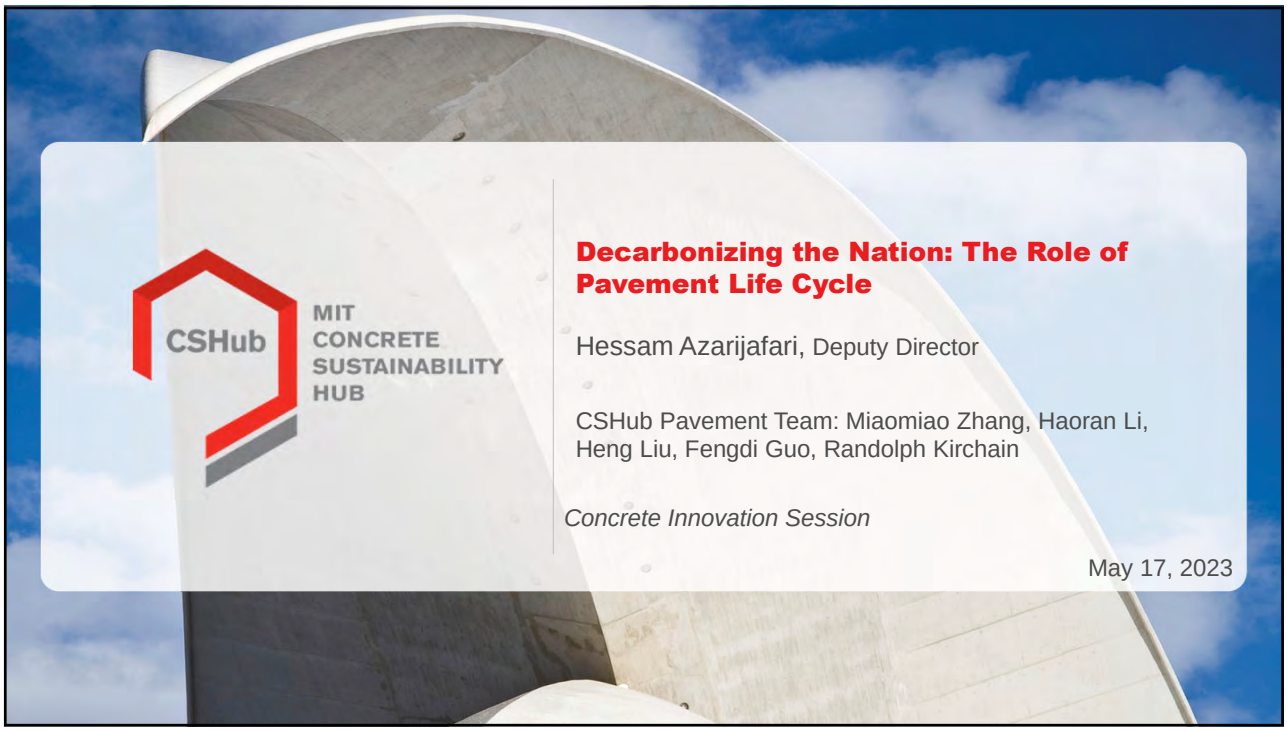
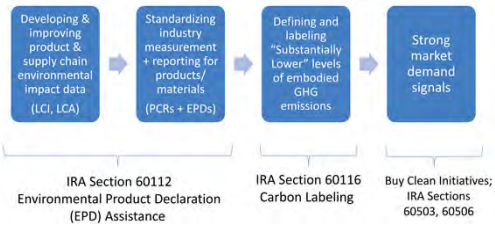
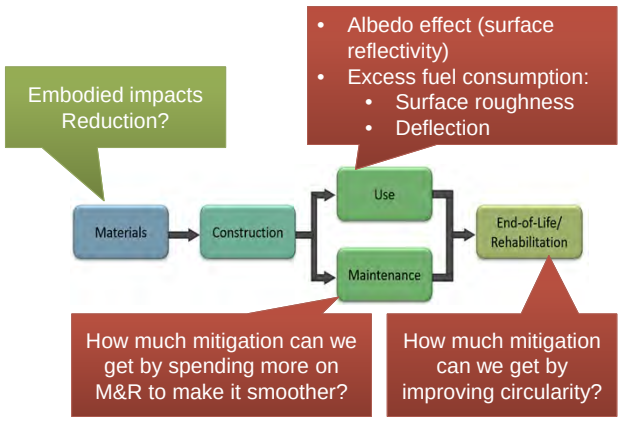


Role of pavement life cycle impact in reducing the nation-wide GHG emissions remains unrecognized



