

EASTMAN

American Institute of Chemical Engineers

AIChE[®]

East Tennessee Local Section

Life Cycle Assessment: A tool for quantifying environmental aspects of sustainability

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Connecting science and sustainability

Our journey continues



What is LCA?

What is life cycle assessment (LCA)?

- LCA is a technique to assess environmental burdens associated with a product, process, or activity by:
 - Compiling an inventory of relevant energy and material inputs and environmental releases (**LCI**)
 - Evaluating the potential environmental impacts associated with identified inputs and releases
 - Interpreting the results to help decision-makers make a more informed decision.

....across the various life cycle stages of the value chain

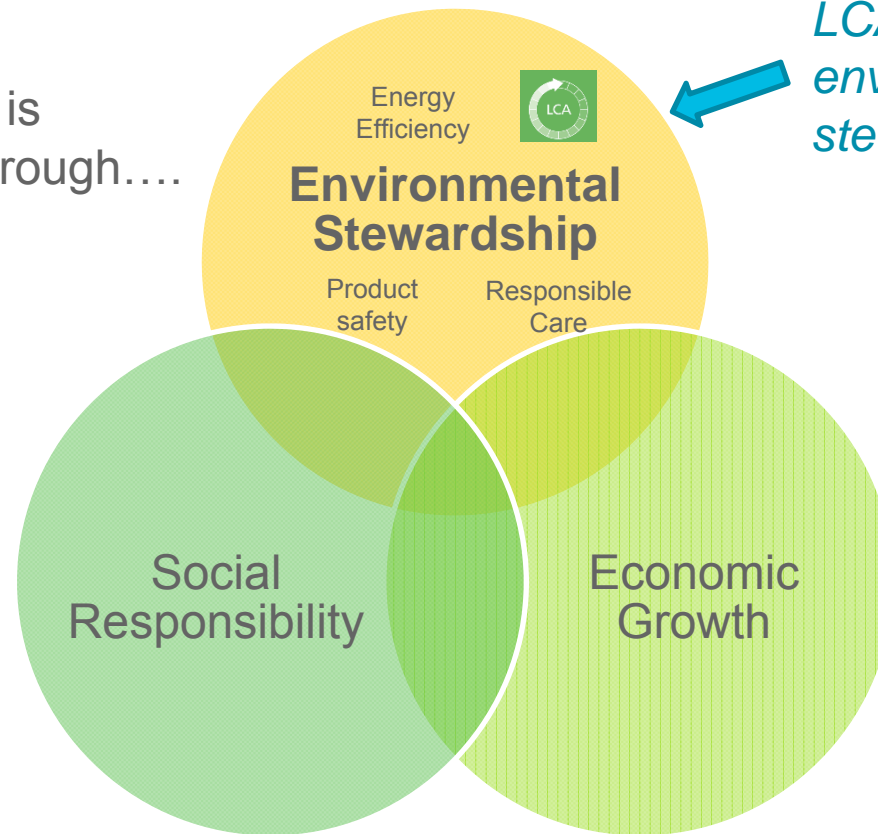


LCA's are tools for building scenarios from which one can learn...rather than truth generating machines

- Dr. Timothy McKone (biofuels LCA expert)

How does LCA fit into Sustainability?

Sustainability is creating value through....



LCA is one aspect of environmental stewardship

...now and for future generations

What is our customer's interpretation of Sustainability?
How can we translate and articulate our value proposition?

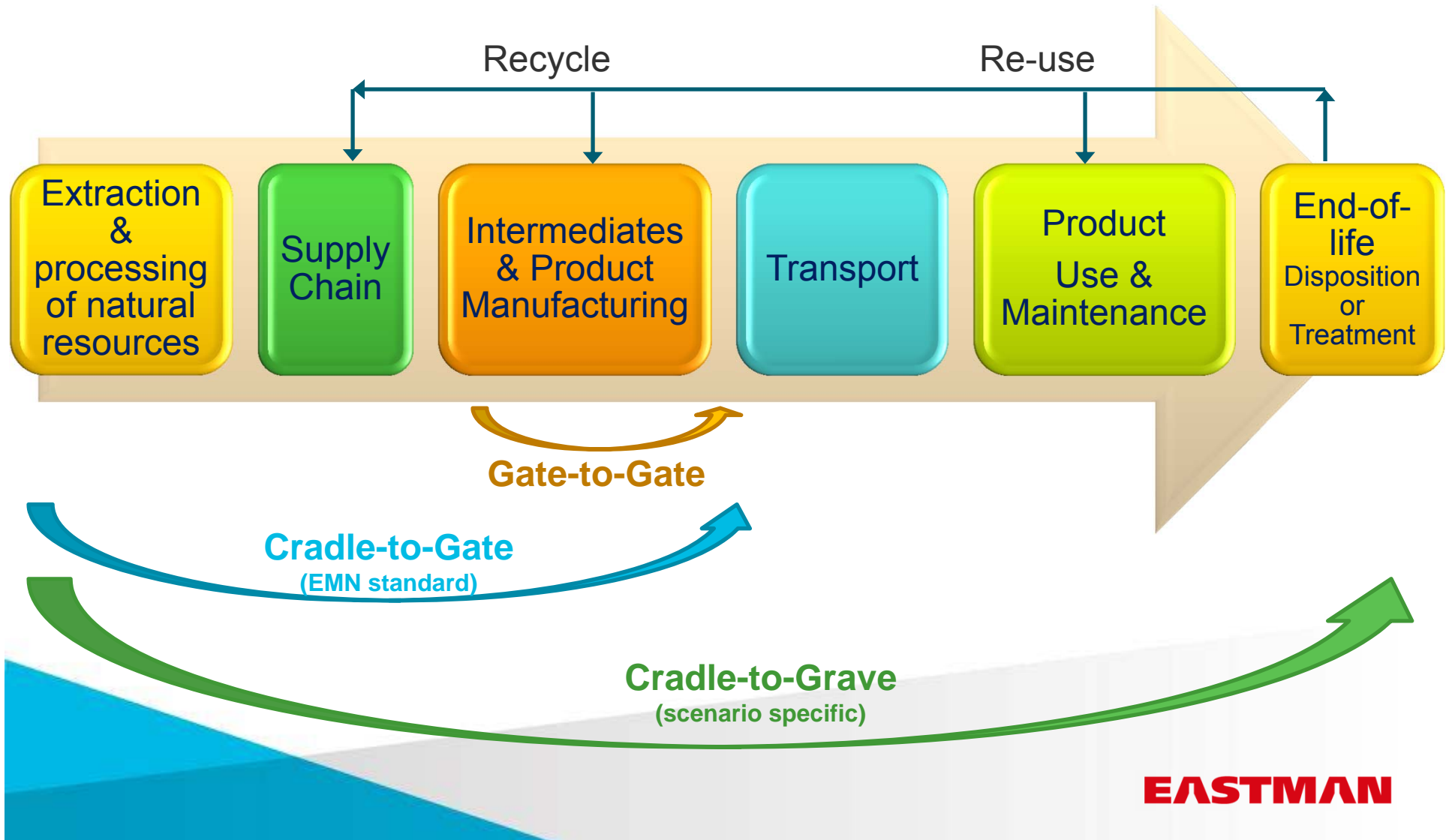
Why are we doing LCA?

