The Secret Life of Materials

Prepared for Metro Regional Center's Green Team

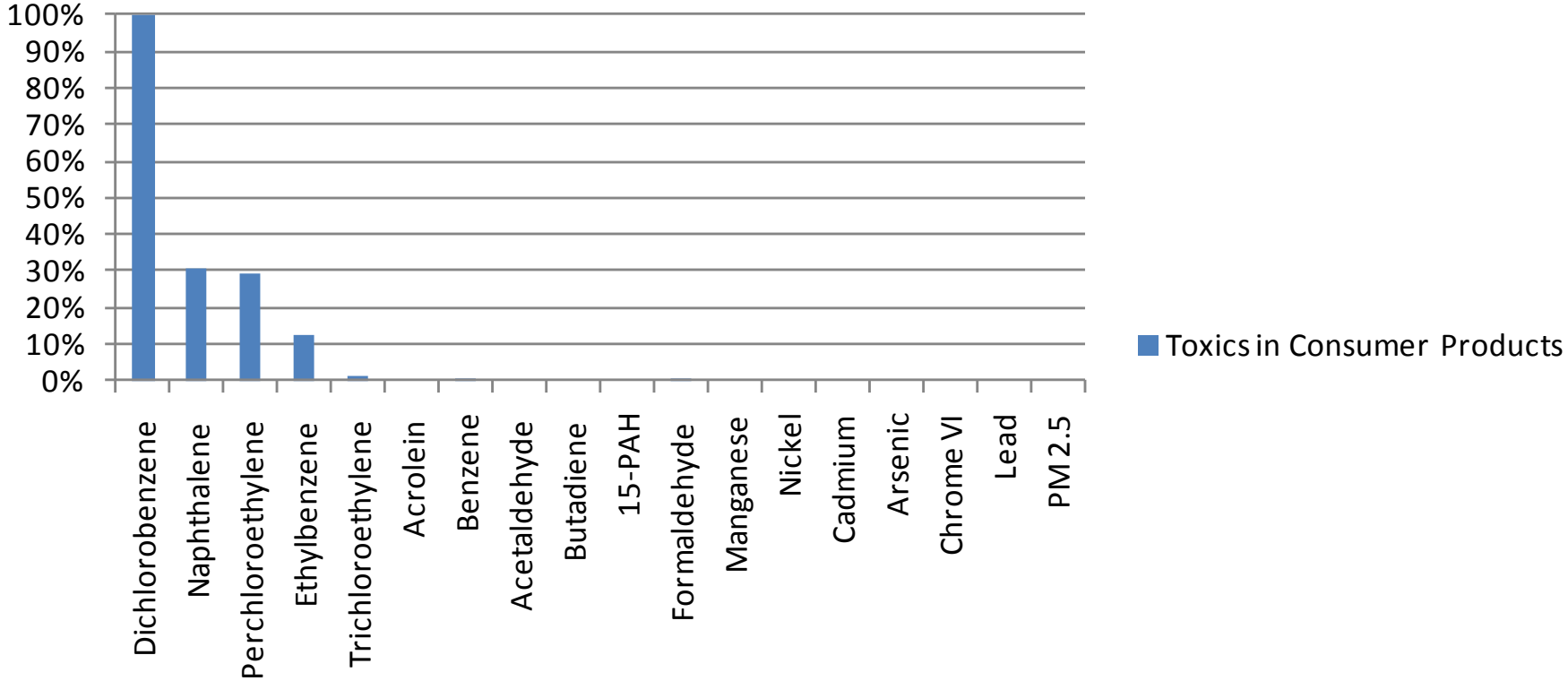
November 30, 2011

David Allaway
Oregon Department of Environmental Quality
Allaway.david@deq.state.or.us
503-229-5479

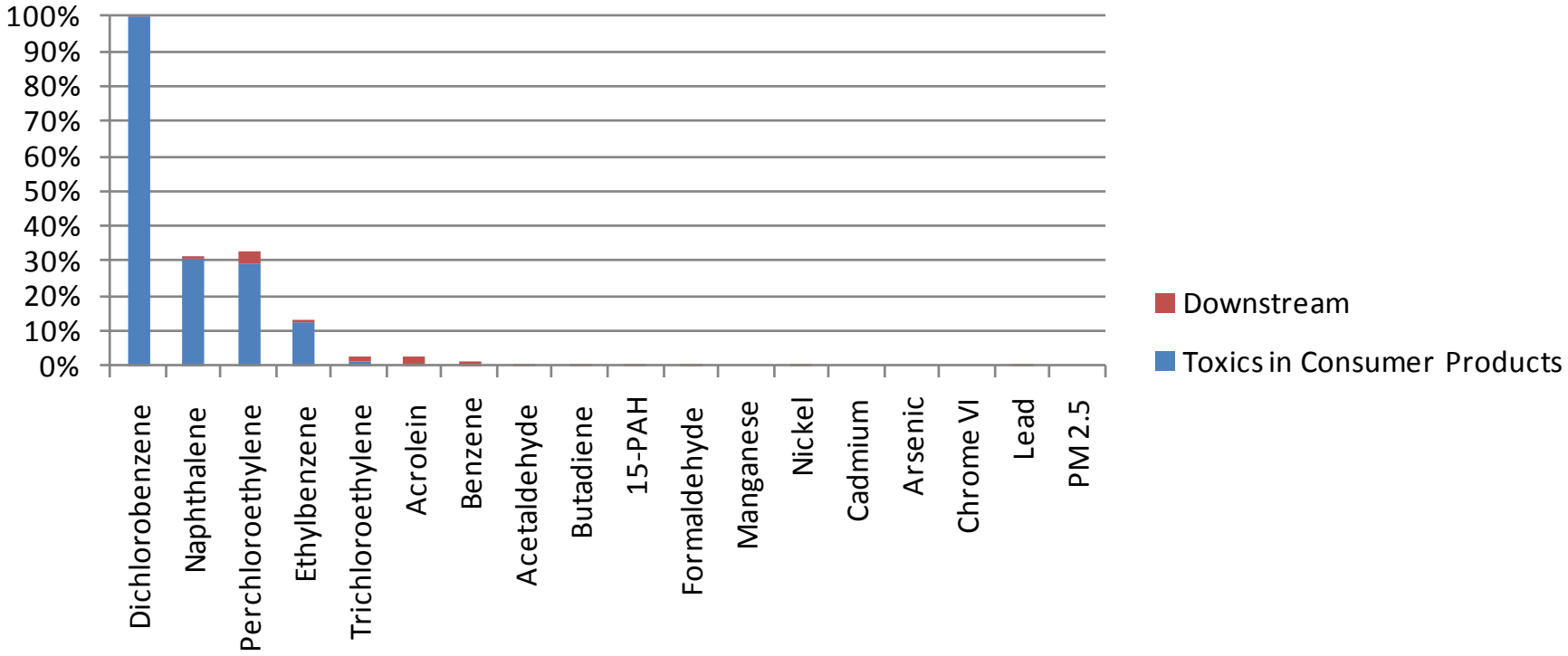
Materials Matter

- Use is increasing, both here and abroad
  - Our economy is tied to global materials markets
- We're increasingly dependent on non-renewable materials
  - With dependence comes economic and geo-political risks
- Rapid rise in material use has led to serious environmental effects

