How do we know it's Sustainable?

THE ROLE OF MFA & LCA

Heather Logan ESR 14

MFA and LCA of Additives in Plastics

This project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant. Agreement No. 859885.

Learning Objectives

What we'll learn today

01 Identify resilient sustainability solutions.

02 Outline how LCA and MFA can help to assess and normalize sustainability solutions

03 Give 1-2 examples of how LCA and MFA can help build a circular economy for plastics.

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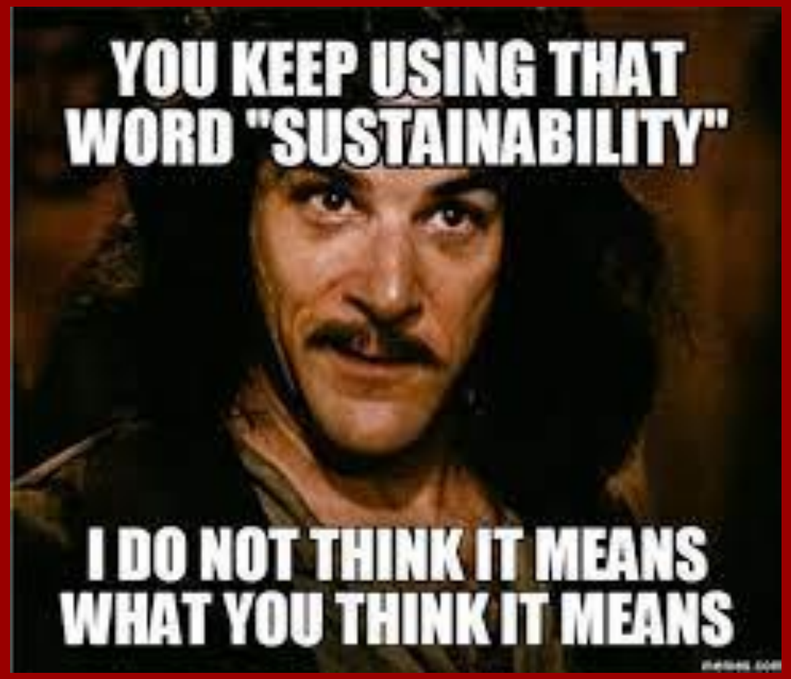
How do we even define sustainability?



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What definition of sustainability do you hear or use most?

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"Meets the needs of the present without compromising the ability of future generations to meet their own needs"

Brundtland Report 1987

"Our Common Future"

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“Sustainable development is development which meets the *needs* of the present without compromising the ability of future generations to meet their own *needs*."

Needs:

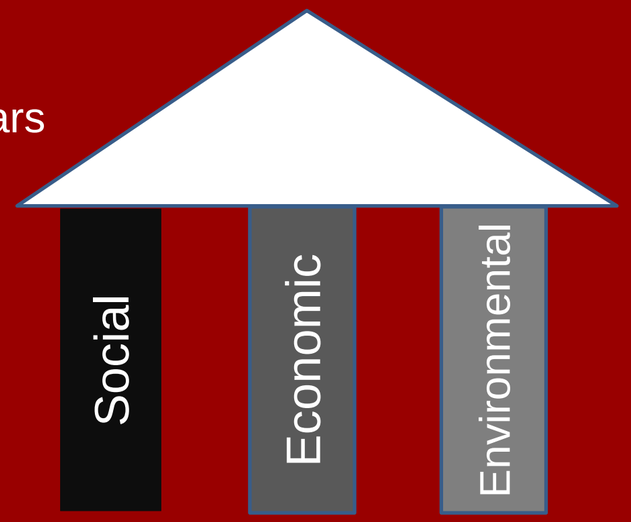
"The concept of 'needs', in particular, the essential needs of the world's poor, to which overriding priority should be given"

Limitations:

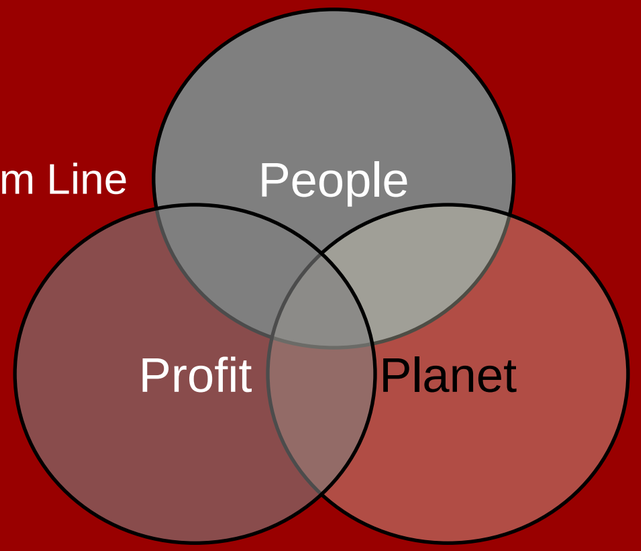
"Limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs"

(Brundtland Commission, 1987)

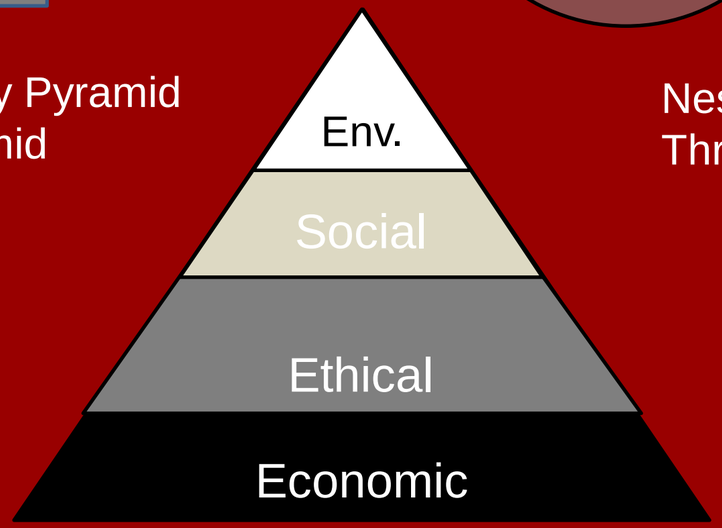
Three Pillars



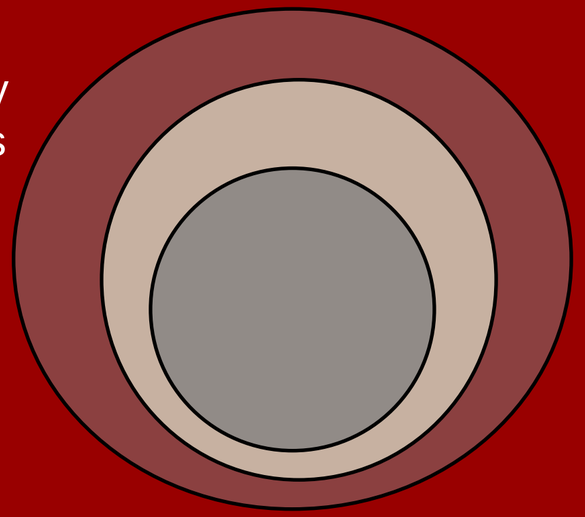
Three P's
Triple Bottom Line
Three Es



Sustainability Pyramid
CSSR Pyramid



Nested Sustainability
Three Dependencies



(Gliedt and Larson. 2018)