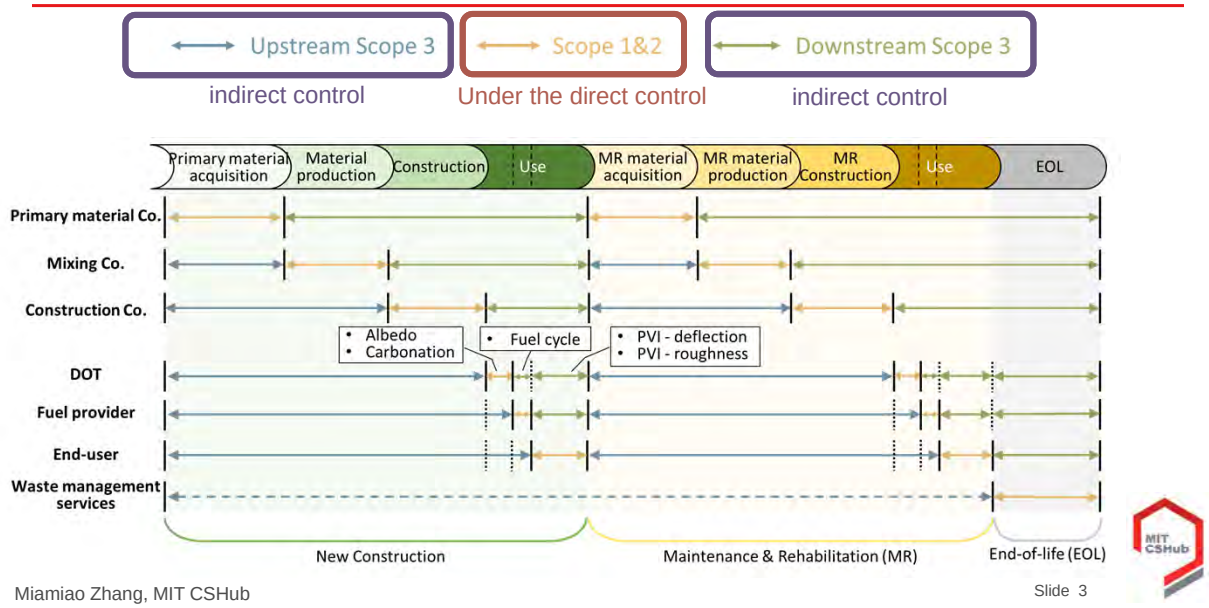
Missing part of the low-carbon pavement policies:

1) Impact of Materials choice on the rest of the life cycle
2) Solutions for achieving low use and end-of-life emissions



Slide 2

Value chain stakeholders can mitigate the climate change impacts of pavements using multiple levers throughout the life cycle



Miamiao Zhang, MIT CSHub

Slide 3

Different stakeholders need different tools to assess the impact of pavement life cycle of the global climate change reduction

Project level tool

Toolkit requirements:
Life cycle scope (Construction, Use, End of life)

Application:
implementation of a decarbonization solutions in a project (segment to city scale)

Potential users:
Design Professionals/ DOT Materials Division

Network level tool

Toolkit requirements:
- Life cycle scope (Construction, Use, End of life)
- Current & future network condition

Application:
Systematic introduction of decarbonization solutions

Potential users:
DOT Asset Managers/Policymakers

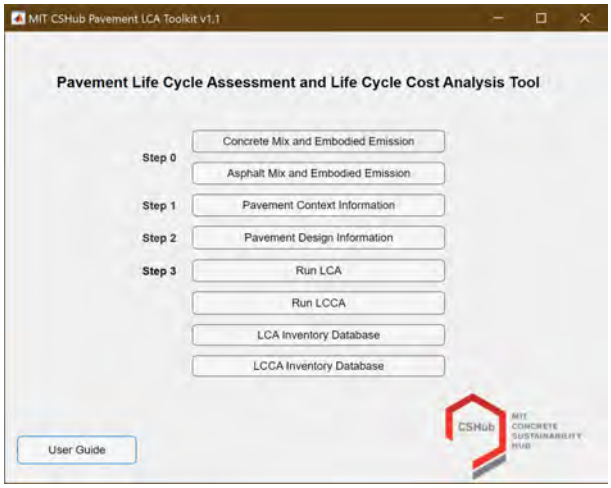
Project-level LCA tool should be able to run possible cases in a computationally efficient manner

Gaps	Proposed solutions
Conducting pavement LCA is costly and labor intensive	Develop a **universal and streamlined** pavement LCA method
Pavement LCA requires extensive data	Leverage **accessible data** and incorporate **uncertainty and variability analyses**
The uncertainty associated with pavement LCA creates challenges in the decision-making process	Employ **probabilistic comparative analysis** to attain high confidence in decision-making process

