
Recycling/
Reuse/
Disposal
Resource
Extraction
Demolition
Athena
Institute
Manufacturing
Occupancy/
Maintenance
On-site
Construction

Using Life Cycle Assessment to Assess Environmental Performance

Wayne Trusty, Athena Institute

International Concrete Sustainability Conference
Dubai, December 2010

Presentation Outline

- Life cycle assessment (LCA) — brief overview
  - Why, what, how
- Highway case studies
  - Material choices
  - Truck energy use
  - Lighting and other considerations
- The LCA toolkit
  - LCA tool for assessing highway designs
- Concluding comments

Athena Institute

Increase in eco-labels

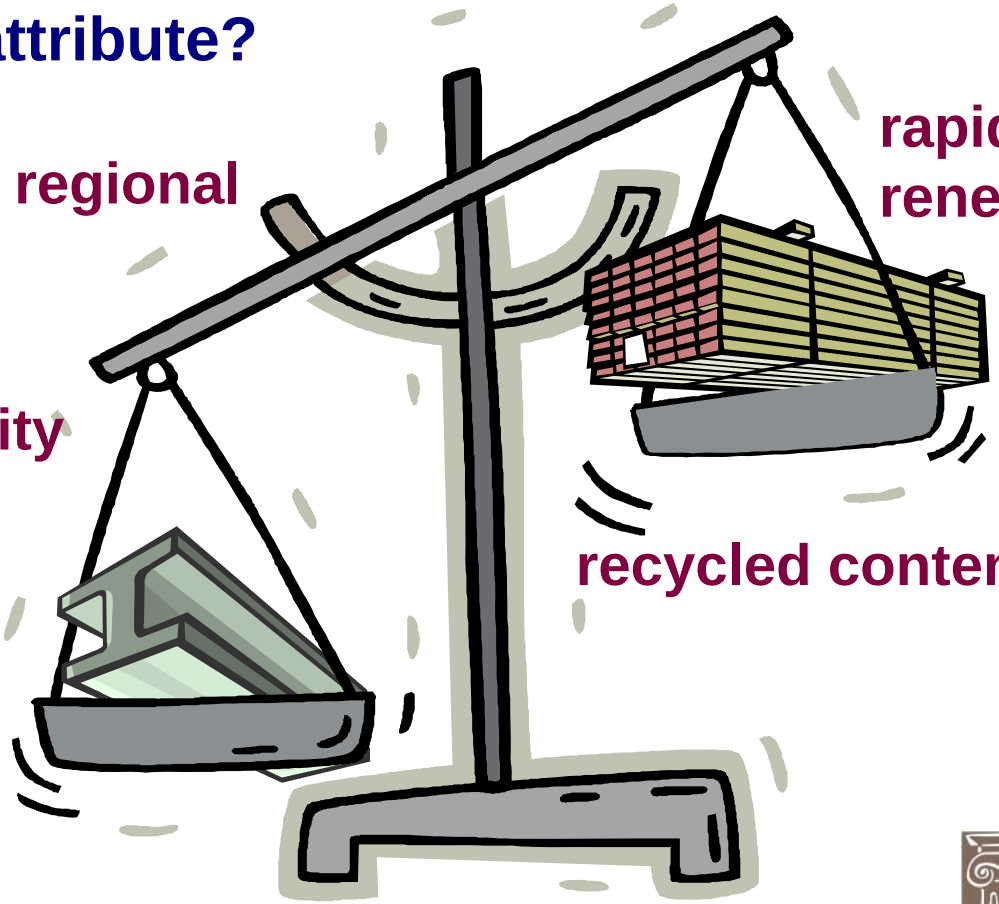
(495 in US, Europe & Asia & growing)

Slide courtesy of D. Allen, US EPA

Athena Institute

Weighing material options

By attribute?



