Policy, Implication, and Application: Unintended Consequences of Load Consolidation in Urban Areas

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Outline

- Truck Load Increases
  - Methodology
    - Transportation Data
    - Environmental Data
  - Results
  - Policy Implications
- Based on paper:

  Sathaye N., Horvath A. and Madanat S., "Unintended impacts of increased truck loads on pavement supply-chain emissions." *Transportation Research A*, Vol. 44, pp 1-15, 2010

Impacts of Freight Movement

- Freight vehicle emissions impacts on human health in California cost over $500 million per year Source: CARB (2006)
- PM emissions from trucks in California cause about 1500 premature deaths per year Source: CARB (2006)
- PM emissions from trucks in Oakland cause a cancer rate of about 844 per 1 million residents Source: BAAQMD (2008)
- Trucking causes about 14% of GHG emissions in the Bay Area and 6% of global emissions Sources: BAAQMD (2006), IPCC (2007)
- About 1% of GHG emissions can be attributed to the supply-chain for highway maintenance activities in the US

Implementations of Policies to Increase Loads

- Public Freight Consolidation Centers
  - Amsterdam -Tenjin, Japan
  - Heathrow Airport -Kassel, Germany
- Utilization requirements in Copenhagen & Amsterdam
- Individual Companies
  - Tesco Supermarket, UK
- Increased Maximum Weight Limits
  - UK (32.5 to 41 tons since 1980)

Sources:

Geroliminis, N. and C. Daganzo (2005) *A review of green logistics schemes used in cities around the world. U.C. Berkeley Center for Future Urban Transport, A Volvo Center of Excellence.*

Browne, M., M. Sweet, A. Woodburn and J. Allen (2005) *Urban Freight Consolidation Centres Final Report. Transport Studies Group, University of Westminster.*

McKinnon, A. (2003) Logistics and the Environment. *Handbook of Transport and the Environment (eds. D. A. Hensher and K. J. Button) pp. 665-685 Elsevier.*

McKinnon, A. (2005) The economic and environmental benefits of increasing maximum truck weight: the British experience. *Transportation Research Part D, 10, 77-9*

Equivalent Single Axle Load (ESAL) Per Vehicle Estimation

- The increase in load for a given axle causes exponential pavement damage

- 4th Power Law: The damage caused by a particular load is related to the load by a power of four.

Source: American Association of State Highway and Transportation Officials (1993) *AASHTO Guide for Design of Pavement Structures*.

Methodology

- Develop traffic information:
  - Vehicle and cargo weights
  - Equivalent Single Axle Loads per Trip
- Use pavement deterioration model to estimate change in overlay frequency
- Estimate HMA overlay supply-chain emissions
- Estimate tailpipe emissions
- Case examples contrast long-distance and local trucking issues

Pavement Deterioration Modeling

- Use Caltrans Highway Design Manual to get pavement thickness
- Estimate ESALs to failure:

$$E[\rho] = exp(12.15 + 6.68 \times \ln(SN + 1) + 2.62 \times \ln(L_2) - 3.03 \times \ln(L_1 + L_2))$$

$$\rho = ESALs\ to\ failure$$

$$L_1 = standard\ axle\ load = 18\ kips$$

$$L_2 = dummy\ variable = \begin{cases} 1\ for\ single\ axles \\ 2\ for\ tandem\ axles \end{cases}$$

Source: Madanat, S., J. Prozzi and M. Han (2002) Effect of Performance Model Accuracy on Optimal Pavement Design. *Computer Aided Civil and Infrastructure Engineering, 17, 22-30.*

- Combine with ESALs/year data to estimate time between overlays

Pavement Overlay Supply-Chain Emissions

- Two lanes of 1-mile length
- 3-inch thick HMA overlay

Energy (TJ)	6.6
PM_{10} (kg)	420
$PM_{2.5}$ (kg)	140
SO_2 (kg)	1000
CO (kg)	1700
Pb (g)	110
NO_x (kg)	770
GHG (kg CO_2 eq.)	560000

Source: Adapted from Horvath, A. (2008) *Pavement Life-Cycle Assessment Tool for Environmental and Economic Effects*.

Tailpipe Emissions

- composite emissions factors based on CARB's EMFAC2007

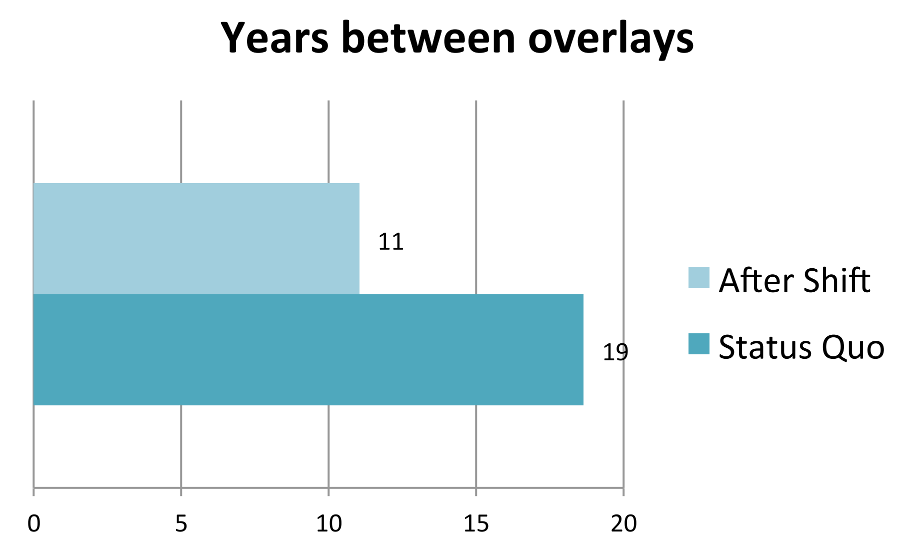
Source: California Air Resources Board (2006) *EMFAC2007 v2.3*.

