Climate-Smart Circularity: Guiding Decision-Making Through Data-Informed Standard Protocols

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Key focus

- Brief about climate-smart circular supply chains
- Why they are important
- Role of life cycle assessment (LCA)
- Some real examples based on my research
  - Problematizing standard waste hierarchy
  - Design rules for climate-smart circularity
- Key message

What are climate-smart circular supply chains (CSCs)?

- Linear supply chains wasteful
- CSCs consume less materials than linear supply chains
- Climate-smart CSCs reduces overall emissions (**A > B**)

Linear supply chain

Make → Use → Dispose

Circular supply chain

Make → Use → Circular → Dispose

Less virgin materials so emissions saved (**A**)

More resources so emissions released (**B**)

Why?

Why climate-smart? You believe that circularity always reduce emissions. Really?

- **Motivation to adopt circularity**
  - **Resource efficiency**: diversion from landfills
  - **Eco-efficiency**: lower GHG emissions
  - **Resilience**: Unpredictable geopolitics, tariffs
- **Conventional wisdom**: follow hierarchy
  - **Embedded beliefs / assumption**: hierarchy ensures lower emissions

We asked: is that assumption true?
When is A > B ?
Savings from virgin > costs of processing waste

Source: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

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We assessed eight discarded material streams across three major GHG contributing sectors in Canada

Textile	Construction	Agrifood
• Cotton • Polyester • Polycotton	• Wood • Concrete • Plastics	• Wet spent grain • Fruit & vegetable residues

- Mix of primary and secondary data
- Mapped different management (circular) pathways of each stream
  - Hierarchy for each stream
- Used life cycle assessment (LCA) to quantify emissions
- Performed sensitivity (best/worst case) analysis

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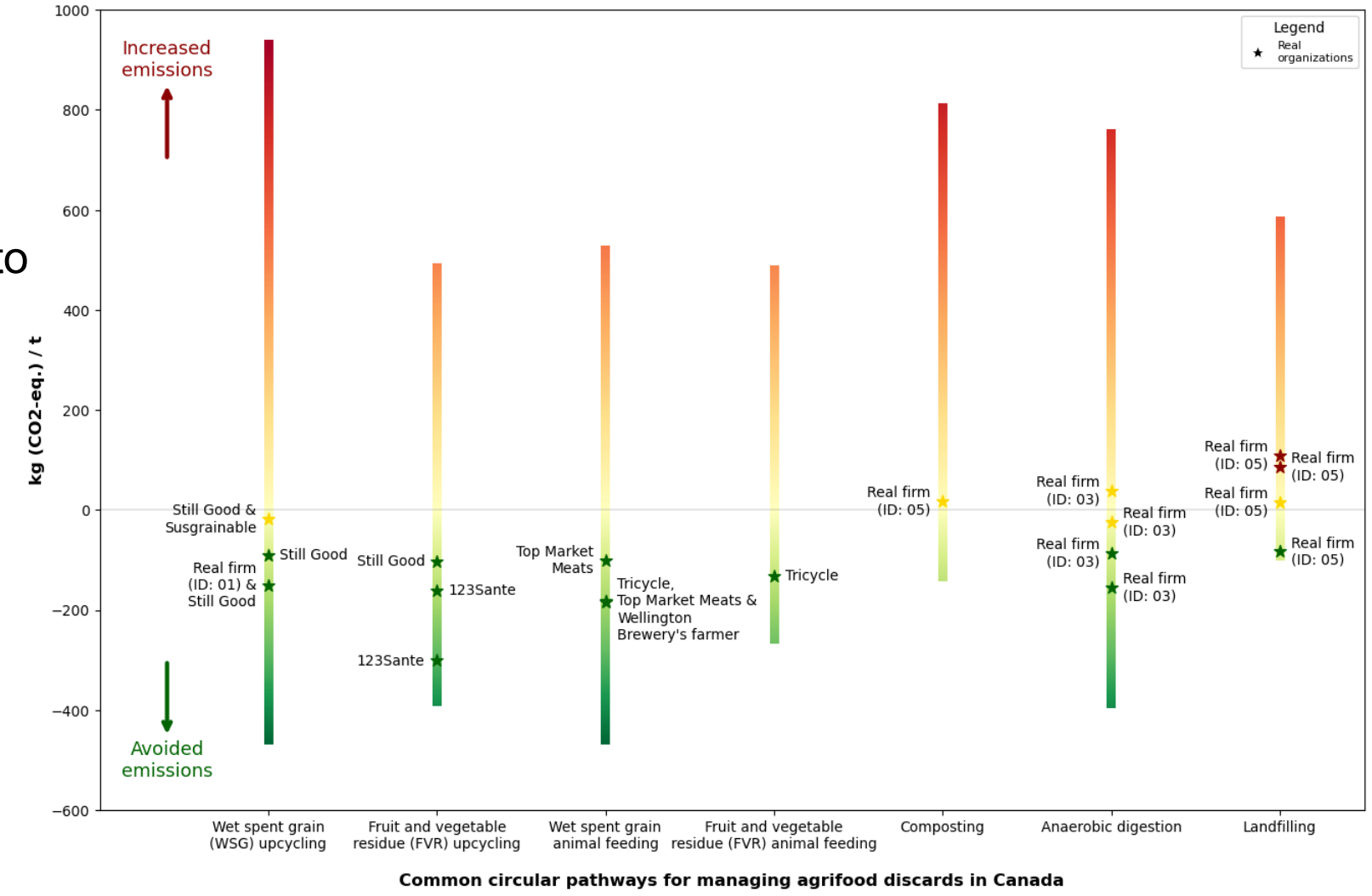
We found that the assumption is not always reasonable