regional

rapid renewability

durability

recycled content

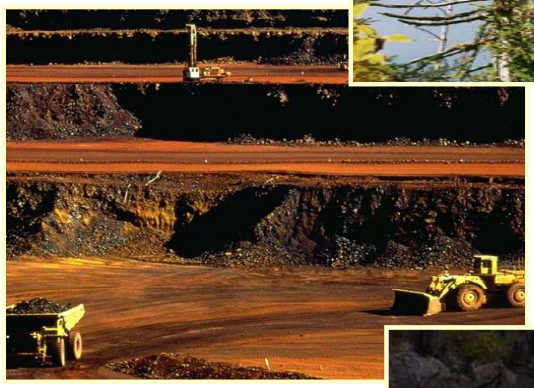
or…

Athena Institute

By environmental performance ➔ LCA

Air pollution

Acid rain damage

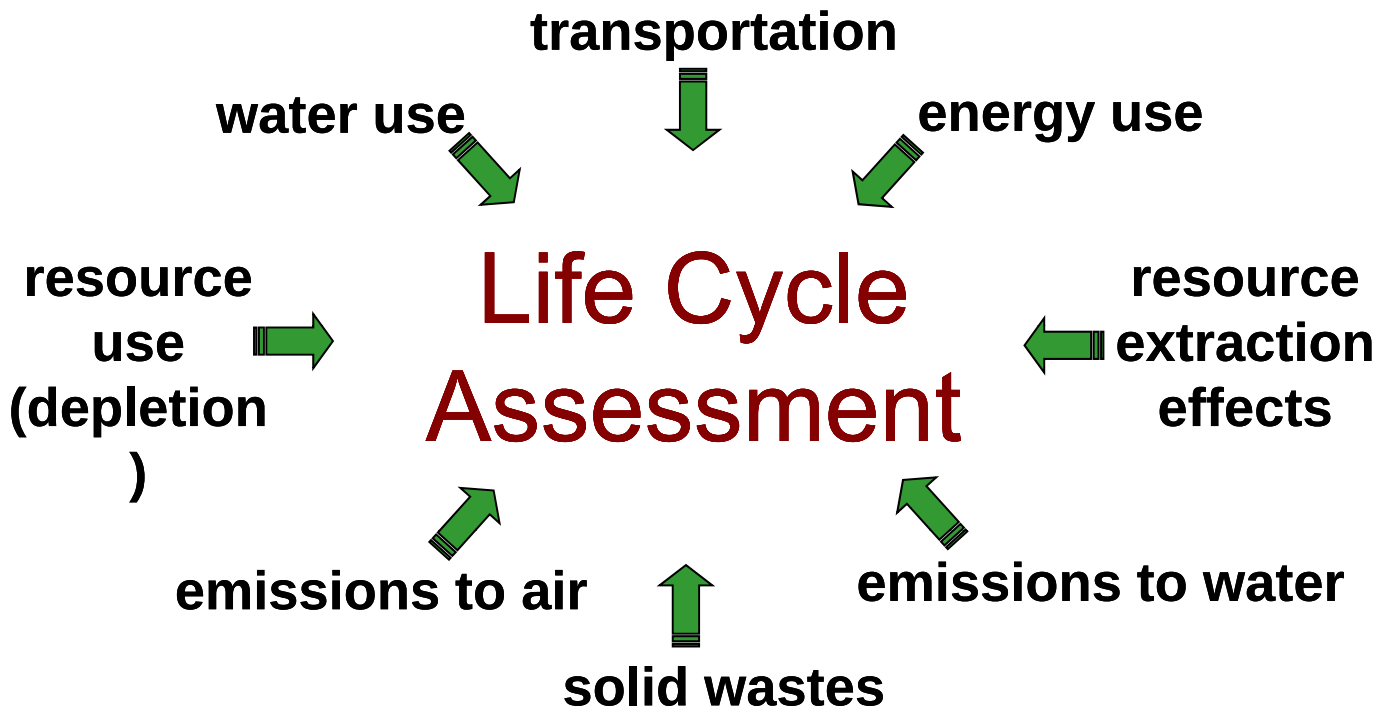


Climate change

Resource depletion

Water pollution

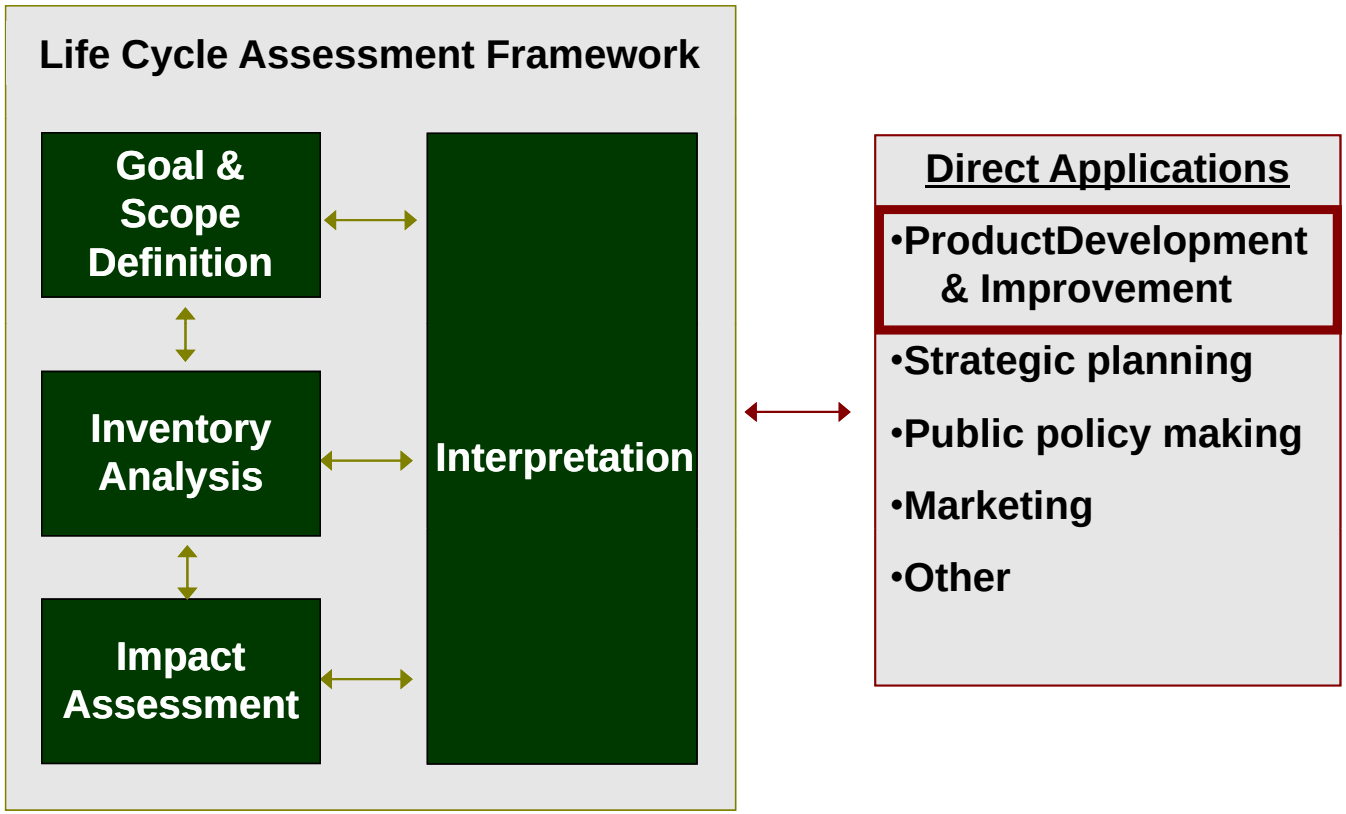
Athena Institute



A methodology for assessing the environmental performance of a product over its full life cycle

Athena Institute

The ISO 14040/44 Framework



Athena Institute

Impact Assessment Phase

Inventory

Mid-point impact indicators

- **fossil fuel consumption**
- **global warming potential**
- **ozone depletion potential**
- **acidification**
- **aquatic eutrophication**
- **smog formation**

Impact Assessment (Valuation)