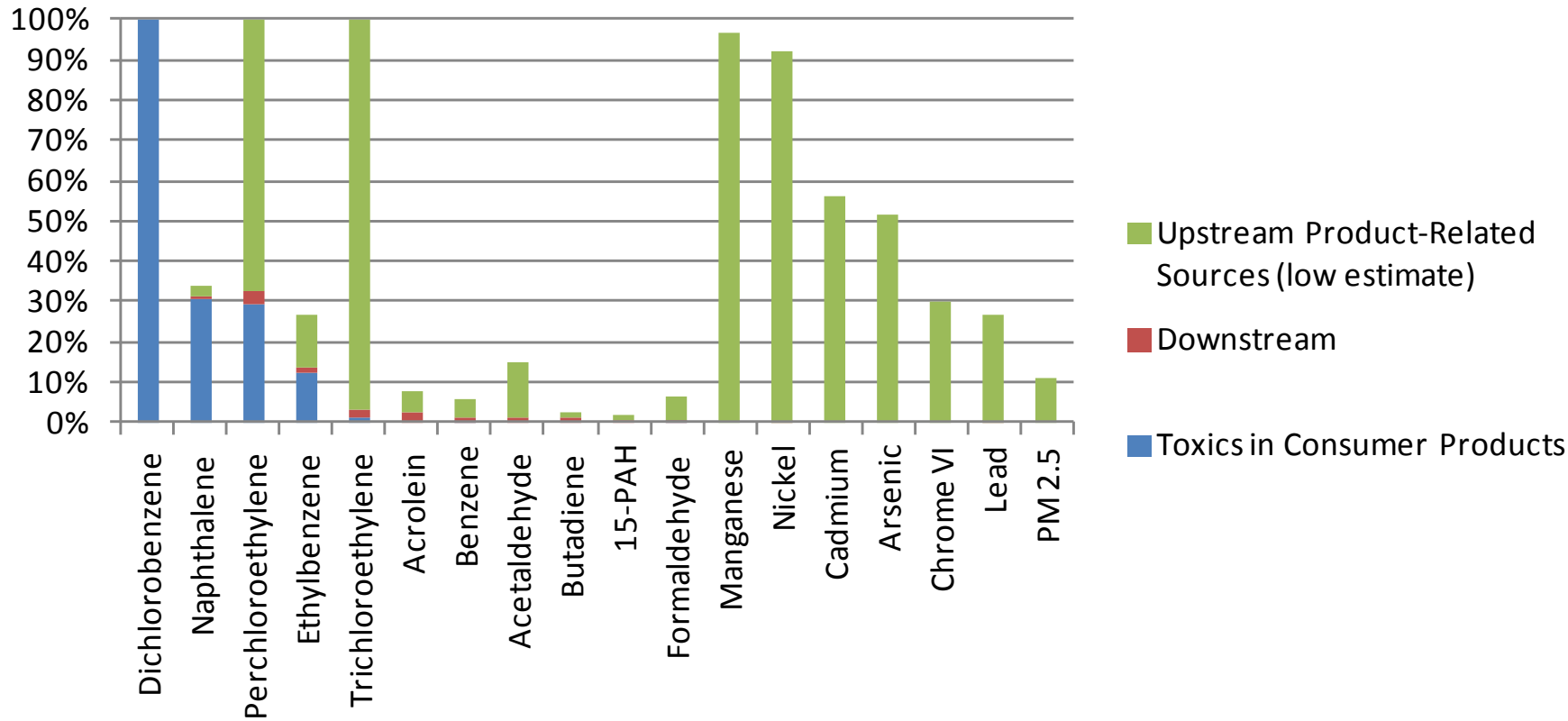
Portland Air Toxics Inventory (2005): Sources of Toxics



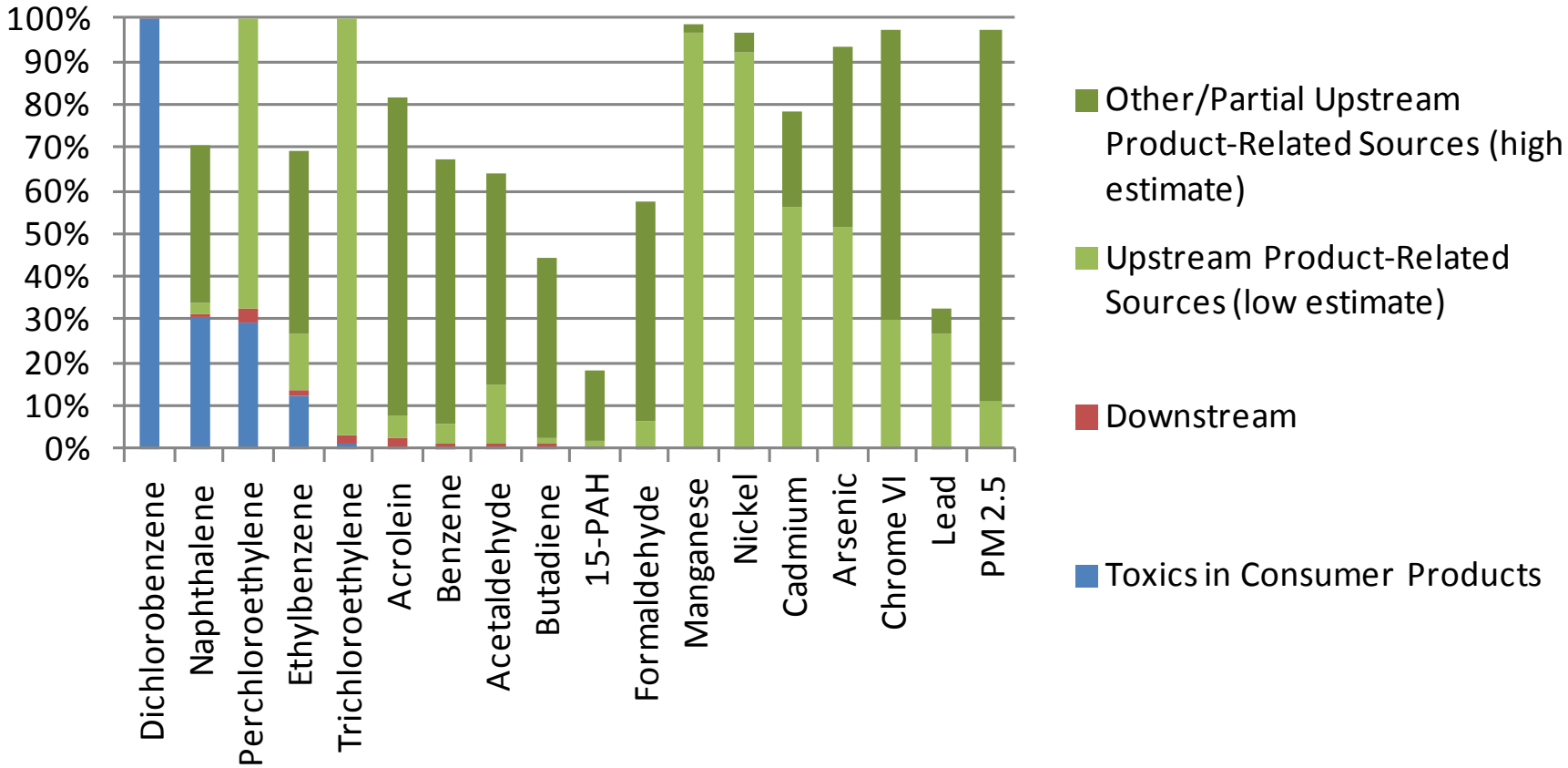
Portland Air Toxics Inventory (2005): Sources of Toxics



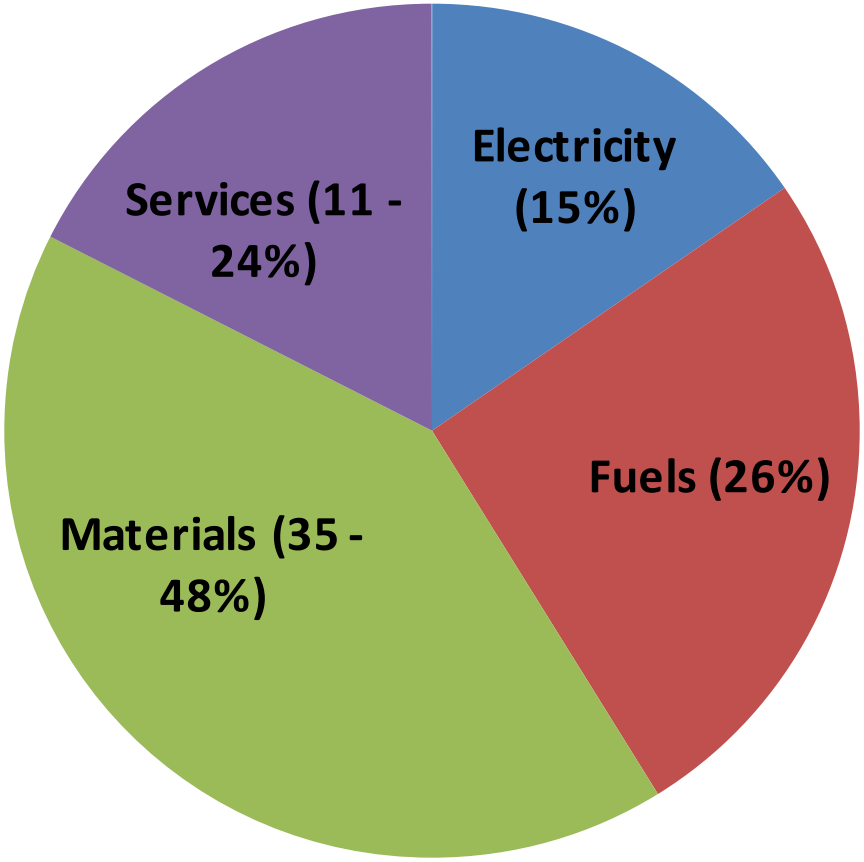
Portland Air Toxics Inventory (2005): Sources of Toxics



Portland Air Toxics Inventory (2005): Sources of Toxics



Oregon Consumption-Based Greenhouse Gas Emissions by Major Category of Consumption ("Final Demand"), 2005