- Informing and Reinforcing Our Sustainability Message
 - Quantitative metric of environmental sustainability
 - Corporate goals and commitments
- Supporting Customer Needs
- Guide product and technology portfolio management and strategy
 - Differentiate and add value in markets/with customers that value sustainability
 - Identify growth opportunities & threats
 - Product positioning
 - Factor in selection of materials

Did you know?

Eastman has internally completed LCA's for over 70 products.

Typical Life Cycle Phases of a Value Chain



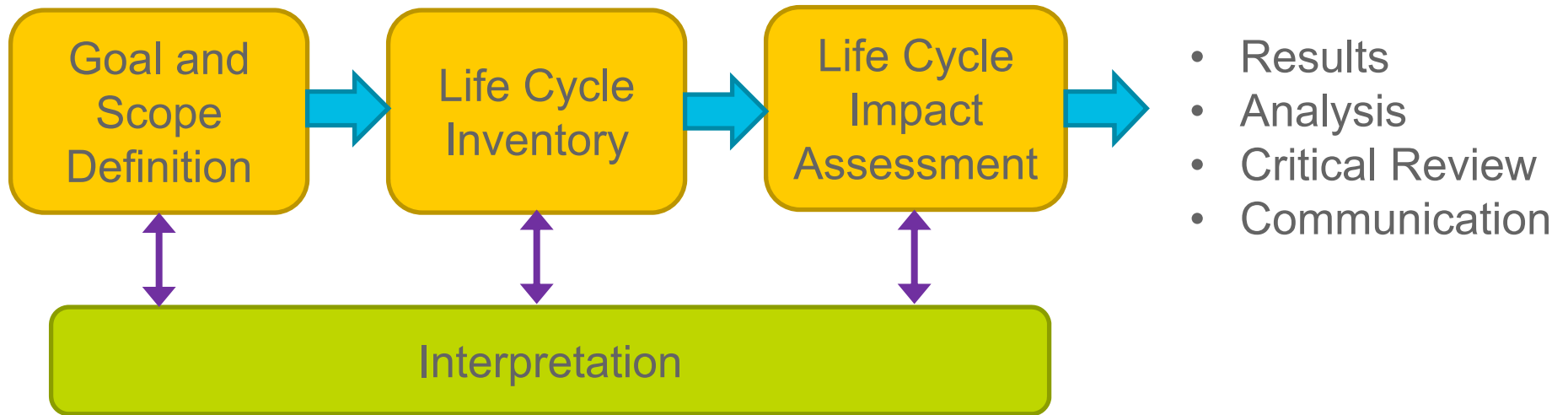
Functional Unit

- Quantified performance of a product system for use as a reference unit
- What is the reference unit of the LCA study?
 - One kilogram of product exiting Eastman's plant gate?
 - One square meter of coated automobile?
 - One 500 mL beverage container?
- Comparisons must be made on the basis of equivalent performance
- kg \neq life cycle performance



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LCA Framework



- Results
- Analysis
- Critical Review
- Communication

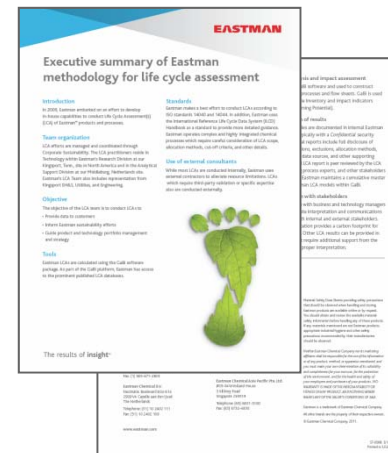
LCA Standards

General Framework: ISO 14040, ISO 14044

Product Carbon Footprint:

