Evaluating the social, economic and environmental consequences that flow from your activities.

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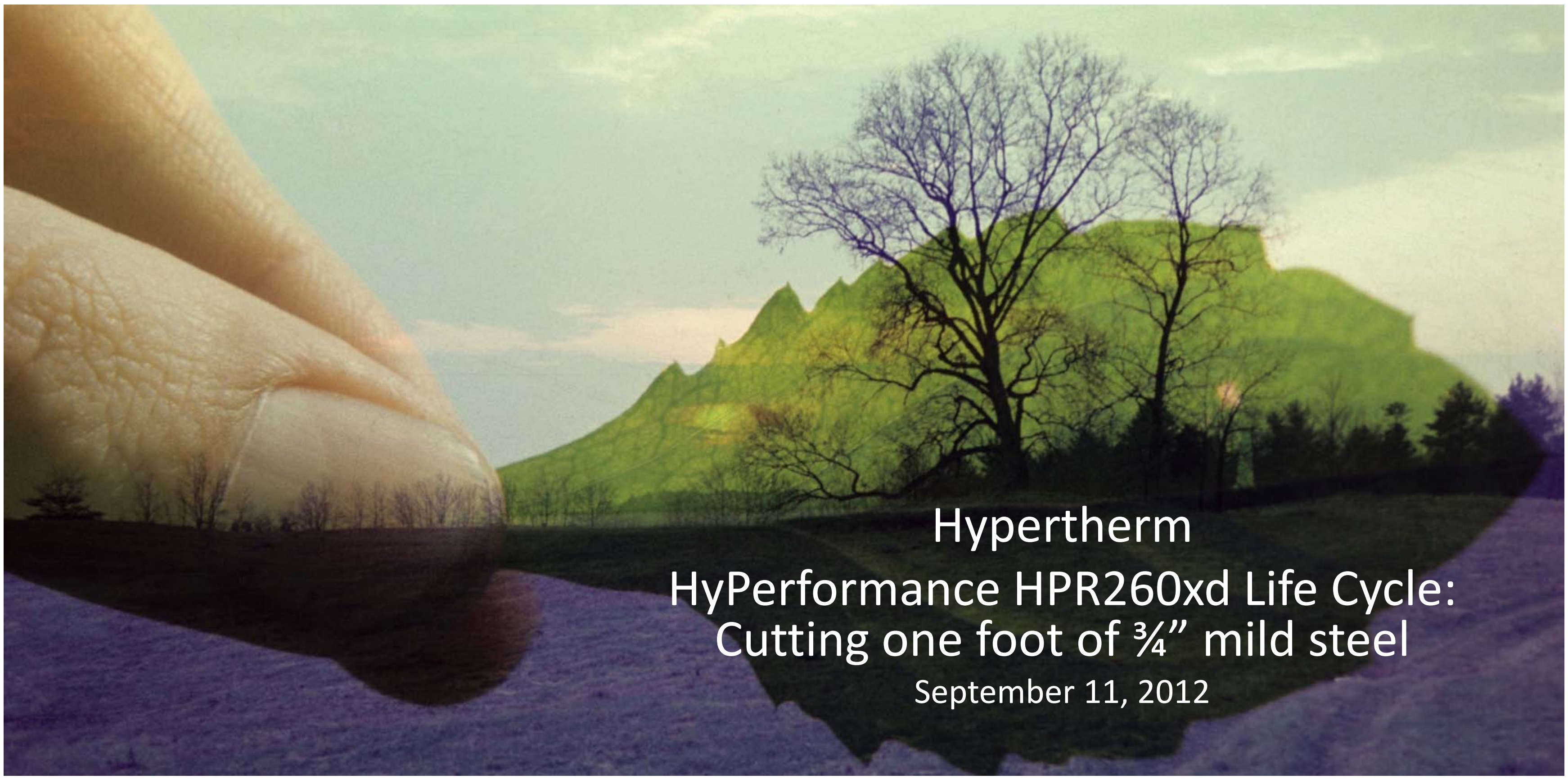

Hypertherm
HyPerformance HPR260xd Life Cycle: Cutting one foot of ¾” mild steel

September 11, 2012

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What a screening level LCA is good for

- Identifies with a reasonable level of certainty where in the product life cycle impacts are occurring (hot spots)

- Allows companies to determine where they have leverage to make change

- May identify obvious changes that will reduce impacts

- May enable comparisons with other systems to understand potential advantages (e.g., marketing advantages) and trade offs

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What a screening level lca is not good for

- Publishing results of a single product LCA
- LCA-based eco-labels (e.g., EPDs)

  These require a more thorough report and peer review

- Carbon and water footprints

  These require consideration of a standard in the modeling and reporting structure and a more thorough report

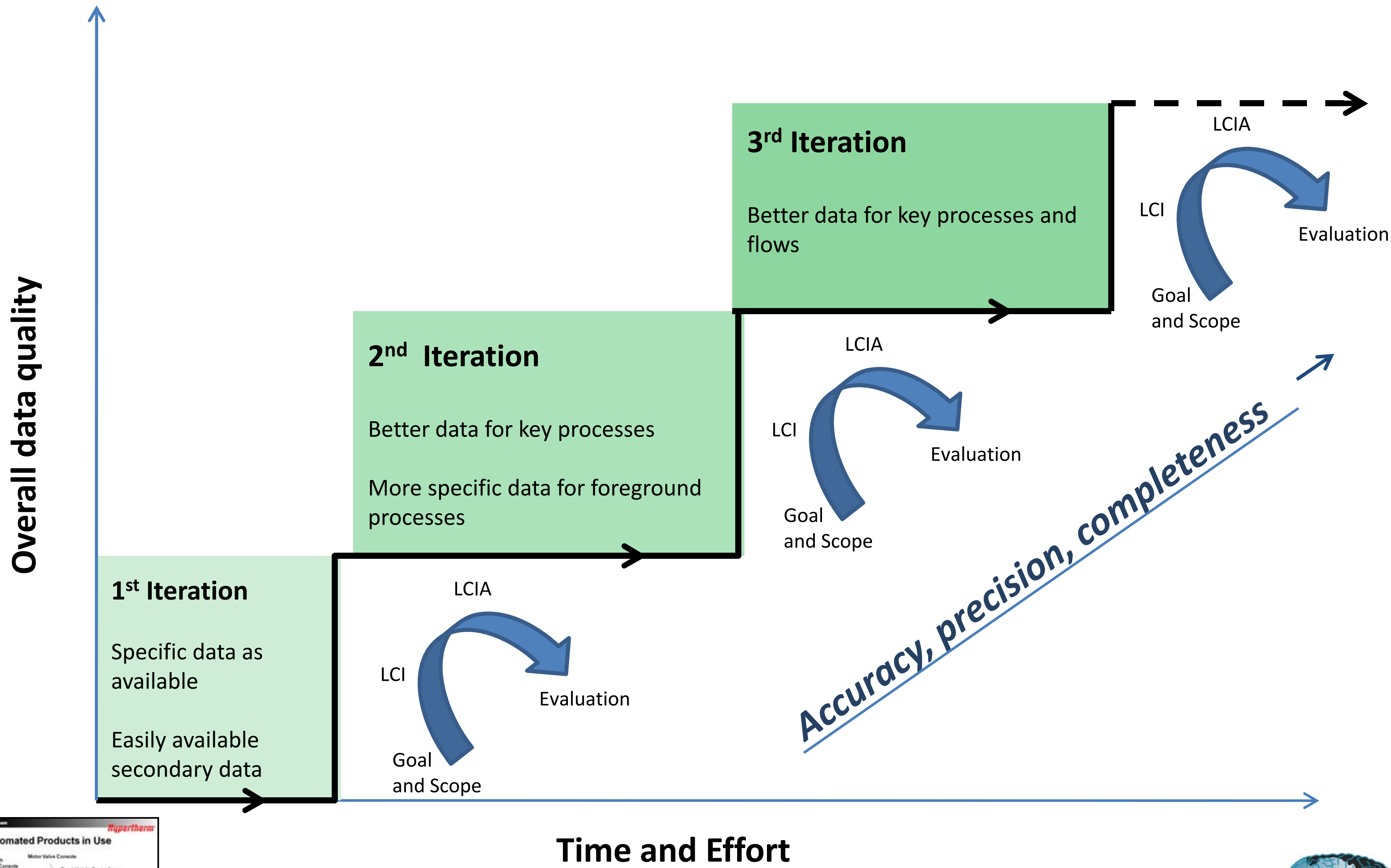
- Sharing comparisons outside of the company for any purpose including marketing claims

  This requires extensive reporting and a 3-party critical review

- Use of the results for policy decisions

  This should include consequential thinking/modeling, extensive reporting and critical review

Iterative Nature of LCA



Taken from: ILCD-Handbook-General-guide-for-LCA-DETAIL

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Goal & Scope

- **Intended application**
  - Cradle to grave screening level LCA of HyPerformance HPR260xd – a mechanized plasma cutting system
- **Reasons for carrying out the study**
  - To help drive product innovation, meet customer demands for information, and identify where the biggest impacts are occurring throughout the life cycle of their plasma cutting equipment
- **Target audience**
  - The initial audience will be internal to Hypertherm: the Sustainability team, the HPR and Powermax engineering teams, the consumables team, the marketing team, the manufacturing team, and the operations and facilities team
- **Functional unit**
  - Cutting one foot of ¾" thick mild steel using the HyPerformance HPR260xd Plasma Cutter at a feed rate of 90 inches per minute

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System Boundaries

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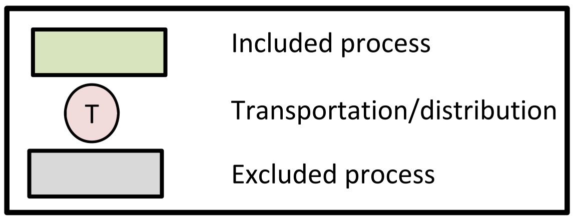

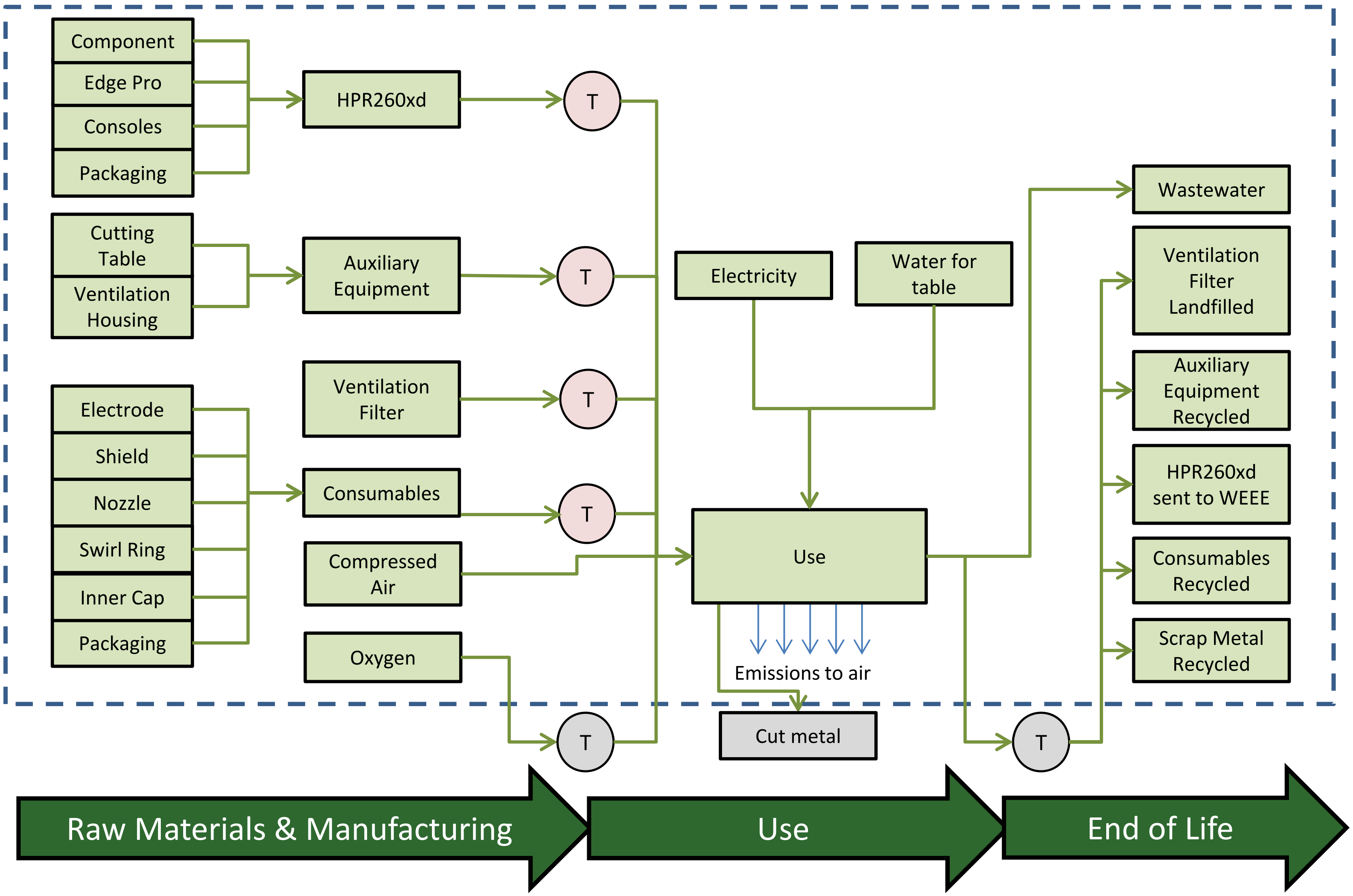

Life Cycle Inventory

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- Based on Hypertherm data
  - ¾” thick mild steel, feed rate of 90 inches per minute, 260 amps
  - Capital equipment lasts 7 years and cuts 302,000 feet per year
  - Consumables (Electrode lasts 1,687.5 feet)
  - Auxiliary equipment (cutting table and ventilation housing) lasts 15 years
  - Ventilation filters last 1 year
  - Electricity use: 0.102 kWh per foot of cut
  - Customer transport distance and modes
    - China 12,508 km by air freight
    - Europe 5,576 km by air freight
    - Kansas 2,253 km by truck
- Based on costing model data
  - Oxygen and compressed air

*For full modeling details, including material and processing processes, as well as packaging data, please see *Hypertherm_Data Collection Workbook for HPR260xd.xlsx*

Assumptions

– Raw materials & manufacturing
  - Hypertherm supply chain is equivalent to “average” supply chain within our LCI dataset
  - Hypertherm processing is similar to “average” processing of a similar type within our dataset
  - No additional production emissions captured
  - Pallets and reusable boxes are assumed to be reused 5 times
  - Cutting table modeled as stainless steel (18/8)
  - Ventilation equipment modeled as mild steel plus consumed filter

*For full modeling details, please see *Hypertherm_Data Collection Workbook for HPR260xd.xlsx*

Assumptions

– Use
  - Air emissions from customer sites are similar to emissions from Hypertherm labs (may change based on metal cut)
  - Water emissions after treatment are similar to emissions from a truck manufacturing facility
  - Employee activities and safety equipment have been ignored

– End of Life
  - Capital equipment disposed according to WEEE: recycling, or sanitary landfill, depending on component
  - Consumables recycled
  - Auxiliary equipment recycled
  - Ventilation filters disposed of in sanitary landfill
  - Scrap metal recycled

*For full modeling details, please see *Hypertherm_Data Collection Workbook for HPR260xd.xlsx*

Impact Assessment Method

Damage Category	Units	From	Comments
Human health	DALY	ReCiPe Endpoint (H)	Accounts for years lived disabled as well as life cut short
Ecosystems	Species * yr	ReCiPe Endpoint (H)	Assessed in units of species * yr, or the number of species that may disappear due to the impact times the area over which they are affected times the duration that the species are affected
Resources	Economic units	ReCiPe Endpoint (H)	Puts a future value on resources which will be unavailable since we are using them today
Climate change	kg CO_2 eq.	IPCC 100a	Same method used by most GHG accounting programs
Water	m^3	ReCiPe Midpoint (H)	Counts the amount of water consumed. **Does not show impact. Used for benchmarking only.**
CED	MJ	Cumulative Energy Demand	Adds up different categories of energy

Impact Assessment Method: ES Method

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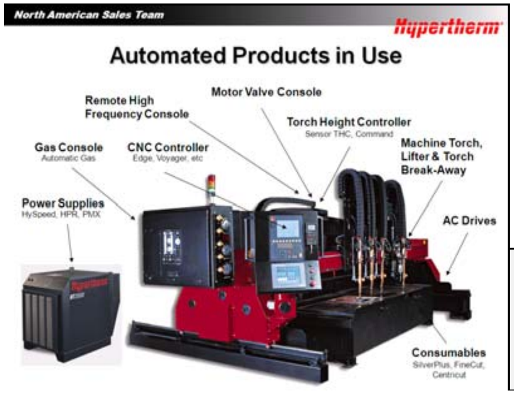
What are the environmental hot-spots?