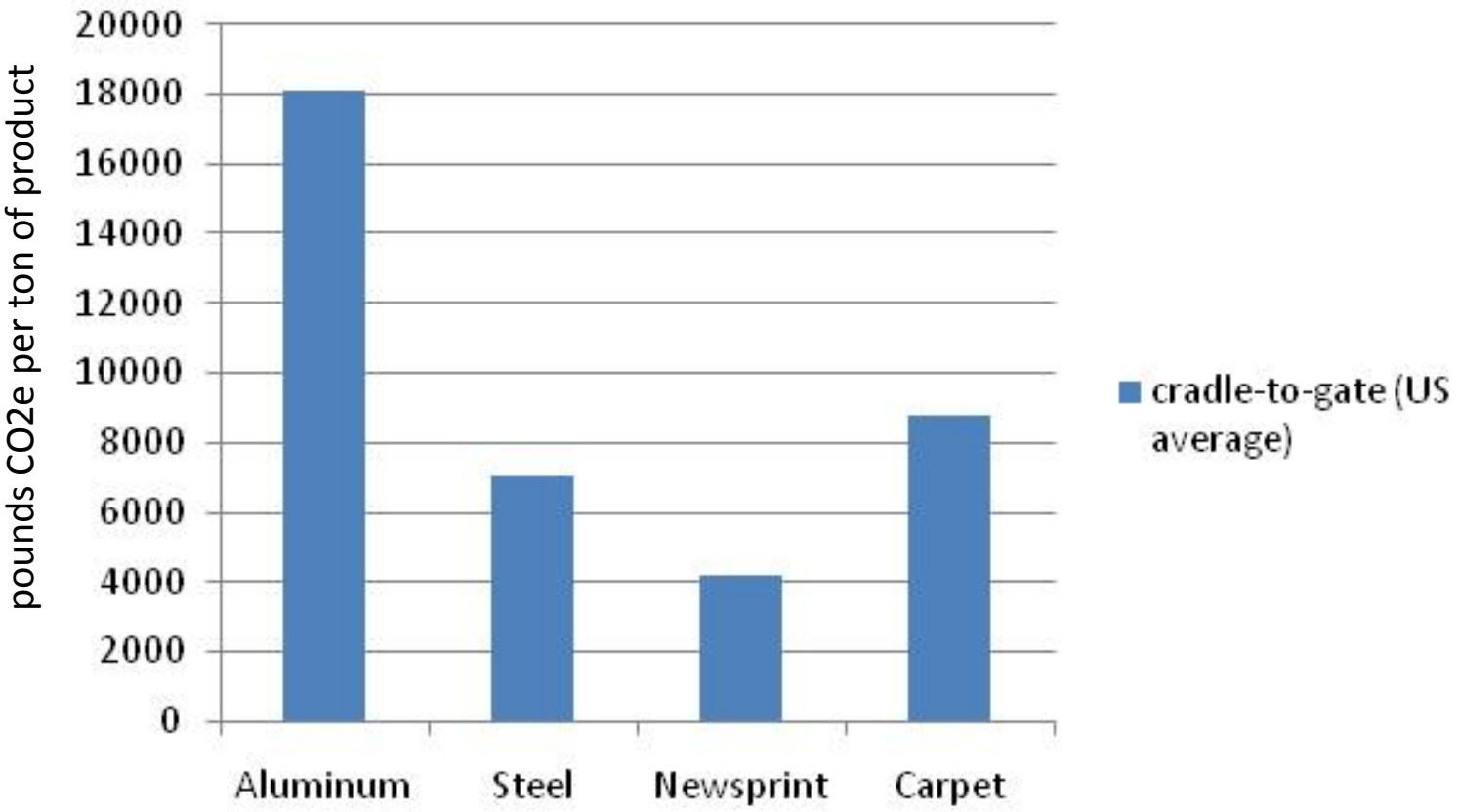


Evaluating the Environmental Impacts of Products: Impacts vs. Attributes

Examples of Impacts	Examples of Attributes
Emissions of air toxics	"Local"
Use of non-renewable resources	Recyclable, compostable
GHG emissions	% recycled content

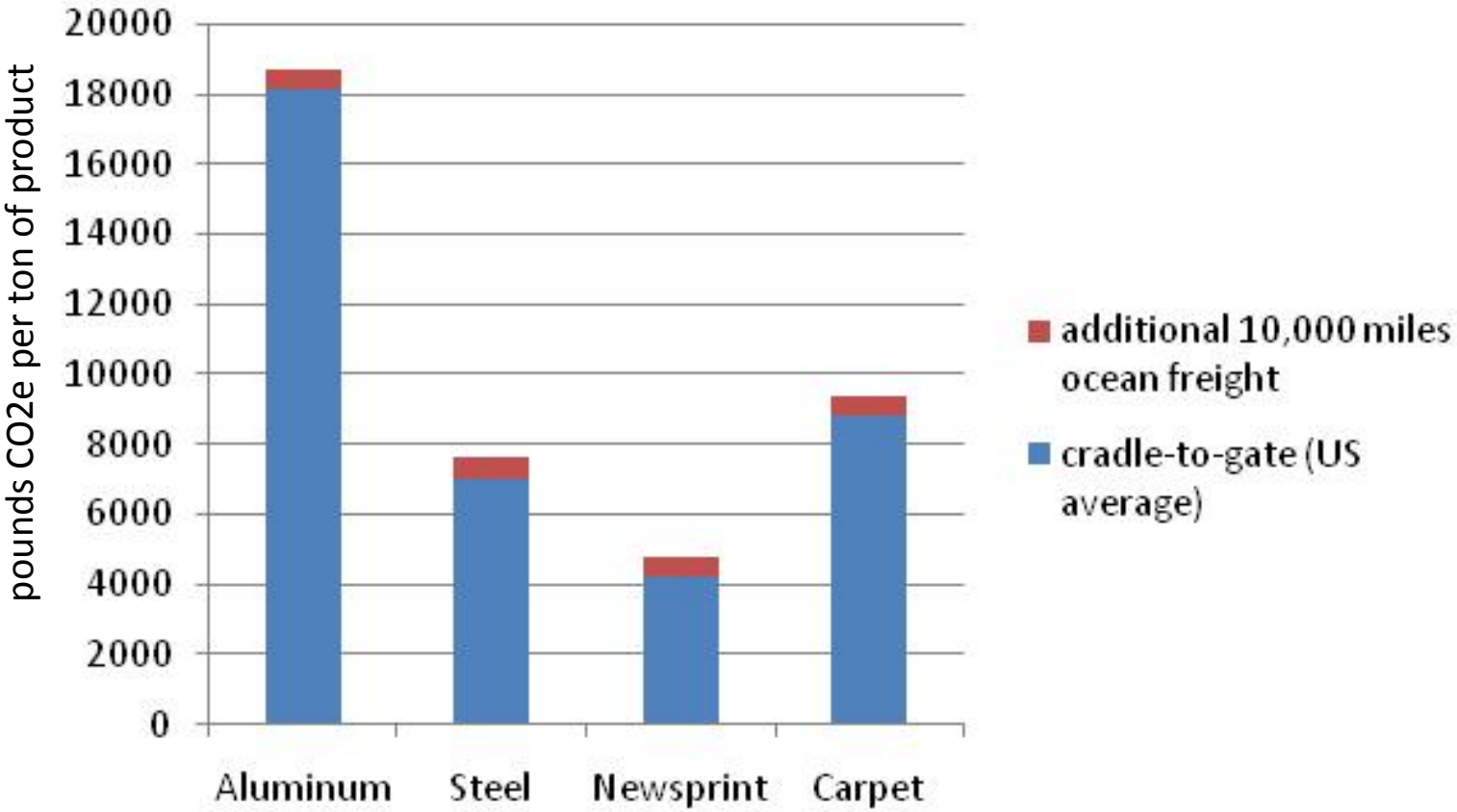
- Impacts are more challenging to evaluate . . . often requires life cycle assessment.
- Attributes are much easier to use – but are they helpful?

Is local better?



EPA (2006)

Is local better?
Transportation often not significant



EPA (2006), DEQ (2009)

Carnegie Mellon University: “Meat vs. Miles”

IN THE NEWS

Environment

6.8 metric tons — The amount of greenhouse gases emitted per year in producing food for the average U.S. household

For food’s ecological impact, meat means more than miles

‘Buying local’ has small effect on greenhouse gases

By Rachel Ehrenberg

BUYING LOCAL CERTAINLY REDUCES THE miles food goes before we eat. But consumers aiming to shrink their ecological footprints will get more bang for their environmental buck by eating less red meat and dairy, reports a new study. The analysis finds that delivering food to the consumer accounts for only 4 percent of food-associated greenhouse gas emissions, while production contributes a hefty 83 percent.

“There are many good reasons for going local,” comments Rich Pirog, associate director of the Leopold Center for Sustainable Agriculture at Iowa State University in Ames. “But this study is important. Food miles alone are not a reliable indicator of environmental impact.”

For the average U.S. consumer, getting the equivalent of one-seventh of a week’s calories from chicken, fish or vegetables instead of red meat or dairy will do more to reduce greenhouse gas emissions than buying all local, all the time, the researchers say. Crunching the numbers revealed that delivery to the consumer accounts for only 1 percent of red meat–associated emissions. But the production path to red meat and dairy products is clouded with nitrous oxide and methane emissions, mainly from fertilizer use, manure management and animal digestion.

“Methane and nitrous oxide production are huge in agriculture,” says first author Christopher Weber of Carnegie Mellon University in Pittsburgh. Other analyses have focused on carbon or energy use. “That misses a huge part of the picture,” he says.

