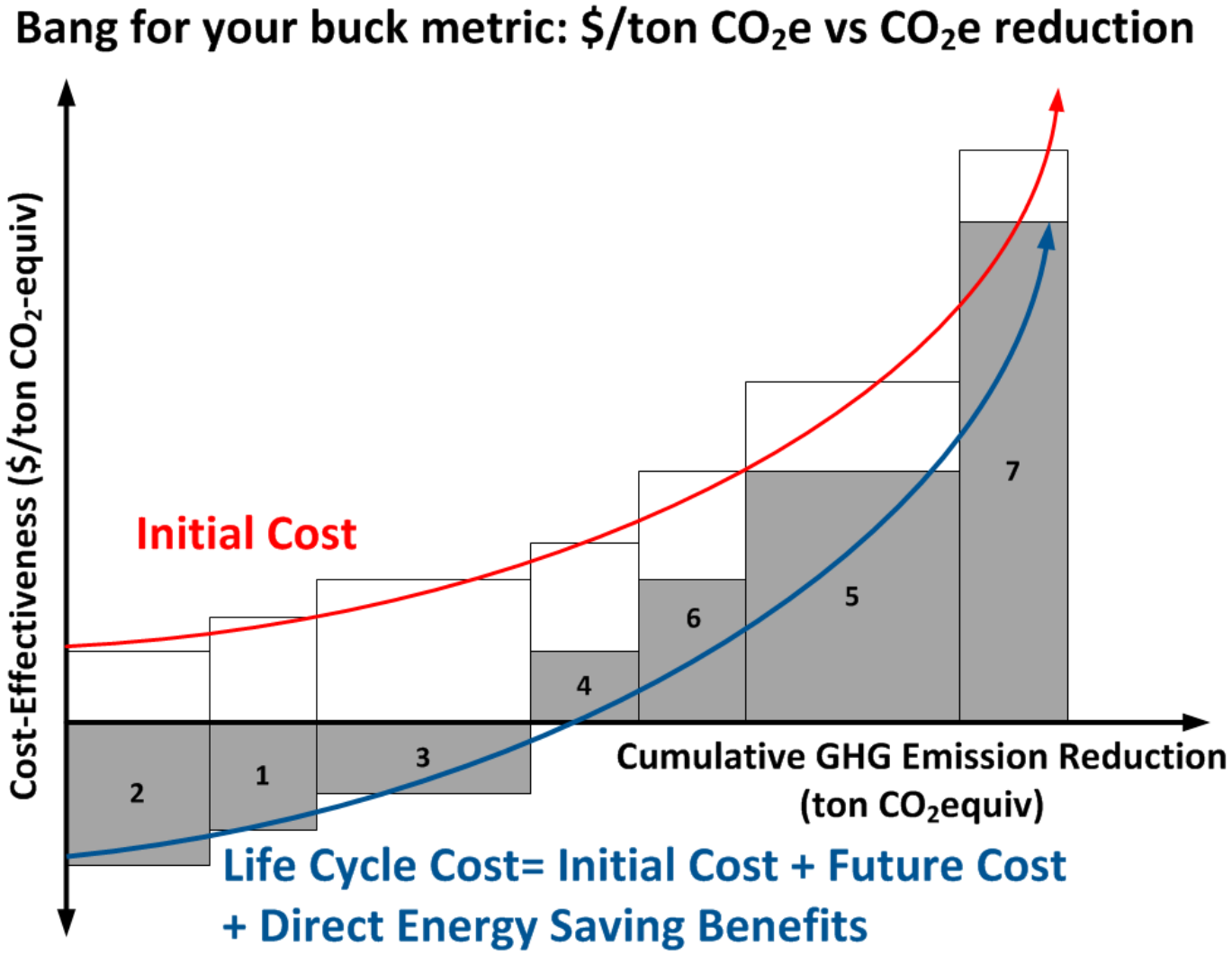
eLCAP and PaveM Functionality and Data Sources



Sustainability

- Calculation of Benefit/Cost for Alternative Strategies to Reduce GHG
  - This project:
    - Evaluate potential strategies that Caltrans could undertake to improve sustainability
    - Primary focus on greenhouse gases, but also on important local issues: air pollution

What Should be Done for Sustainability?