- PAS 2050
- GHG Protocol Product Standard
- ISO 14067 (pending)

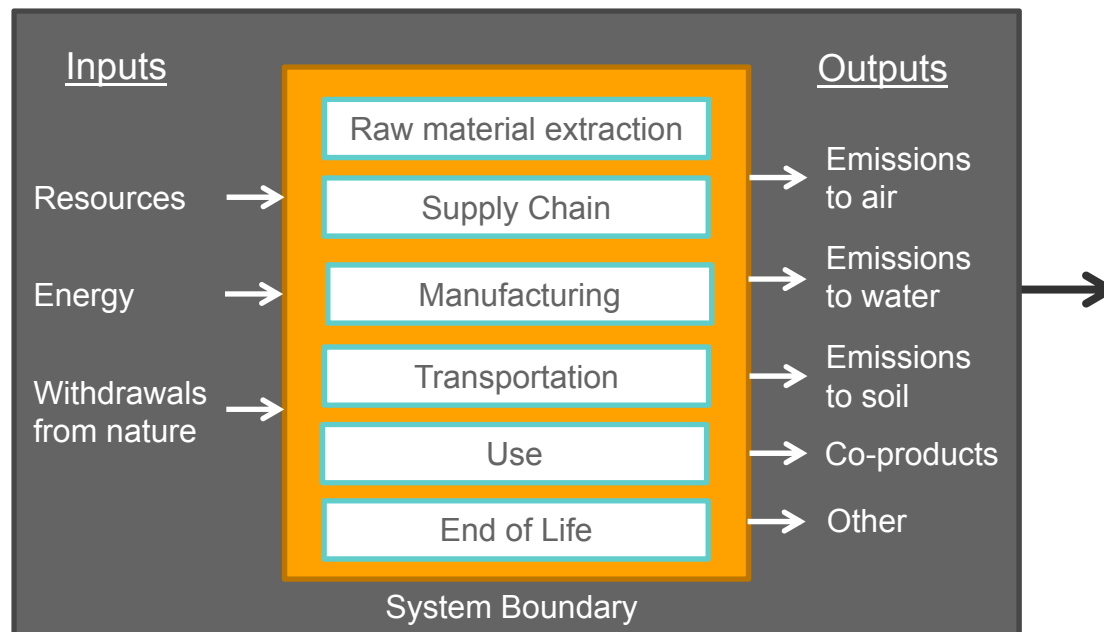
Water Footprint: Water Footprint Network



Eastman Methodology summary is published

Life Cycle Inventory

*Define scope & functional unit. Collect data.
Build model. Generate list of flows to and
from environment (resources, emissions, etc)*



Life Cycle Impact Assessment

- *Assess potential for system to impact environment*
- *Per standard metrics & characterization models published by various agencies*
- *Eastman normally uses CML methods (Leiden University)*



GaBi Software
PRODUCT SUSTAINABILITY

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Common LCIA Category Indicators


Reference: ILCD Handbook "Impact Assessment methodologies for use in Life Cycle Assessment". JRC

	Indicator of....	Common Unit
Abiotic depletion, fuel	Potential depletion of non-renewable <u>energy</u> resources	MJ
Abiotic depletion, non fuel	Potential depletion of non-renewable <u>material</u> resources	kg antimony-equivalents
Global Warming	Potential effects to climate due to infrared radiative forcing caused by emission of greenhouse gases	kg CO ₂ -equivalents
Ozone Depletion	Potential degradation of the ozone layer	kg CFC11-equivalents
Acidification	Potential to contribute to the acidification of an ecosystem	kg SO ₂ -equivalents
Eutrophication	Potential Impacts to water quality due to excessive nutrient enrichment	kg phosphate-equivalents
Photochemical Ozone Creation	Potential to create photochemical smog	kg ethylene-equivalents
Primary Energy Demand	Net consumption of energy resources, as fuel and feedstock	MJ

Carbon & Energy Footprints

- Product “Carbon Footprint”
 - Net emission of greenhouse gases aggregated as CO₂-equiv
 - a.k.a. “Greenhouse Gas Inventory”
 - Technical LCA calculation method is “Global Warming Potential”
 - Prominent standards: PAS 2050, GHG Protocol

 - Primary Energy Demand
 - Inventory of energy resources used (coal, crude oil, natural gas...)
 - Includes use as both fuels and as feedstocks

 - These two impact categories generally have a well accepted scientific basis and lower degree of uncertainty
- 