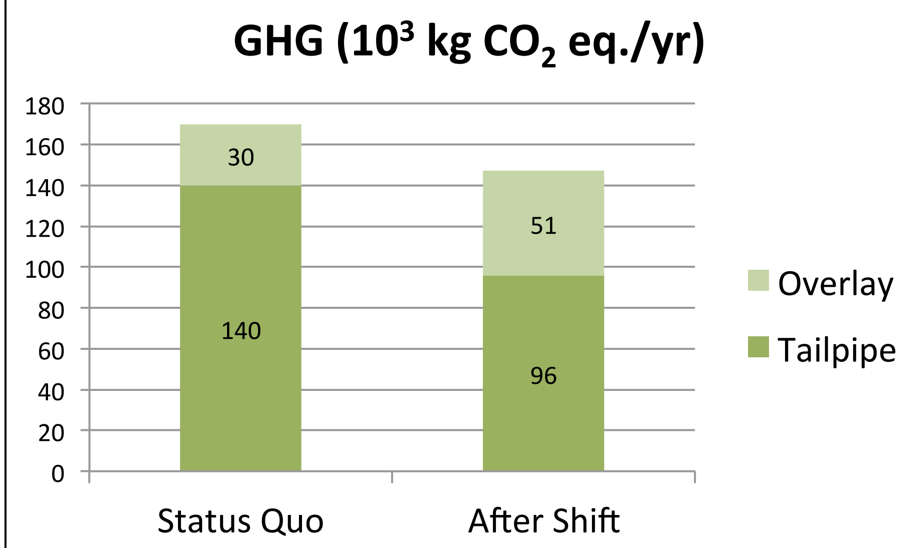
Main supply-chain emissions contributors:

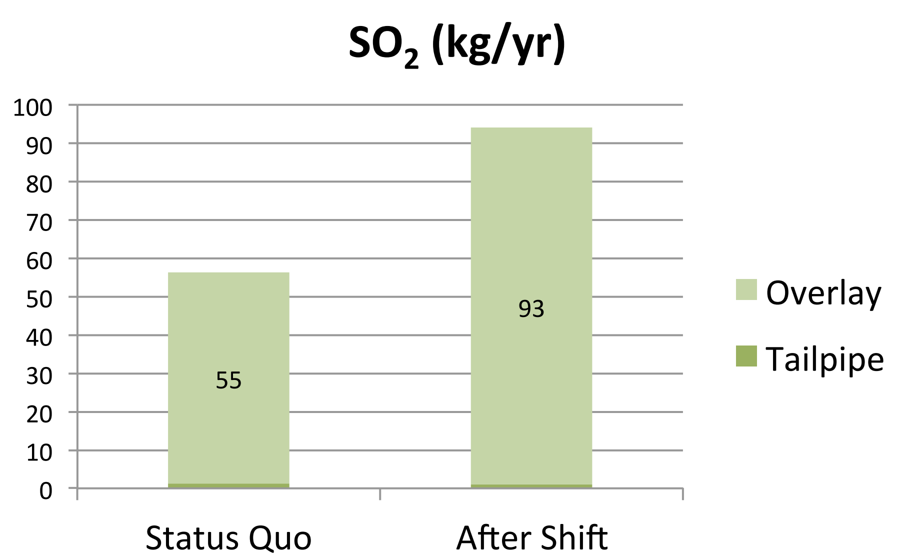
- Aggregate Mines
- Petroleum Refineries
- HMA Plants