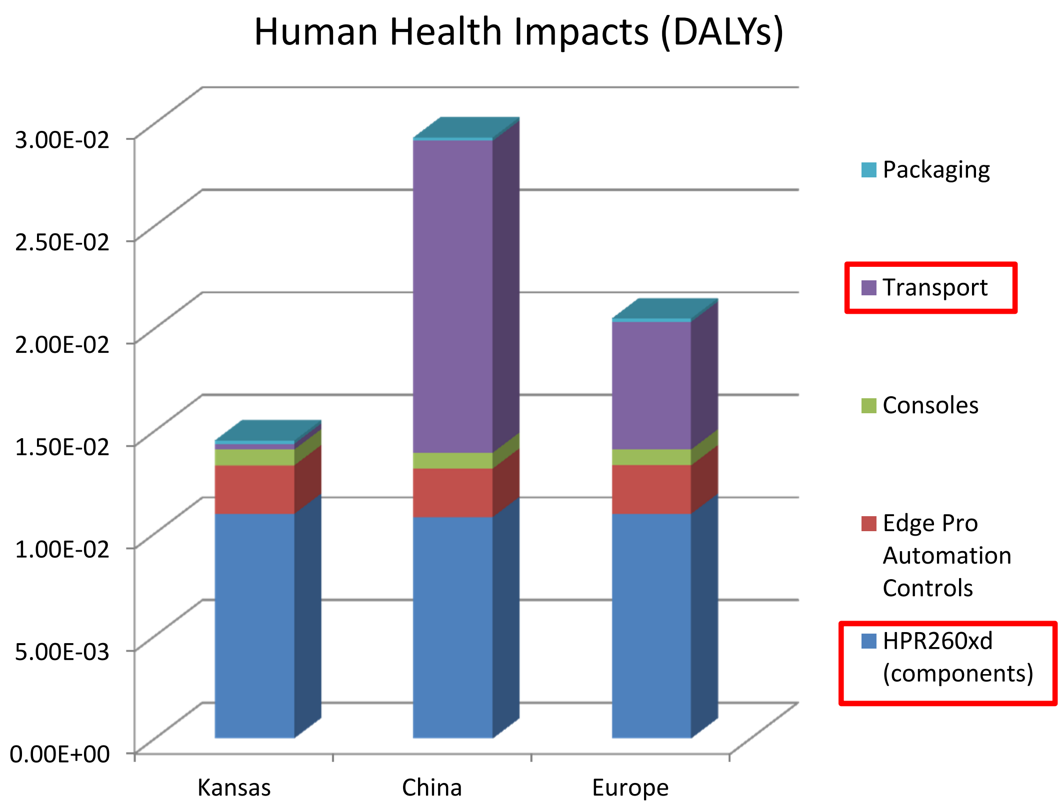
CONTRIBUTION ANALYSIS

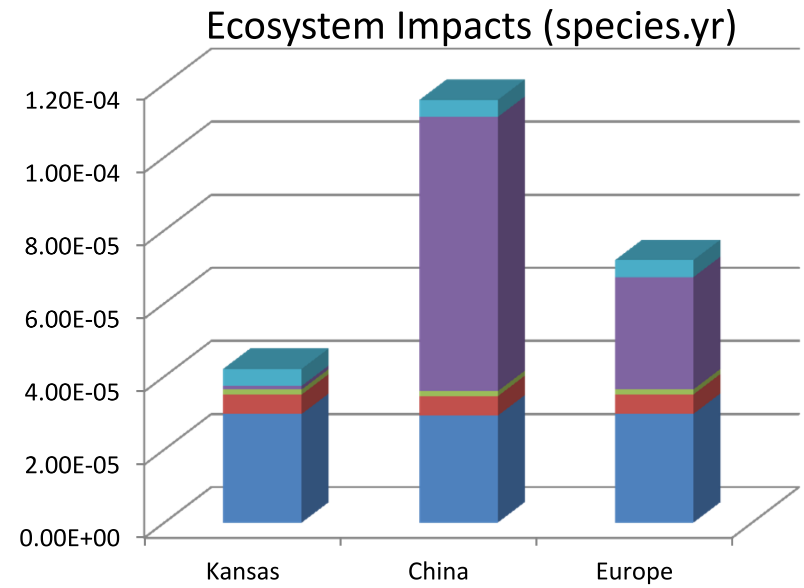


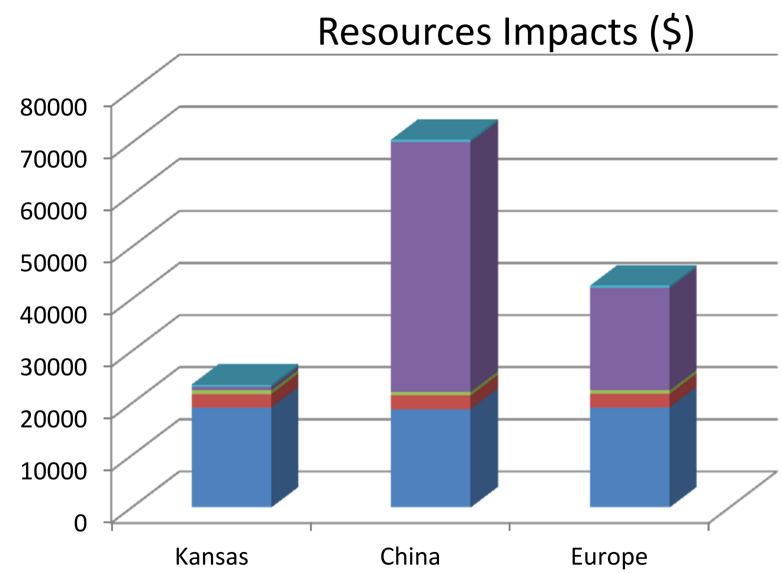
Objective
To understand the cradle-to-grave impacts of the HyPerformance HPR260XD plasma cutting equipment

Contribution Analysis

HPR260xd, Equipment Only



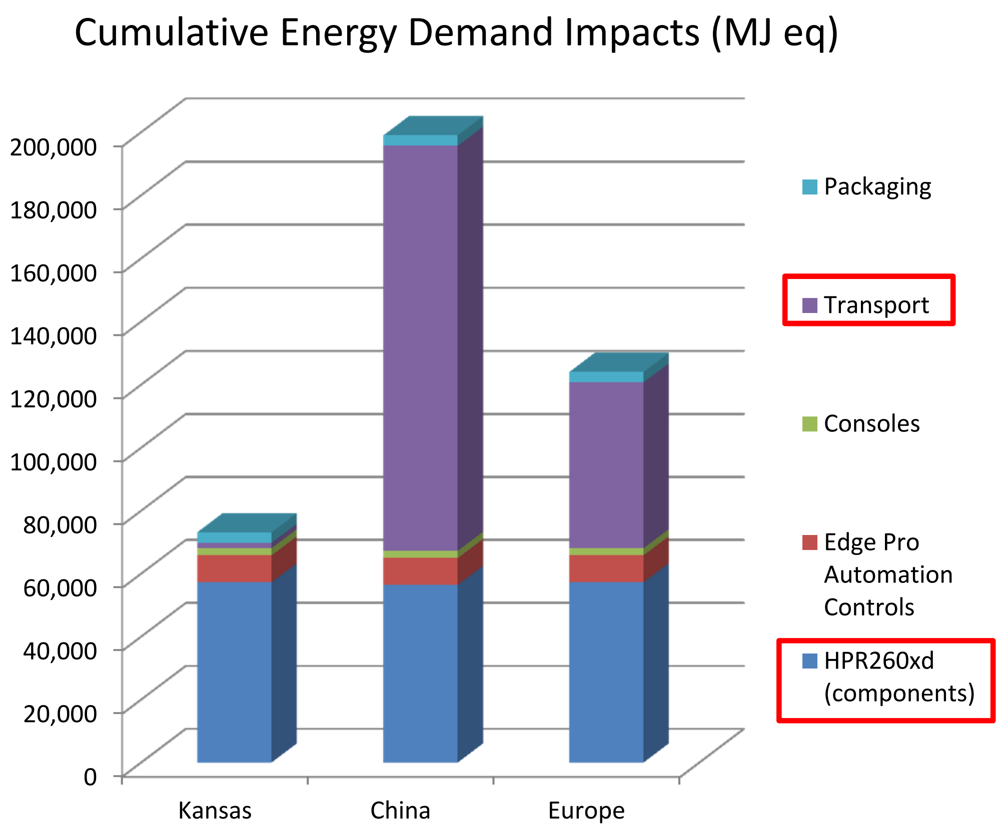


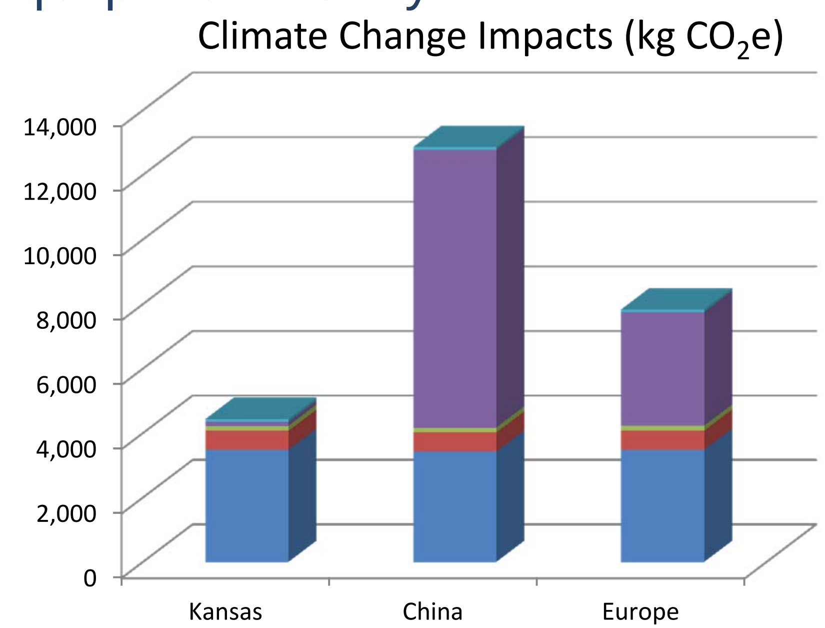


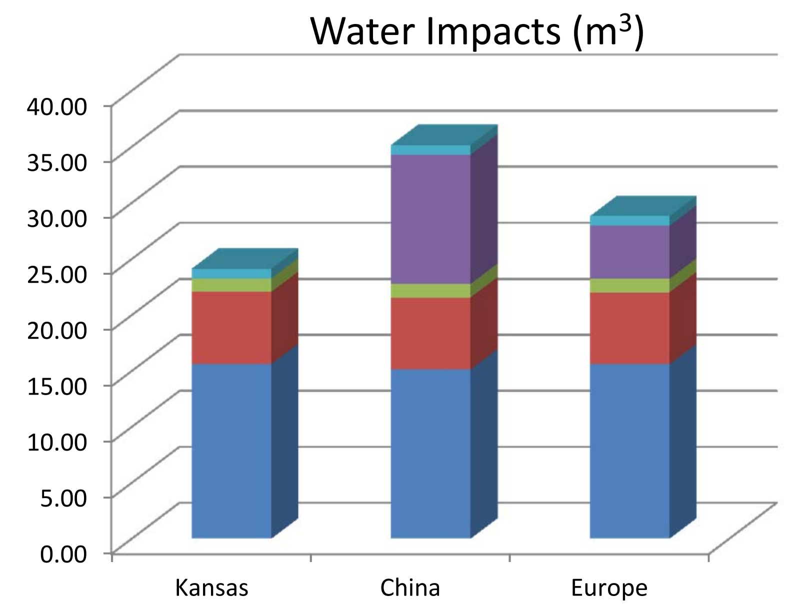
Impact Assessment Method: ES Method

Contribution Analysis

HPR260xd, Equipment Only







Impact Assessment Method: ES Method

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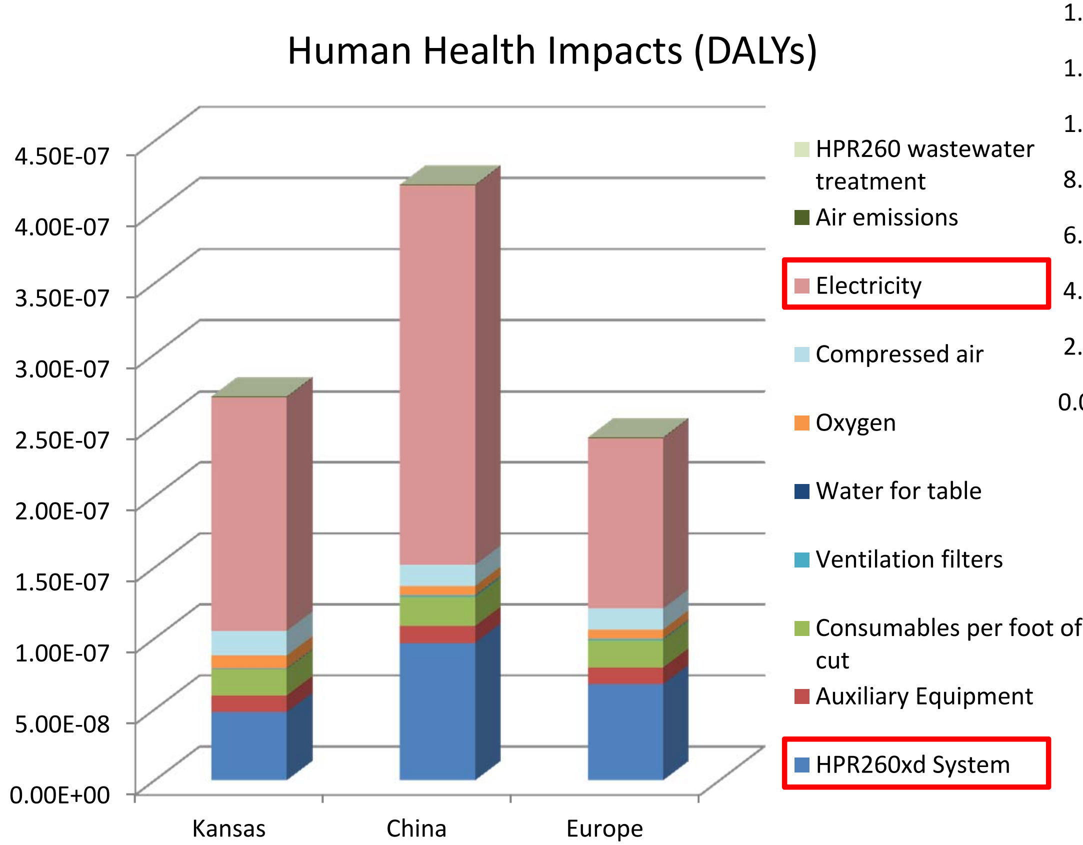
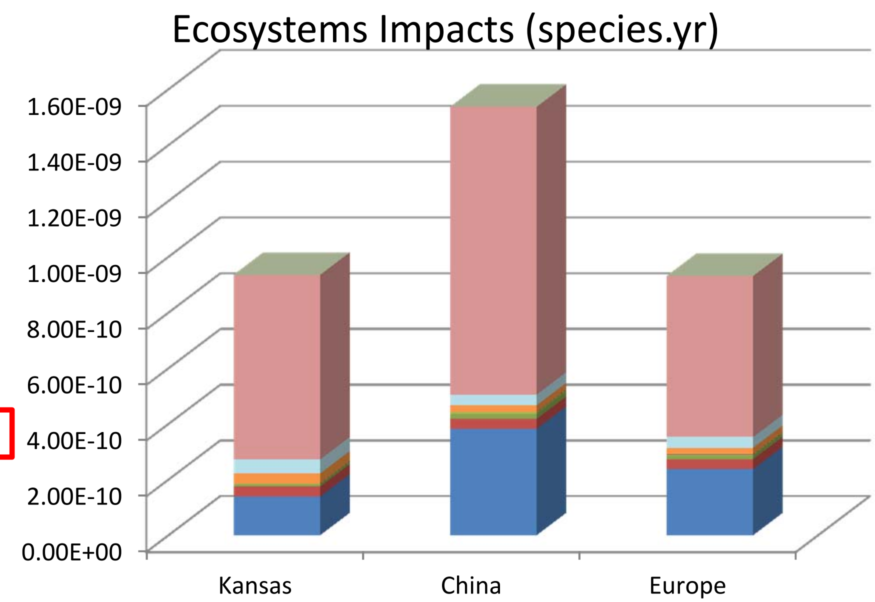
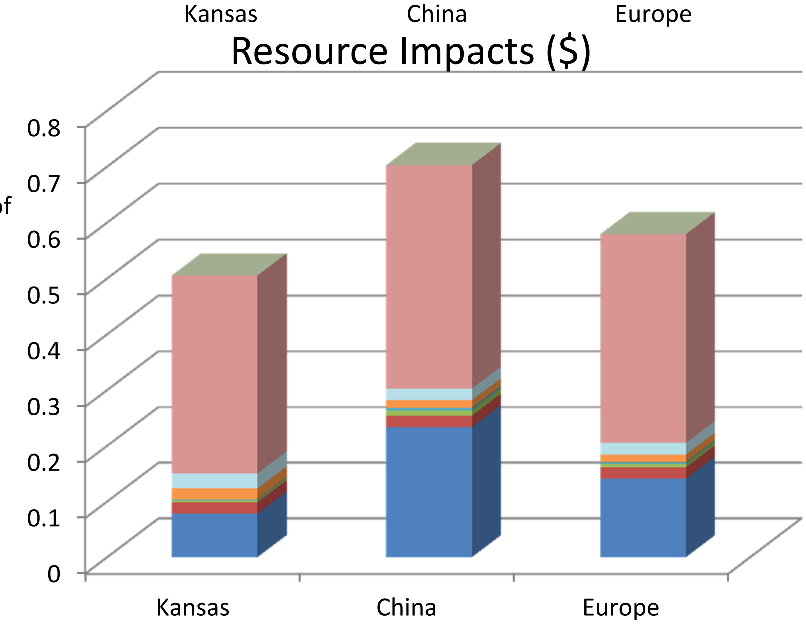
Contribution Analysis