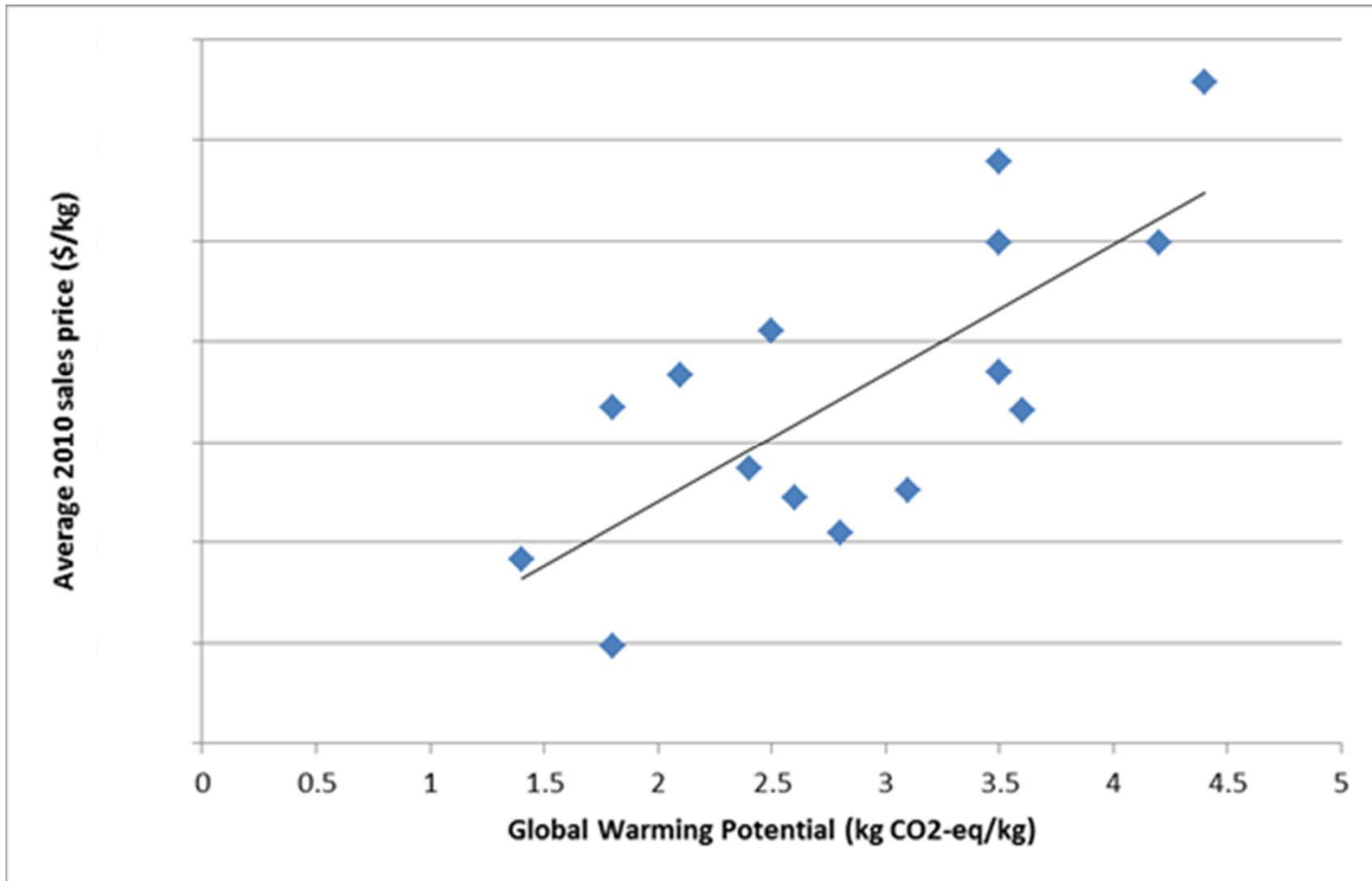
Global Warming Potential

- Each greenhouse gas has unique characterization factor to convert it to equivalent mass of CO₂
 - typically for 100 year time horizon in atmosphere
- Some examples:

Gas	kg CO ₂ -eq / kg
CO ₂	1
Methane	25
Nitrous Oxide	298
Fluoroethane	12,200
Sulfur Hexafluoride	22,800

