Modeling Transport in LCA

Liila Woods* & Joyce Cooper
University of Washington
Design for Environment Laboratory

UWME DFE Lab: http://faculty.washington.edu/cooperjs/
Email: cooperjs@u.washington.edu

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Agenda

- Background
- Transport Model Development
- Materials Case Studies
- Conclusions
- Acknowledgments

Background: The role of Transport

- Like electricity generation, transport is a part of most, if not all, life cycles.
- Environmental issues common to transportation modes include:
  - fuel consumption
  - emissions associated with fuel combustion
  - risk of accidents that result in spills cargo (i.e. oil spills)
  - noise pollution
  - materials acquisition and processing, manufacturing, maintenance, and end-of-life options for equipment
  - development, operation and maintenance of supporting infrastructures (i.e. highways, stations or ports, rail lines)

Background: Modeling Transportation

- Select studies on a variety of products present transport fuel use and emissions as part of the inventory results, at times showing it to be a significant contributor to the system impact
  - Documentation of many studies contain no mention of transportation
  - Little guidance was found in archival literature on how to model transportation in LCA
    - SETAC guidance and results of other studies including methodological details indicate key parameters are:
      - Transportation mode, engine type, distances traveled, backhaul (or "return load" considerations), cargo-payload, travel conditions (e.g., vehicle size and age; transport conditions such as urban, rural, or highway driving)

Transport Model Development

- Transportation contribution should include:
  - Hauling for materials production and waste management
  - Transportation related fuel production
    - Plus equipment and infrastructure life cycles
- Data set name should include:
  - Transportation mode/ engine type/ cargo-payload/ travel conditions
- LCA computations and documentation should include:
  - Backhaul considerations and distances traveled

Transport Model Development: Backhaul

- Backhaul (return trip) should be attributed to the study system if the trip is not moving goods for another product system.
  - In a LCA based on very specific hauling conditions, mode-specific backhaul can be estimated for each material moved.
  - In commodity LCAs, where hauling conditions are an aggregate of many assumptions
    - Little consistency was found in backhaul assumptions used in LCA studies or studies investigating specific transportation systems
    - Data varied by mode and by study

Transport Model Development: Backhaul Assumptions

	Minimum Backhaul	Maximum Backhaul
Ocean Freighter	0	0
Barge	0	76%
Rail	0	30%
Truck	0	68% (as empty truck)



Transport Model Development: Distance Estimation- Methods

- Methods
  - Point-to-Point
    - Utilize studies identifying commodity origins and destinations with distance estimation programs
  - Commodity Averages
    - Utilize national and international commodity transport survey data and studies
- Additional Considerations
  - Process co-location

Transport Model Development: Distance Estimation- Point to Point

Steel mill products

For use the US	
US	74%
EU	5%
Canada	5%
Mexico	4%
Brazil	3%
Russia	2%
Turkey	2%
China	2%
RO Korea	1%
Japan	1%
Taiwan	0.8%
Ukraine	0.4%
Argentina	0.3%
Sweden	0.2%

US to US destination	
Freighter	0mi
Road	350mi
Rail	290mi

Steel mix
BOF 48%
EAF 52%

Grid mix
…

On-site gen mix
…

Ancillary mat'l mix
…

EU to US destination	
Freighter	8,300mi
Road	450mi
Rail	550mi
S water	1,700mi

EU Steel mill prod	
EU	55%
Brazil	28%
Australia	5%
Canada	4%
Mauritania	4%
South Africa	3%

EU to EU destination
Freighter
Road
Rail
S Water

Steel mix
BOF 61%
EAF 39%

Grid mix
…

On-site gen mix
…

Ancillary mat'l mix

- Trade databases provide ports (origin+destination) and production cities (w/ country transport)
- Distance is estimated using
  (a) 3 point great circle distance or
  (b) GIS logistics tools
  DISTANCE JUST NEEDS AUTOMATION