Weak vs Strong Sustainability

Determining how resilient sustainability solution are:

Weak Sustainability

- Often results in **tradeoffs**
- Often **Incremental**
- Relies on the **substitution** of synthetic capital in exchange for the depletion of natural capital.

Strong Sustainability

- Transitions are **multidimensional** and **resilient** across generations
- Capital is **maintained congruently**.
- Checks are built in to **plan** for the future, **adapt**, and **grow** over time.

(Neumayer. 2013)

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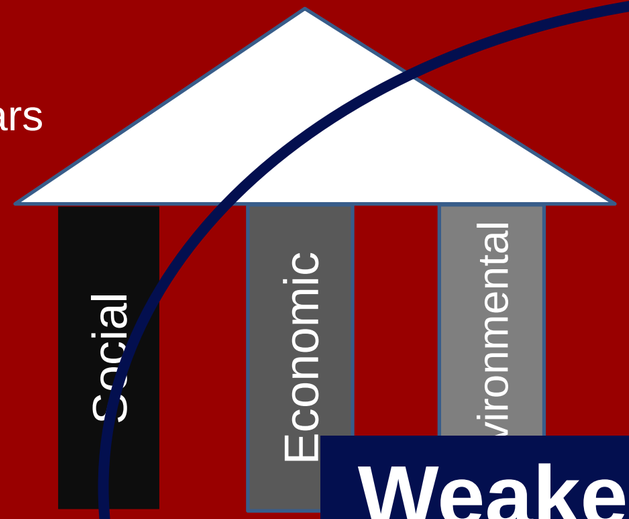
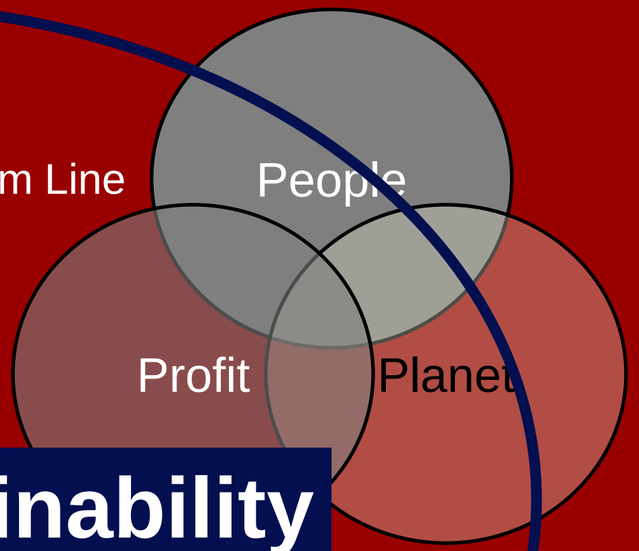
Three Pillars

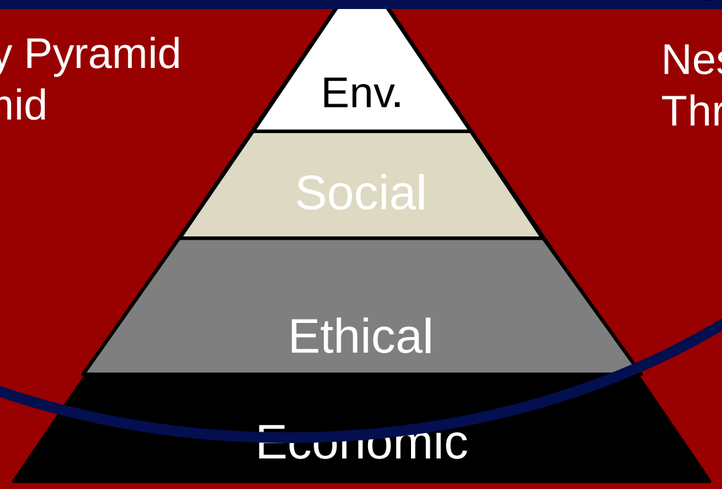


Three P's
Triple Bottom Line
Three Es

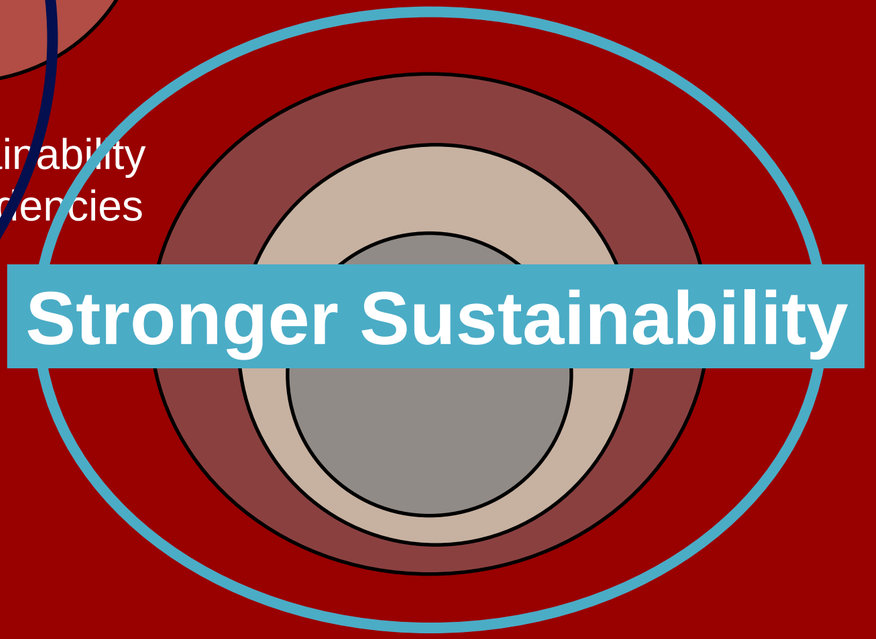


Weaker Sustainability

Sustainability Pyramid
CSSR Pyramid



Nested Sustainability
Three Dependencies



Stronger Sustainability

(Gliedt and Larson. 2018)