<u>THE GOAL</u>: to measure ultimate impacts on human and ecosystem health

Athena Institute

The LCA Tool Kit

***For LCA practitioners* – SimaPro, GaBi, Umberto**

LCA in the background

Level 1 — Product Focus

BEES

- **free download from NIST**

Level 2 — Assembly Focus

ATHENA EcoCalculator

- **free download**

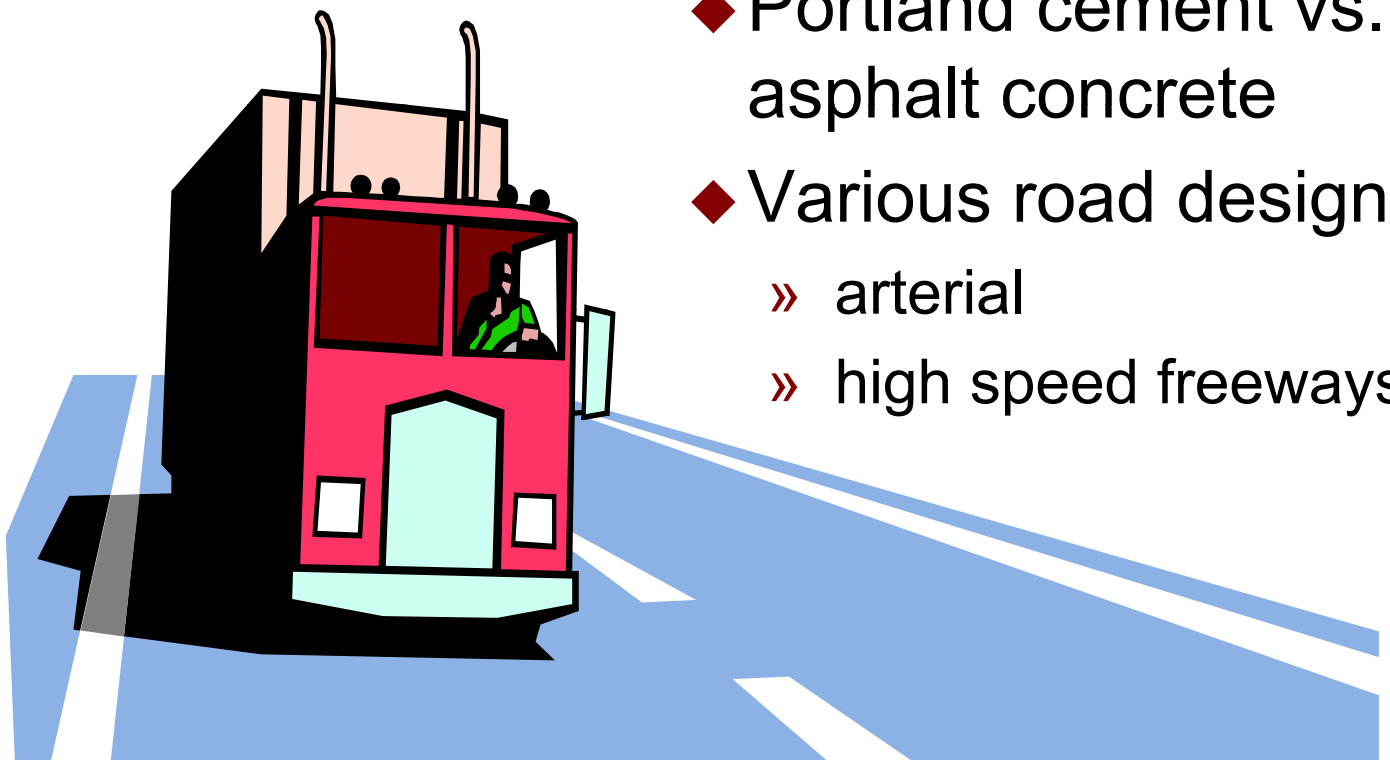
Level 3 — Whole Building

ATHENA Impact Estimator

Under development through APP

Athena Institute

Highway Case Studies



- Portland cement vs. asphalt concrete
- Various road designs
  - » arterial
  - » high speed freeways

Athena Institute

Study Background

- Embodied energy and global warming effects
  - Athena Sustainable Materials Institute
  - 2006 up-date and extension of 1999 study
  - For Cement Association of Canada (CAC)
- Companion to National Research Council study of truck energy use
  - Funded in part by CAC and Federal Government
  - Three phases over several years — 2002-2006