Slide 5

Run the LCA Tool

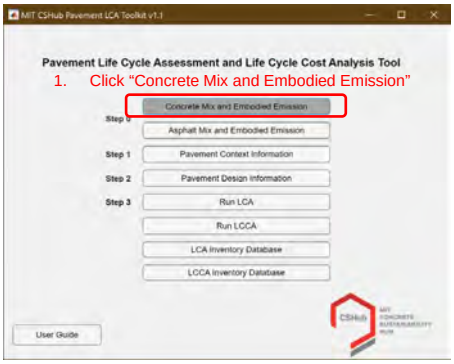
Main User Interface

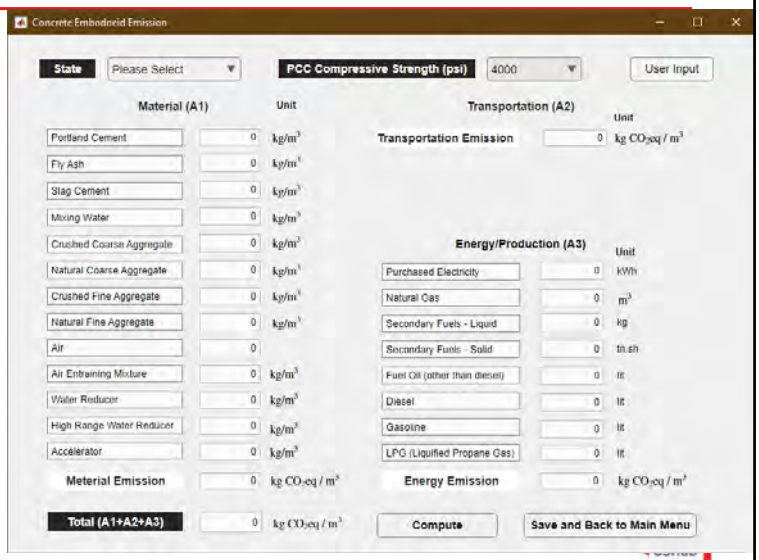


Haoran Li and Heng Liu, MIT CSHub

Slide 6

CSHub tool allows the detailed or high-level definition of mix data



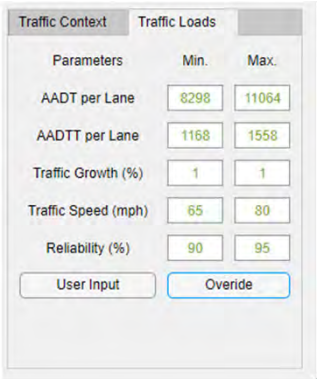


Slide 7

CSHub tool Accommodates any level of information on the pavement design

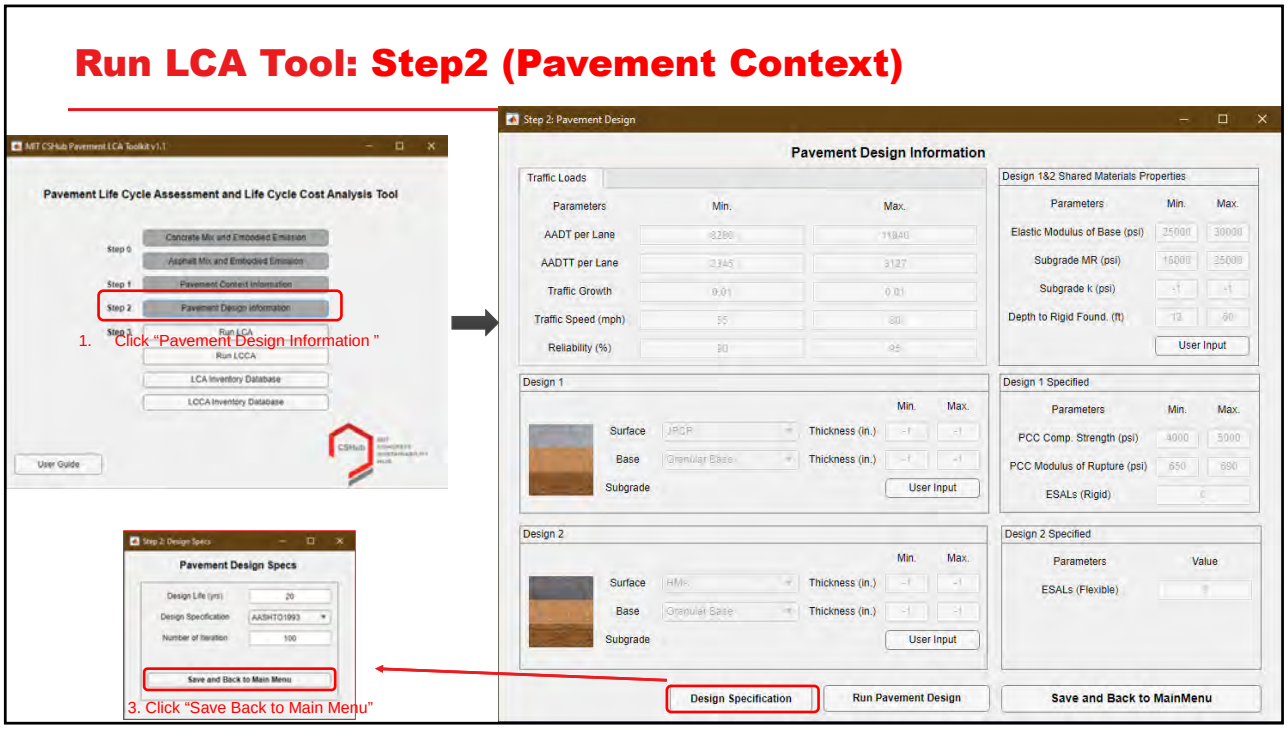
Option1:
High Level Case

Option 2:
Detailed design &
context information