Sustainability Principles

- Socio-Ecological System Integrity
  - Preserving people and the environment
- Livelihood Sufficiency and Opportunity
  - Those basic needs
- Intra-generational Equity
  - Achieving Solutions for people today
- Inter-generational Equity
  - And thinking what this looks like up to 7 gens out
- Resource Maintenance and Efficiency
  - Responsible use (circular?) reducing/avoiding unnecessary waste
- Civility and Democratic (Representative) Governance
  - Fair, just, and representative of all people within a given jurisdiction
- Precaution and Adaptation
  - Plan for the future and stop to reflect/grow
- Immediate and Long-Term Integration
  - What is needed today, what about in the future, how to apply all at once

SDGs and Wicked build upon this approach

(Gibson et al., 2005; 2006; 2017)

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What is one word that you think of when you think of a resilient sustainability solution?

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How do we measure sustainability impacts quantitatively?

IMPROVE OUR ACCOUNTING AND REPRESENTATION OF HOW PRODUCTS, GOODS, AND RAW MATERIALS FLOW IN A GLOBAL MARKET

Supply chains are globally sourced and interconnected

“Raw materials” have intricate and dynamic systems of production and create significant impacts within small or local communities and economies

The same is often true for bulk waste and recycling burdens

Accurate mapping of material flows help us assign correct accountability and responsibility for these impacts

Material Flow Analysis (MFA)

What is MFA?

- Analytical Tool
- ISO 14051
- Resource use and stock calculation
- Tracks inputs and outputs within a given system
- Highlights hotspots for assessment or consideration

What are the limits?

- Can be used to assess environmental and economic flows but can’t assign burden estimates
- Not useful as a predictive tool
- Most useful in sustainable transitions when coupled with other sustainability assessments

(Kaufman, 2012.; Balanay & Halog 2019.)

What can we learn from coupling LCA and MFA?

- Identify opportunities to tune and improve the socioenvironmental integrity and resource maintenance and efficiency performance of either practices within a system or of materials used to create products/goods.

What is Life Cycle Assessment?

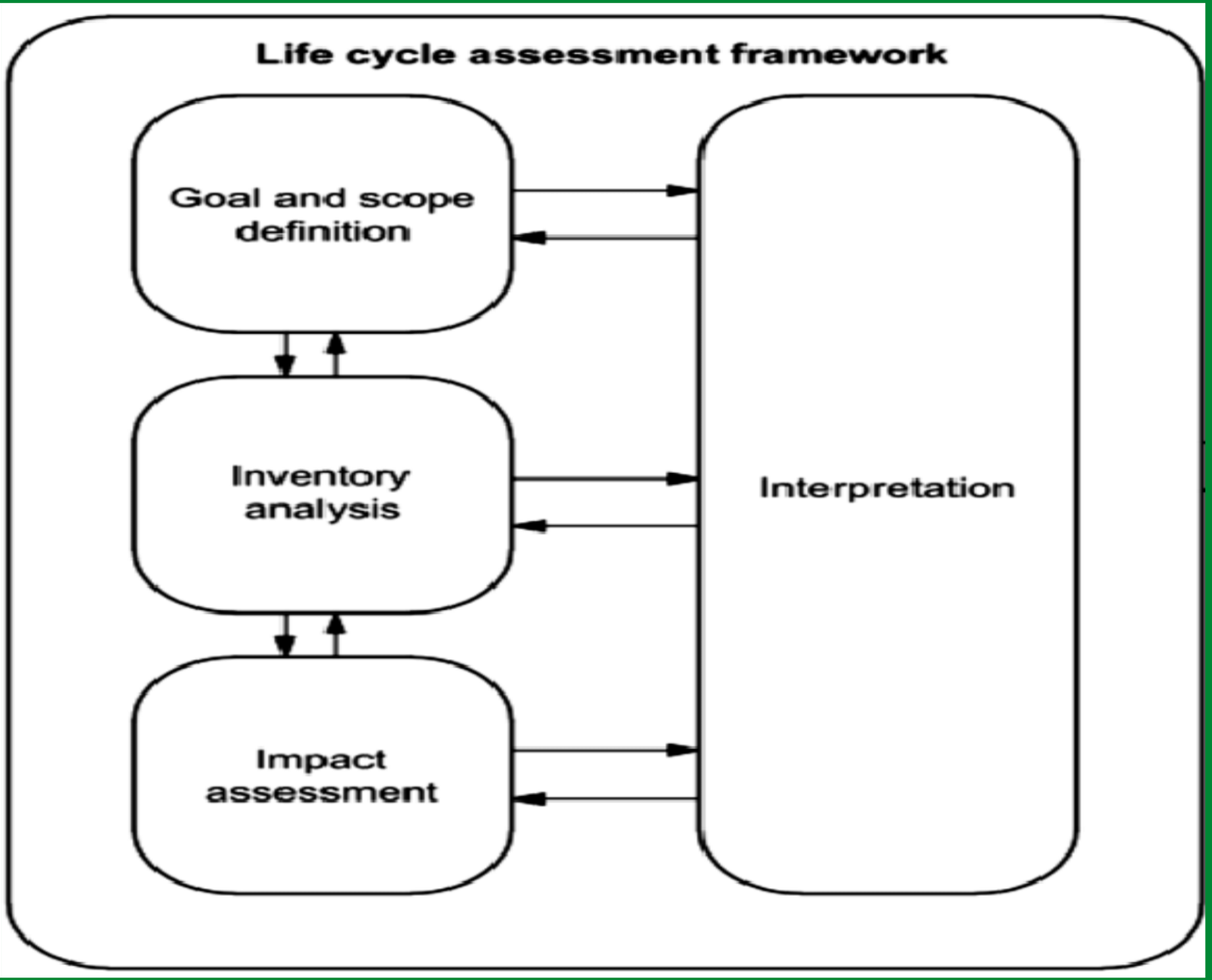
Examines the comprehensive life cycle perspective of a product or system within a given frame

Can compare systems or products to find better alternatives but does not measure what is good enough