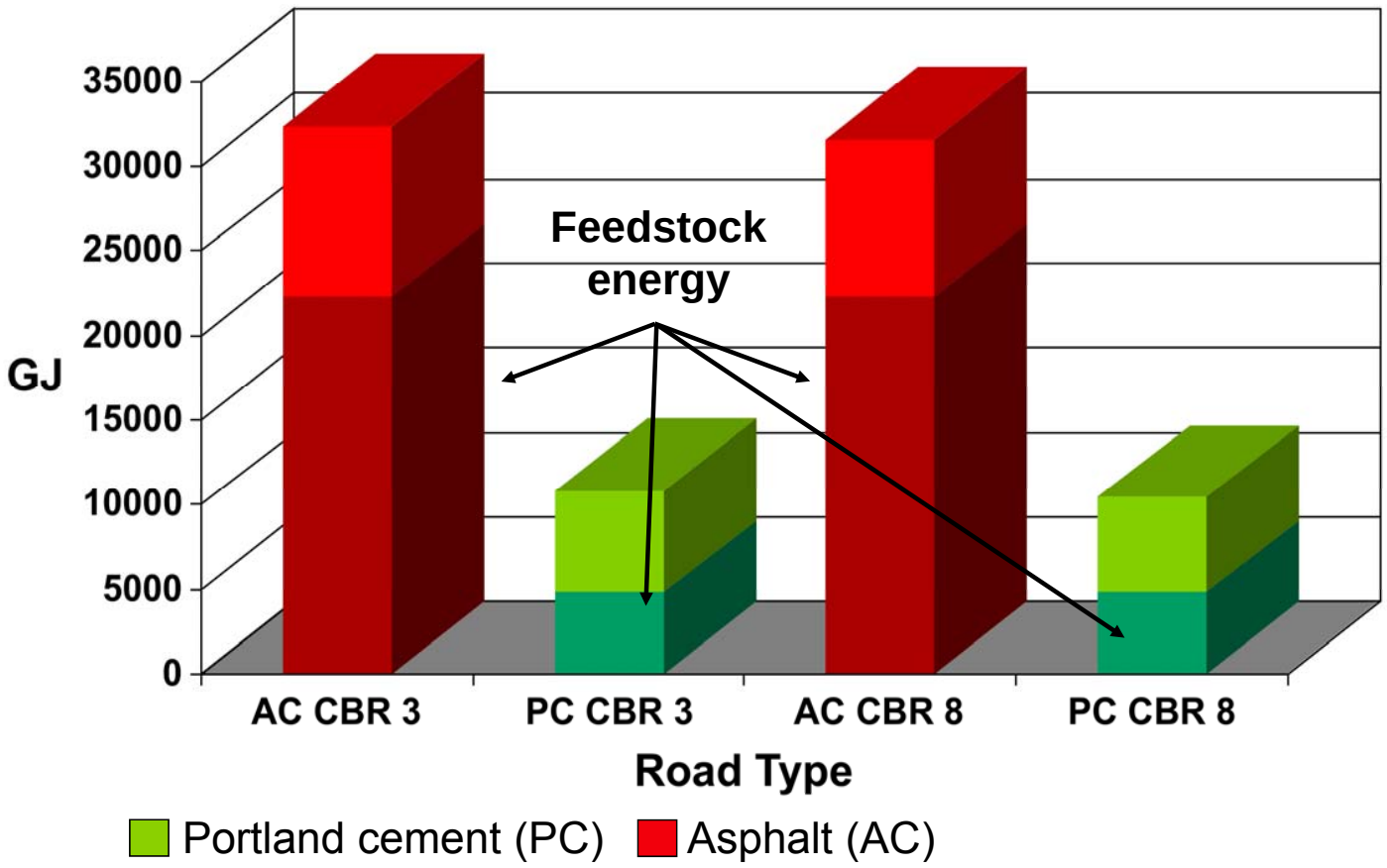
2006 Athena Study Scope

- Several road types:
  - Canadian average arterial roads and high volume freeways
    - California Bearing Ratio (CBR) 3 and 8
  - Urban freeways
- One 2-lane or 3-lane km is the functional unit
- Study boundaries at sub-grade and finished surface, including asphalt paved shoulders
  - Excluded clearing, sub-grade, lane divider painting, etc.
  - Designs using AASHTO Guide for Design of Pavement Structures & CAC method for rigid pavements
- 50 year study period captures major rehabilitations