- **Research on managing food discards**
  - **No** pathway **consistently** reduced emissions relative to virgin production
  - Standard waste recovery hierarchy does not ensure lower emissions

Let's consider more examples

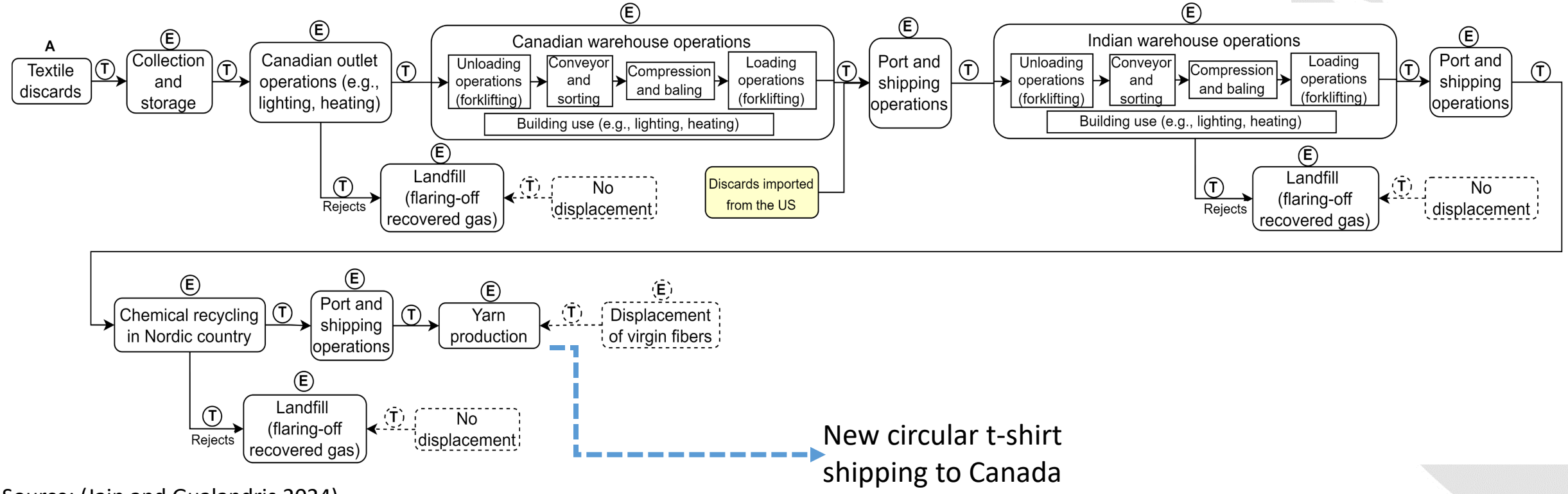


Source: (Jain and Gualandris 2024)