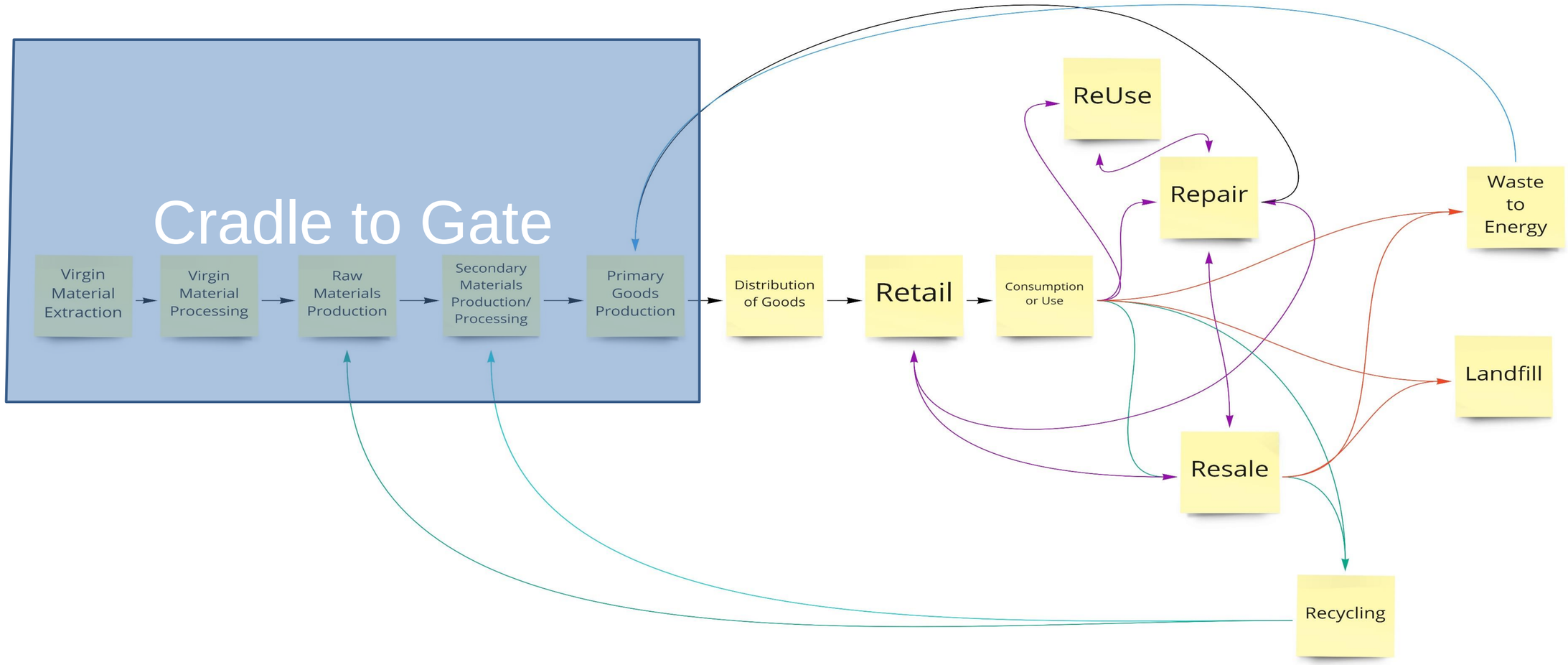
Provides a best estimate of impacts based on scientific research

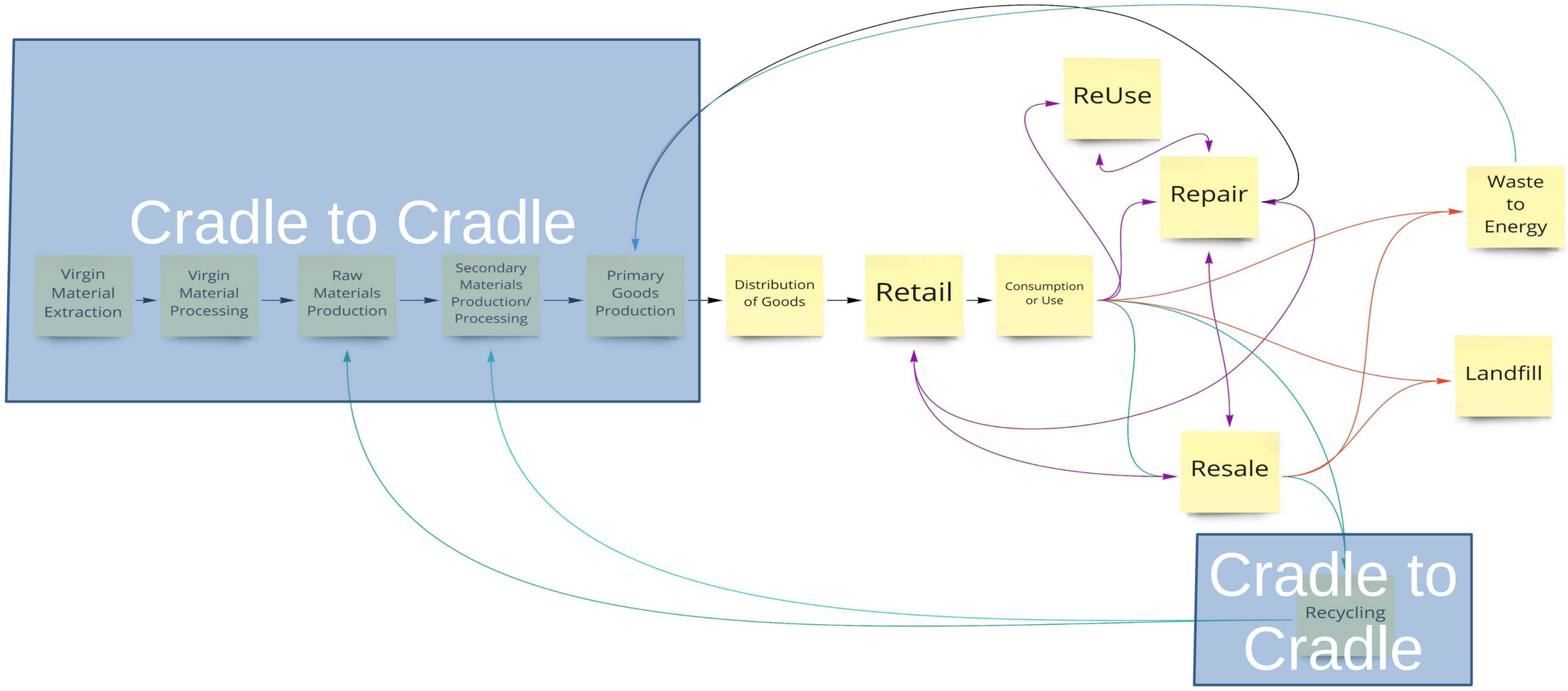
Quantitatively assesses the potential impact of a product or system on the environment

What is Life Cycle Assessment?