Intergovernmental Panel on Climate Change 2007

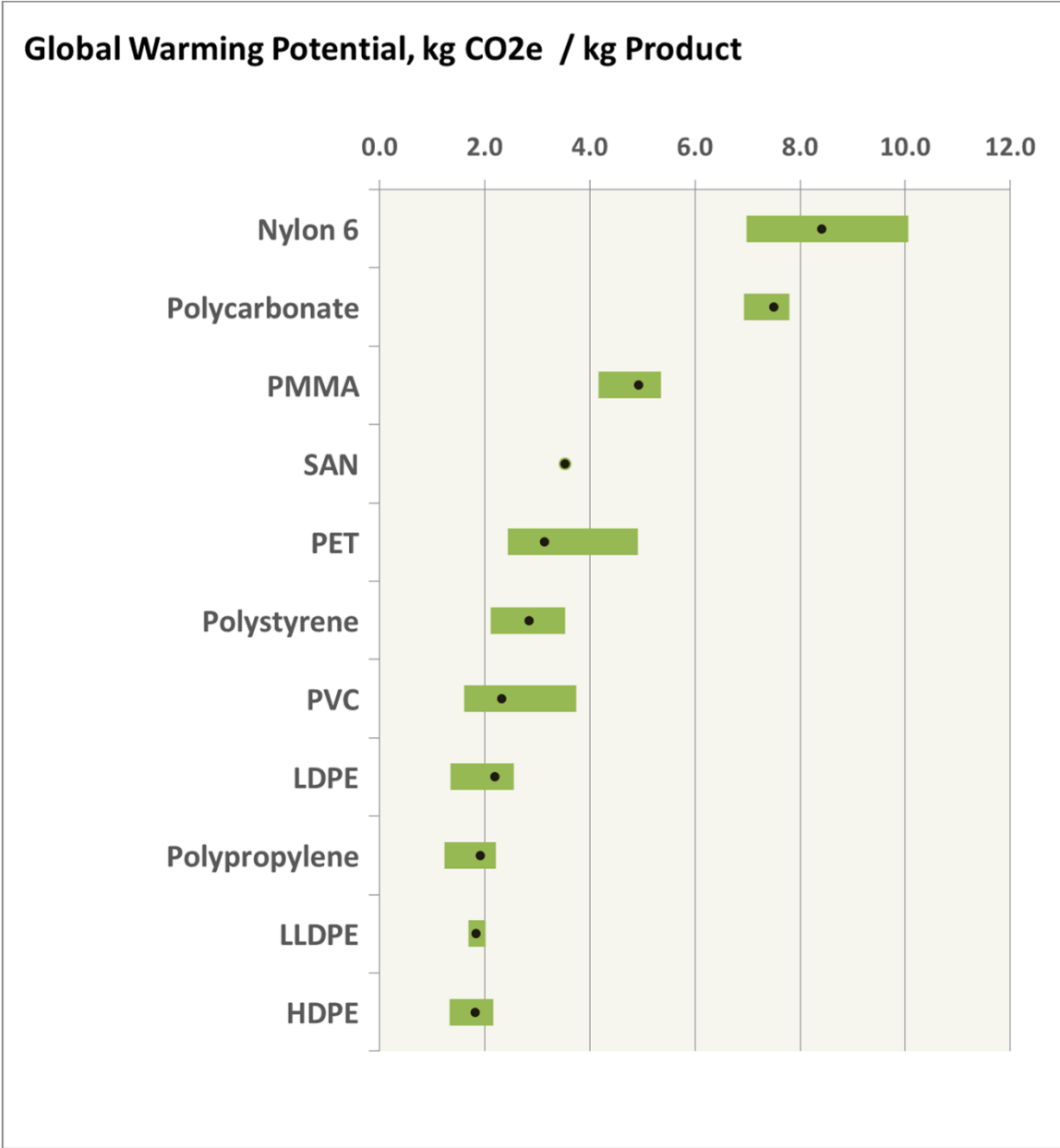
More processing = more value
= higher carbon footprint