“I shop locally,” notes Weber, who conducted the study with colleague H. Scott Matthews. “But there’s been so much emphasis on food miles. We felt it was important to look at the whole life cycle.”

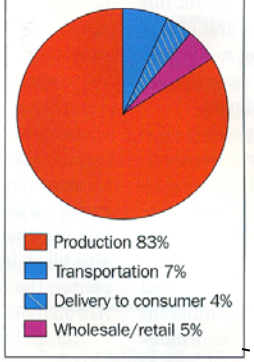
Using data from the U.S. departments of Commerce, Agriculture and Transportation and from other sources, Weber and Matthews modeled the total greenhouse gas emissions generated in making and moving all sorts of foods, ranging from cereals to fish to cheese. The work appears in *Environmental Science & Technology* and paints a broad brush, cautions Weber. Because the model uses Commerce Department data, the food categories are defined by the department’s food sectors. So while cheese and milk are considered separately, fruits and vegetables are put in the same category.

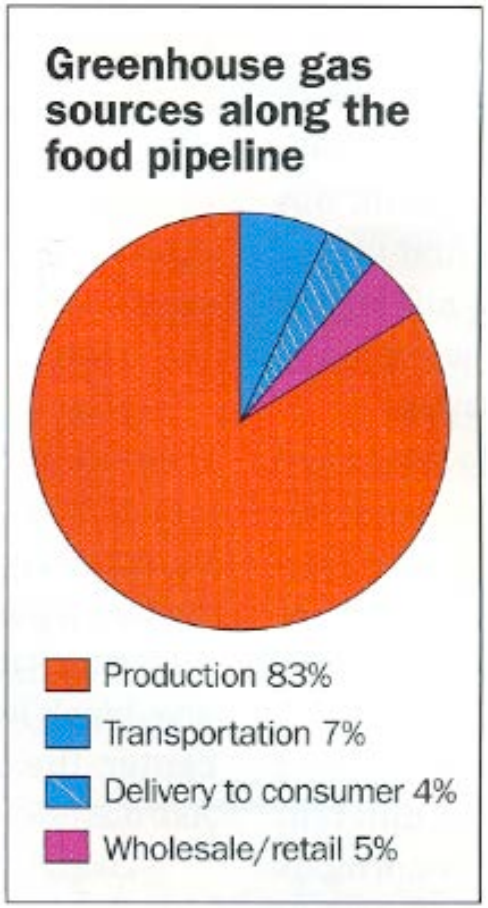
Apples and oranges aside, “more quantitative assessments like this are needed to help us understand the consequences of our choices,” comments Greg Keoleian of the Center for Sustainable Systems at the University of Michigan in Ann Arbor.

Overwhelmed? Don’t be. This new study just reemphasizes the sound advice people have been getting since elementary school, Pirog says.

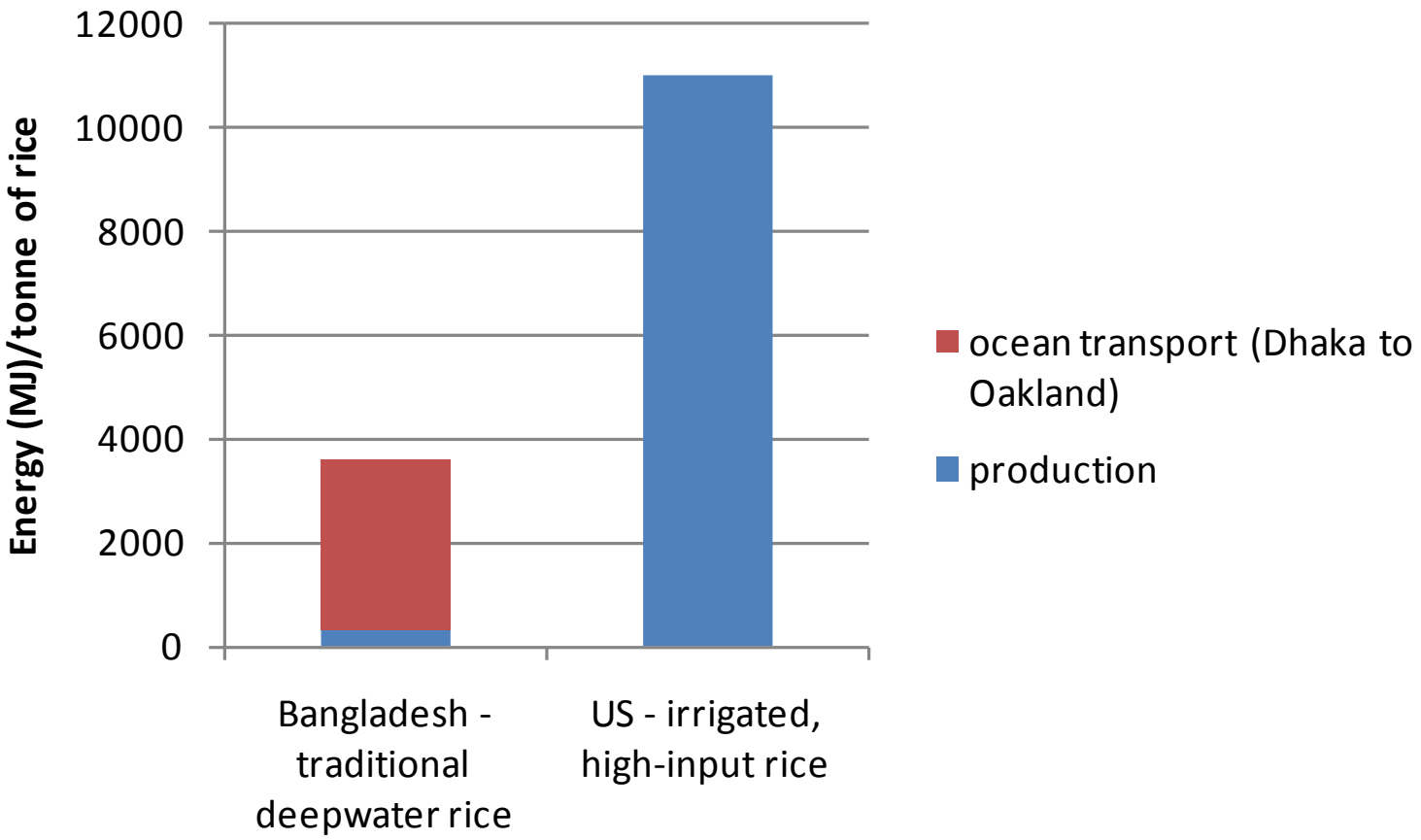
“Eat a healthy balanced diet, with a minimum of processed food. Eat a moderate amount of dairy and meat. Eat more whole grains and veggies. Following that advice will probably reduce your carbon footprint,” he says.

Greenhouse gas sources along the food pipeline





Imported vs. local rice?



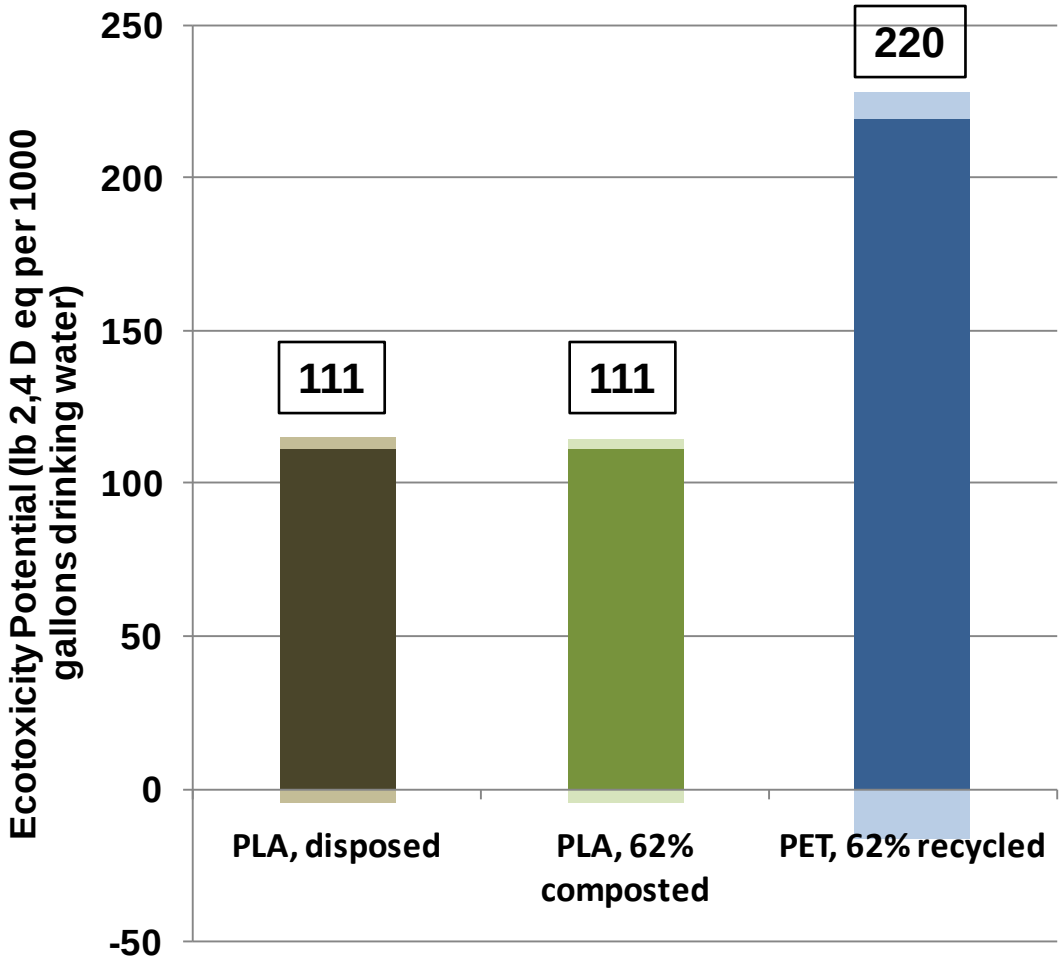
Pretty and Ball (2001), DEQ (2011)