(ISO 14044, 2006.)


Cradle to Gate
Virgin Material Extraction
Virgin Material Processing
Raw Materials Production
Secondary Materials Production/ Processing
Primary Goods Production
Distribution of Goods
Retail
Consumption or Use
ReUse
Repair
Waste to Energy
Landfill
Resale
Recycling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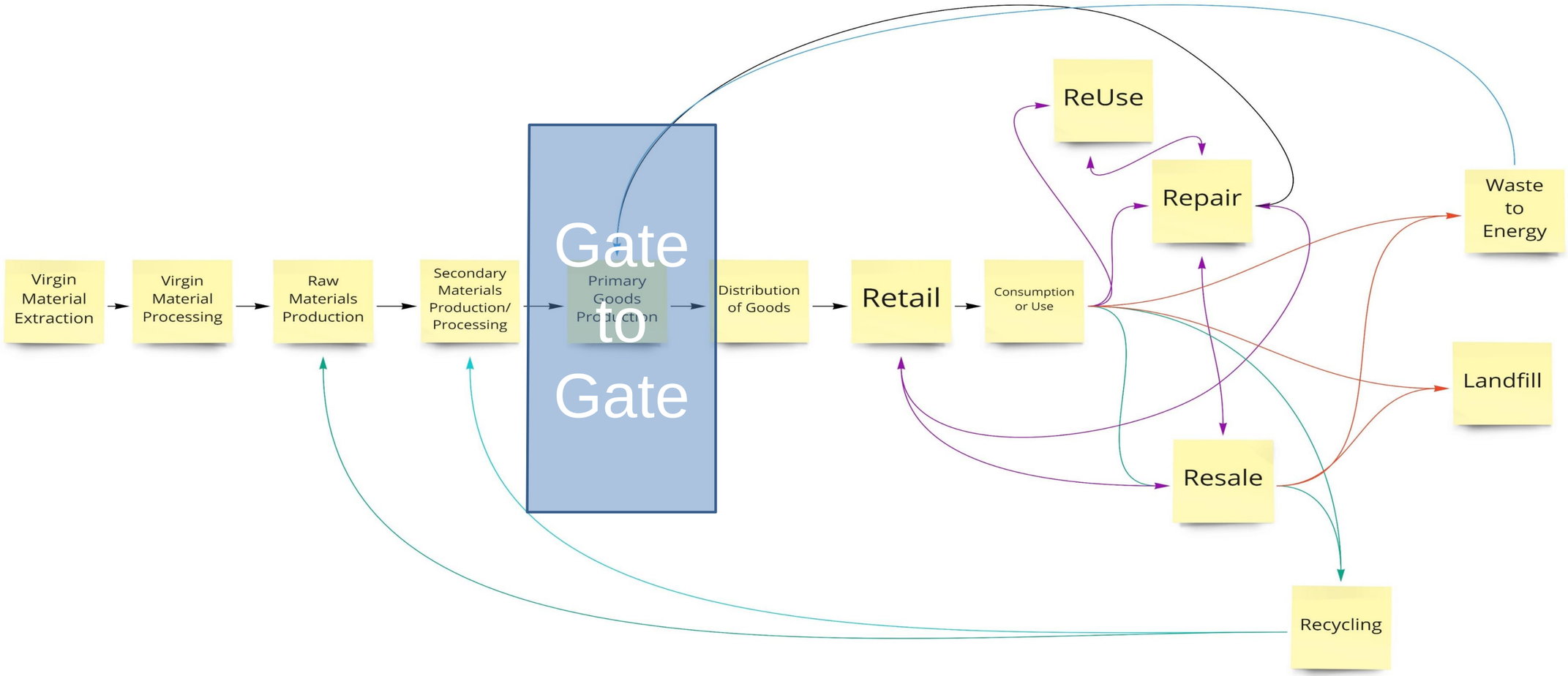