Typical Polymers

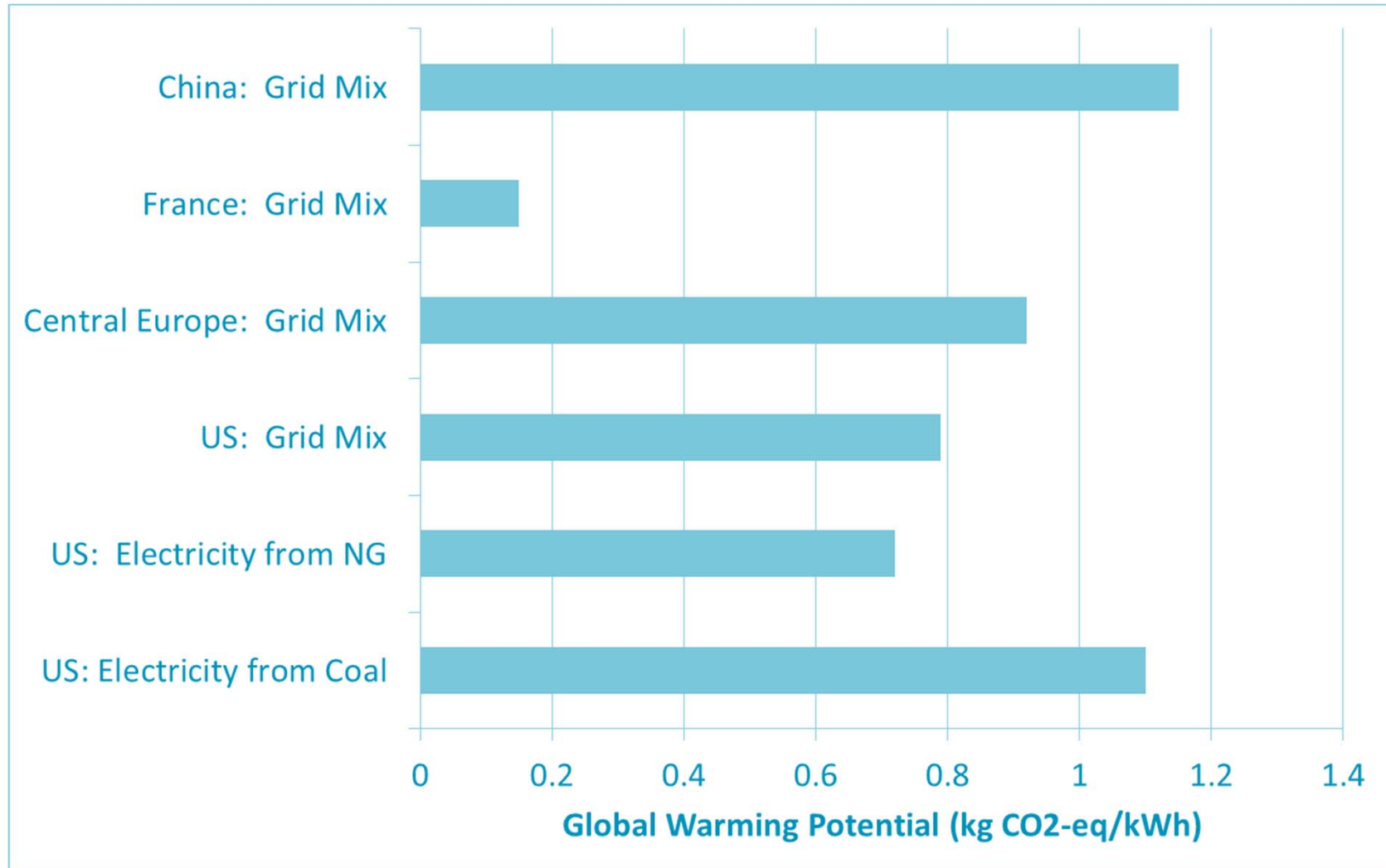
cradle-to-gate

sources:
USLCI,
PlasticsEurope,
Ecolnvent, PE
International



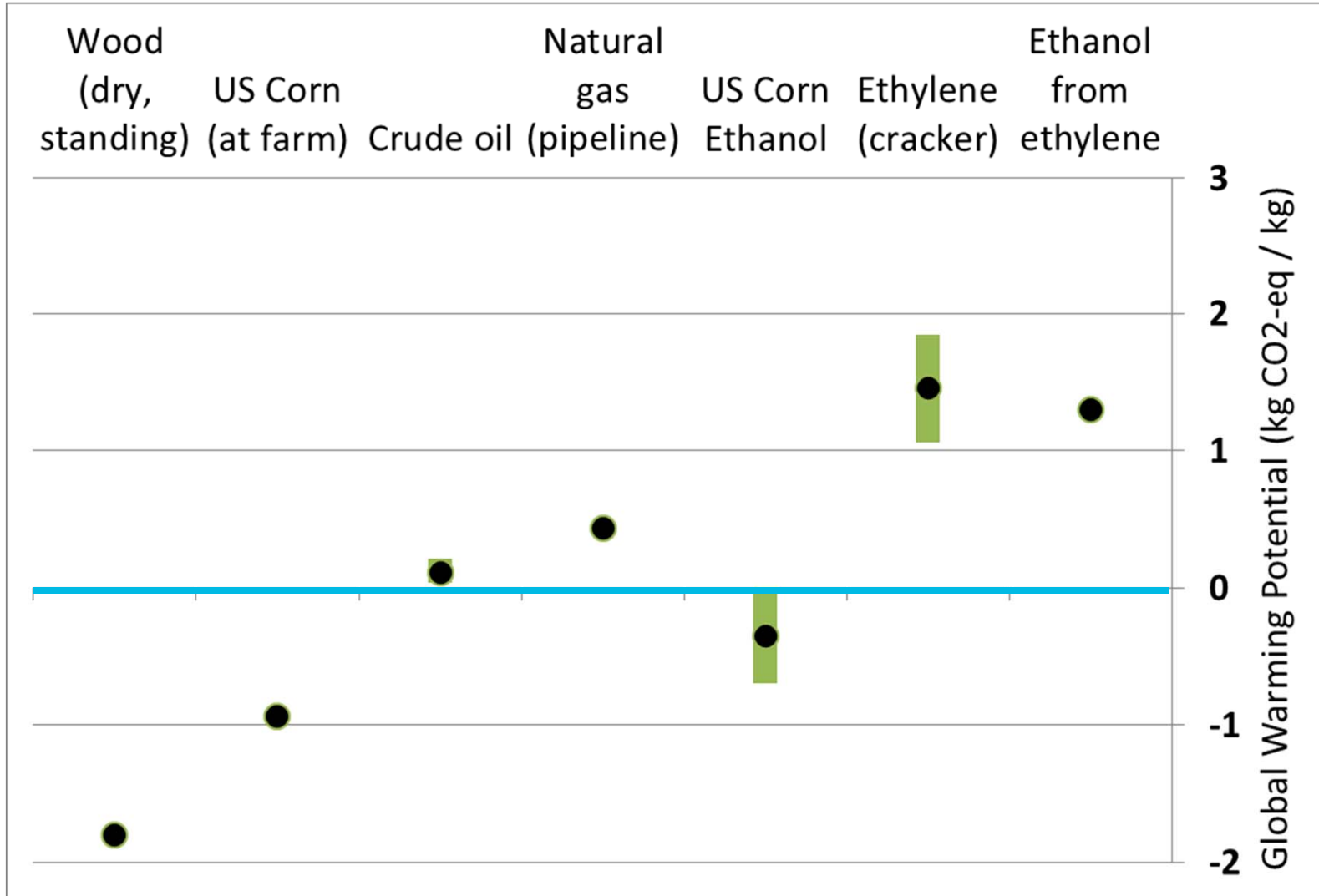
Typical Electricity

cradle-to-grid



Sources: EcolInvent, PE International

Some Feedstocks & Derivatives



Sources: Ecolnvent, PE International, PlasticsEurope, USLCl

Water Footprint

- Likely to be the next “big issue”
- *Very challenging because it involves not just accounting for quantities, but also changes in water quality (chemical & thermal)*
- Geographical / regional considerations
- Immature accounting standards
- Lack of credible impact assessment methods
 - accounting, by itself, has no environmental relevance
- Inconsistencies in published LCA databases
- Lack of meters and plant data

Interpretation

- *“LCIA results do not predict impacts on category endpoints, exceeding of thresholds, safety margins or risks”*
– ISO 14044:2006