Athena Institute

Canadian High Volume Freeways

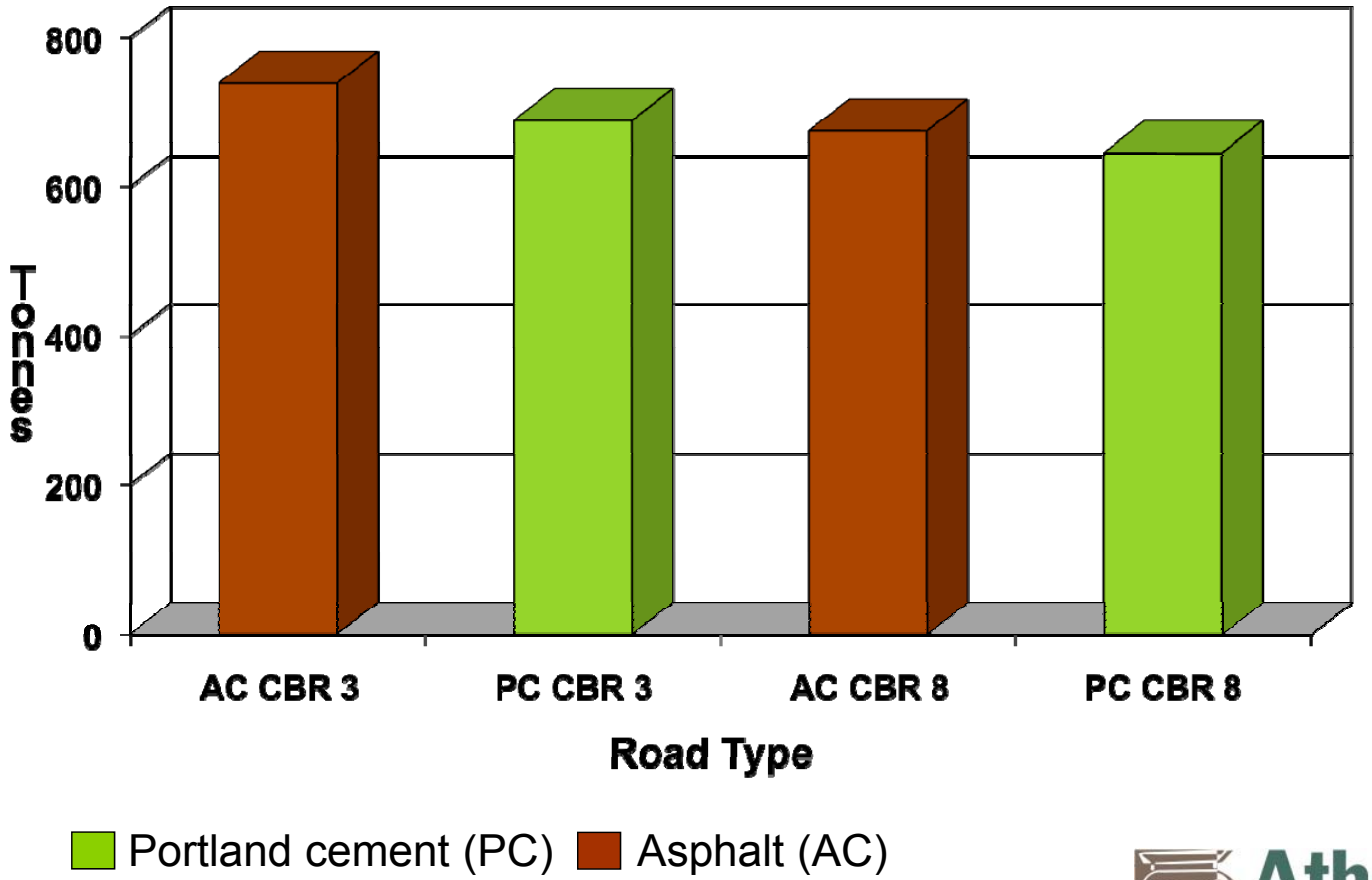
primary energy use (0% RAP)



Athena Institute

Canadian High Volume Freeways

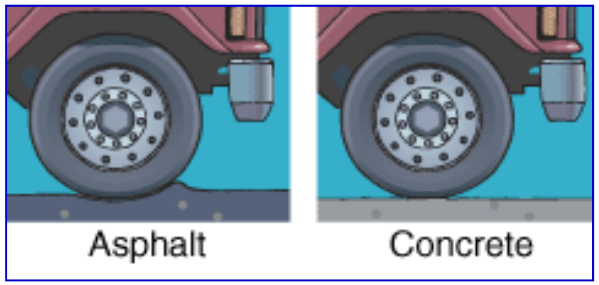
global warming potential
(tonnes of CO_2 equivalent, 0% RAP)