Around the world: Circular story of a cotton t-shirt discarded in the US/Canada

- Generated in Toronto
- Charity store for reselling
- Port in Montreal for export to India for sorting
- India to Europe (Sweden/Finland) for chemical recycling
- Back to India for new manufacturing
- Back to Canada for use

Representative supply chain of chemical recycling a cotton t-shirt discarded in the US/Canada

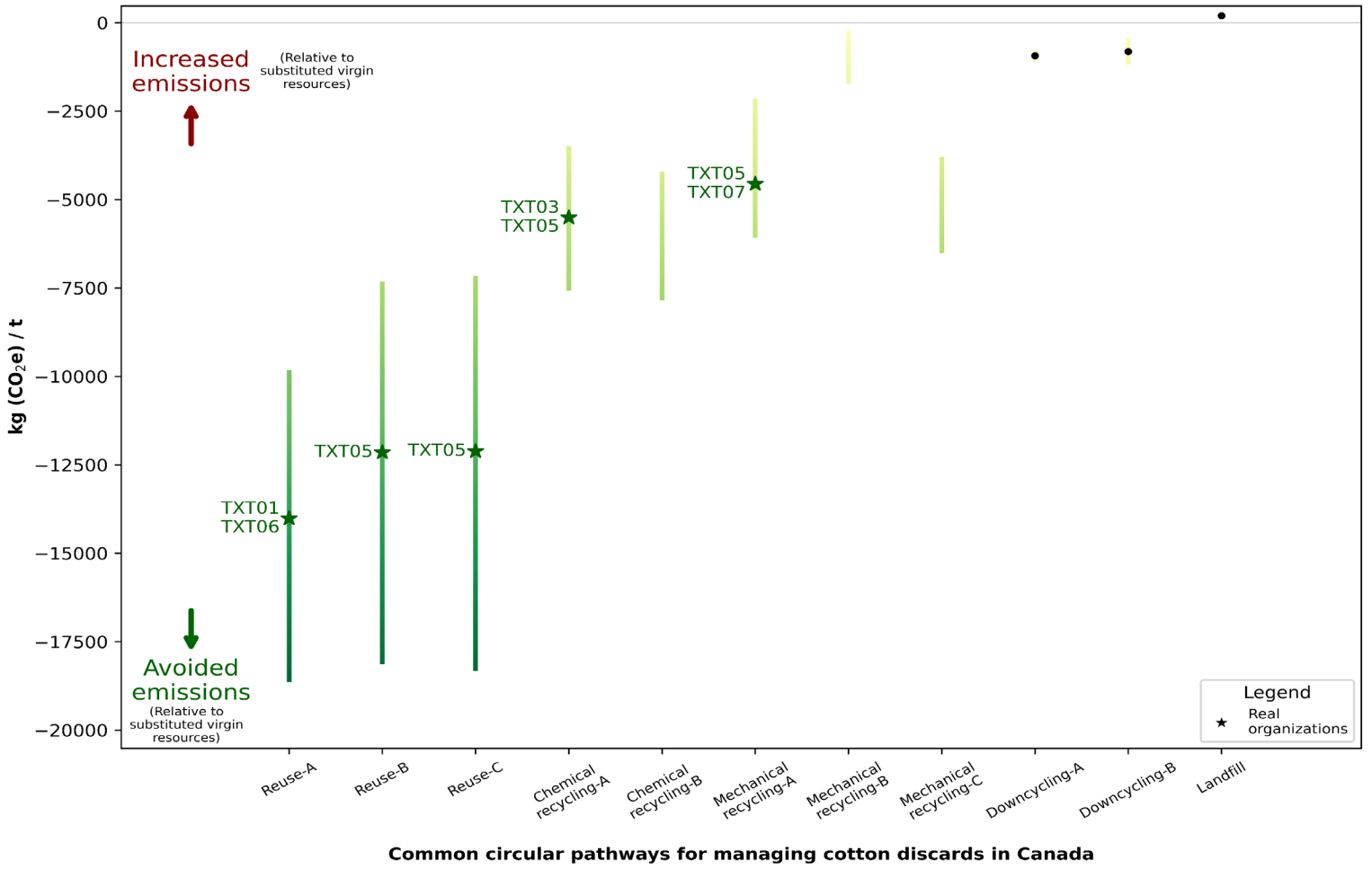


Source: (Jain and Gualandris 2024)