Per foot of cut, ignoring scrap



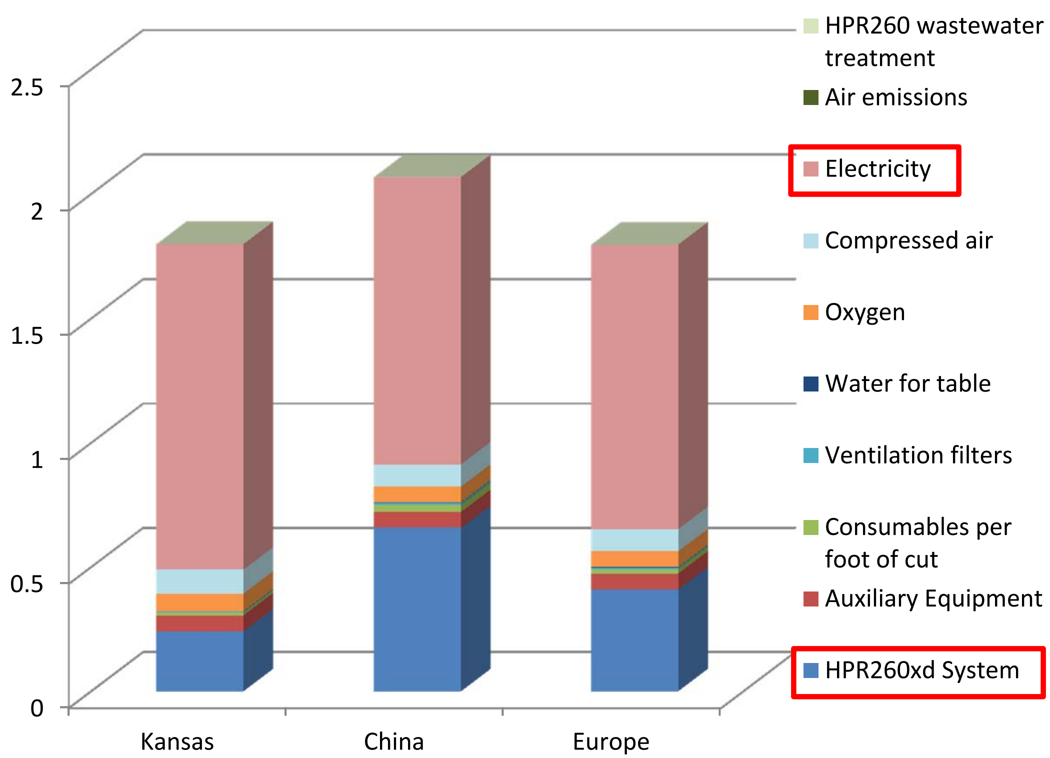


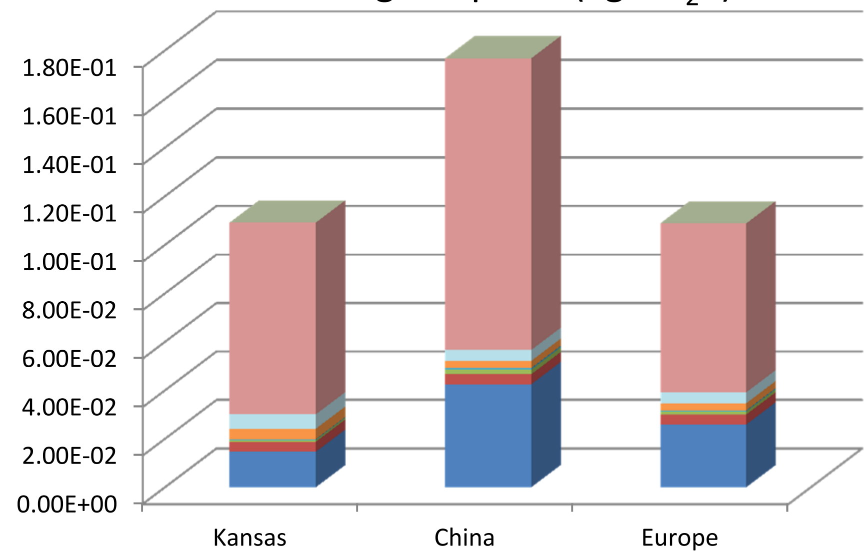


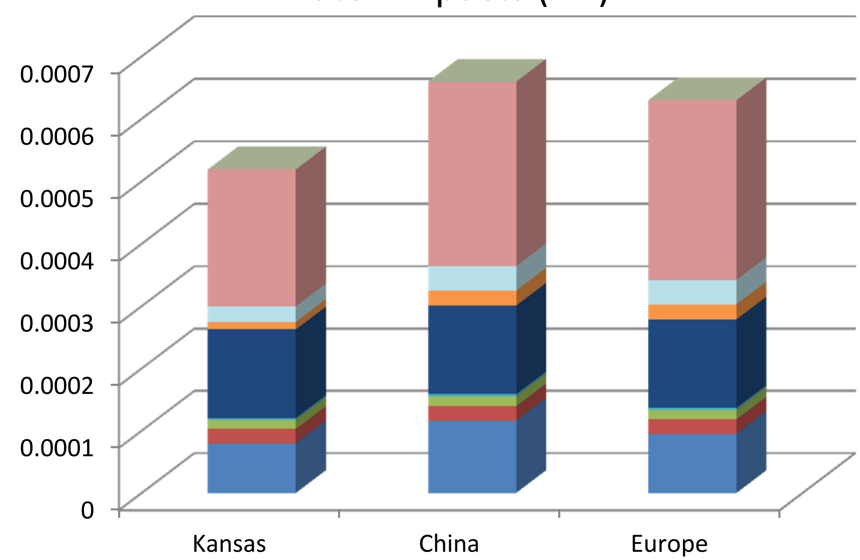
Impact Assessment Method: ES Method

Contribution Analysis

Per foot of cut, ignoring scrap







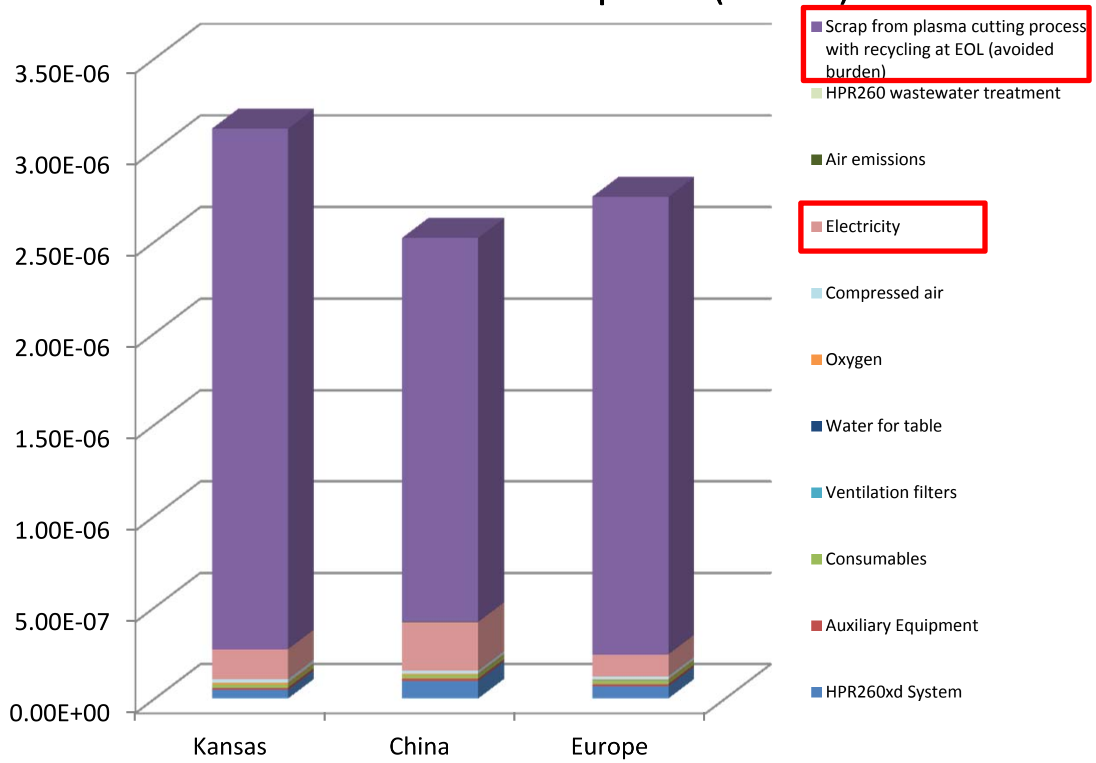
Impact Assessment Method: ES Method

Contribution Analysis

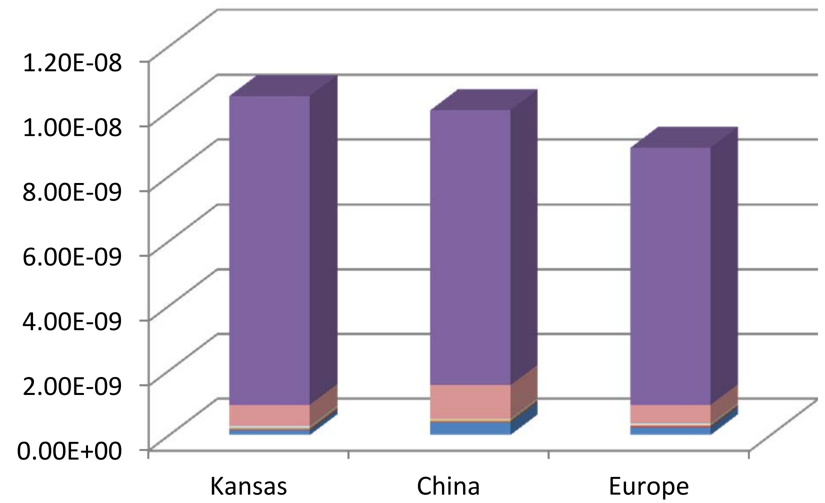
Per foot of cut with scrap

3.72 lbs of scrap per foot of cut

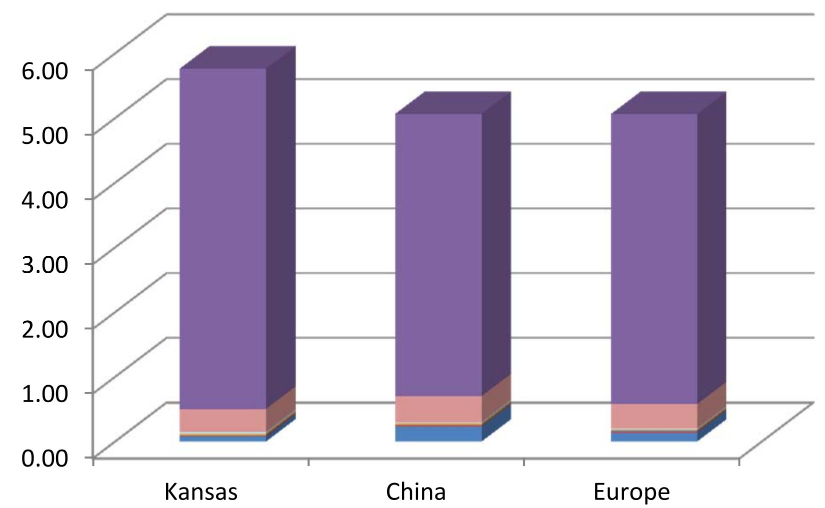
Human Health Impacts (DALYs)



Ecosystem Impacts (species.yr)



Resources Impacts ($)