It is the **production mixes** for a wide range of life cycle processes which becomes tricky

Transport Model Development: Distance Estimation- Commodity Averages

- Commodity Averages
  - As a place holder for point-to-point data
  - Case studies adapt method described by He & Wang using the 2002 US Commodity Flow Survey (CFS) to estimate US commodity transport distances
    - Distances are presented by Standard Classification of Transported Goods (SCTG)
    - Includes transport within the US and from foreign ports
    - Codes are a better match to He & Wang's application of CFS (codes include a more specific representation of what they are moving)

Transport Model Development: Distance Estimation- Co-Location Rules

- Some materials do not require transport because the unit processes could be assumed to be located at the same facility.
  - Flows designated as "in ground" that are converted into a flow designated as "at mine"
  - Flows of water, treated water, and air
  - Material processing steps such as crushing, milling, packing materials, or a phase change are assumed to be co-located with the preceding unit process*
  - Special co-location situations identified in literature*

*Assumption requires further investigation through literature review (e.g., in the US, an evaluation of USGS information sources often provides insights on this co-location rule).

Materials Case Studies: Transportation Contribution to Select Metal Components

	Aluminum components	Brass Components	Copper Components	Carbon Steel Components	Stainless Steel Components
Total energy	1.0%	0.5%	0.5%	1.7%	0.3%
CH4	1.5%	2.0%	1.8%	4.6%	0.9%
CO	5.8%	2.7%	1.8%	1.4%	1.4%
CO2	2.3%	2.4%	2.2%	4.0%	1.1%
N2O	6.9%	14%	3.3%	17%	2.8%
NOx	17%	6.3%	4.7%	30%	9.1%
PM10	0.7%	0.2%	0.1%	0.7%	0.2%
SOx	1.1%	0.2%	0.6%	5.8%	0.7%
VOC	9.3%	2.0%	1.5%	13%	4.2%

AVERAGES based on: average transport assumptions, primary and secondary materials, a range of applicable transformation processes including casting, drawing, extrusion, machining, sheet rolling, stamping, and welding

Materials Case Studies: Normalization

Transportation contribution for US materials production as compared to total US emissions
(values not listed, including energy consumption, are < 0.01%)