DEQ's Life Cycle Analysis of Water Delivery

- 3 basic systems:

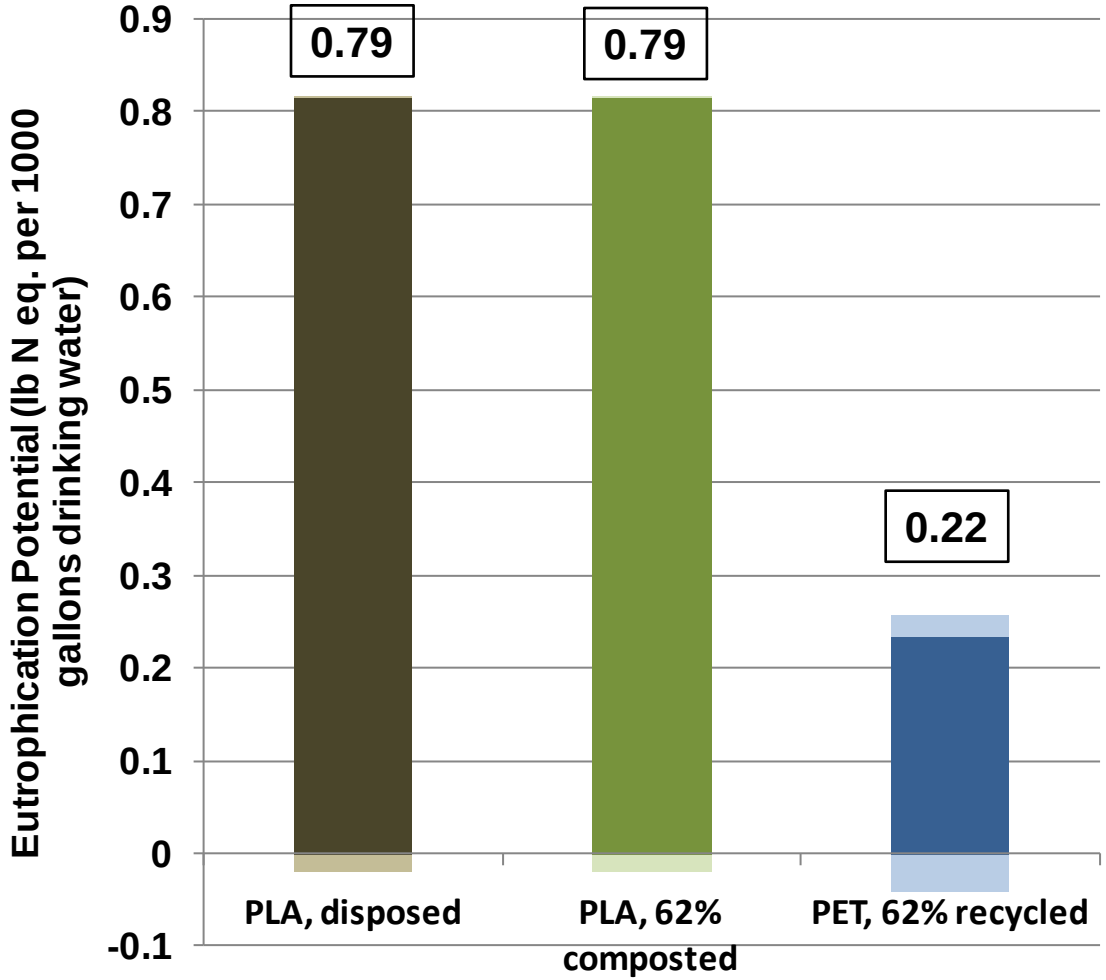
Full study at:
http://www.deq.state.or.us/lq/sw/wasteprevention/drinkingwater.htm

Compostable (PLA) and Recyclable (PET) Water Packaging – Ecotoxicity Potential



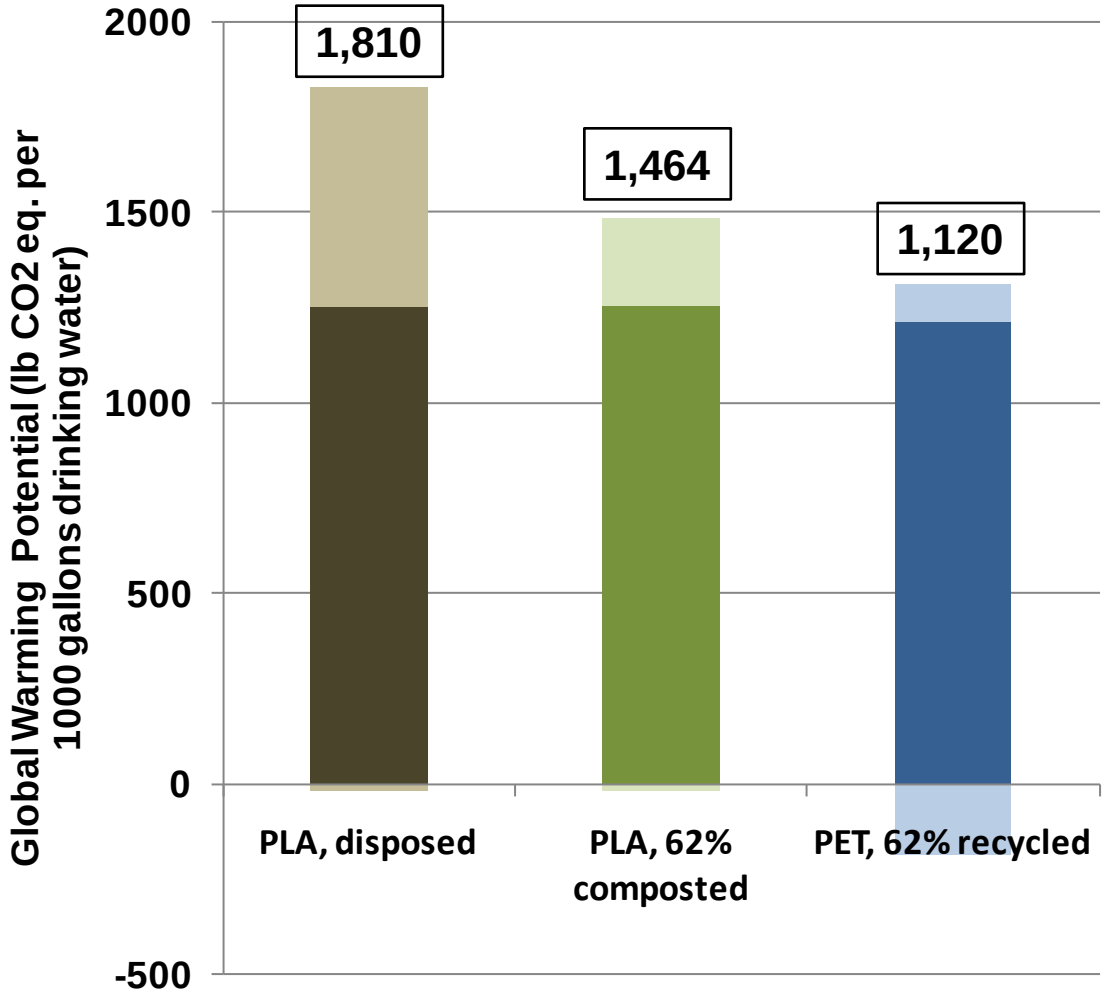
Darker colors are “upstream” impacts; lighter colors are “downstream” impacts (discards management)

Compostable (PLA) and Recyclable (PET) Water Packaging – Eutrophication Potential