We found that the assumption is always reasonable

- **Research on managing cotton discards**
  - Pathway **consistently** reduced emissions relative to virgin production
  - Standard waste recovery hierarchy lowers emissions

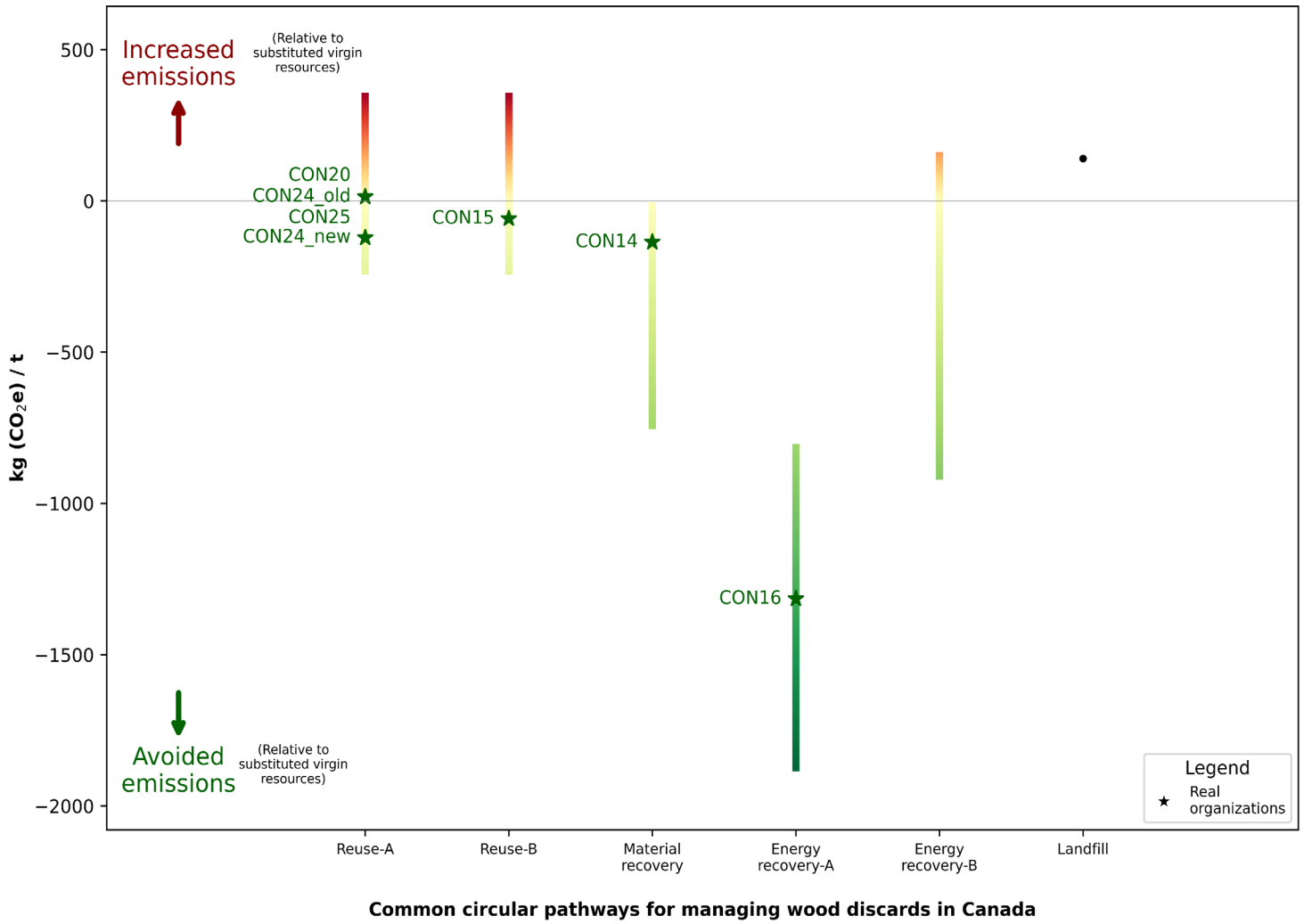
Let's consider another example



Source: (Jain and Gualandris 2024)