...instead, they are intended to be
“indicators” of relative significance

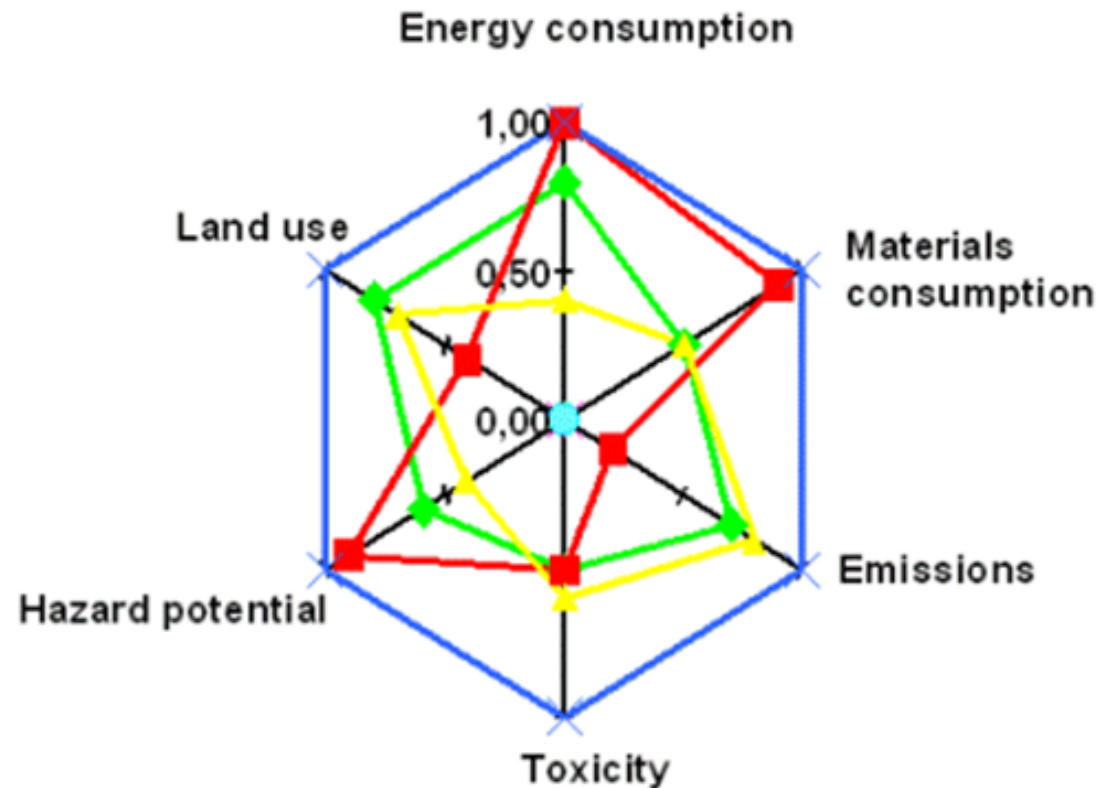
- Beware of comparing LCIA results derived from different studies

Trade-offs and context

Carbon footprint is one aspect of air emissions, which is one aspect of overall environmental emissions, which is one aspect of environmental impacts, which **is only one aspect of Sustainability**

Value choice-
Which factors are
more important?

Trade-offs are
common



**Key assumptions that have a
major impact on results**

Data collection

- Critical element of an LCA
- Sources
 - Eastman: SAP, process data, HMB's, permits, etc
 - External databases – are they representative?
 - Engineering estimates, patents, literature, suppliers, etc
- Requires significant Eastman resource demand
 - Even if LCA is being done by external consultant
 - Manufacturing staff are typically limited in availability to provide LCA support
 - Utility metering upgrades are underway but there are still gaps
- Opportunity for IT enhancements

Major External LCA Databases

- Government Organizations
 - U.S. National Renewable Energy Laboratory - USLCI Database
 - EU Joint Research Commission – ELCD Database

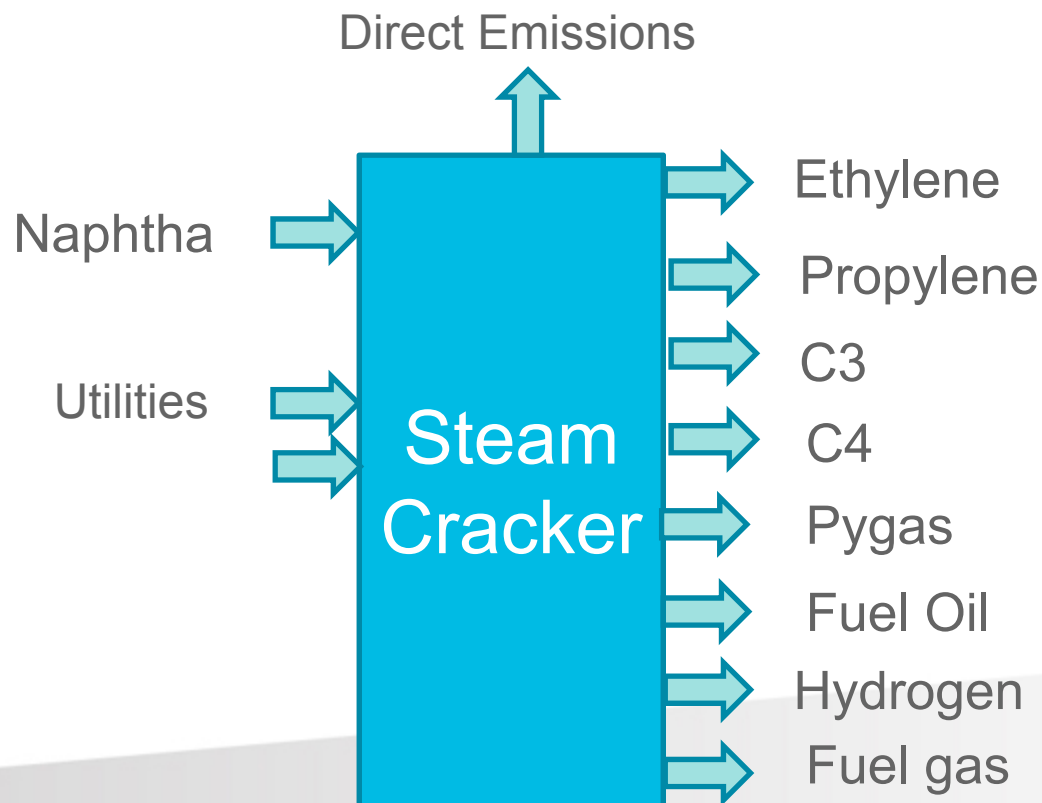
- Non-Profits and Industry Associations
 - Swiss Center for Life Cycle Inventories - EcoInvent Database
 - PlasticsEurope Database