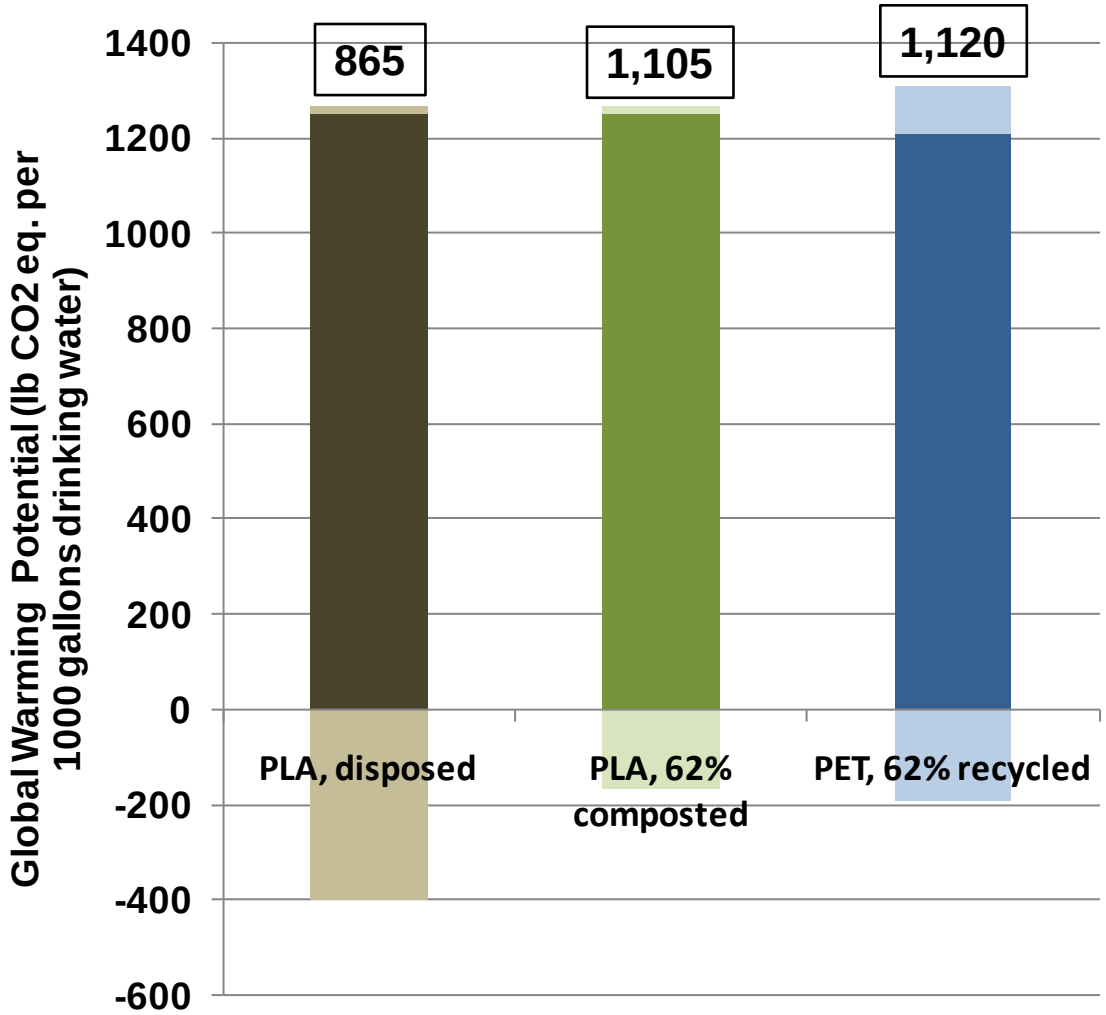
Darker colors are “upstream” impacts; lighter colors are “downstream” impacts (discards management)

Compostable (PLA) and Recyclable (PET) Water Packaging – Global Warming Potential (PLA decomposes in landfill)



Darker colors are “upstream” impacts; lighter colors are “downstream” impacts (discards management)

Compostable (PLA) and Recyclable (PET) Water Packaging – Global Warming Potential (PLA inert in landfill)



Darker colors are “upstream” impacts; lighter colors are “downstream” impacts (discards management)

DEQ/Metro/EPA's Life Cycle Analysis of E-Commerce Packaging

- Full study at: http://www.deq.state.or.us/lq/pubs/docs/sw/packaging/lifecycleinventoryshort.pdf

DEQ/Metro/EPA's E-Commerce LCA: Materials Evaluated

Corrugated box*

Void Fill (for boxes)

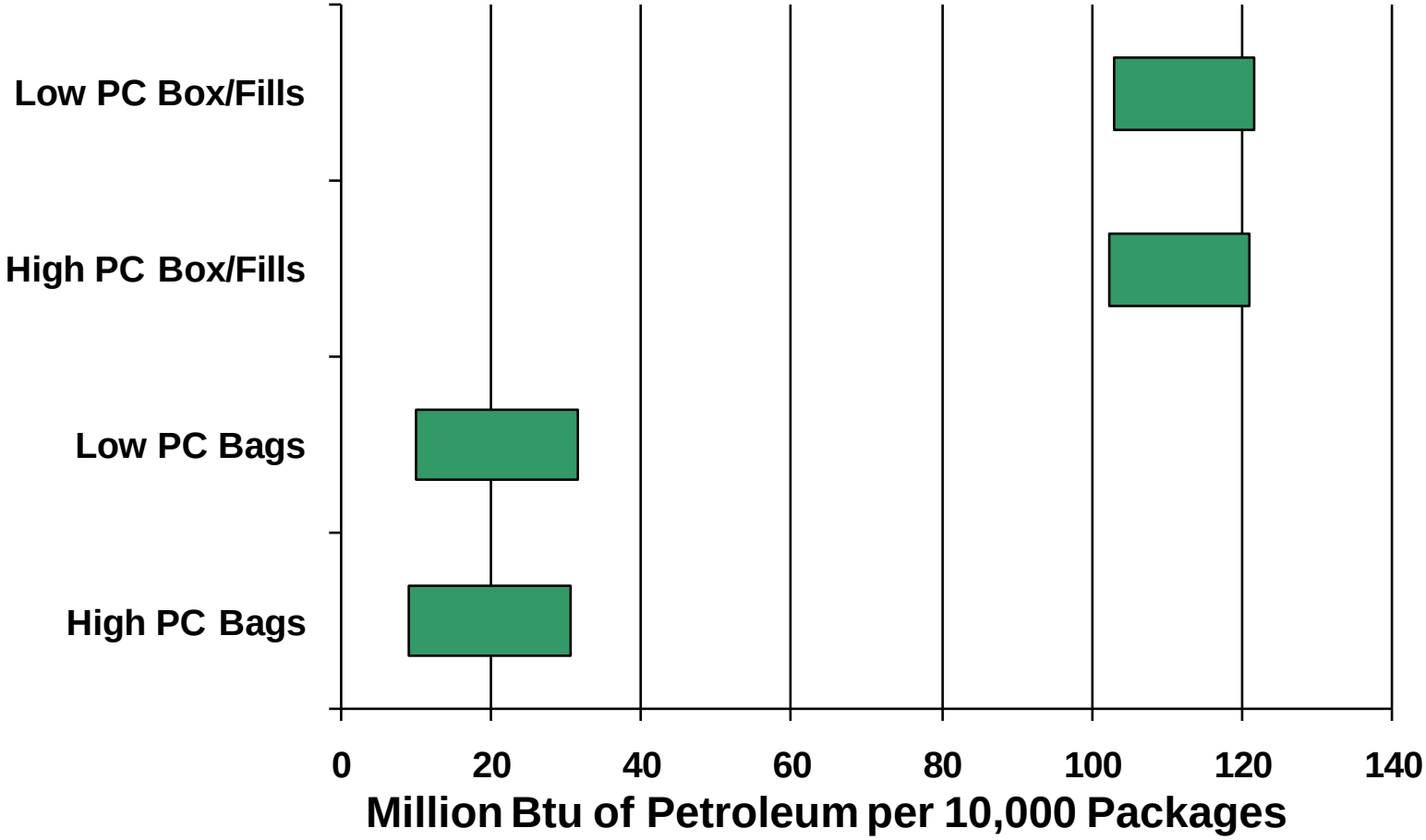
Polystyrene loose fill*
Corn starch loose fill
Molded paper loose fill
Inflated "air pillows"*
Newsprint dunnage*
Kraft dunnage*
Shredded office paper
Shredded boxes