Adapted from Lutsey, N (2008) Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-08-15

- Many alternatives to improve sustainability
- How to prioritize?
- Cost from Life Cycle Cost Analysis (LCCA)
- Environment from Life Cycle Assessment (LCA)

Sustainability

- Fast Model for Energy Consumption Due to Pavement Structural Response
  - Previous work
    - Evaluated models for effects of roughness and texture on vehicle fuel economy
    - Evaluated effects of pavement structural response on vehicle fuel economy
    - Data analysis and simulation being completed by this summer
  - This project:
    - Develop a fast tool for use in design and pavement management to calculate effect

Sustainability

- Consideration of Environmental Product Declarations
  - Previous work:
    - Supported Caltrans and FHWA in approach to implement EPDs
  - This project:
    - Support Caltrans on implementation of AB 262
    - Support Caltrans on pilot projects for requiring EPDs for pavement materials in projects under development in 2018 and 2019; review specs, review results

Goals of Requiring EPDs

from soon to be published FHWA report

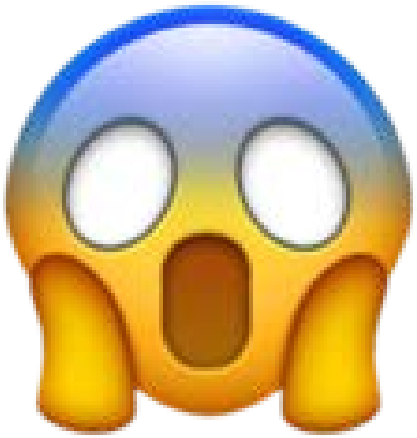
- Have good information for reporting emissions and resource use from pavement work
- Have good information for LCA use in:
  - Pavement designs, specifications
    - Different types of structures
    - Different types of materials in structures
    - Different construction quality requirements
  - Pavement asset management
    - Selection and timing of treatments
    - Trigger levels for distresses

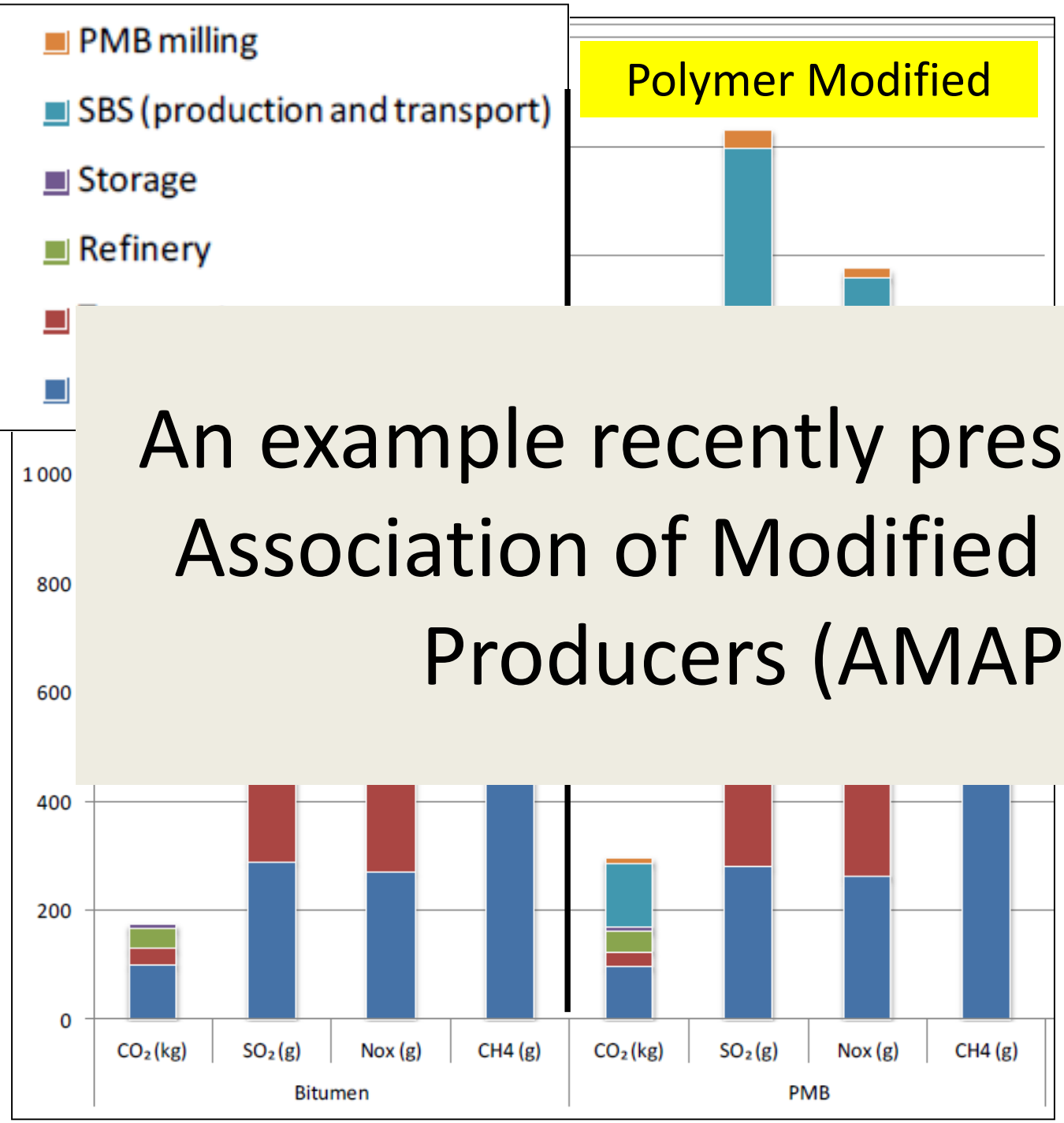
Recommended 3 Stage Approach for Implementing EPD Requirements *from soon to be published FHWA report*