We found that the assumption is not always reasonable

- **Research on managing wood discards**
  - **No** pathway **consistently** reduced emissions relative to virgin production
  - Standard waste recovery hierarchy does not ensure lower emissions



Source: (Jain and Gualandris 2024)

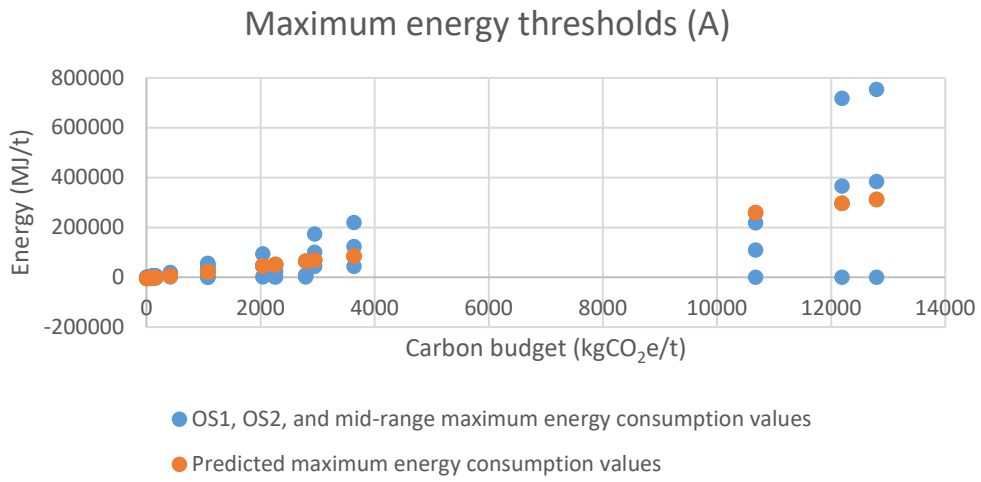
More than problematizing waste hierarchy, we wanted to explore if there are any structural similarities or pattern across different discard (waste) streams

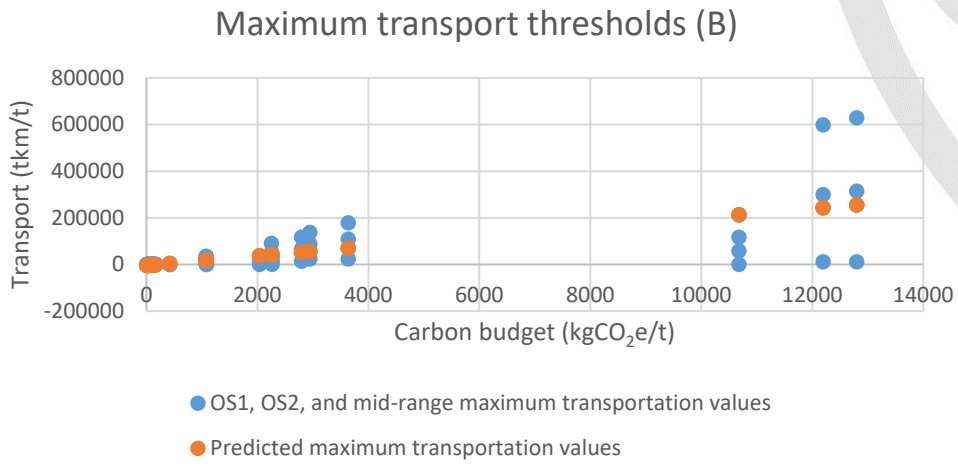
- Design rules useful before undertaking full LCA
- Circular pathways within certain thresholds of energy and transportation (distance) are mostly climate smart
  - Max energy threshold = carbon budget/carbon intensity of energy consumption
  - Max transportation threshold = carbon budget/carbon intensity of transportation