Shipping Bags

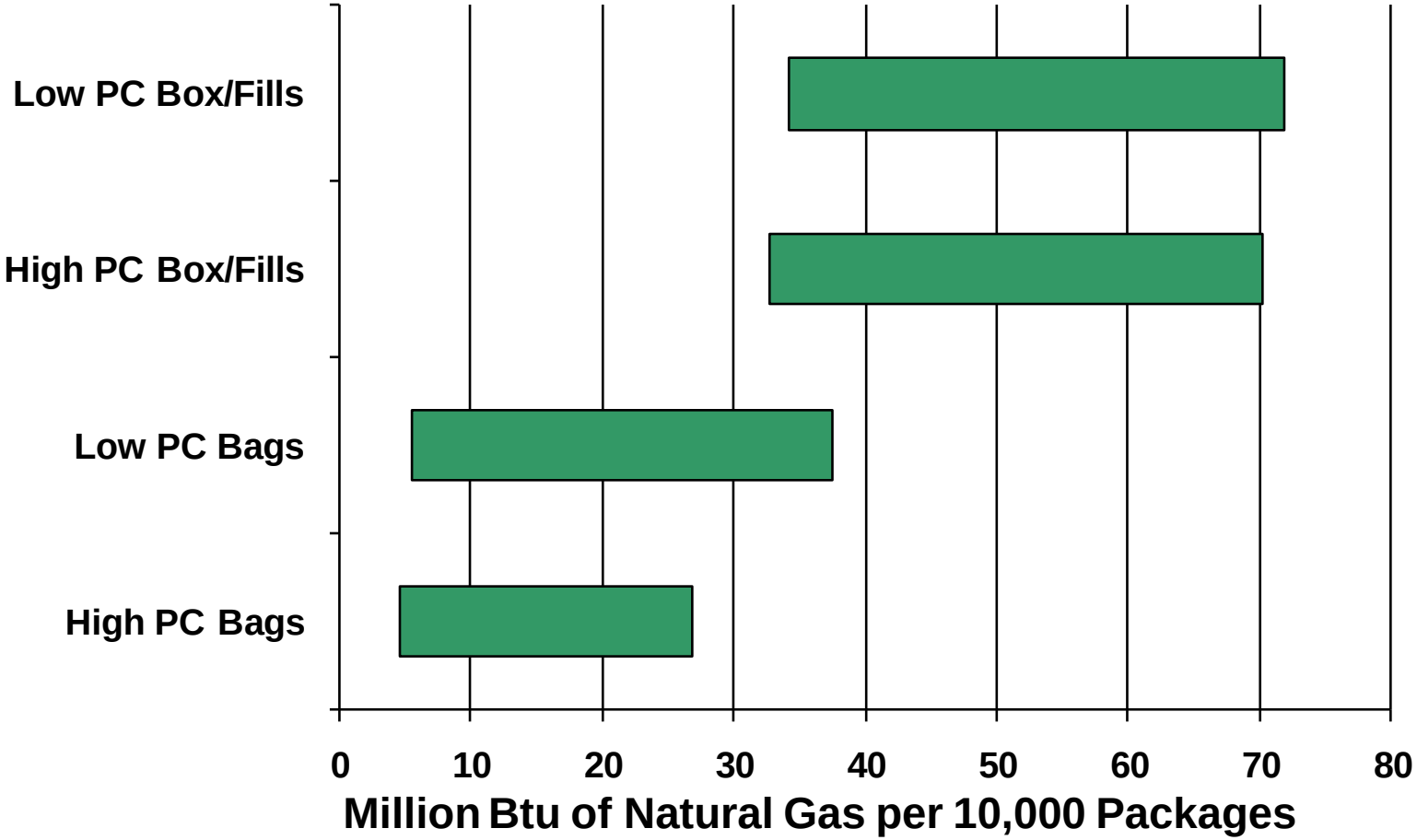
Unpadded all-kraft mailer*
Unpadded all-poly mailer*
Kraft mailer with ONP padding*
Kraft mailer with poly bubble padding*
Poly mailer with poly bubble padding*

*Different levels of post-consumer content also evaluated.