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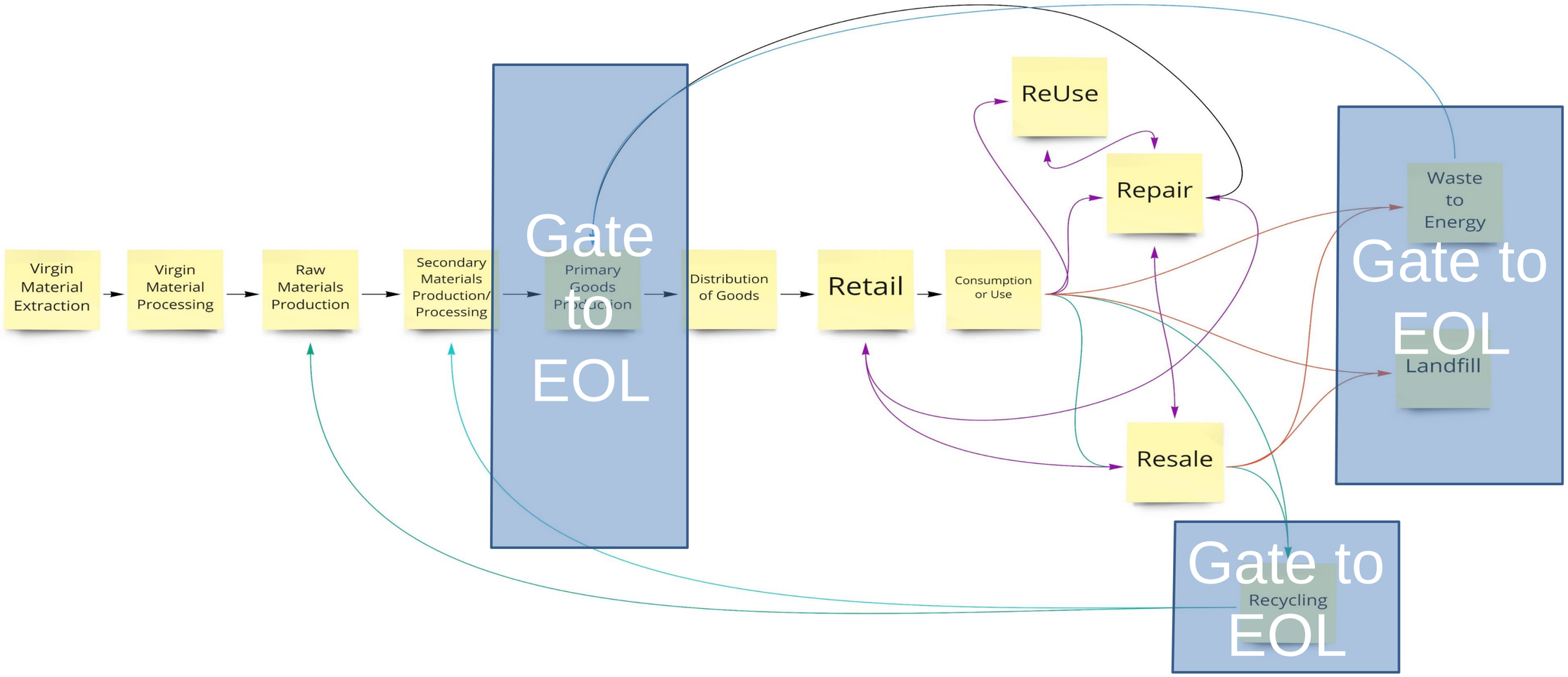
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Raw Materials Production
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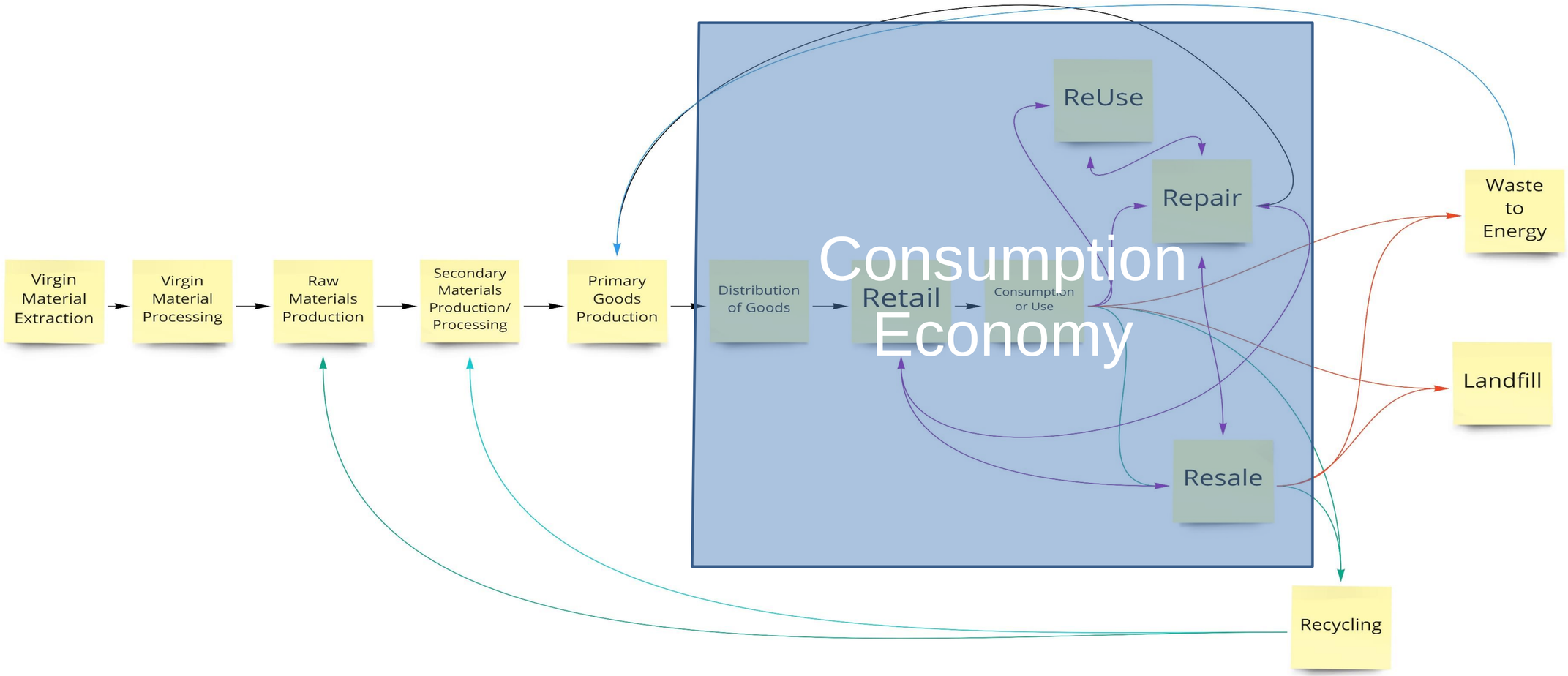
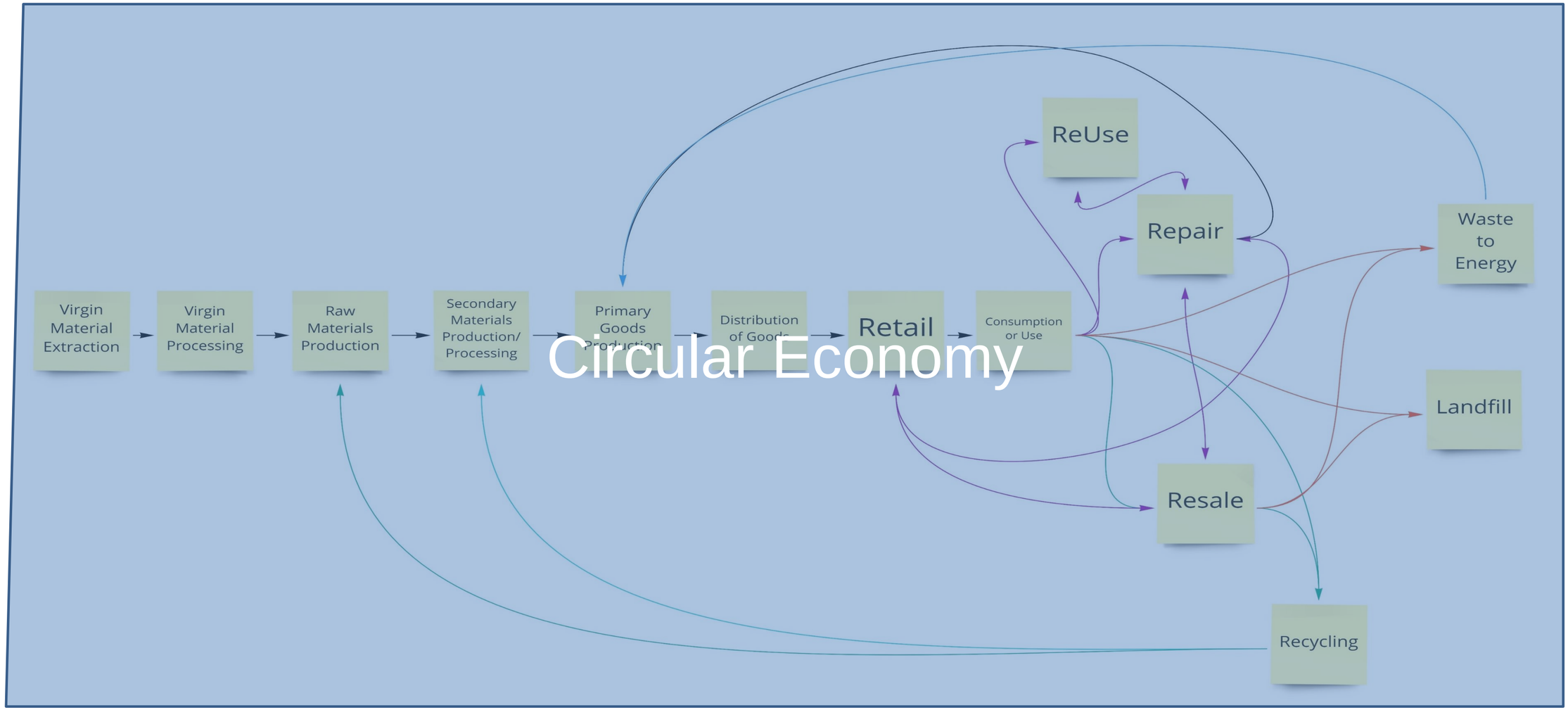
Gate to EOL
Recycling
Gate to EOL