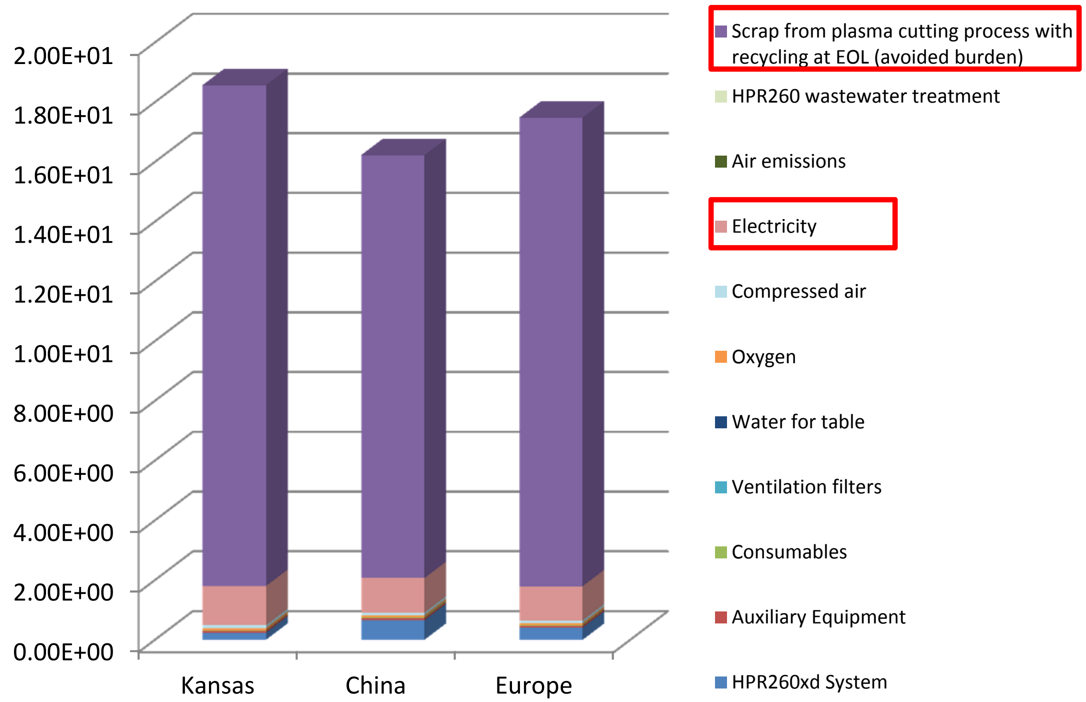
Impact Assessment Method: ES Method

Contribution Analysis

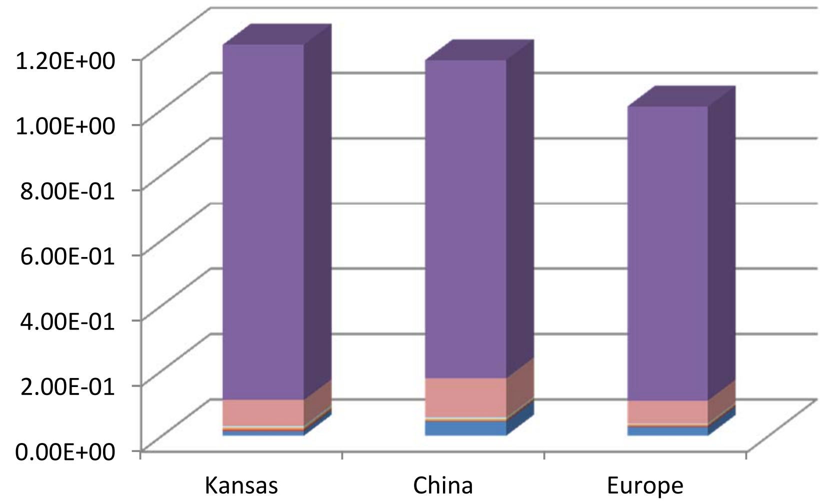
Per foot of cut with scrap

3.72 lbs of scrap per foot of cut

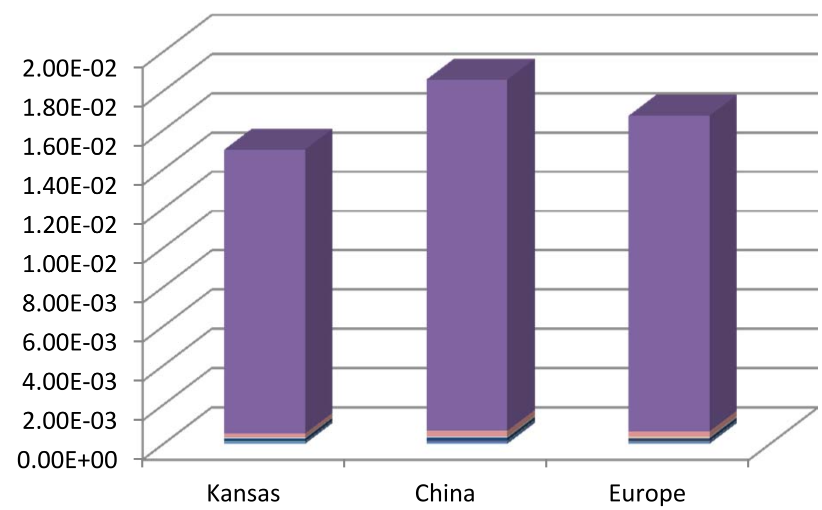
Cumulative Energy Demand Impacts (MJ)



Climate Change Impacts (kg CO_2e)



Water Impacts (m^3)



Impact Assessment Method: ES Method

Contribution Analysis

Per foot with scrap, in China

	TOTAL	Air emissions	Scrap from plasma cutting process	Water for table	Auxiliary Equipment	Consum-ables per foot of cut	HPR260xd System	Ventilation filters	Oxygen	Compress-ed air	Electricity	HPR260 waste water treatment
Human Health (DALYs)	**2.52E-06**	2.78E-10	2.10E-06	1.19E-10	1.17E-08	2.04E-08	9.69E-08	1.16E-09	6.54E-09	1.49E-08	2.67E-07	2.34E-11
Ecosystems (species.yr)	**1.00E-08**	1.47E-14	8.49E-09	5.33E-13	3.58E-11	1.78E-11	3.83E-10	5.58E-12	2.48E-11	3.83E-11	1.03E-09	8.68E-14
Resources ($)	**5.07E+00**	0	4.36E+00	2.32E-04	2.06E-02	9.87E-03	2.33E-01	3.60E-03	1.38E-02	2.12E-02	4.00E-01	3.50E-05
CED (MJ eq)	**1.62E+01**	0	1.42E+01	8.60E-04	6.40E-02	2.77E-02	6.58E-01	1.00E-02	6.36E-02	8.94E-02	1.15E+00	1.06E-04
Climate Change (kg CO2e)	**1.15E+00**	0	9.76E-01	5.47E-05	4.12E-03	1.85E-03	4.25E-02	6.55E-04	2.96E-03	4.49E-03	1.20E-01	1.02E-05
Water (m3)	**1.86E-02**	0	1.79E-02	1.42E-04	2.29E-05	1.60E-05	1.16E-04	3.59E-06	2.41E-05	3.93E-05	2.95E-04	1.99E-07

Impact Assessment Method: ES Method

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Comparison against Reference

	Human Health (DALYs)	Ecosystems (species. yr)	Resources ($)	CED (MJ eq)	Climate Change (kg CO_2e)	Water (m^3)
Cutting with the HPR260xd for 8 hours*	3.17E-03	1.26E-05	6,384	20,446	1,453	23.4
Driving a passenger car for 8 hours	3.31E-04	1.81E-06	1,013	2,907	184	0.450

***With scrap, in China**

Cutting with the HPR260xd results in about 10x as many impacts as driving a car at 65 miles per hour.

Impact Assessment Method: ES Method

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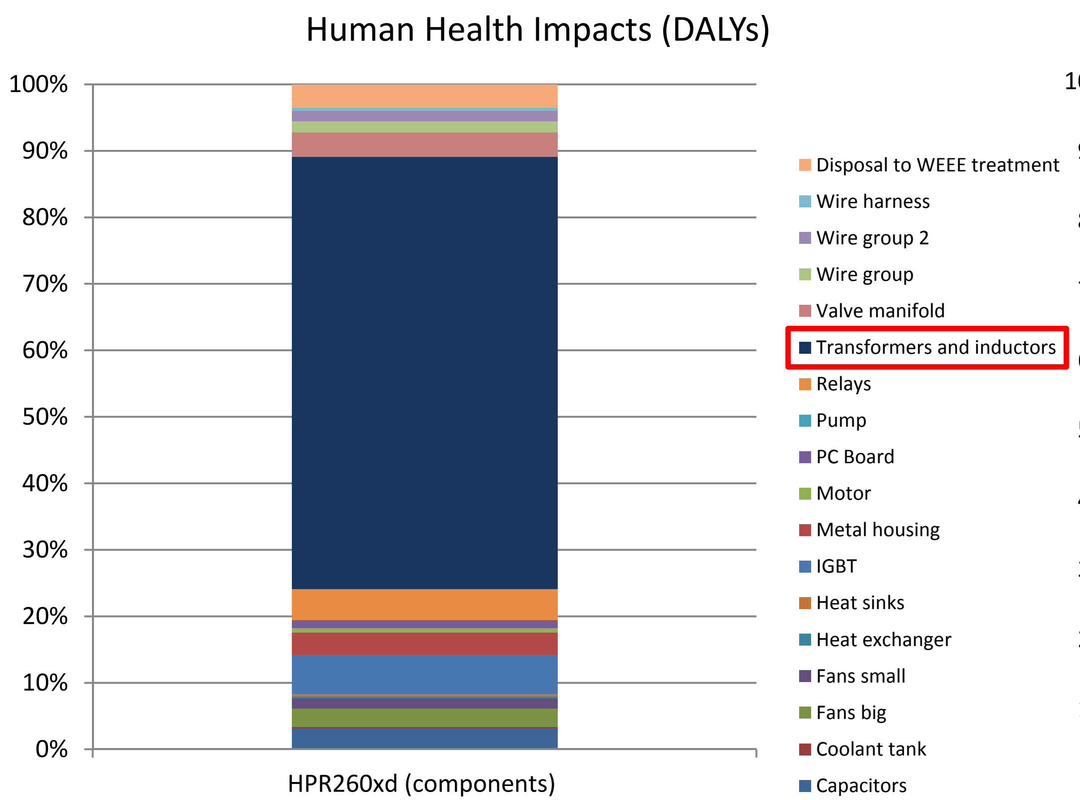
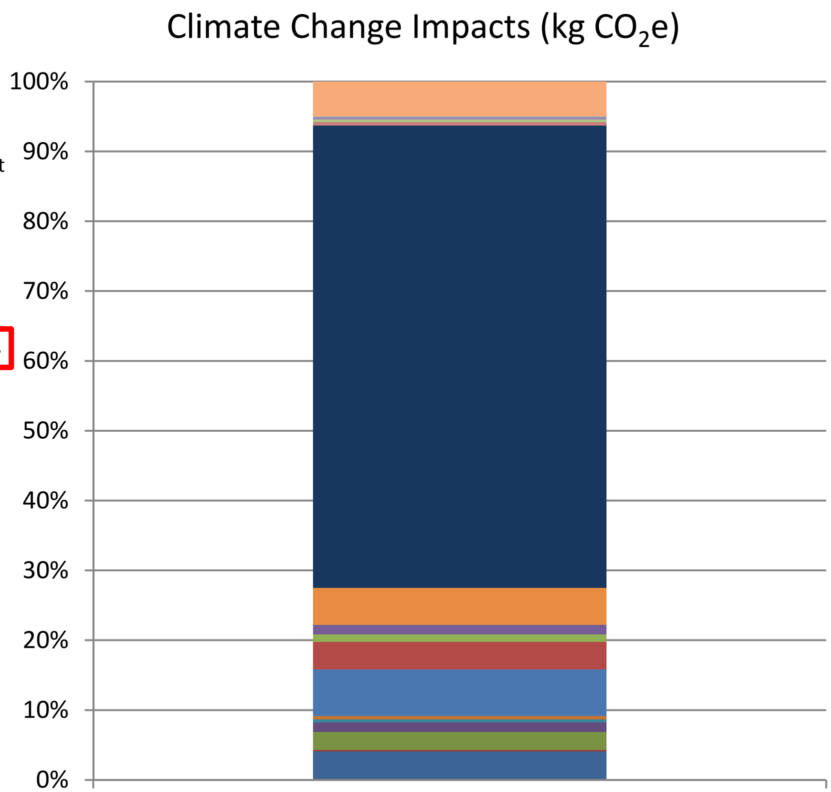
Contribution Analysis

HPR components only

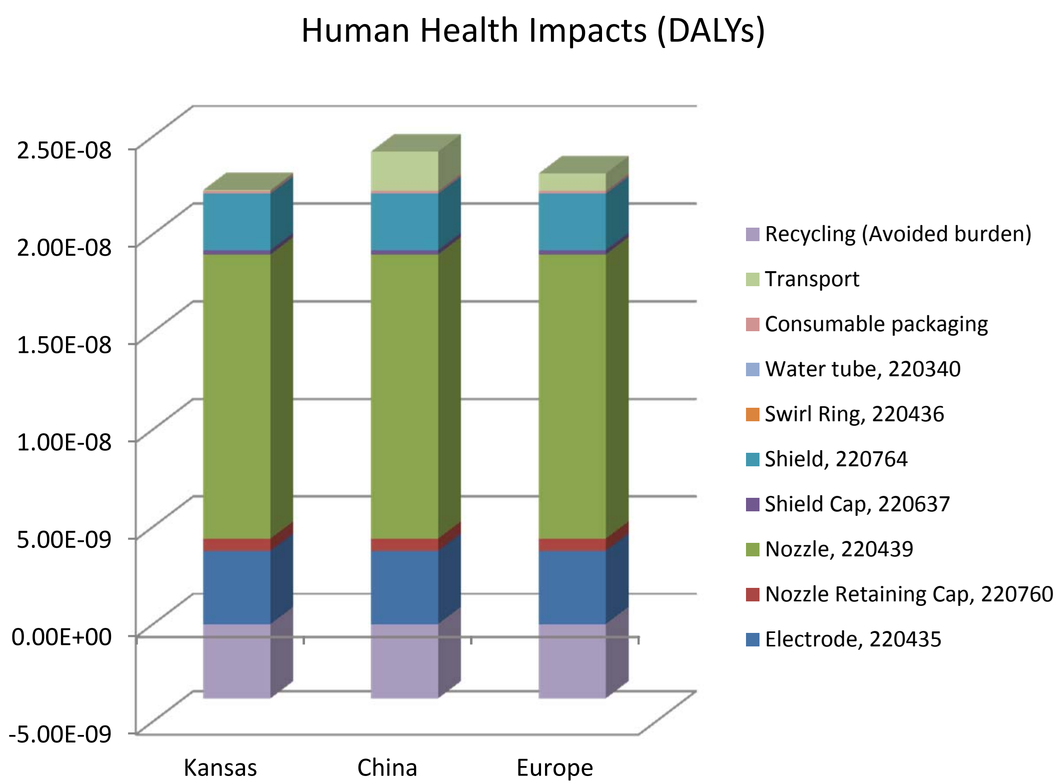


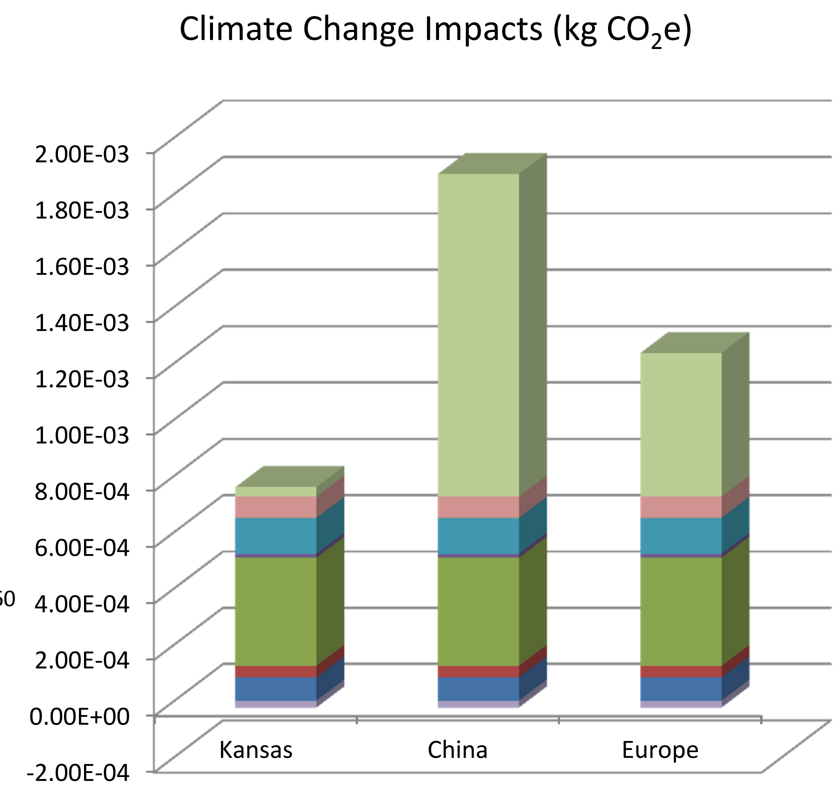


Impact Assessment Method: ES Method

Contribution Analysis

Consumables per foot of cut





Impact Assessment Method: ES Method

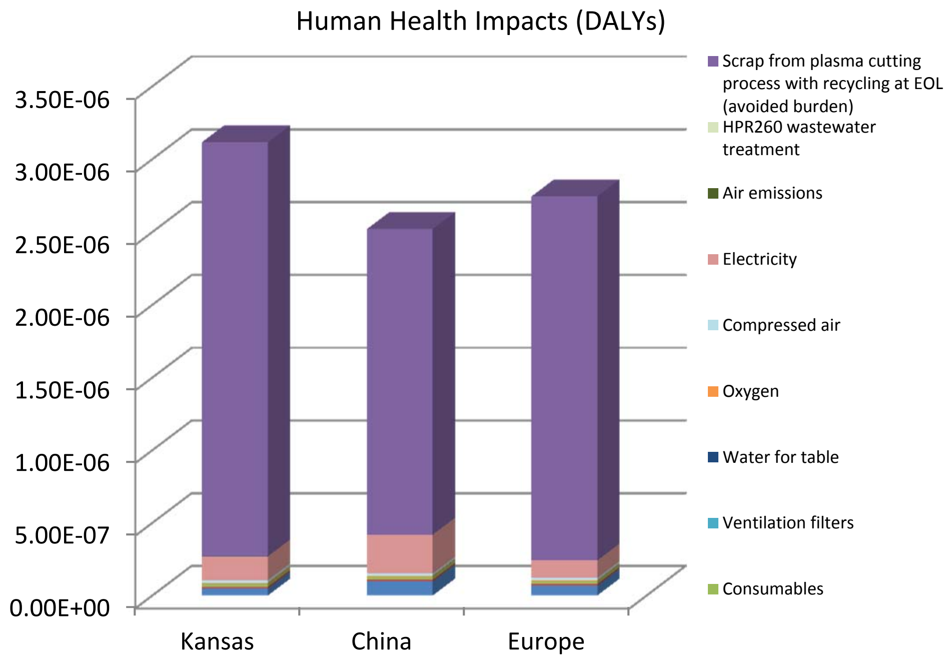
Contribution Analysis
Environmental Hot-Spots