Sector		2030 Carbon Budget (kg CO_2e/t)	Real Case (MJ/t, t·km)	Operational Parameters for Climate-Smart Pathways		
				OS1 (MJ/t, t·km/t)	OS2 (MJ/t, t·km/t)	Mid-Range Point (MJ/t, t·km/t)
Textile DMS Pathways	CT-RU	12 800	(177, 12 034)	(754 363, 12 034)	(177, 628 989)	(384 537, 314 567)
	CT-CR	3639	(44 104, 23 358)	(220 389, 23 358)	(44 104, 178 303)	(123 482, 108 534)
	CT-MR	2796	(1331, 13 656)	(10 059, 13 656)	(1331, 116 763)	(5608, 66 241)
	CT-DC	1078	(613, 7010)	(56 033, 7010)	(613, 34 366)	(35 117, 17 334)

Simple design rules can guide firms with circular pathways

- Statistical analysis w.r.t. carbon budget (savings from displaced virgin material) and waste processing thresholds (energy and transportation) of different circular pathways
- Thresholds grow linearly to the carbon budget associated with displaced materials
  - For every doubling of carbon budget, energy consumption (Graph A) of circularity can grow 24 times and remain climate-smart
  - For every doubling of carbon budget, transportation (Graph B) of circularity can grow 20 times and remain climate-smart





Why should we think about CSCs being climate smart?

Questionable environmental benefits of circularity

Reputational damage (even from false perception) if no of transparency and evidence

Anti-greenwashing regulations across many countries – penalties

Lost money from carbon savings

Key takeaways

- **Circular supply chains can just be complex and globalized (e.g., t-shirt)**
- **Norms and beliefs about circularity not always supported by evidence**
  - Circularity does not always lower emissions
  - No to one-size-fits-all waste hierarchy
  - Depends on material
- **Life cycle assessment useful in designing climate-smart circular supply chains**
- **Some design rules (protocols) helpful**
- **Designing for circularity should be a full-time job**
  - Be inspired, but don't copy-paste circular practices

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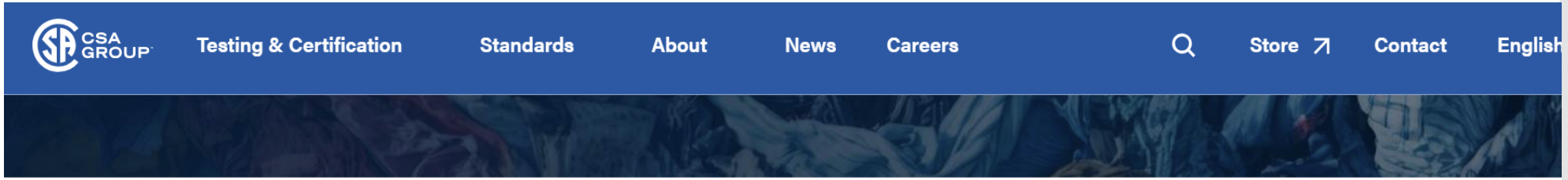
Our research available online for free on Canadian Standard Association's website



Executive Summary

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Citation

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Executive Summary

While circularity is often assumed to be climate-smart, which is defined as reducing greenhouse gas (GHG) emissions relative to the emissions associated with the production of virgin materials, the goals of closing material flows and reducing net GHG emissions relative to virgin materials are not always aligned. Inappropriately designed circular pathways could unintentionally counteract efforts to catalyze the climate transition. This report investigates the conditions that make circularity climate-smart by examining multiple circular pathways for seven discarded material streams (DMSs) across three key Canadian sectors.

The research conducted for this report identified structural similarities across circular pathways that are climate-smart, with the goal of providing evidence-based guidelines to support the development of an effective circular economy. The following seven DMSs from three key sectors were assessed:

Contact an Expert

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Thank you

Yes to circular questions

No to linear questions

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