Athena Institute

NRC Study: Truck Energy Use

- Scope
  - road tests with sophisticated on-board instrumentation
    - spring, summer (day and night), fall, winter
    - four temperature conditions (<-5, -5 to 10, 10 to 25, >25 ºC)
    - tanker and van semi-trailers
    - empty, typical full & legal loads



- Results
  - statistically significant fuel savings on concrete compared to asphalt
    - 0.8 to 6.9% depending on speed, conditions and vehicle type
  - related reductions in emissions, e.g.,
    - ↓7.31 t of CO_2 at 3.85 % fuel savings for tractor trailer traveling 160,000 km/yr @ .43 litres/km

Athena Institute

Reduced Fuel Costs and Emissions

Annual Potential Savings & Emission Reductions—Typical Major Arterial Highway			
	vs flexible asphalt pavement		
	Minimum 0.8%[9]	Average 3.85%	Maximum 6.9%[10]
Total Fuel Savings (litres)	377,000	1,813,000	3,249,000
Total Dollar Savings ($)	338,000	1,625,000	2,912,000
Total CO_2 Equivalent Reductions (tonnes)	1,039	5,000	8,960
Total NO_x Reductions (tonnes)	11.8	56.6	101.4
Total SO_2 Reductions (tonnes)	1.5	7.2	12.8

Assumes 100 km section of concrete pavement with 3,000 trucks per day

References:
(1) Effects of Pavement Structure on Vehicle Fuel Consumption – Phase III, NRC, CSTT-HVC-TR-068, Taylor and Patten, January 2006.
(2) Additional Analysis of the Effect of Pavement Structures on Truck Fuel Consumption, NRC, G.W. Taylor, August 2002.

Athena Institute

Other Factors to Consider

- Right of way and sub-base construction
  - » Width
  - » Cuts and fills
- Shoulder paving alternatives
- Construction equipment energy use and emissions
- Lighting requirements
- Differences in sound barrier requirements

Athena Institute

Concluding Comments

- LCA is an evolving physical accounting system
- Complements life cycle costing
- A useful tool for infrastructure design and material choice decisions
- Being used and sometimes misused in a highly competitive atmosphere
  - » product-to-product
  - » database-to-database
  - » tool-to-tool
- Requires reliable data and tools
  - » especially for non-practitioners

Athena Institute


AthenaInstitute
The Athena Institute – unparalleled excellence in fostering a sustainable built environment
About the Institute
Impact Estimator
EcoCalculator
Databases
Projects
Reports & Publications
Our Members
Site Info
Careers
What's New
WELCOME
At the Athena Institute, we believe that better information and tools are critical to achieving a sustainable built environment. We also believe that a life cycle assessment (LCA) approach to sustainability is the only way to create a level playing field for the vast array of building materials in use.
From our Canadian offices, and through our US affiliate, Athena Institute International, the not-for-profit Athena organization undertakes and directs innovative research and development activities that allow architects, engineers and others to factor environmental considerations into the design process from the conceptual stage onward.
Over the past decade, the Institute has developed groundbreaking software, world-class databases and
www.athenaSMI.org
U.S. Life Cycle Inventory Database Roadmap
The National Renewable Energy Laboratory (NREL), a facility of the US Department of Energy, has released a new Roadmap for the US Life Cycle Inventory Database.
Click here to download the brochure.
EcoCalculator
for assemblies
Version 3.3 is now available!
common building assemblies (free of charge).
Award Winning Tool
Since its launch in July, 2007, the EcoCalculator has been recognized with awards for innovation from both the US Environmental Protection Agency (EPA) and the Sustainable Buildings Industry Council (SBIC).
First Athena Chair in L.C.A.
The Athena Institute is pleased to report that the position of Athena Chair in Life Cycle Assessment at the University of Calgary has been filled.
More.
UNIVERSITY OF CALGARY
Important New Study
This study, recently completed for Parks Canada, compares the effects of keeping historic buildings as opposed to building new structures in the same locations.
More.