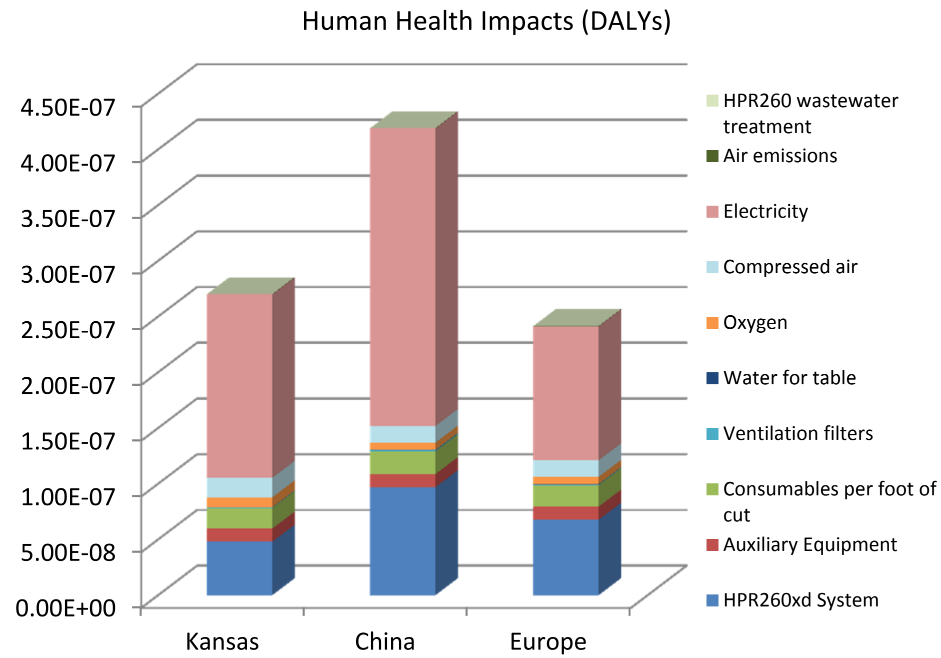
Per foot of cut with scrap

- Scrap from plasma cutting process
- Electricity

Per foot of cut, ignoring scrap

- Electricity
- HPR260xd equipment





Objective

To understand the cradle-to-grave impacts of the HyPerformance HPR260XD plasma cutting equipment

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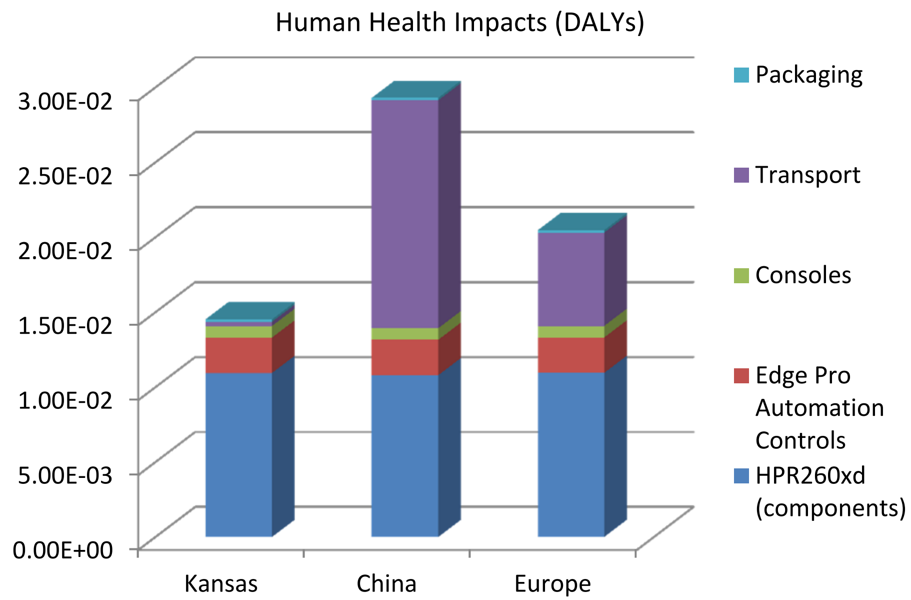
Contribution Analysis
Environmental Hot-Spots

<u>HPR260xd, equipment only</u>

— Transport

— HPR260xd (components)



<u>Objective</u>
To understand the cradle-to-grave impacts of the HyPerformance HPR260XD plasma cutting equipment

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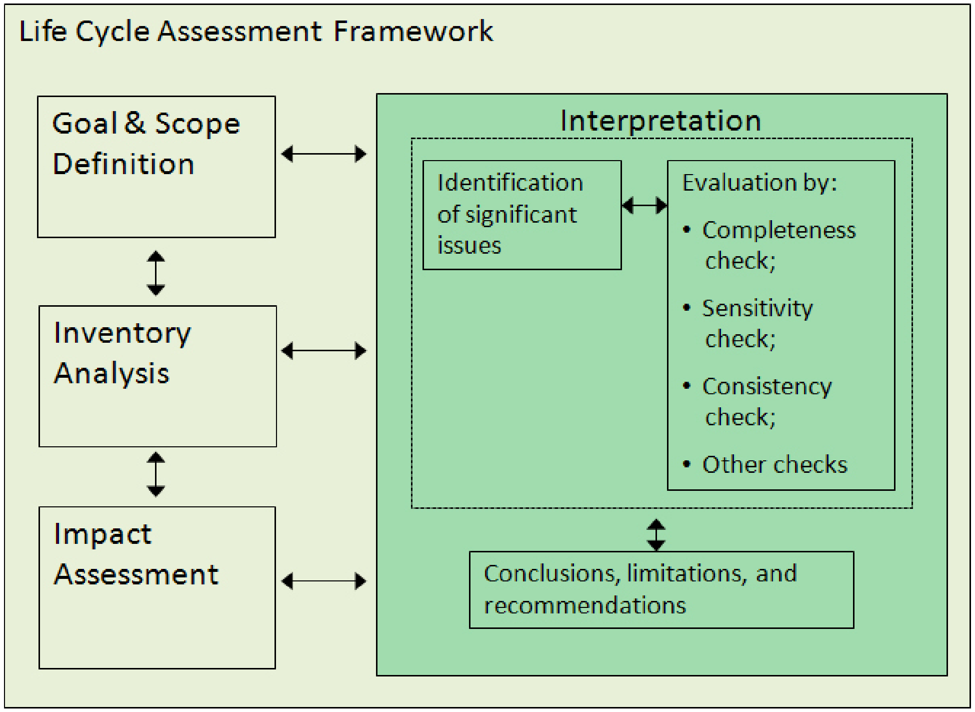
Contribution Analysis
Environmental Hot-Spots

Interpretation

- To gain insight so you can efficiently guide and refine the study
- To derive robust conclusions and well founded recommendations



ISO 14044:2006

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How sensitive is the LCA model to changes in key parameters?

SENSITIVITY ANALYSIS

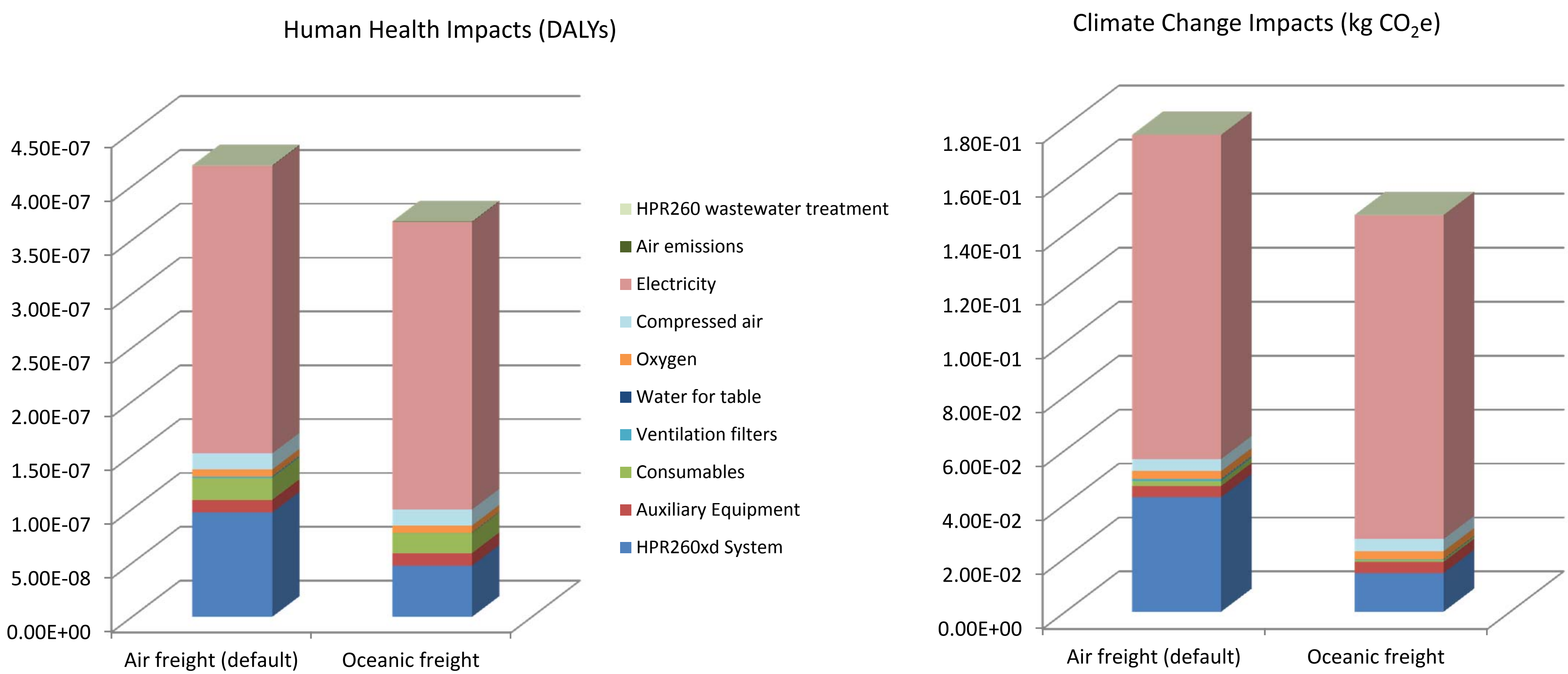
Sensitivity Analyses

- Transportation mode comparison
- Consumable transportation mode comparison
- Conversion efficiency
- Recycling model
- Consumable end of life
- Comparison to costing model

Sensitivity to Per Foot of Cut Transportation Mode

Air vs. Oceanic Freight

Characterized Results: Per foot of cut, ignoring scrap, in China



Impact Assessment Method: ES Method

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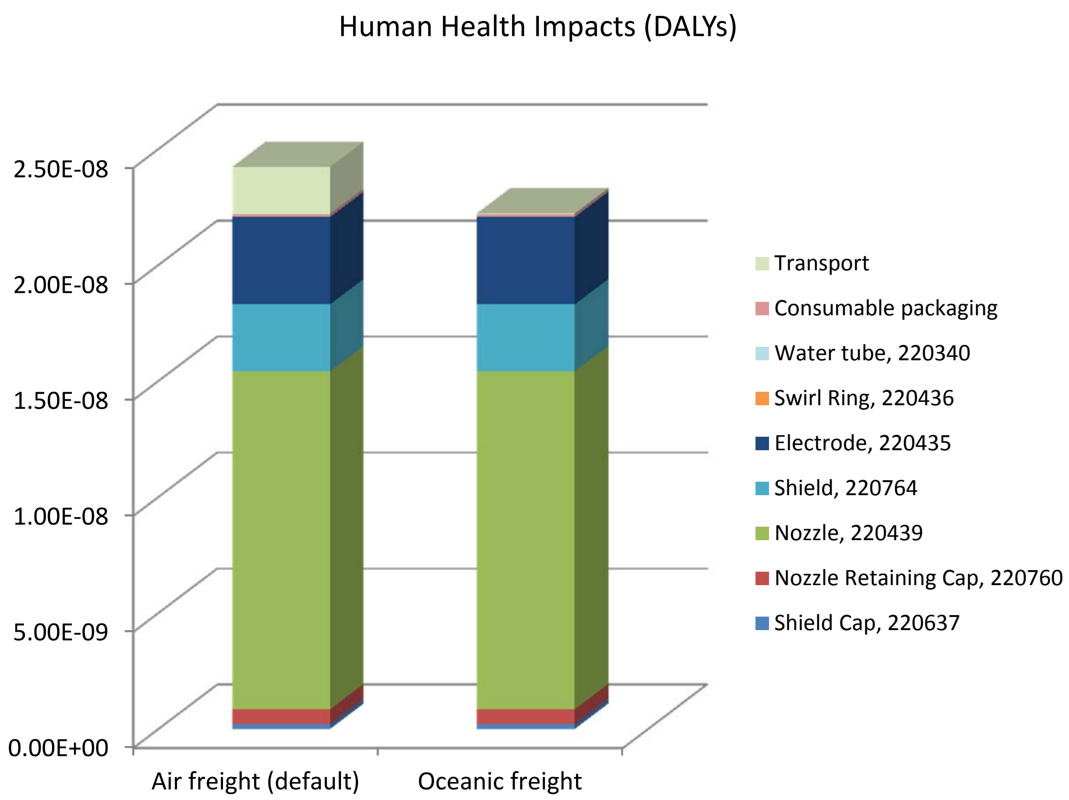
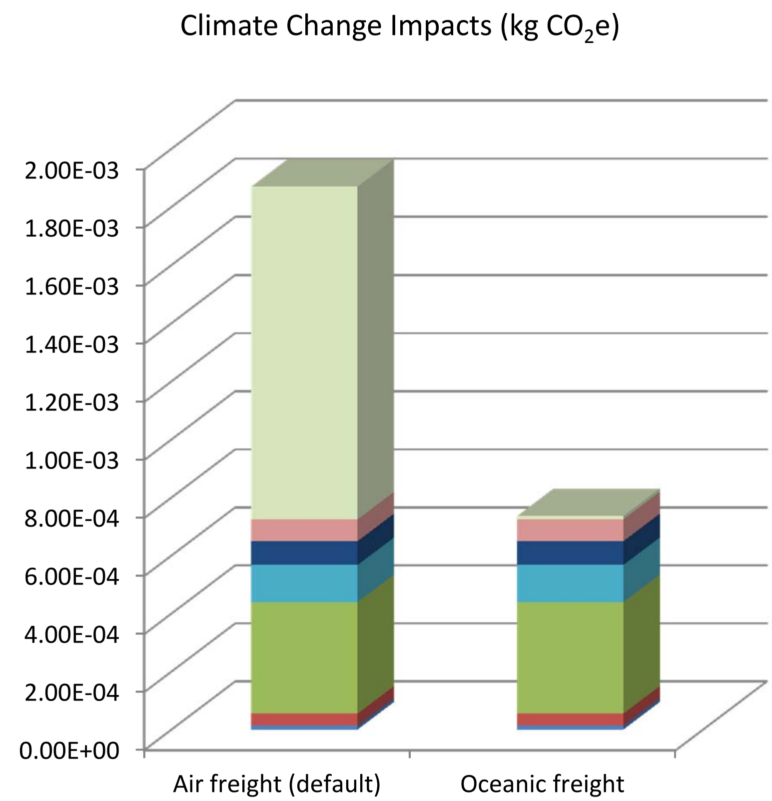
Sensitivity to Consumable Transportation Mode