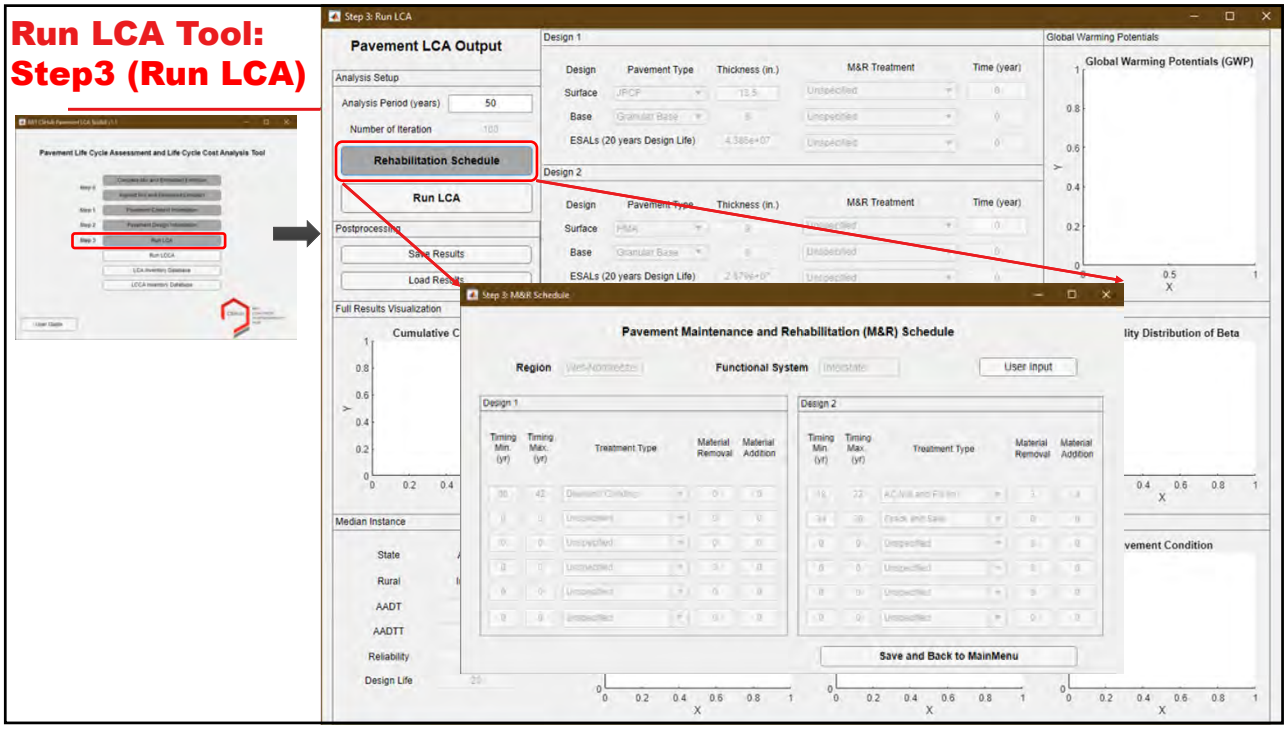


Slide 8

Run LCA Tool: Step2 (Pavement Context)



Run LCA Tool: Step3 (Run LCA)



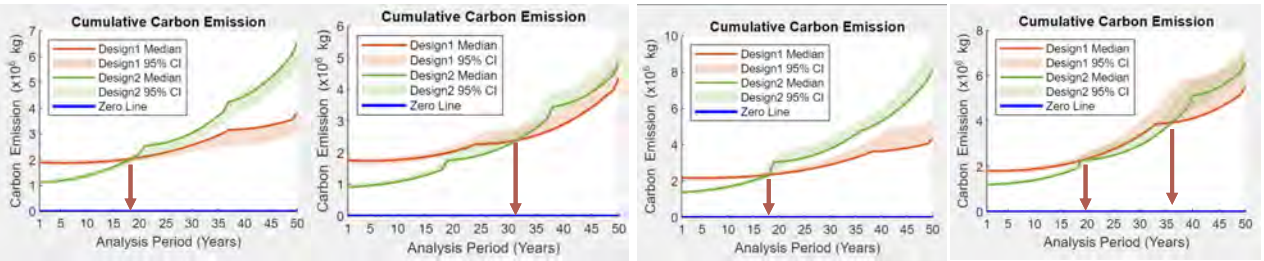
CSHub tool will allow us to rapidly support states as part of climate challenge

Results section

Lessons learned: Payback period of using concrete pavement in warm region is faster

Case study of Interstate highways

Climate Region			
1: Dry-Nonfreeze (Arizona)	2: Dry-Freeze (Colorado)	3: Wet-Nonfreeze (Florida)	4: Wet-Freeze (Massachusetts)