Virgin Material Extraction
Virgin Material Processing
Raw Materials Production
Secondary Materials Production/ Processing
Primary Goods Production
Distribution of Goods
Retail
Consumption or Use
Consumption Economy
ReUse
Repair
Resale
Waste to Energy
Landfill
Recycling

Circular Economy



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Its all in how you frame it

- Environmental (LCA)
- Time based (Dynamic LCA)
- Economic (LCC)
- Social (SLCA)
- Geographic Representativeness (Territorial LCA)
- Prospective (PLCA)
- Sustainability (LCSA)

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What kind of LCA approach do you think might best help you assess the sustainability impact of your research?

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CASE OF ADDITIVES IN PLASTICS FOR A CIRCULAR ECONOMY

Why additives in plastics?

- 6,000-10,000+ additives are commonly used in plastics within the EU (Aurisano et al., 2021; Wiesinger et al., 2021).
- Additives can make up between .01- 70% of a plastic's net weight (Aurisano et al., 2021).
- Homogeneous polymer streams are crucial to achieve circularity with current recycling technologies (Eriksen et al., 2019.; Pivenko et al., 2015), how are additives considered?

What we are asking:

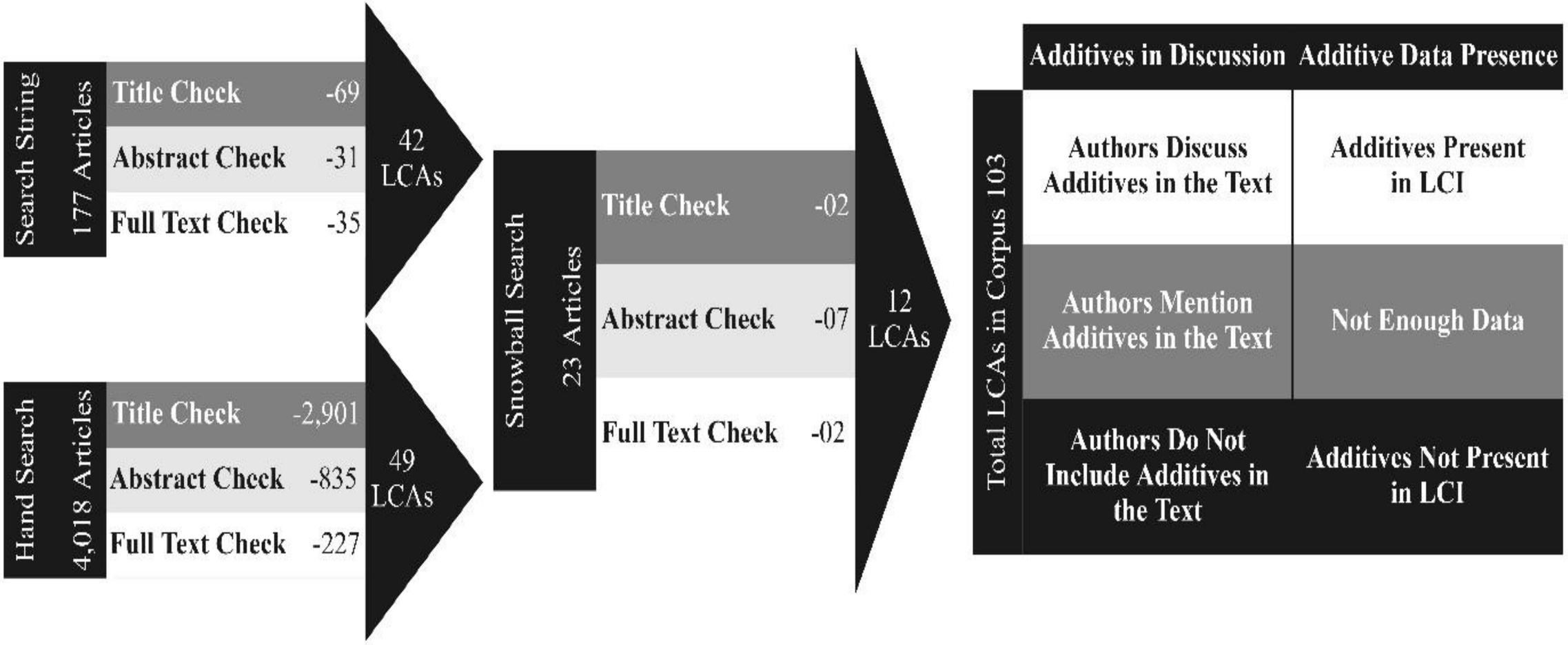
How do LCA's today account for additives in assessments which consider multiple loops?

What is the quality of additive data in existing LCI databases? How does this quality impact the certainty of assessments on circular plastic systems?

How can accurate additive data influence LCAs of plastics in multiloop LCA models?

Which additives improve plastic circularity in select polymer/use cases?