Air vs. Oceanic Freight

Characterized Results: Consumables per foot of cut, in China





Impact Assessment Method: ES Method

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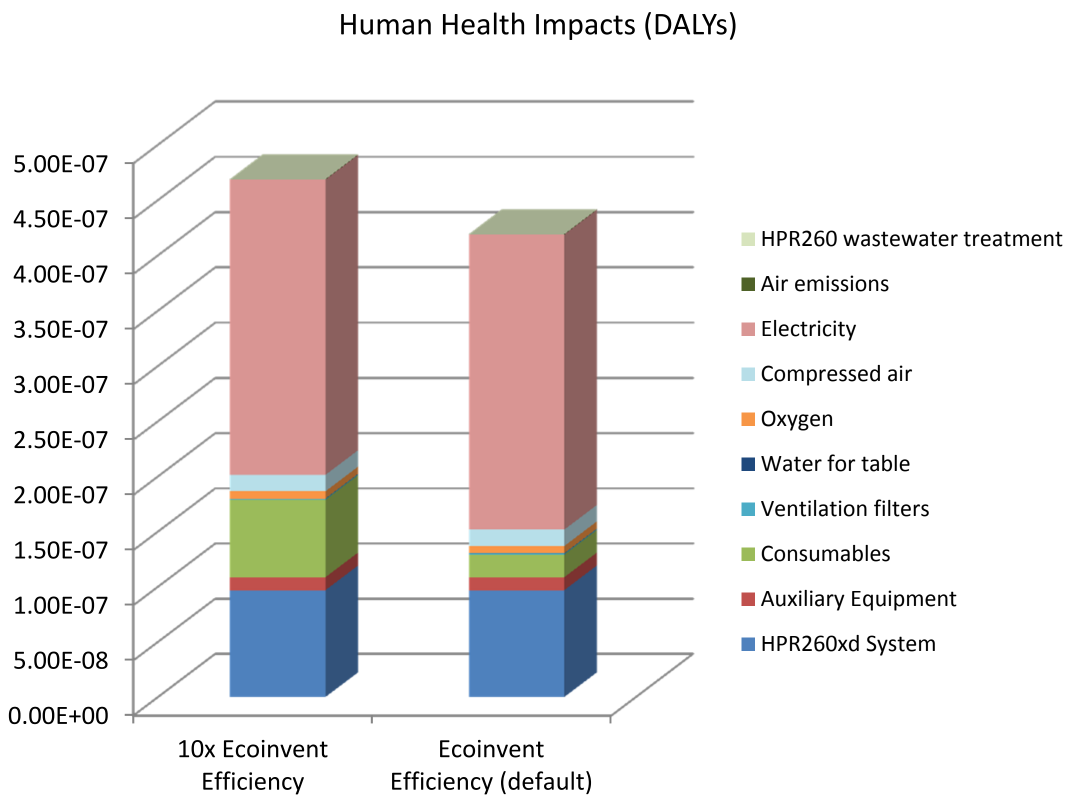
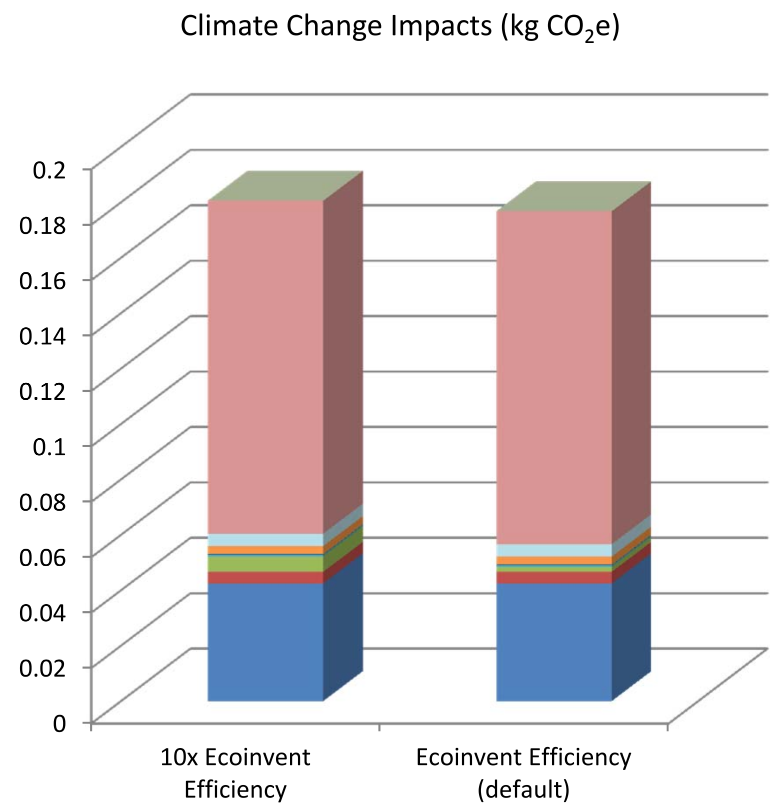
Sensitivity to Conversion Efficiency Comparison

Ecoinvent vs 10x Ecoinvent

Characterized Results: Per foot of cut, in China





Impact Assessment Method: ES Method

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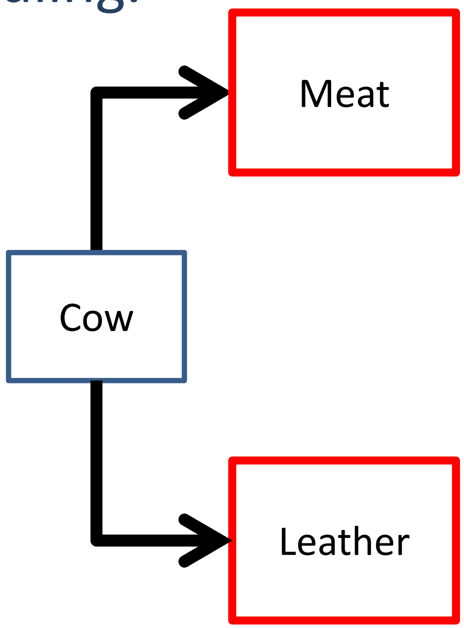
Handling Co-products

Multiple output processes require special handling.

Examples:

- *Meat and leather from the same cow*
- *Beer and fodder from the same brewery*

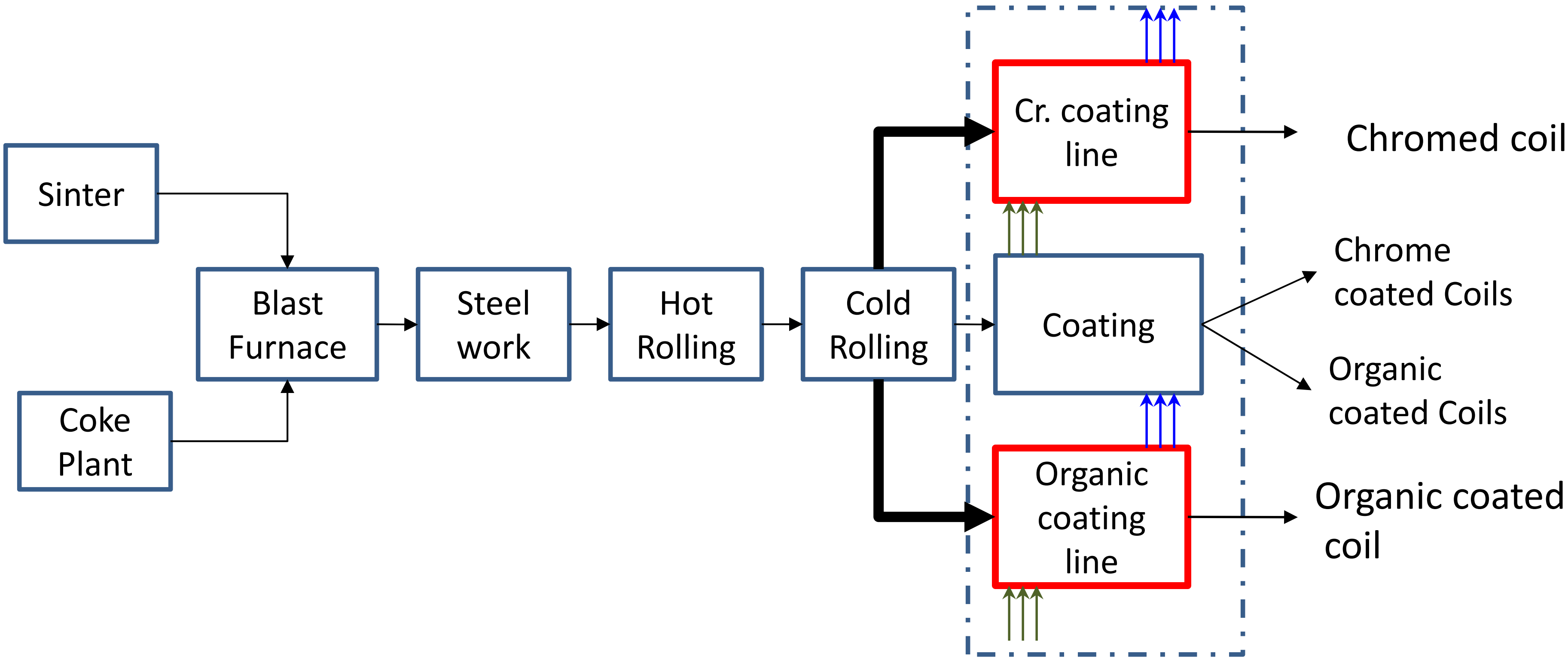


<u>Two strategies:</u>

- Avoid allocation (2 methods)
- Divide impacts over products (allocation)

Avoid Allocation

- 1. Dividing the unit process:



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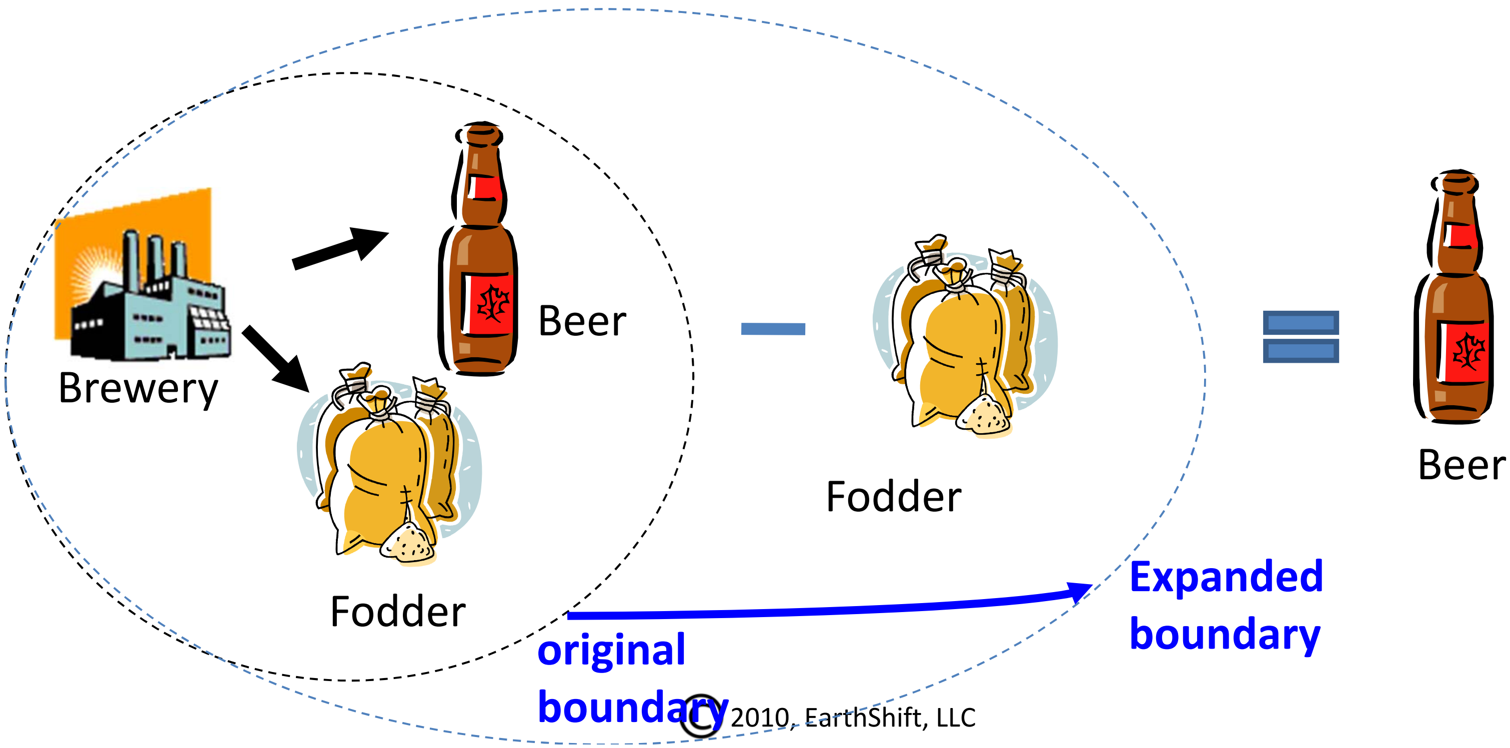
Avoid Allocation

2. Expand system boundaries:
   - Make inventory of alternative process that can produce the same output
   - Subtract the emissions from this process from the main output (Process sheet: avoided products)



Allocation options

Divide impact:

- Use physical causality to determine percentage
- Use socio-economics to determine percentage

		fictional allocation %	
		mass	income
Salt electrolysis	Chlorine	46%	63%
	Caustic Soda	52%	35%
	Hydrogen	2%	2%

- Allocation method should be consistent in practice

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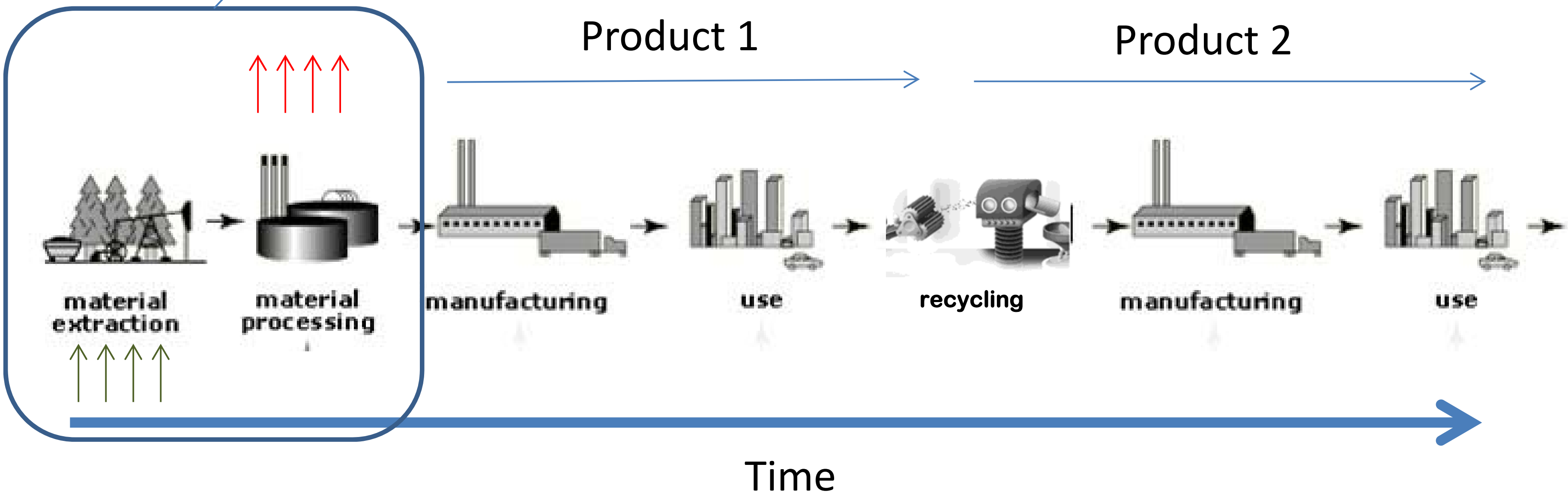
Recycling—a special case of allocation

How do you allocate these flows between product 1 and product 2?