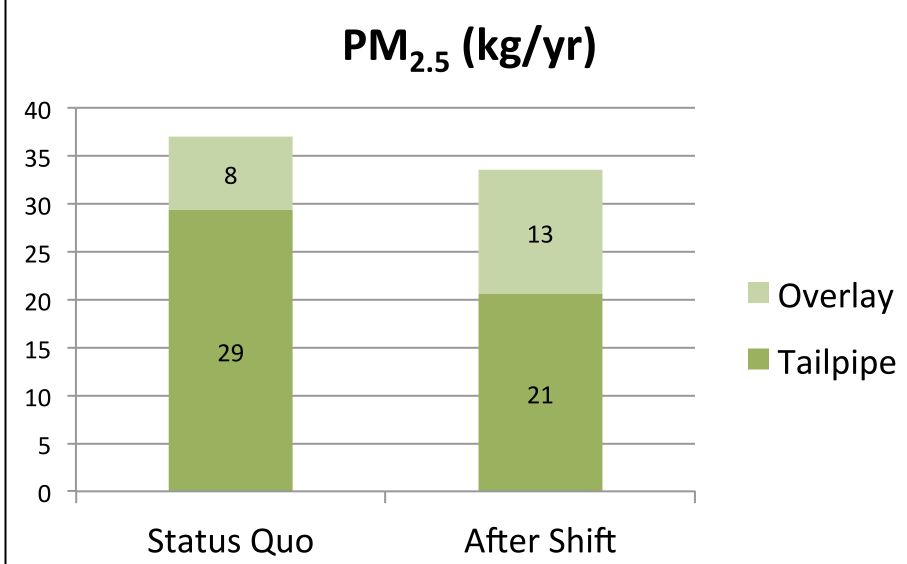
Source: maps.google.com

Within-Vehicle Class Consolidation on SR-13

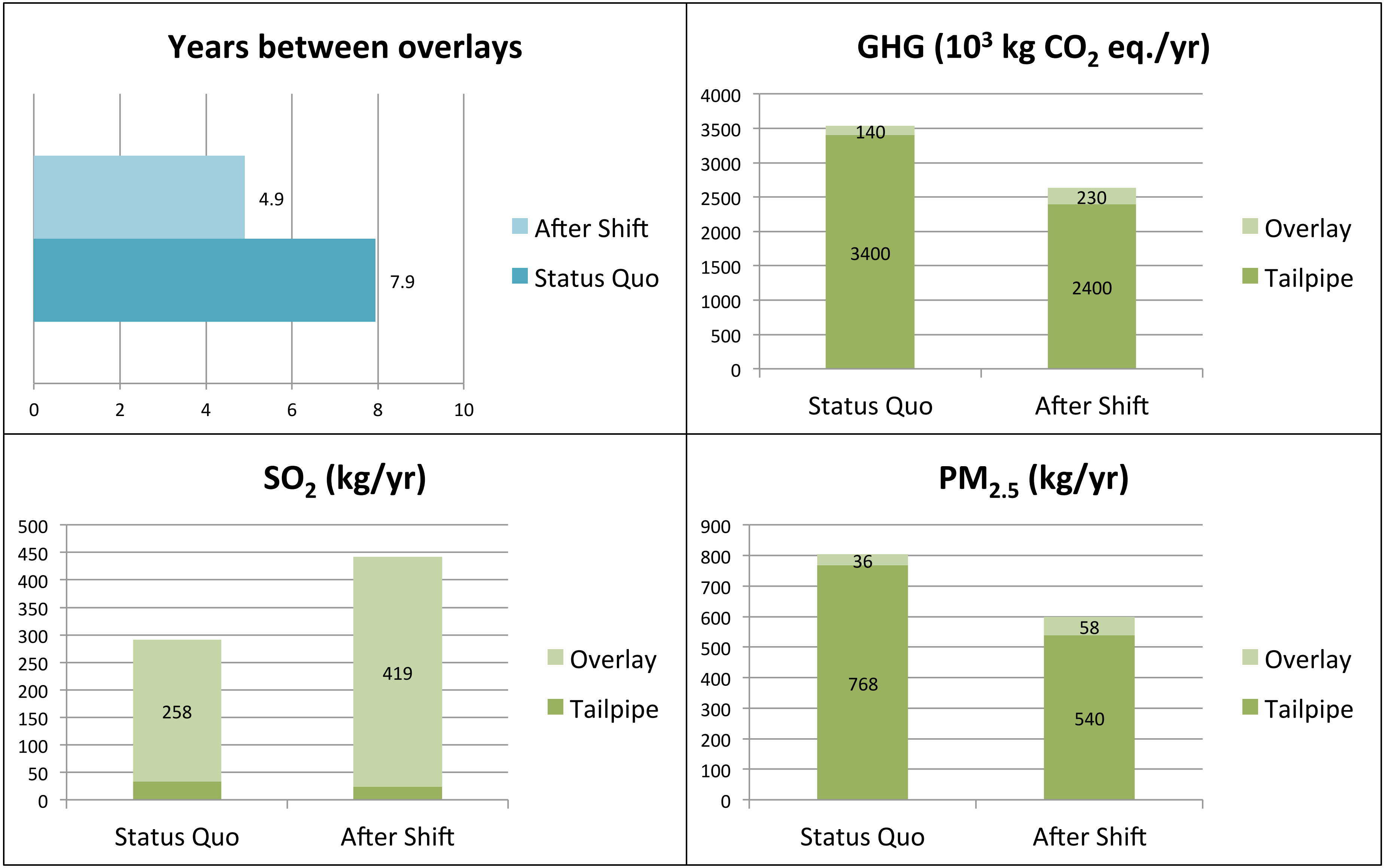