1. Develop rules and then require reporting, move towards standardization of EPDs (1-2 years)
2. Develop standardization, rigor, review process, level playing field, appropriate applications (3 to 5 years)
3. If desirable and have made sufficient progress, consider using for procurement
   - Defining principle: Must take into account equivalent performance

What happens if industry does not produce EPDs?

- If you don’t produce EPDs, someone will estimate the environmental impact of your product for you
- With whatever information they can find





PMB manufacture causes about 60% more air emissions than straight bitumen in Europe

An example recently presented to Association of Modified Asphalt Producers (AMAP)

will soon be publishing EPDs

Eurobitume LCI
Bernard et al.
Nantes LCA 2012

AB 262, Bonta. Public contracts: bid specifications: Buy Clean California Act

- What the law requires:
  - By January 2019 establish “average of facility-specific GWP” for each product based on “national and international databases”
  - Facility-specific GWP for products bought by state agencies (State Contracting Manual) cannot exceed “national average”
  - Documented through submission of EPD consistent with ISO 14025
  - Update average every 3 years
- Steel, flat glass and fiberglass insulation are in law
- Concrete, asphalt mix, cement, asphalt binder got “carve outs”
  - Not ready to produce facility-specific EPDs routinely
  - Expect new legislation for asphalt, concrete soon