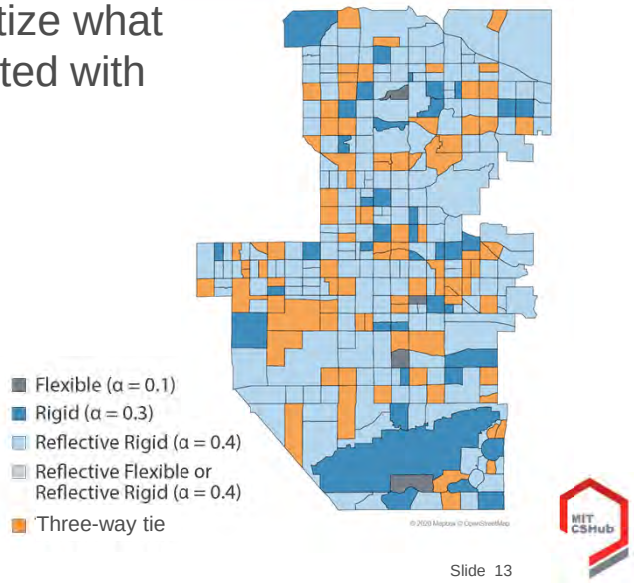
Slide 12

Lessons learned: cool pavements are the most preferred options in the majority of urban areas

Objective: Identify and prioritize what segment should be constructed with cool materials

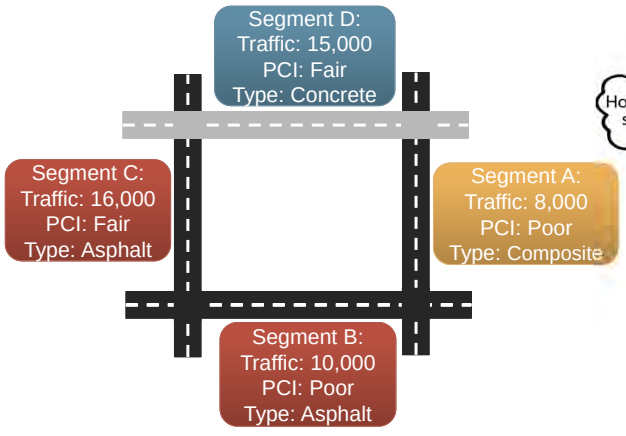
For Phoenix

- Rigid Pavement is the dominant low GHG solution
  - Reflective: 73% of lane-kms
  - Conventional:9% of lane-kms
- More information needed to choose: 17% of lane-kms
- 1% of lane-kms should remain as flexible



Slide 13

Network level tools need to consider multiple criteria of performance, budget, and available treatment actions



Action	Cost	Service life
Mill & Fill	$$	10
Asphalt overlay	$	5
Concrete overlay	$$	20
Reconstruction	$$$	25

Slide 14

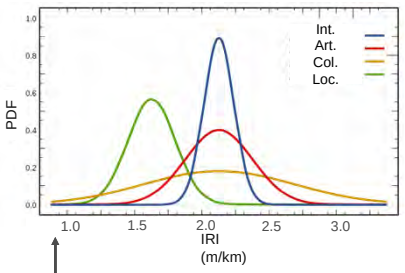
Objective: To investigate the role of life cycle environmental performance of U.S. pavement in lowering GHG emissions

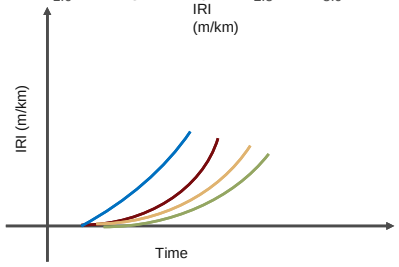
Complexity of Evaluating Pavement Network Impacts in State-level

Traffic level

Road classes in states (Interstate, Arterials, Collectors, Locals)

- Traffic is different
- Surface condition is different
- Deterioration rate is different
- M&R is different

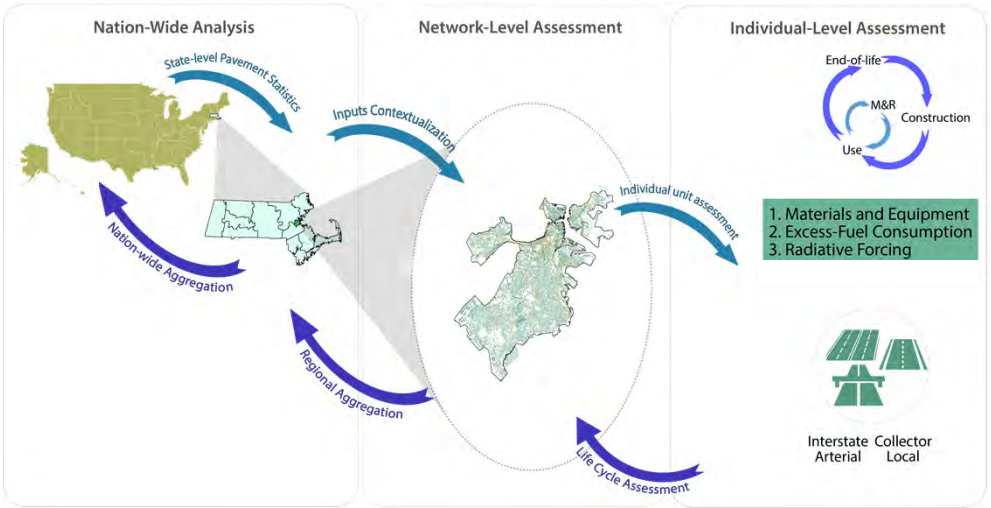




Budget for maintenance and repair is limited.