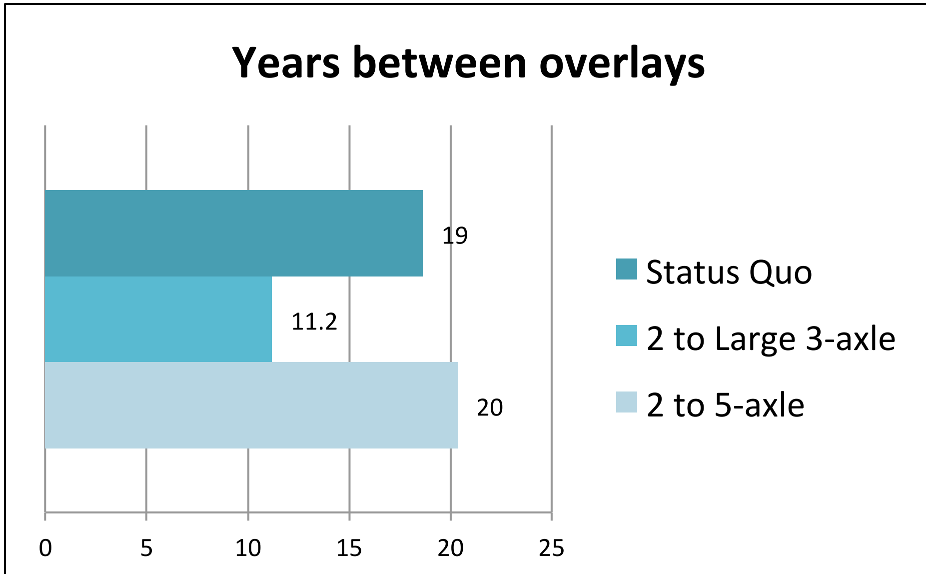


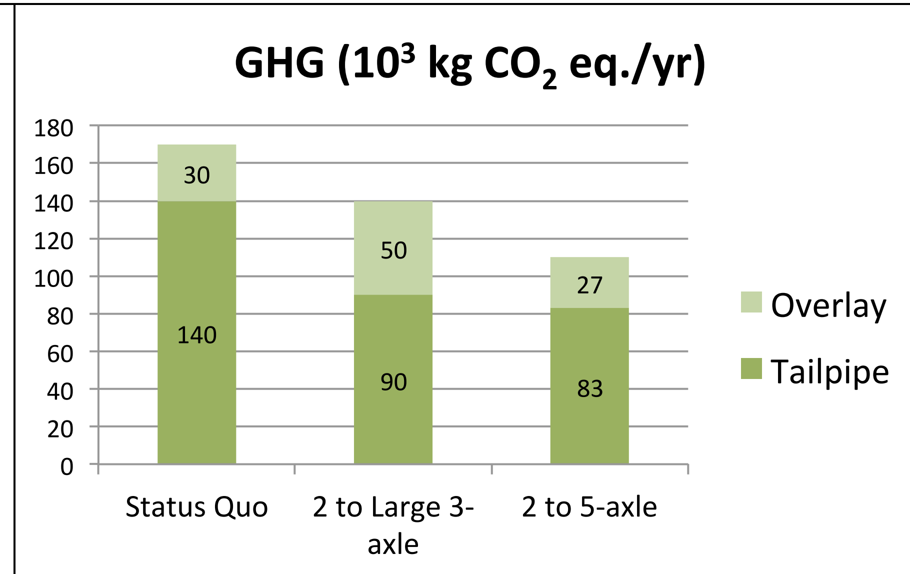


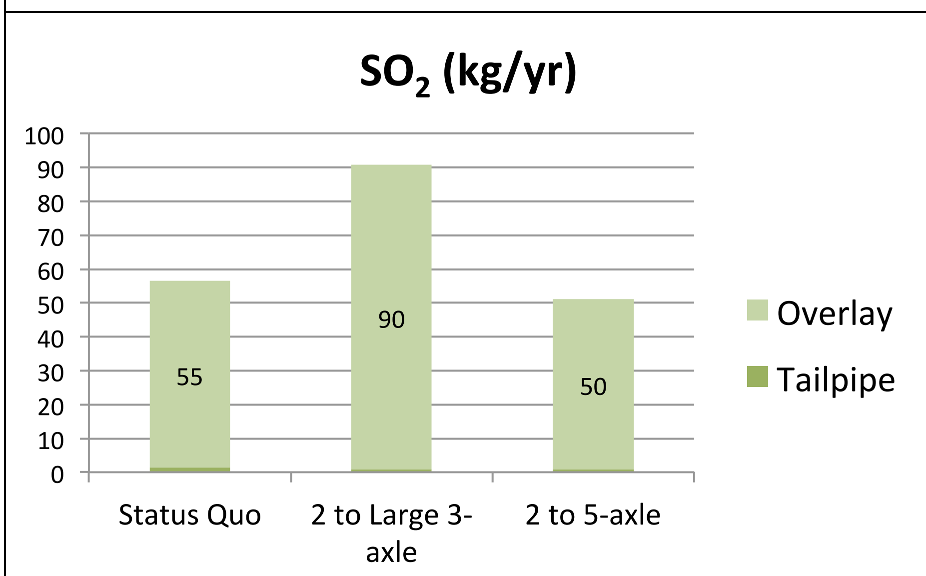
Within-Vehicle Class Consolidation on I-80