- Private Developers (Data for sale)
 - PE International
 - Franklin Associates

- Not much data available from emerging economies

Allocation

- How do you distribute inputs & outputs among multiple co-products?
- Mass? Economics? Energy? Exergy? Avoided production credits?
- Apply to all products? Only value added products? Prime olefins?



Recycling

- How do you equitably share credits between producers of virgin material versus producers of n^{th} cycle recycled material?
 - is recycled material “burden-free” at inlet gate of recycler?
 - Cradle-to-Cradle



Product X carbon footprint = 3.78366619 kg CO₂e/kg?

Uncertainties

- Parameter uncertainty: error, uncertainty, and variability in data used in inventory model

- Model uncertainty: disregarding potentially relevant aspects of real world in model structure
 - non-linear processes, data gaps, spatial & temporal aspects of emissions, interactions

- Scenario uncertainty: choices made in scenarios
 - choice of functional unit, system boundaries, allocation procedure, recycling, impact assessment methods, assumptions

- How to quantify & communicate?

Application of LCA

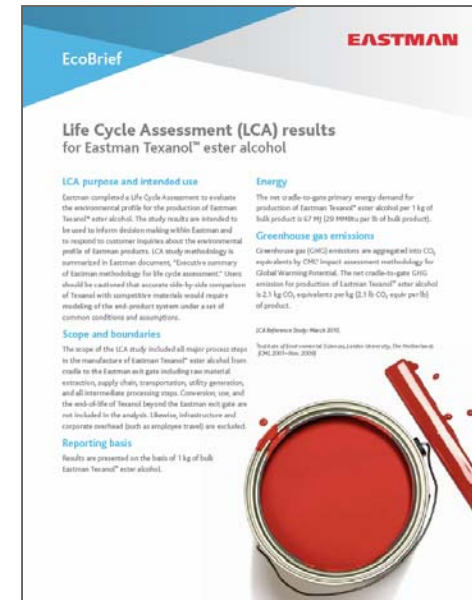
Screening LCA's

- Full ISO compliant LCA's are needed for credible external communication
- Simplified LCA's can be very useful for internal analyses
 - Valuable to apply early in innovation or design to compare alternatives
 - Likely to focus on limited set of LCIA metrics
 - Could also consider sustainability aspects outside of LCA:
 - Product safety – toxicity
 - Process safety
 - Materials targeted for de-selection
 - Social issues
 - Recyclability
 - Regulatory issues
 - Promote life cycle thinking throughout organization

External Communication

Eastman Standard External LCA Documents

- EcoBriefs
 - Energy & GHG Inventory only
- EcoFootprints
 - Broader spectrum of LCIA results
 - Typically requires confidentiality agreement



Other Possibilities

- Eco-labels
- Environmental Product Declarations
- Eco-efficiency (BASF)
- Indices
- Other

LCA Limitations

- Results reflect the data, methods & assumptions...for specific scenarios
- Useful interpretation requires understanding of details
 - Published databases limited in documentation
 - Minimal data available for Asia or Latin America
 - LCA models & reports contain confidential information
- Standards are still evolving and not harmonized
- Results require interpretation (dialogue is key!)
 - Risk of misapplication
 - Difficult to compare separate studies
 - Communication challenges
- Full ISO compliant LCA is resource intensive

LCA Benefits

- Significant insights into processes
 - Hot spots?
 - What is under Eastman control?
 - Where to focus R&D or to press suppliers?
 - What are downstream implications?
 - Where do trade-offs exist?
- Quantitative metrics and value proposition for sustainability
- Ability to engage in meaningful dialogues
 - Internal & external
 - Partnership
- Provide info to decision makers (material selection, R&D, etc)

A photograph of a family—a woman in a light blue shirt and dark blue skirt, a man in a red and white plaid shirt and blue jeans, and a young child in a floral dress—walking away from the camera on a grassy hill. The foreground is dominated by large, green, pointed leaves, possibly from a plant like an iris. The sky is bright blue with scattered white clouds.

Our sustainability
journey continues.

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www.eastman.com/sustainability

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