Slide 15

Objective: To investigate the role of life cycle environmental performance of U.S. pavement in lowering GHG emissions



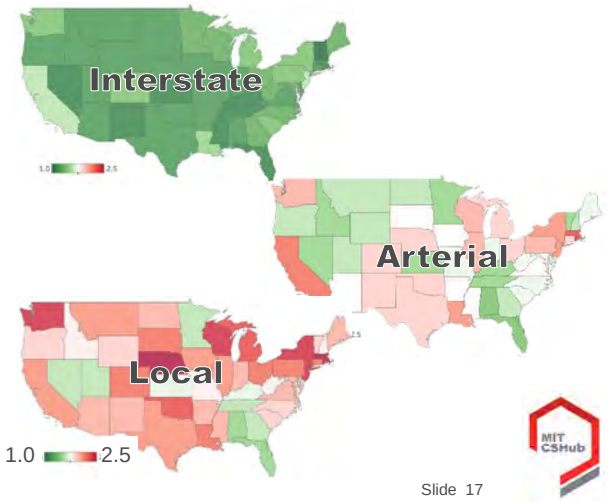
Slide 16

Scaling CSHub Analyses to the National Scale

First step is Future of Concrete Analysis

- Current network condition data (IRA only) from FHWA by state
- Climate data:
  - NOAA
  - NWS
- Major Progress
  - Statistical characterization of all states
  - Climate zone proxy deterioration models
  - Calibrated decision trees for EVERY STATE

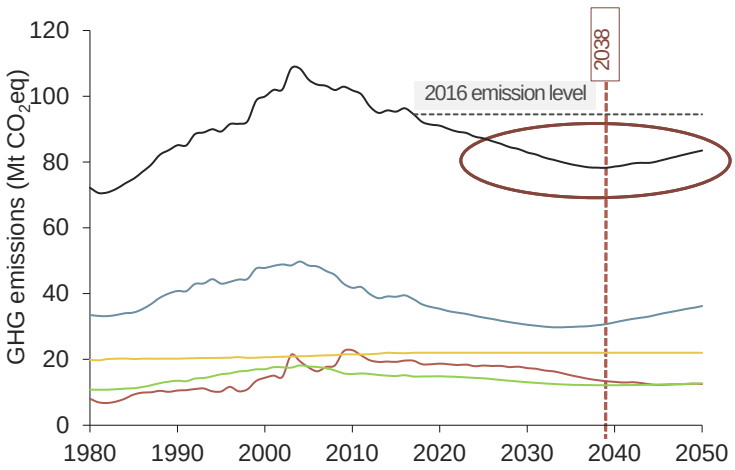
Average Condition of Pavements Varies Widely (IRI in/mile)



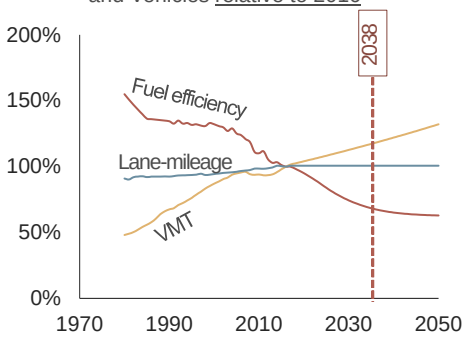
Slide 17

After 2038, an increasing trend is expected for the U.S. road emissions

Life cycle GHG emissions of the pavement network will decrease but there is an increasing trend after 2038 (Action required!)



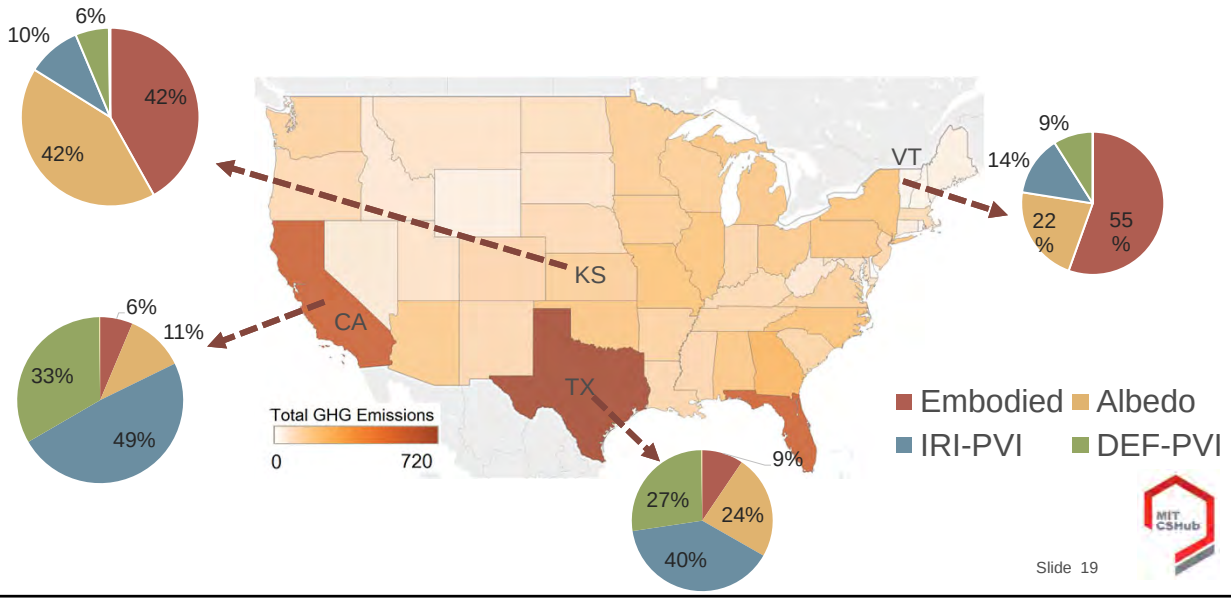
Historical stats of Roads and Techs and Vehicles relative to 2016