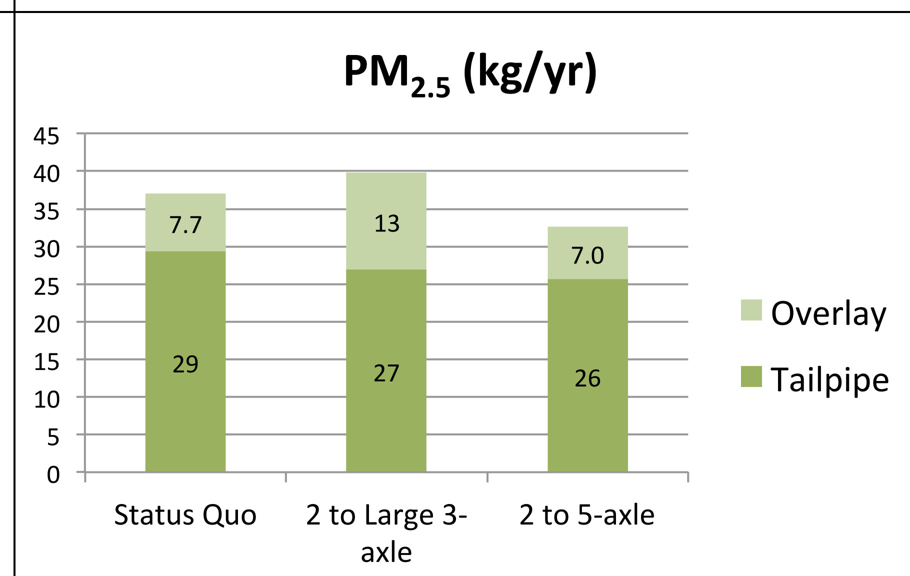


Consolidation to different truck sizes on SR-13

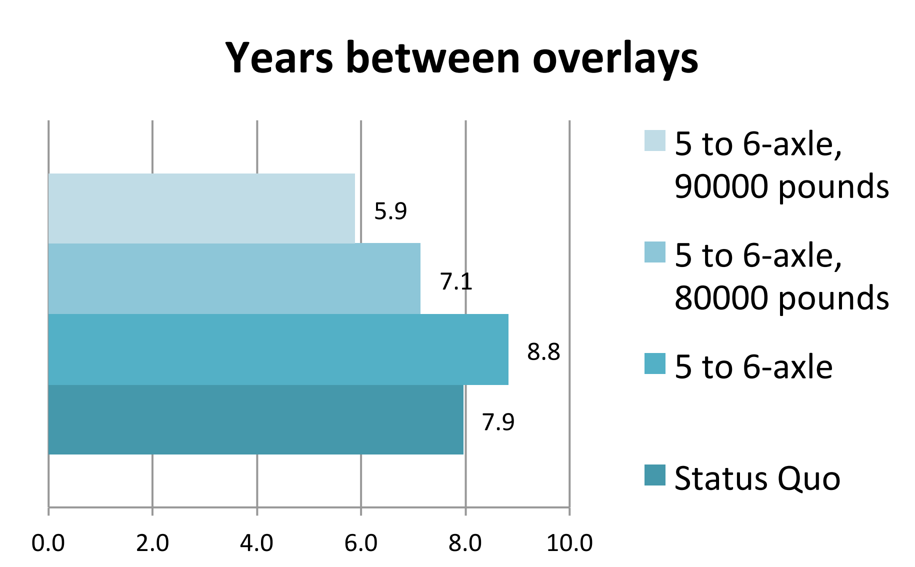


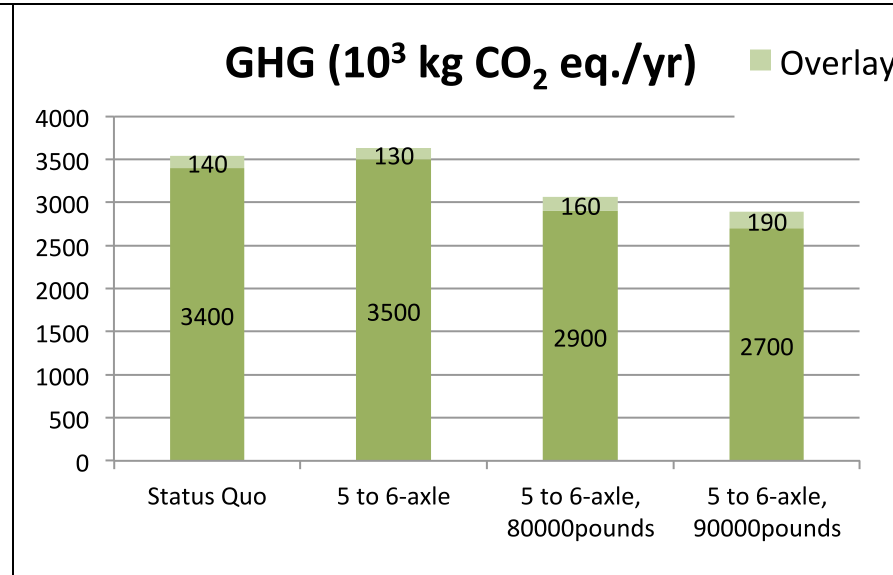


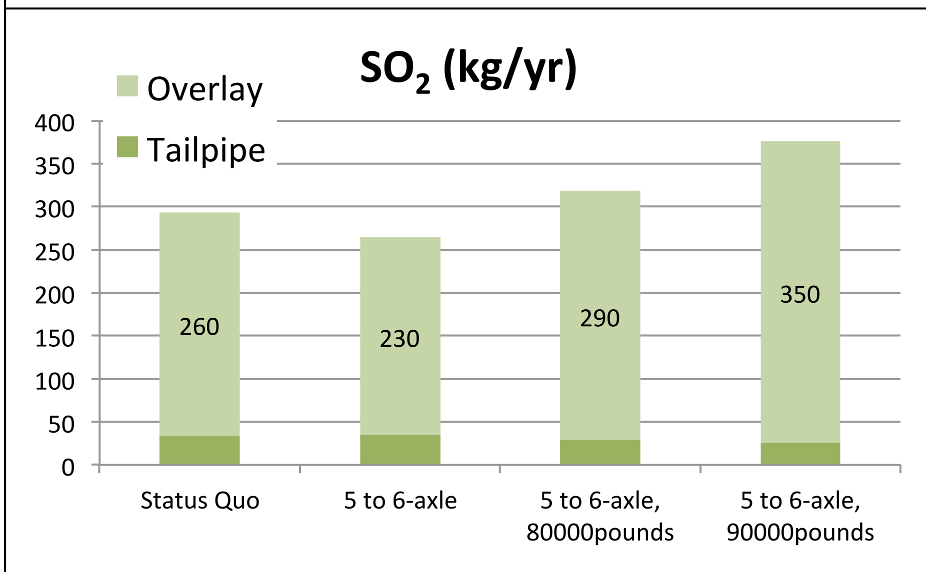


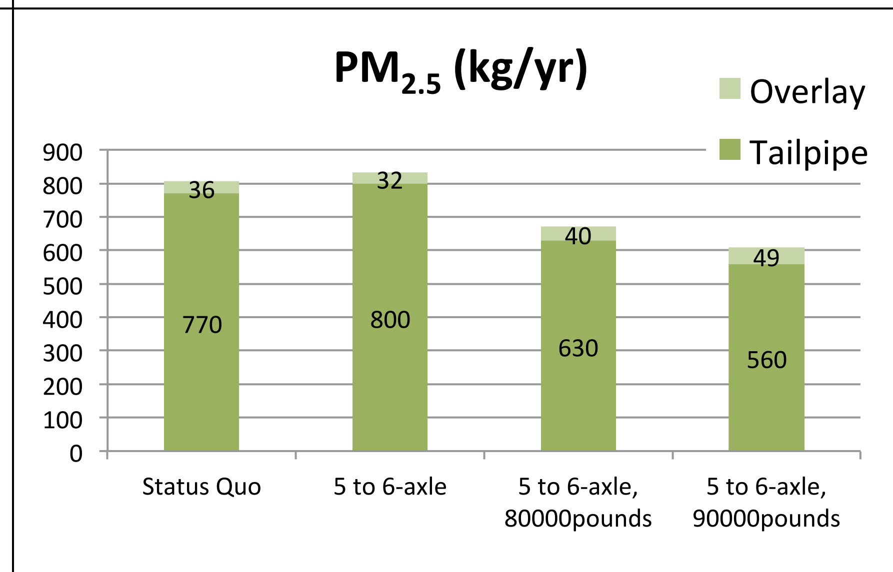


Weight Limits and Consolidation on I-80









Impact Considerations

- Criteria pollutants need local intake assessment. EPA's AIRData cites local industries:
  - Asphalt plant in West Berkeley within 200 meters of residences
  - Refineries in Richmond, aka the "Cancer Belt"
  - Aggregate Mines in Pleasanton

Related Supply-Chain Considerations

- Other types of pavement MR&R activities have different supply-chain emissions
  - e.g. example, steel reinforcement has high associated Pb emissions (EIO-LCA)
- Effects of system boundaries
  - e.g. high SO_2, CO and Pb emissions associated with vehicle manufacturing, maintenance and decommissioning

Source: Facanha, C. (2006) *Life-cycle Air Emissions Inventory of Freight Transportation in the United States. Doctoral Dissertation, Department of Civil and Environmental Engineering, UC Berkeley.*

Effects Related to City Logistics Policies

- Indicates possibility of a trade-off between car and truck travel
  - e.g. consolidation of food industry in UK increased car VKT, but reduced truck VKT