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Recycling Allocation in our model

- Credit is given to first life (per foot of cut) for cut metals and consumables that are recycled at end of life (avoided burden-burden passed onto second life)

- No credit is given for plastics and capital equipment that are recycled at end of life, but no burden for incineration or landfilling is given (cut off—second life gets to take the material with no burden)

- Different treatment is due to the nature of the recycling industry where most metal is reused, whereas many plastics end up in the landfill anyway

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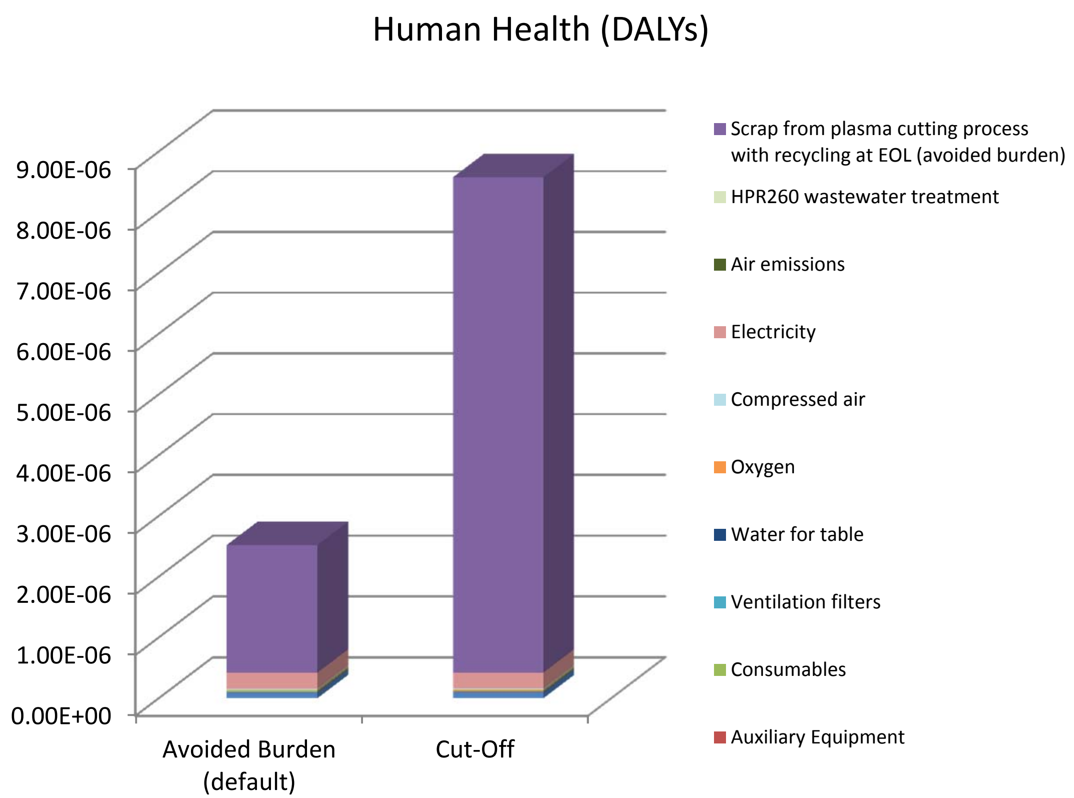
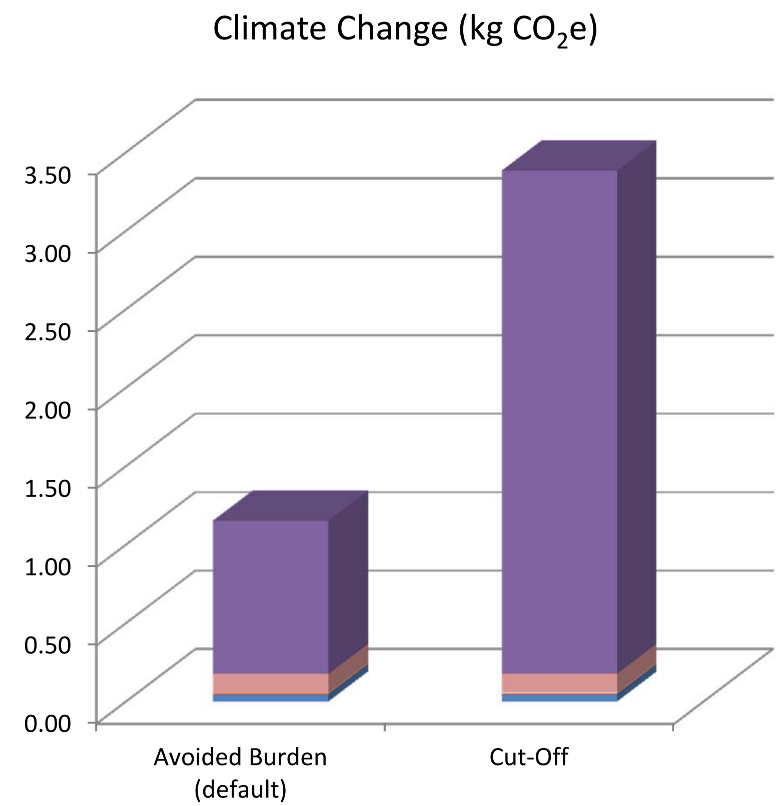
Sensitivity to Recycling Model

Avoided Burden vs. Cut-Off

Characterized Results: Per foot of cut with scrap, in China





Impact Assessment Method: ES Method

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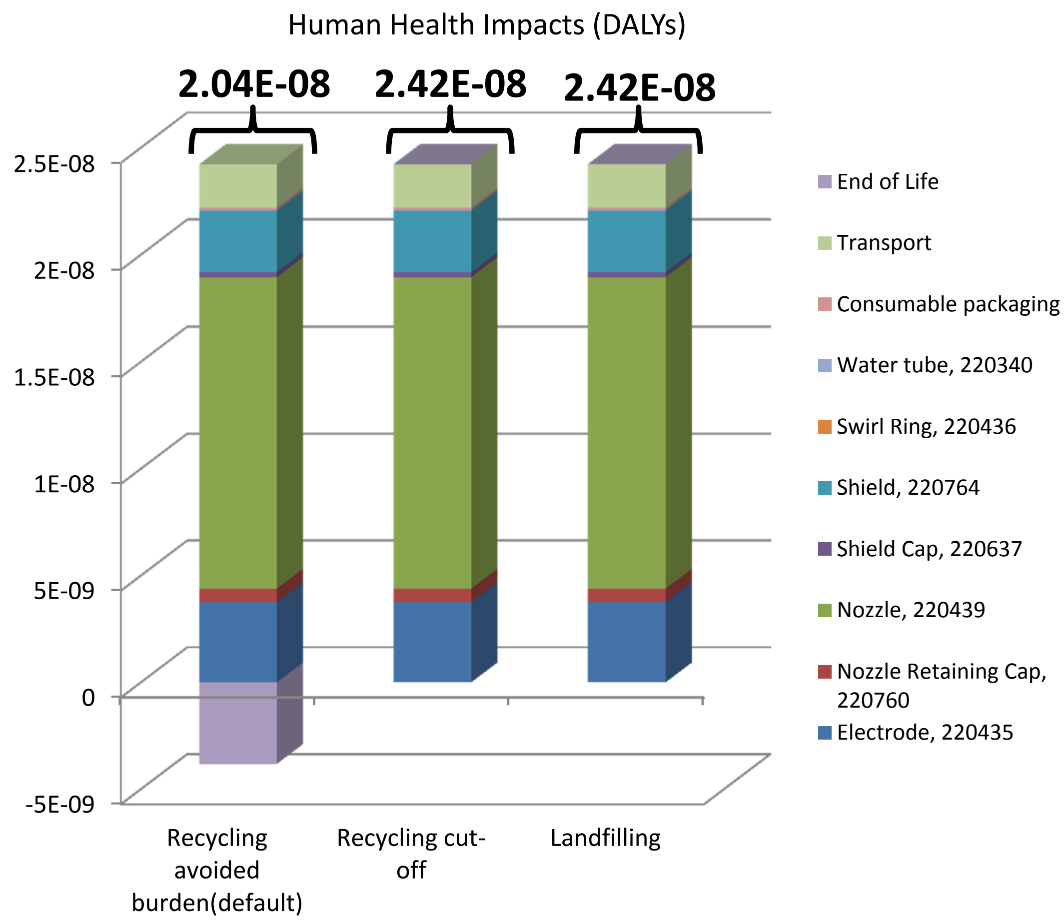
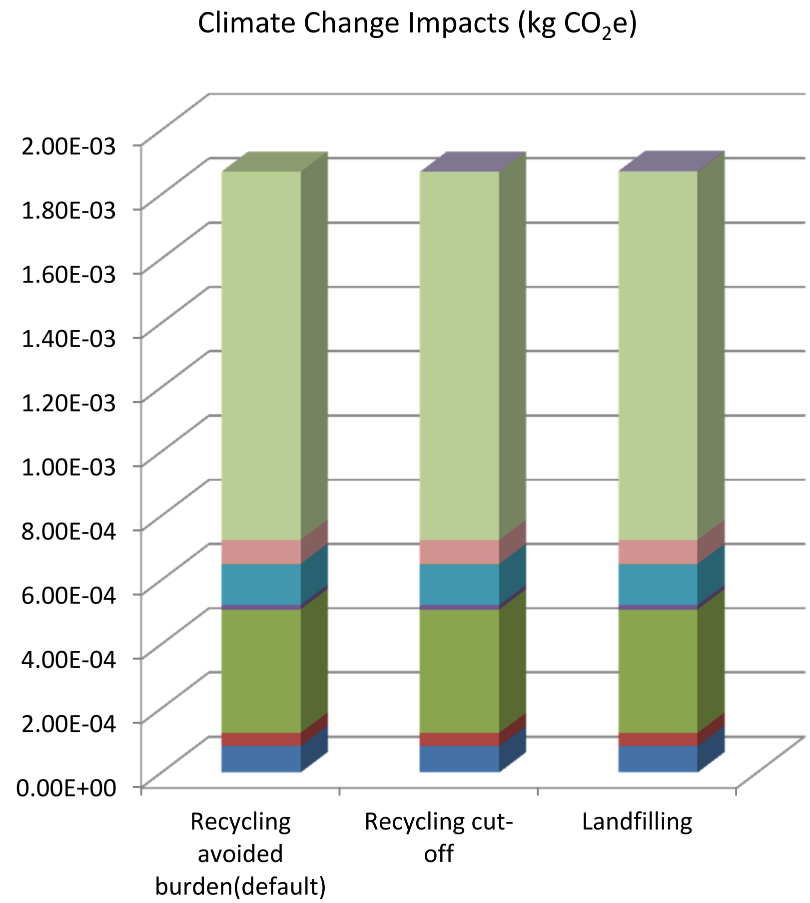
Sensitivity to Consumable End of Life
Recycling vs. Landfilling
Characterized Results: Consumable, in China



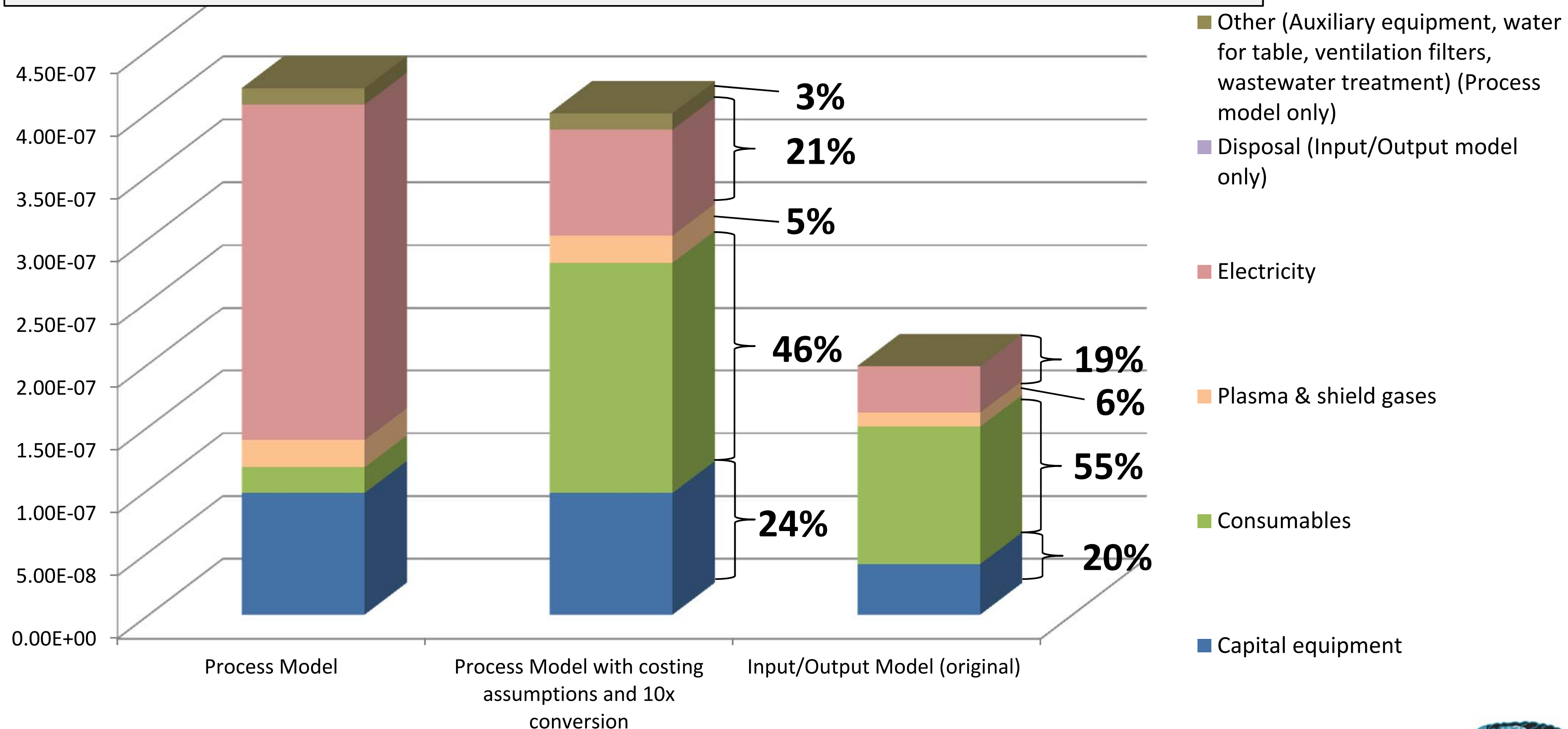


Impact Assessment Method: ES Method

Comparison to Costing Model

Characterized Results: Per foot of cut, ignoring scrap, in China

- I/O Model does not reflect inflation since 2003
- Adding more conversion shows a closer match to I/O ratios—do we need to recheck?