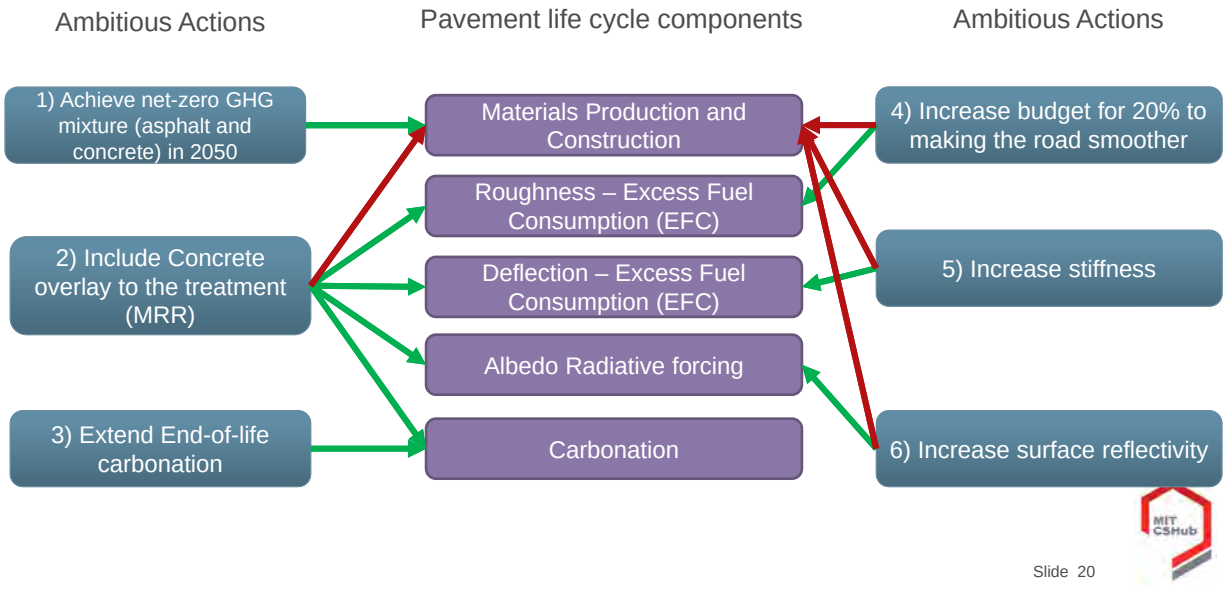
Sources: FHWA, US EIA, and BTS

Slide 18

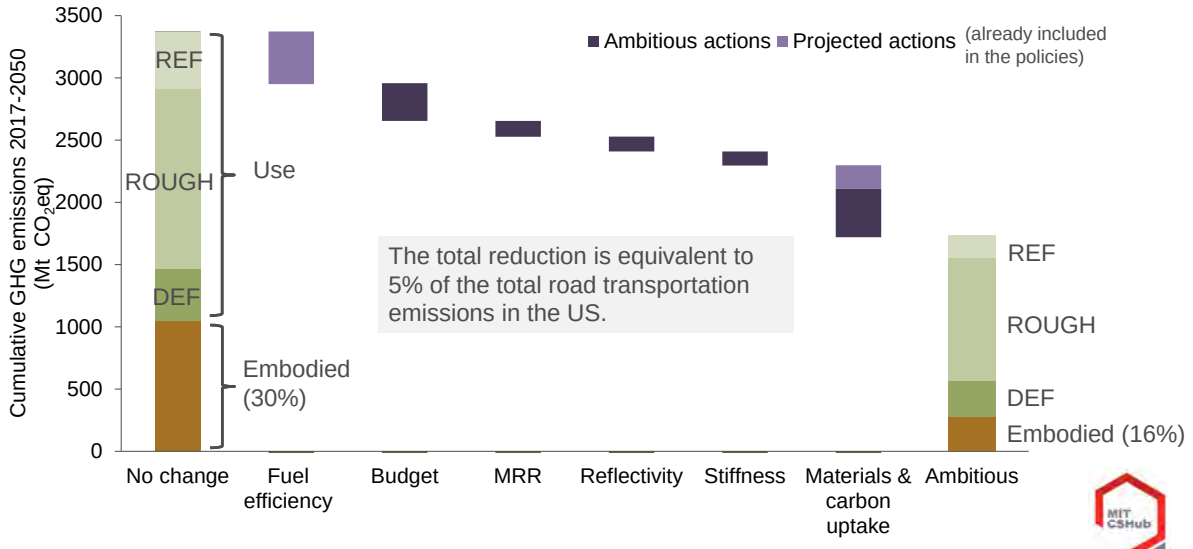
Projected Nation-wide results show that the contribution of life cycle phases is varying significantly in different states