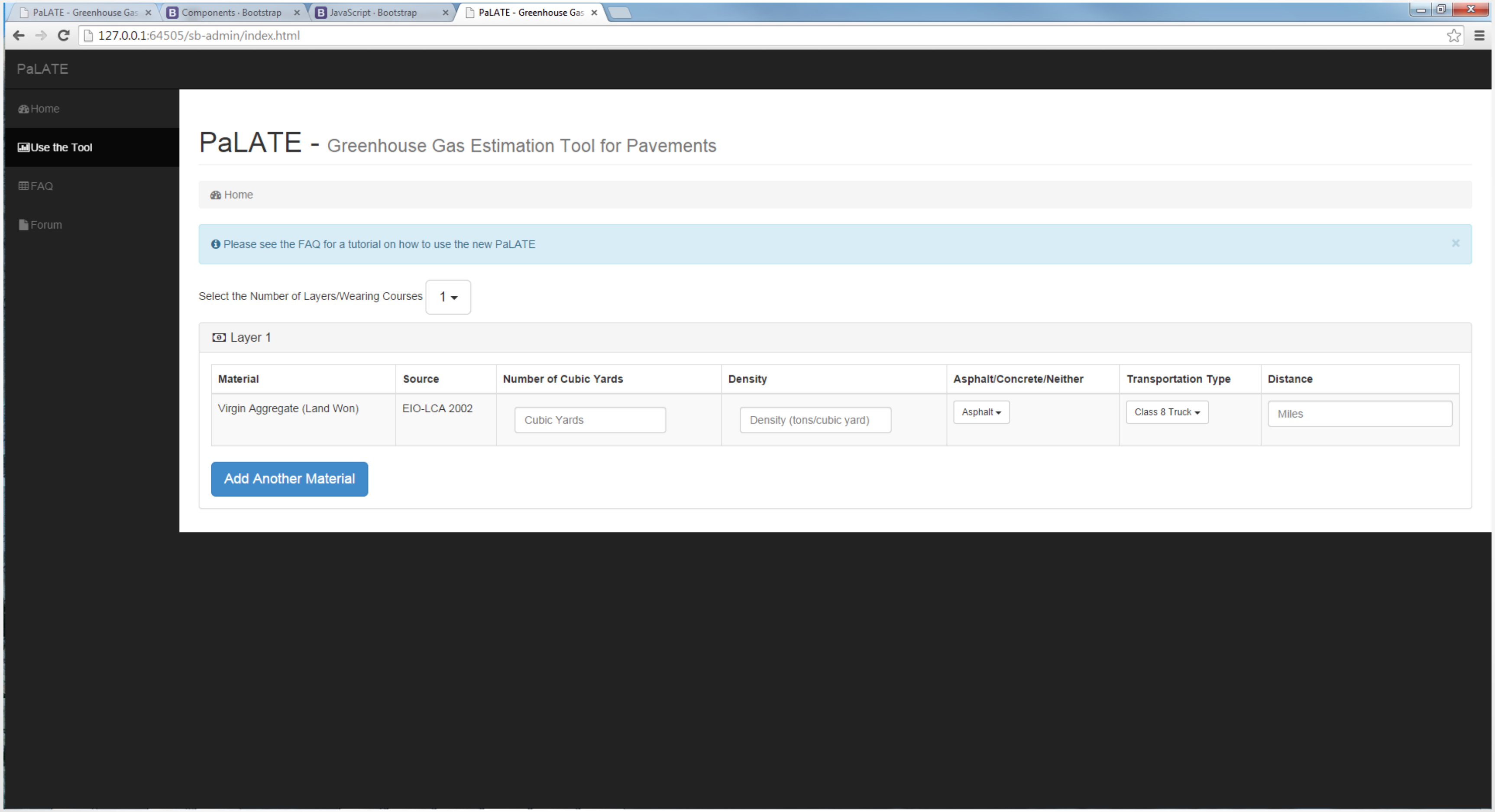
  Source: McKinnon, A. and A. Woodburn (1994) The Consolidation of Retail Deliveries: Its Effect On CO2 Emissions. *Transport Policy, 1, 125-136.*

- Although there are tailpipe emissions benefits, eliminating empty trips may cause little change to supply-chain emissions

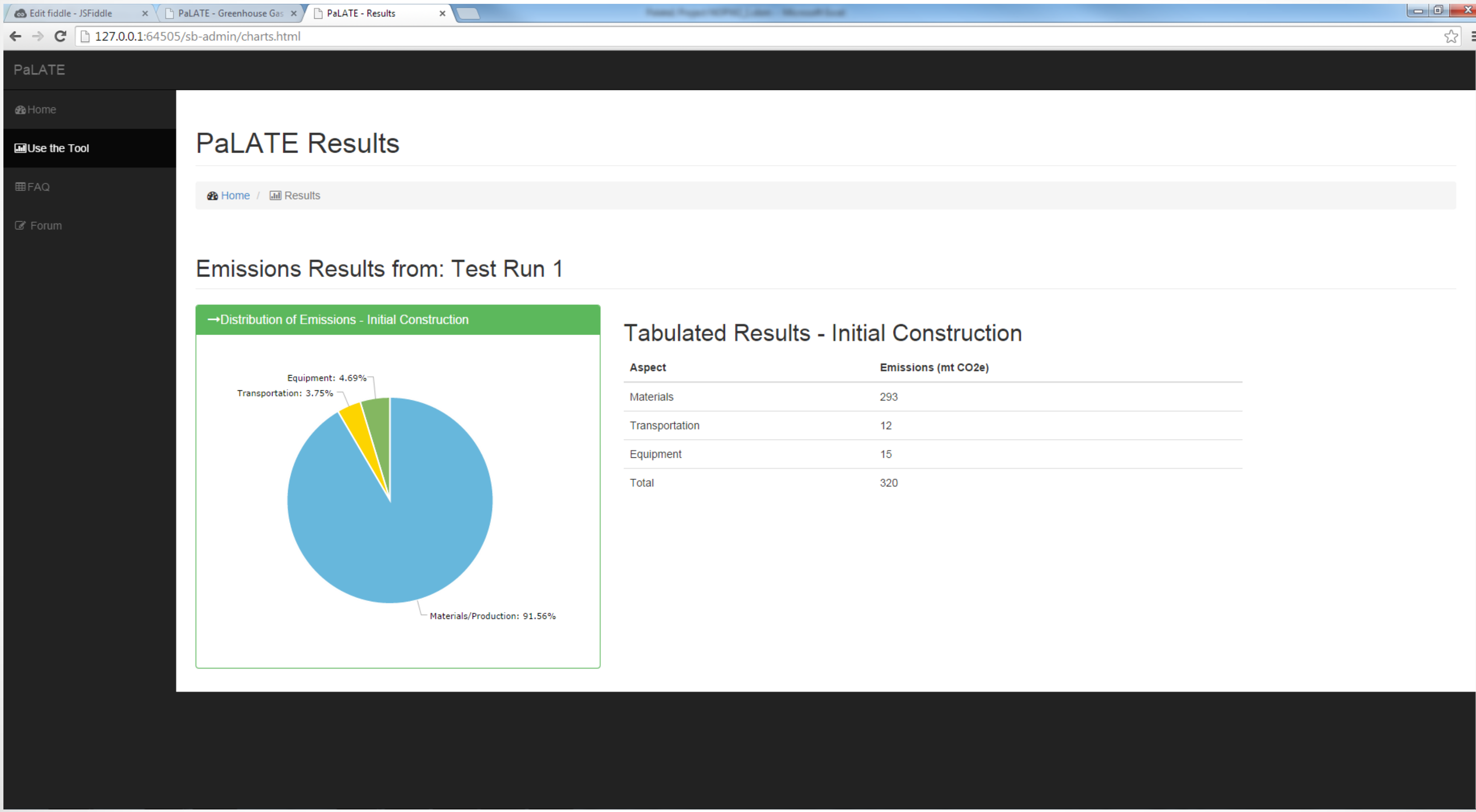
- Circumvention of bans on large trucks causes reversed trade off
  - e.g. Southern California proposed truck bans