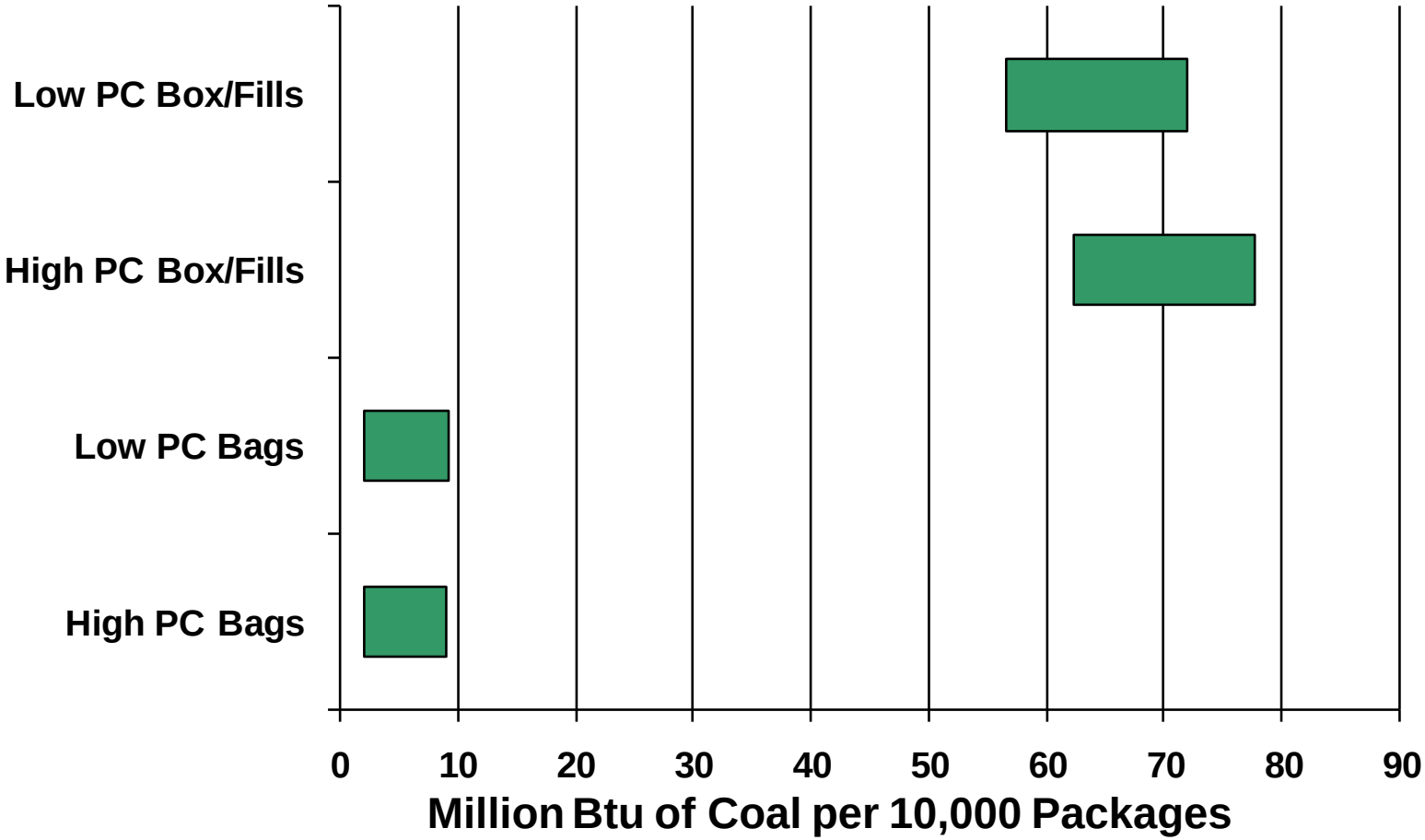
E-Commerce Results: Petroleum



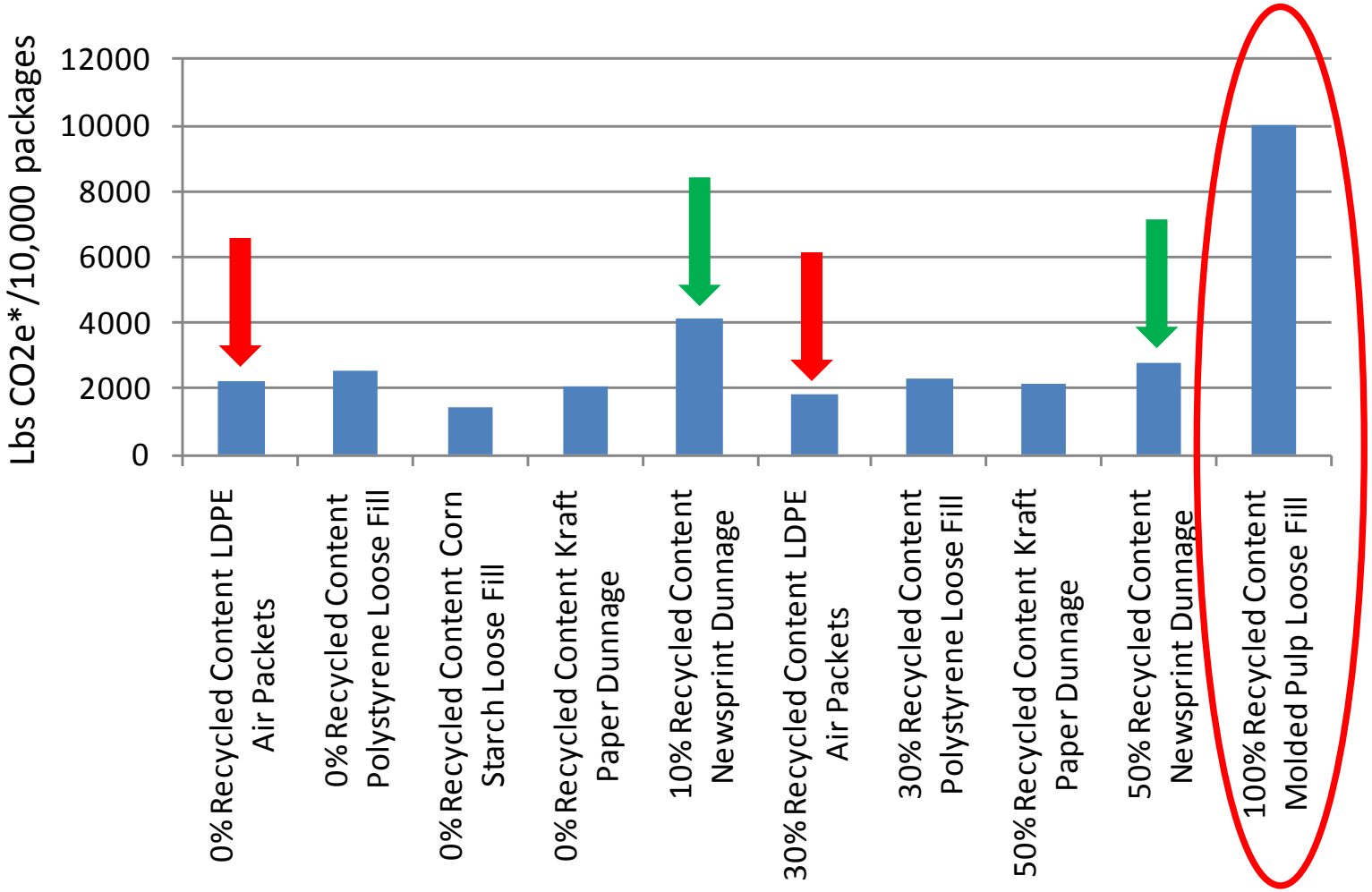
E-Commerce Results: Natural Gas



E-Commerce Results: Coal



Void Fills in E-Commerce Packaging (Boxes)

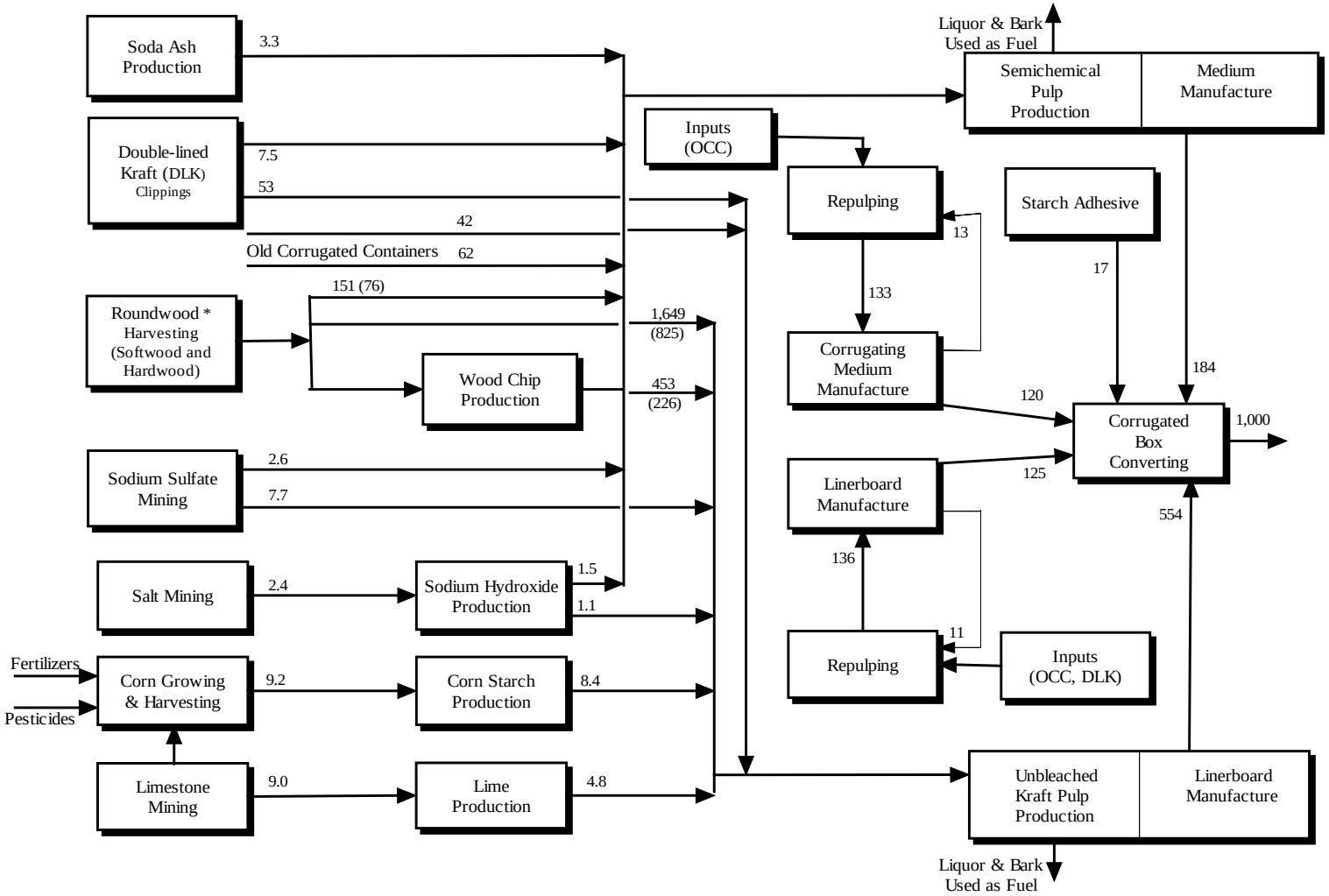


*on a cradle-to-distribution center basis

Understanding Impacts: Life Cycle Assessment (LCA)

- The science of estimating environmental *impacts* across the “life cycle” of a product (or service)
- A powerful tool for understanding impacts, where/how impacts occur, and how to reduce them
- Far from perfect; rapidly evolving
- Two basic approaches:
  - Process LCA
  - Input/output LCA

Process LCA: A Partial Example



Process LCA

- Inventory analysis: accounting of energy and material flows
- Impact analysis: conversion of those flows into "impact categories", such as:
  - Acidification
  - Ecotoxicity
  - Eutrophication
  - Global warming
  - Ozone depletion
  - Smog
  - Human Health
    - Cancer
    - Non-cancer
    - Respiratory effects

Process LCA (continued)

Limitations:

- Potentially complex, time consuming and expensive (to conduct and to use)
- Trade-offs between impact categories
- Some impacts not evaluated well (e.g., use-phase toxics; marine debris; foreign processes)

Advantages:

- Offers a relatively comprehensive view of impacts
- Identifies which actions/alternatives, within the life cycle of a product, are important, impactful
- Gaining widespread use in industry

The ABCs of EPDs and PCRs

<u>EPDs (environmental product declarations):</u>

- Akin to a “nutrition label” for products, but addresses environmental impacts
  - “Carbon footprint” a type of EPD
- Product/brand specific
- Almost always derived from process LCA

<u>PCRs (product category rules):</u>

- Standard accounting rules for developing an EPD for a category of products (e.g., floor coverings)
- Intended to improve comparability between EPDs

Input-Output LCA

	Engine	Parts	Steel	Plastics		Conferences
$20,000 Car	$2,500	$2,000	$1,200	$800	. . .	$10

	Steel	Aluminum		Attorneys
$2,500 Engine	$300	$200	. . .	$20

	Iron Ore	Coal		Steel
$300 Steel	$45	$30	. . .	$2

Input-Output LCA (continued)

- Traditional (economic) input-output analysis estimates financial flows through the supply chain
- Estimate *emissions intensities* (direct emissions/dollar) for different industries
  - Single-region or multi-region
- Life cycle emissions = (emissions/dollar) x (dollars)
- Examples:
  - www.eiolca.net (and applications of EIO-LCA, such as Washington State's "Consumer Environmental Index")
  - CEDA (Comprehensive Environmental Data Archive)
  - Stockholm Environment Institute's and Oregon's consumption-based GHG emissions inventory

Input-Output LCA (continued)

Limitations:

- Limited granularity (e.g. “fresh fruits and vegetables”)
- Price/quality problem

Advantages:

- Quick and easy (once model is constructed)
- No cut-off error
- Well-suited for community-scale assessments

Where do we go from here?

Where do we go from here?

- Prioritize; don't sweat the small stuff
  - European research (individual consumption): Big impacts are housing, mobility, food, energy-consuming products
  - Top-ranked materials (per EPA): cotton, apparel, industrial chemicals; vehicles; meat; paper; housing
- Think holistically
  - Don't optimize just one life-cycle stage (especially end-of-life)

Where do we go from here? (continued)

- “Less is best” (usually!)
- Use attributes carefully
- For the committed: seek out life cycle impact data (environmental product declarations)
  - Where product category rules exist
  - Do your homework/ask questions
  - Be prepared for a challenging ride ahead

Thank you! Questions?

David Allaway

Allaway.david@deq.state.or.us

503-229-5479