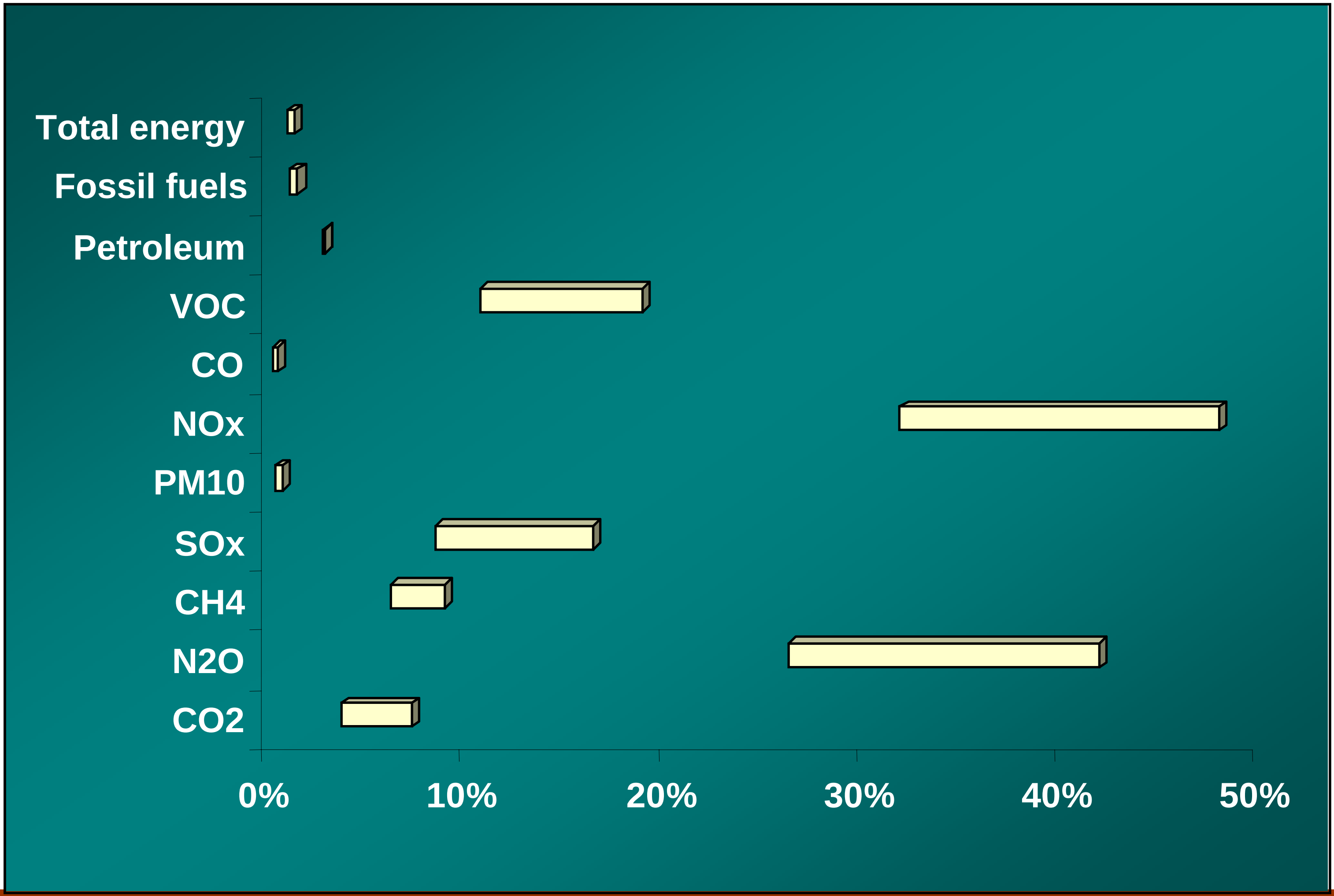
	US Aluminum	US Carbon Steel	US Copper	US Stainless
US Production (metric tons) % virgin % recycled data year	3.60E+06 69% 31% 2005	9.24E+07 45% 55% 2005	1.24E+06 96% 4% 2005	2.40E+06 45% 55% 2004
VOC		0.02%		
CO		0.01%		
NOx	0.04%	0.36%	0.02%	0.02%
PM10	0.01%	0.09%		
SOx		0.05%		
CH4		0.02%		
N2O		0.01%		
CO2		0.03%		