    Source: Campbell, J. (1995) Using Small Trucks to Circumvent Large Truck Restrictions: Impacts on Truck Emissions and Performance Measures. *Transportation Research Part A, 29, 445-458.*

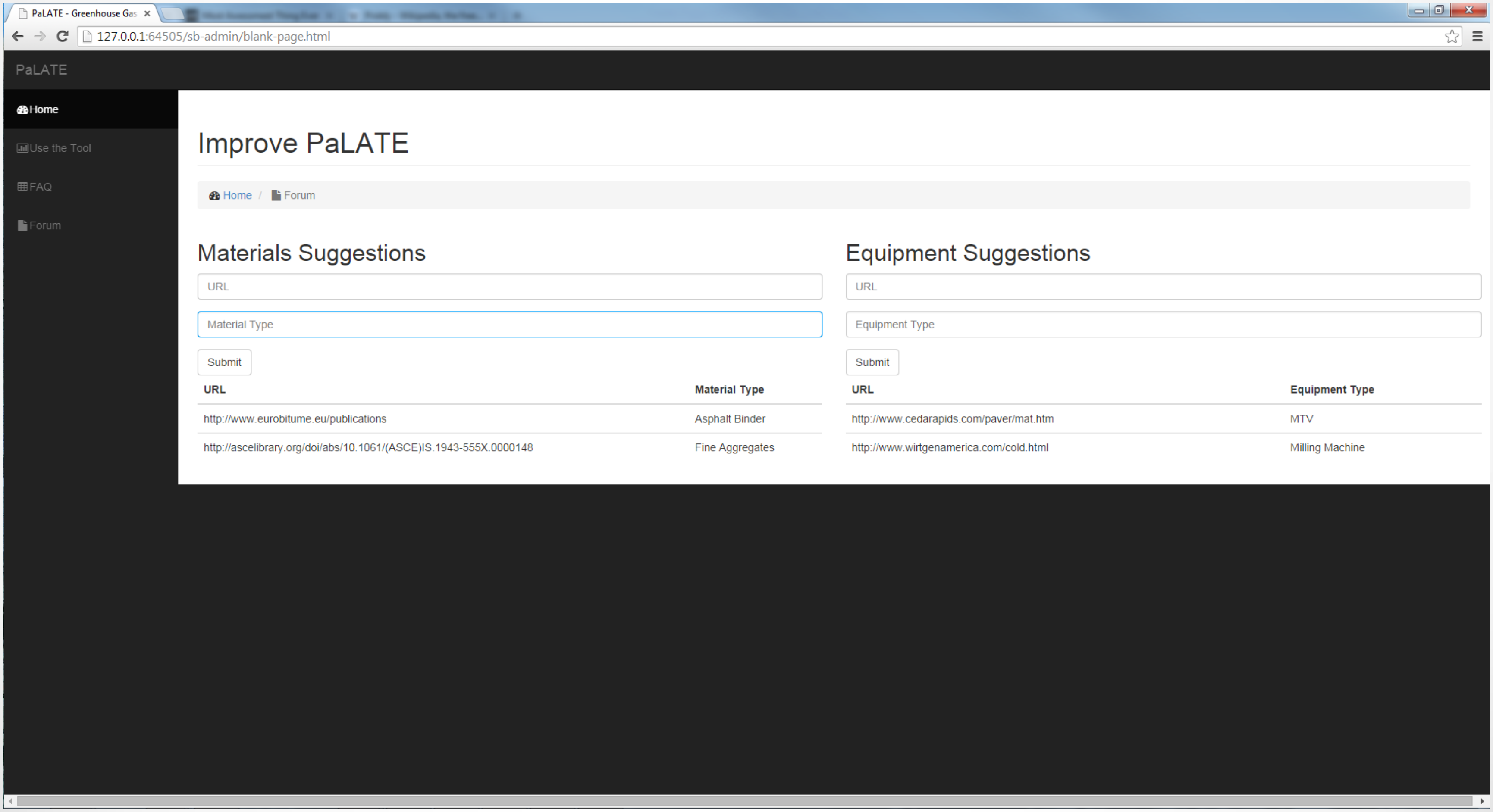
Introducing PaLATE-Web



New Web-Tool Design



Keep PaLATE-Web Up to Date



Conclusions

- Increasing loads is beneficial for many pollutants including GHGs, but can increase PM and SO_2 emissions
  - Benefits are more likely for long-distance vehicles
- Unintended environmental impacts should be accounted for in future freight policy analyses
- Policy assessments should account for the nuances of both the environment and transportation systems