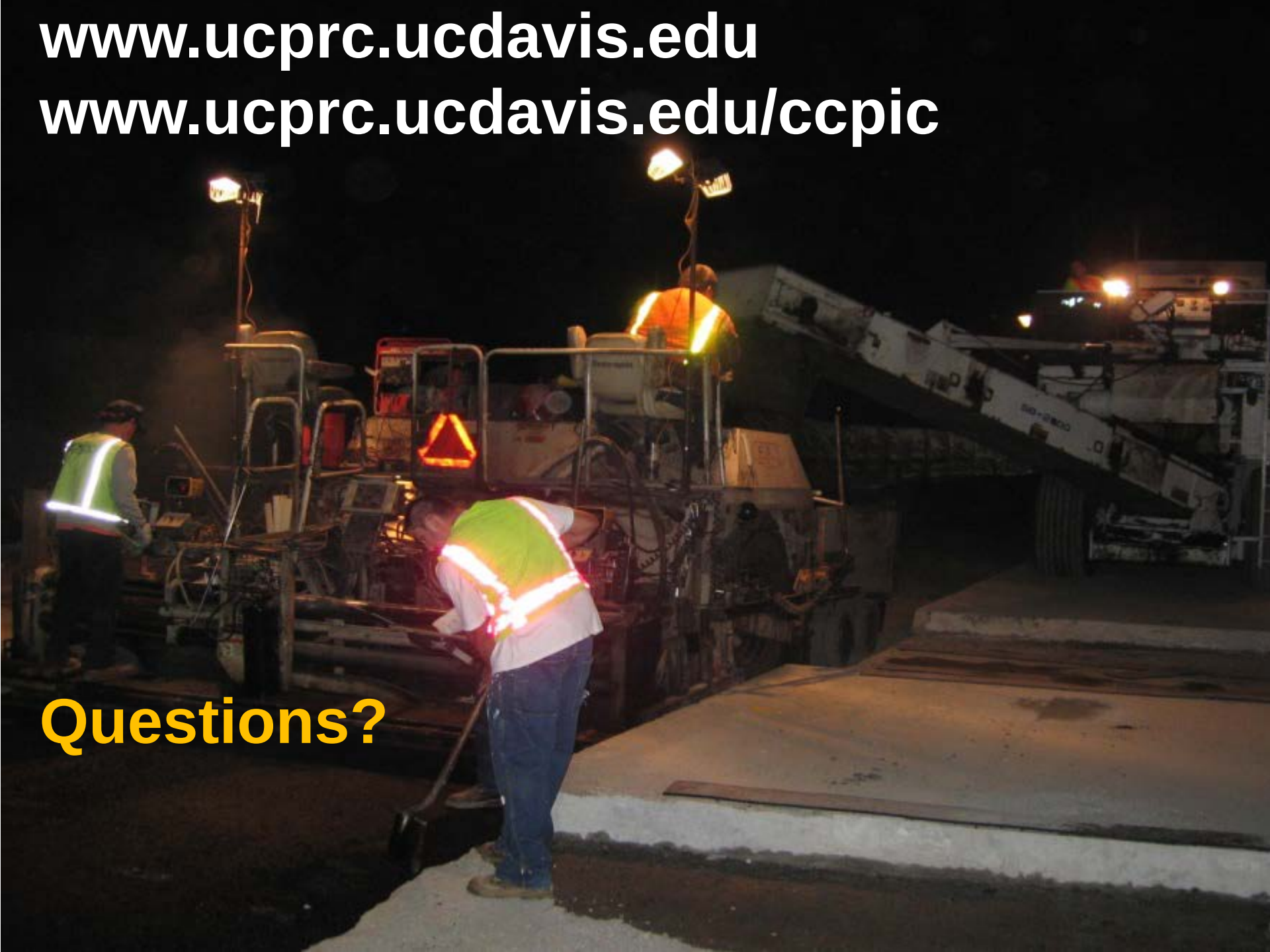
What are CA agencies trying to do with EPDs?

- Caltrans:
  - Implement AB 262 as best possible
- Caltrans/UCPRC
  - Keep moving ahead with developing technical capacity, good, cost-efficient procedures for asking for EPDs
    - Pilot projects for EPDs in new projects in 2018
  - Try to get implemented ahead of new legislation
  - Use in design, pavement management, specifications
- FHWA Sustainable Pavements Task Group
  - Develop standardized rules and processes, clarify uses
  - Technology transfer

Takeaways: what do our customers want?

- Deliver more in terms of sustainability:
  - Cost, safety, smoothness, construction delay, small environmental impacts, local pollution
  - Asphalt paving: compaction, tack coats, recycling as long as equal or better performance
- Deliver innovation that can be used
  - $9 on development, implementation for each $1 of research
- Find ways to communicate pavement to the public
  - Rightly or wrongly, government is often not seen as cost-effective deliverer of these services
  - Communicate the innovations and quality improvement
  - Use LCCA and LCA results
  - They are interested!

www.ucprc.ucdavis.edu
www.ucprc.ucdavis.edu/ccpic



Questions?