Impact Assessment Method: ES Method

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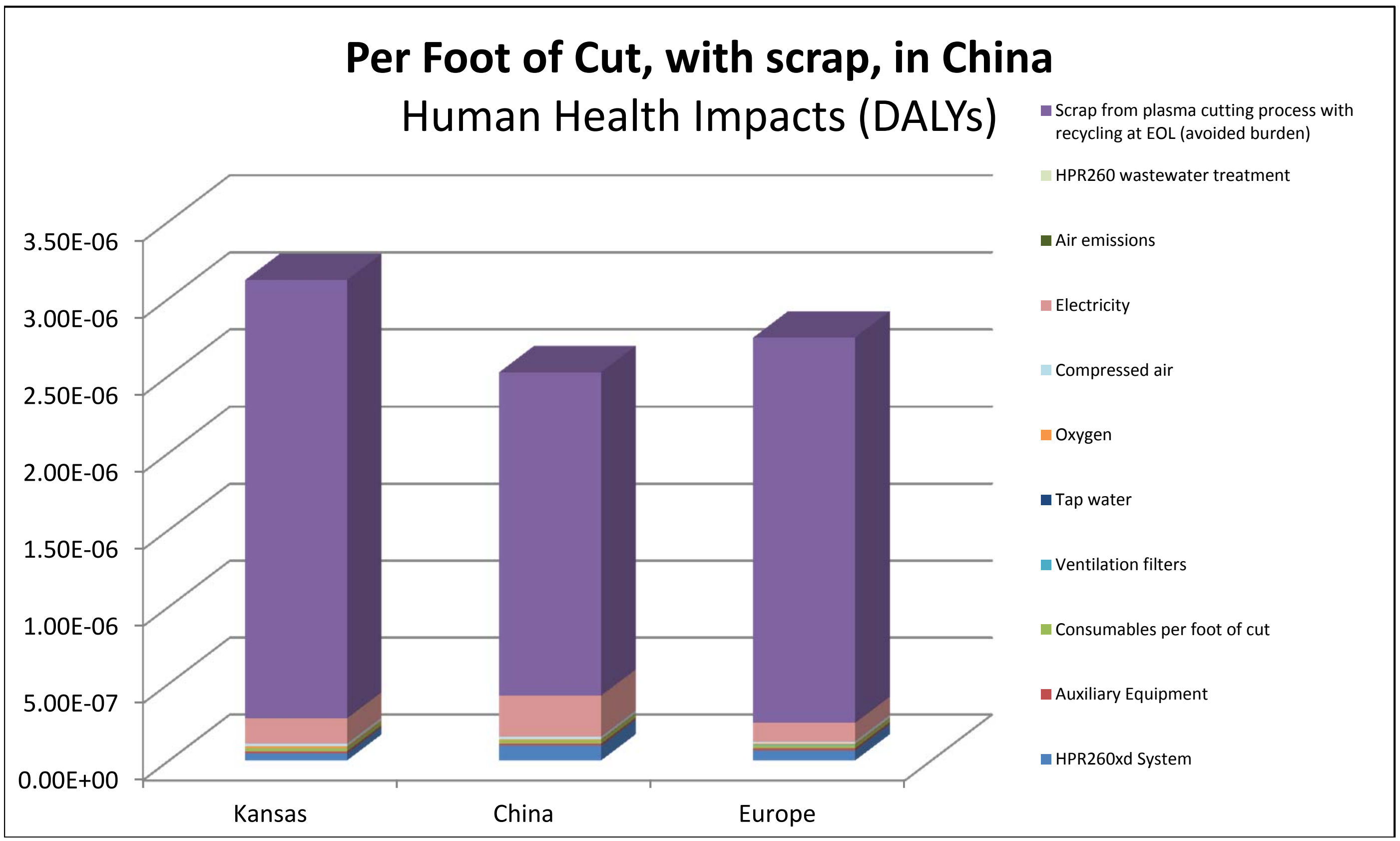
What are the key findings? What are the next steps?

KEY FINDINGS AND NEXT STEPS

Key Findings

This is a screening level LCA. The results and key findings are intended for an internal audience only.

1. The majority of cradle to grave environmental impacts associated with the HyPerformance HPR260xd Life Cycle are coming from the scrap and electricity.
   - Scrap (83 – 96% of total cradle to grave impacts)
   - Electricity (2 – 11% of total cradle to grave impacts)



2. HPR260xd System, Auxiliary equipment, and Consumables are not significant contributors when scrap is included.

Key Findings

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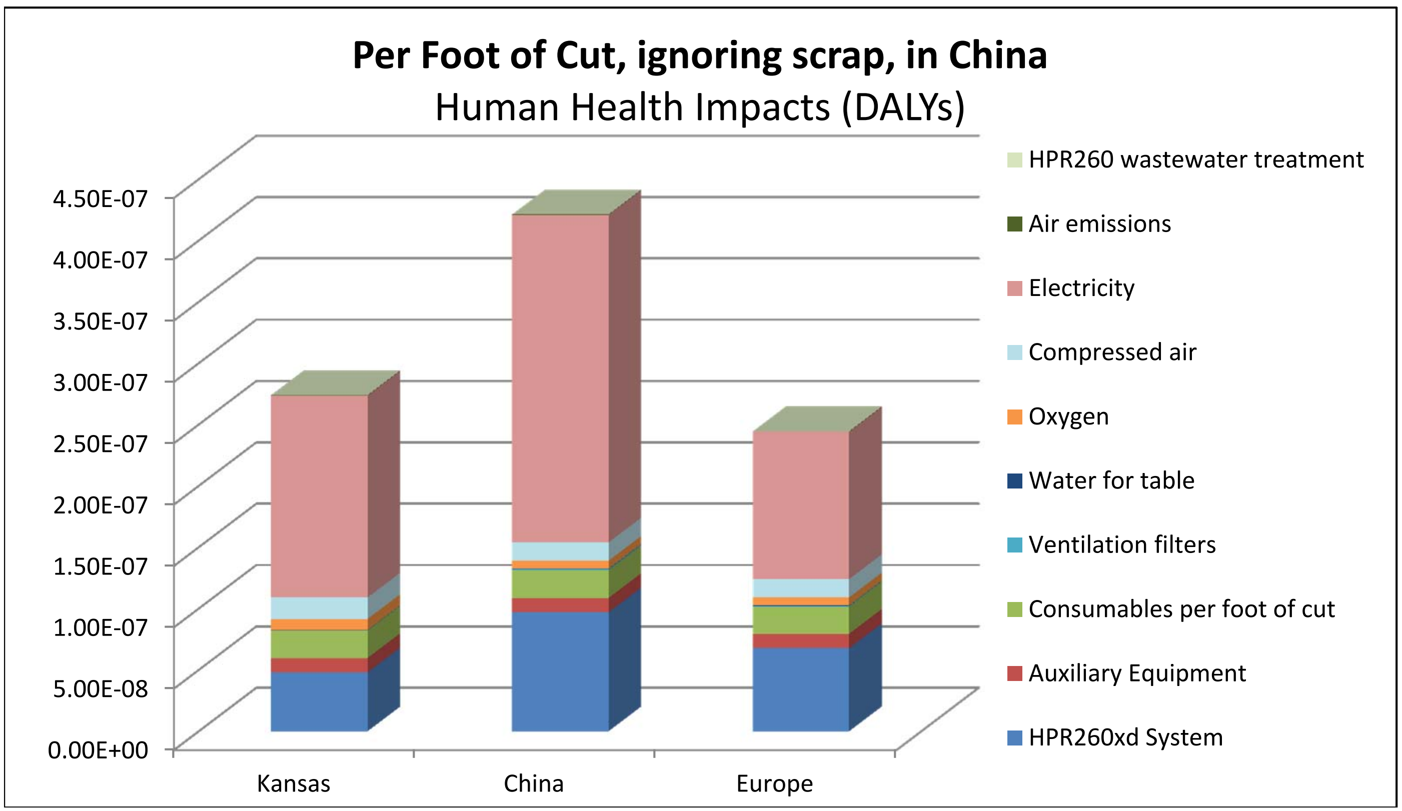
3. When ignoring scrap, the majority of cradle to grave environmental impacts associated with the HyPerformance HPR260xd Life Cycle are coming from the electricity and HPR260xd System.

- Electricity (45 – 68% of total cradle to grave impacts)
- HPR260xd System (18 – 33% of total cradle to grave impacts)



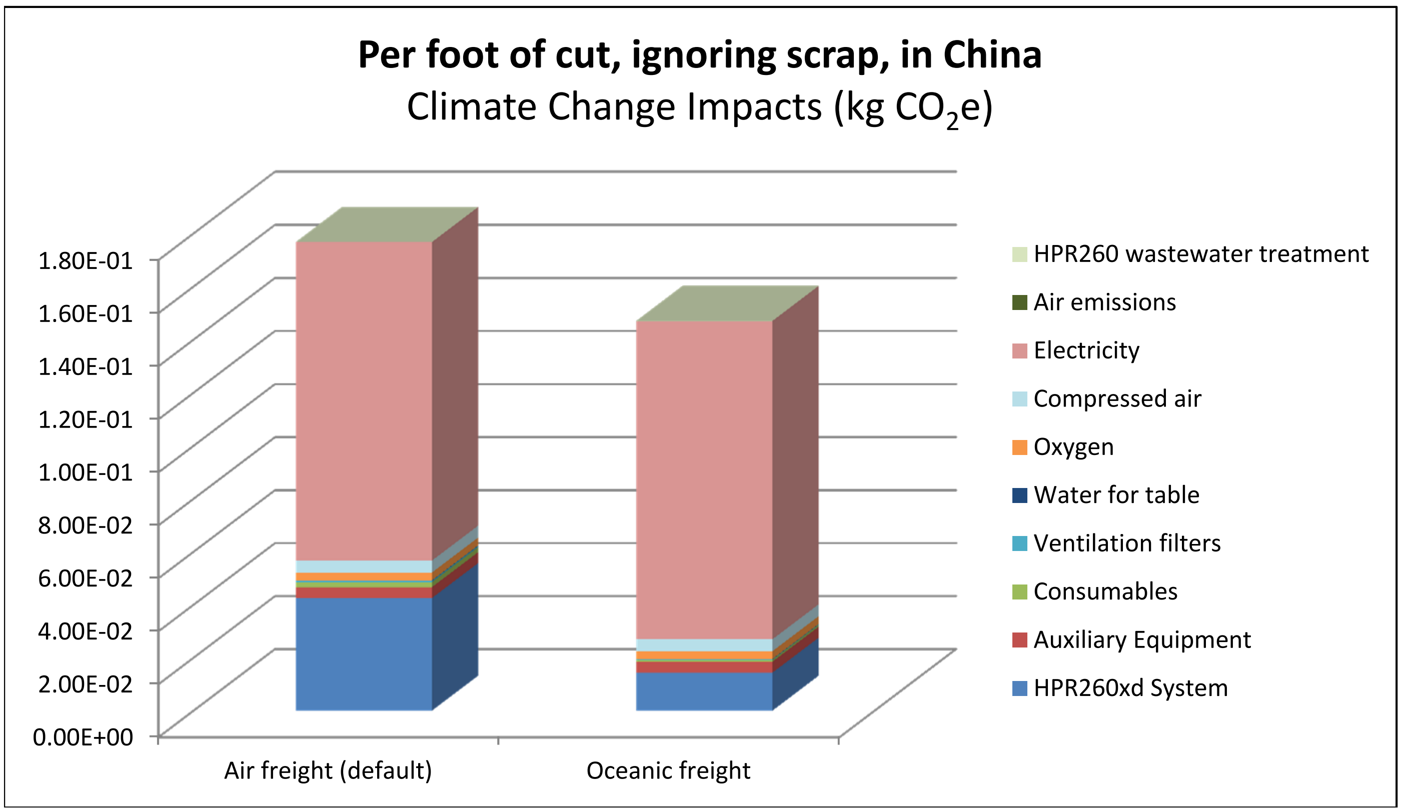
4. Auxiliary equipment, consumables, and ventilation filters are not significant contributors.

Key Findings

This is a screening level LCA. The results and key findings are intended for an internal audience only.

5. Results are sensitive to transport mode.

   — 6 - 23% decrease in impacts when transported by oceanic freight vs. air freight



Recommended Next Steps

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- Innovate around scrap reduction!

- Work on reducing electricity requirements during use phase
  - *Are there synergies with other shop equipment that might be usable?*
  - *Or excess heat from the cutting process that might be reused here or elsewhere?*

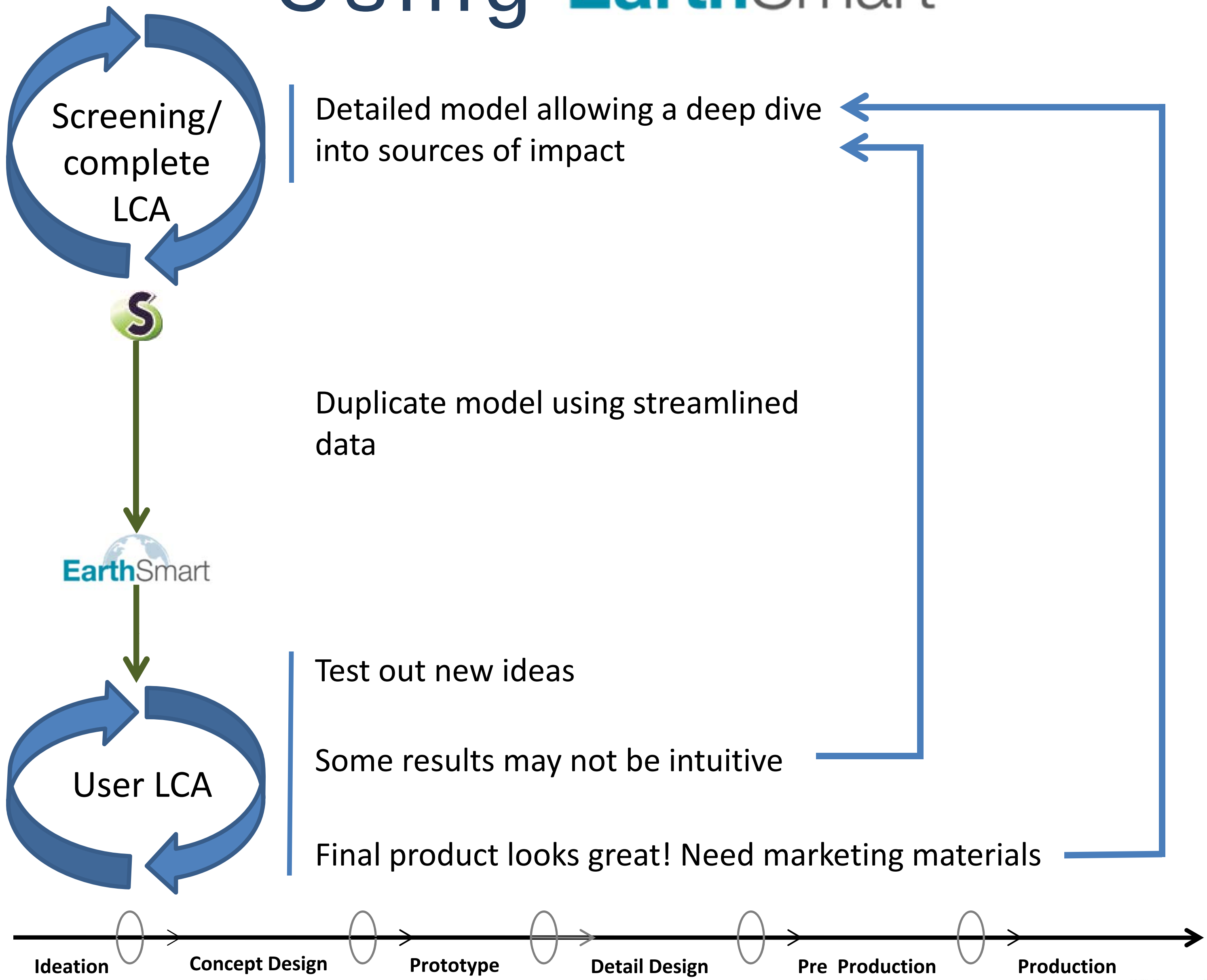
- Encourage recycling of all materials (especially metals) at end of life through customer outreach

- Encourage the use of ocean freight over air freight

- Consider gathering primary data on transformers and conversion efficiency

- Move the model to EarthSmart and provide access to team to play with alternatives

Using EarthSmart



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