Strategies for reducing GHG emissions through interventions in pavement life cycle

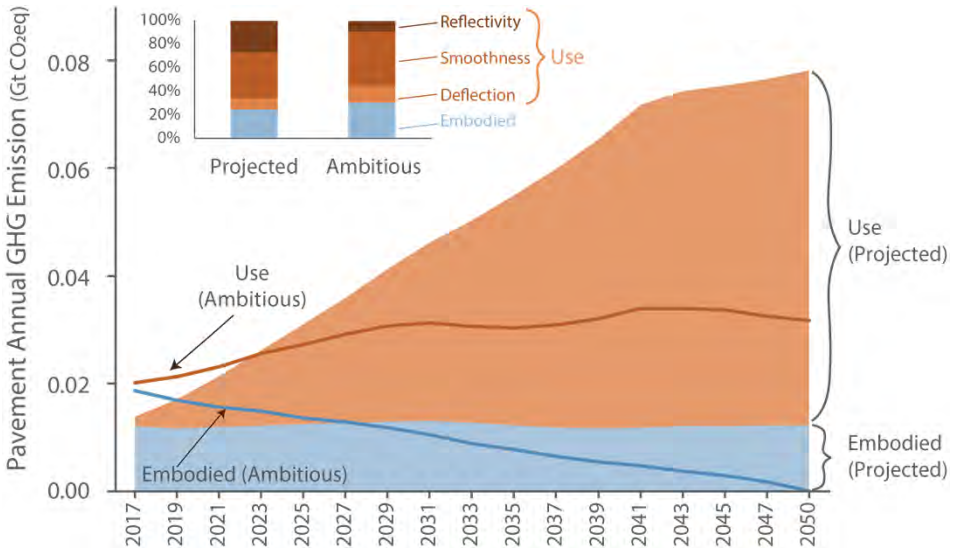


Ambitious actions can lower the cumulative pavement life cycle impacts by 50% during the 2017-2050 period



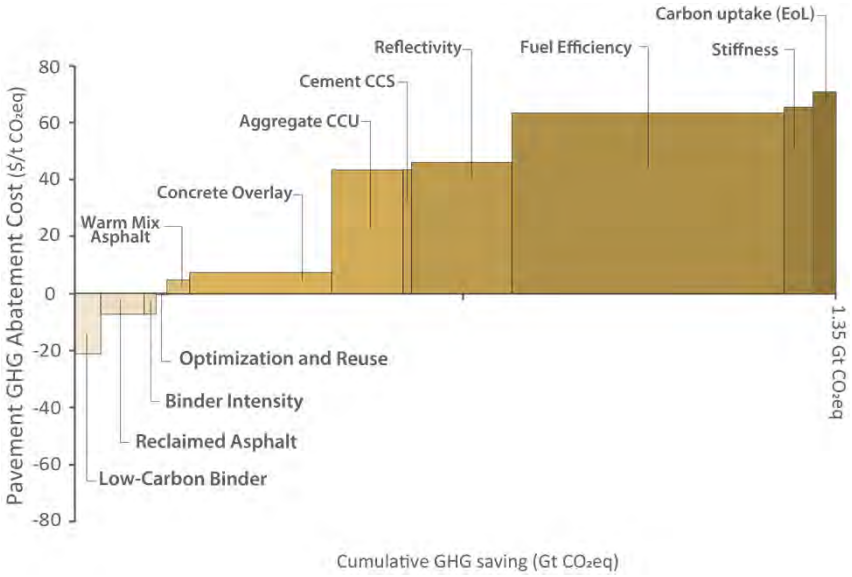
Slide 21

Considering all the ambitious solutions, the use phase impact will dominate the pavement life cycle GHG emissions



Slide 22

Embodied impact solutions are among the lowest cost ones while opportunities for the use phase solutions are larger



Slide 23

Conclusions

- Pavement can be a significant enabler for decarbonizing the nation.
- Project-level tools can empower the decision makers on identifying and prioritizing the lowest GHG emissions alternative (from the segment to city level)
- Network-level tools need to be used by DOTs to assess their policy implication on pavement decarbonization.
- Embodied solutions owe the lowest abatement costs while the use phase solutions have larger saving potential.
- Proposed scenarios can offset 5% of the U.S. road transportation emissions (major contributor).

Slide 24

Thank you!

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Hessam@mit.edu

Slide 25