Materials Case Studies: Normalization

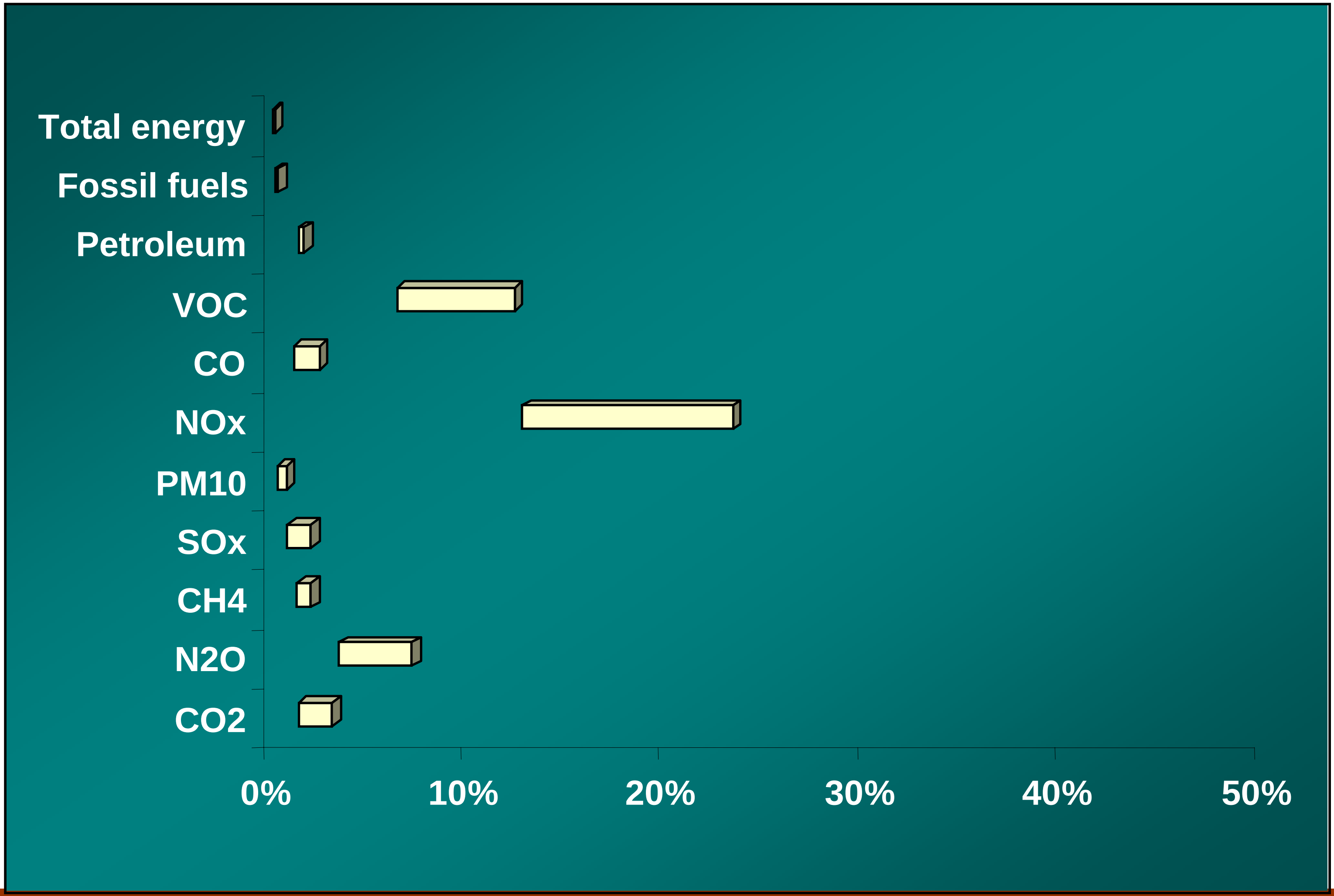
- Transportation Contribution of Select Metals normalized to US Impacts

		US Aluminum	US Carbon Steel	US Copper	US Stainless
US production (metric tons)		3.60E+06	9.24E+07	1.24E+06	2.40E+06
% virgin		69%	45%	96%	45%
% recycled		31%	55%	4%	55%
data year		2005	2005	2005	2004
Contribution to global warming (from as CO_2, N_2O, & CH_4)	CO_2 equiv		0.03%		
Contribution to photochemical smog (from CH_4, NO_x, CO, & VOCs)	NOX equiv	0.03%	0.22%	0.01%	0.01%
Contribution to acidification (from SO_x & NO_x)	H+ equiv	0.02%	0.20%	0.01%	0.01%

Materials Case Studies: Variation of the Transportation Contribution to BOF Steel (without transformation)



Materials Case Studies: Variation of the Transportation Contribution to EAF Steel (without transformation)



Conclusions

- Transportation can be important to commodity materials life cycle results
  - Particularly when NOx, VOC, and N2O are considered
  - Normalization indicates impacts are large when only the material is considered and small when compared to US values
  - A range of numbers provides insight into the variation of transport contribution
- Transport assumptions are important and should be described
  - Distance transported, backhaul, class description, etc.

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