How can policy, regulation, and design guidelines on additives improve plastic recycling streams and bring us closer to a circular economy for plastics?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Abstract Check -31
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49 LCAs
Snowball Search
23 Articles
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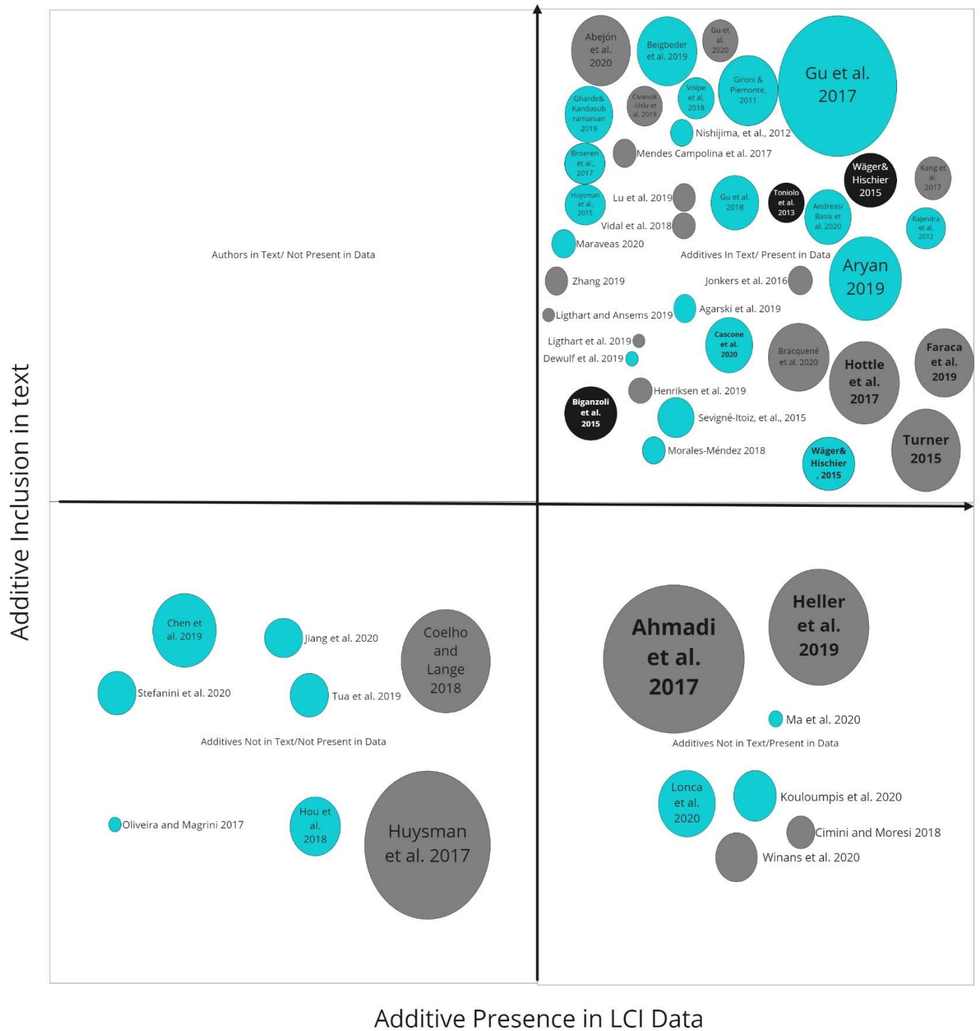
12 LCAs
Total LCAs in Corpus 103
Additives in Discussion
Additive Data Presence
Authors Discuss Additives in the Text
Additives Present in LCI
Authors Mention Additives in the Text
Not Enough Data
Authors Do Not Include Additives in the Text
Additives Not Present in LCI


Additive Inclusion in text
Additive Presence in LCI Data
Authors in Text/ Not Present in Data
Additives In Text/ Present in Data
Additives Not in Text/Not Present in Data
Additives Not in Text/Present in Data
Abejón et al. 2020
Beigbeder et al. 2019
Gu et al. 2020
Gu et al. 2017
Gironi & Piemonte, 2011
Volpe et al. 2018
Ghardes& Kandasubramanian 2019
Nishijima, et al., 2012
Mendes Campolina et al. 2017
Broeren et al., 2017
Wäger& Hischier 2015
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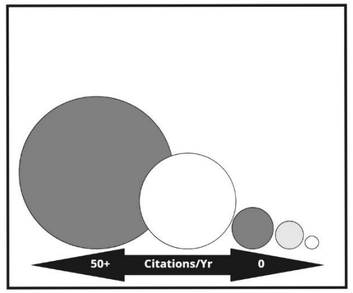
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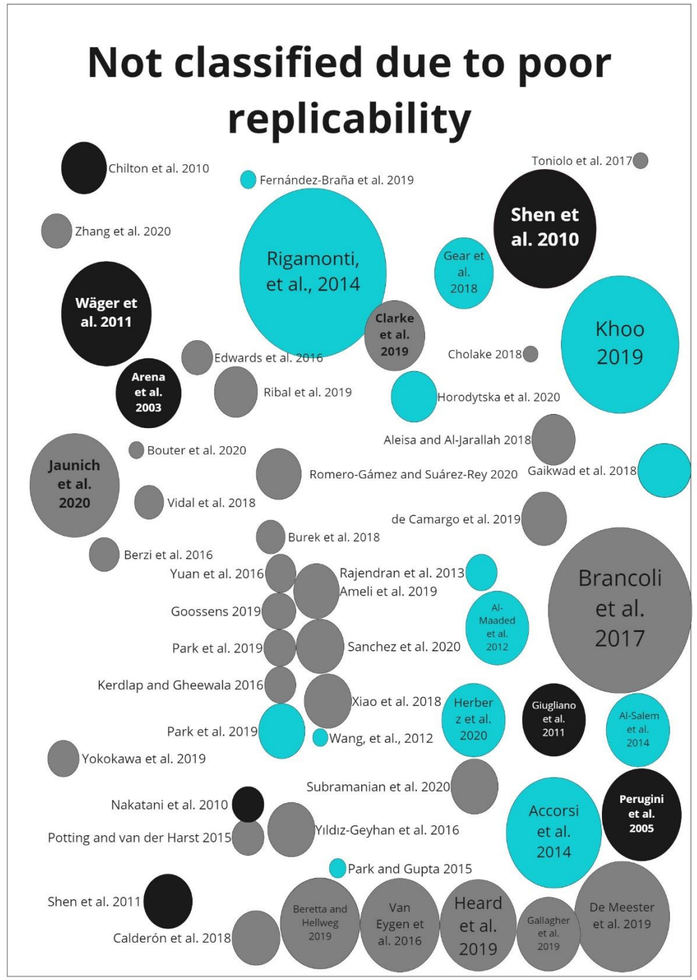
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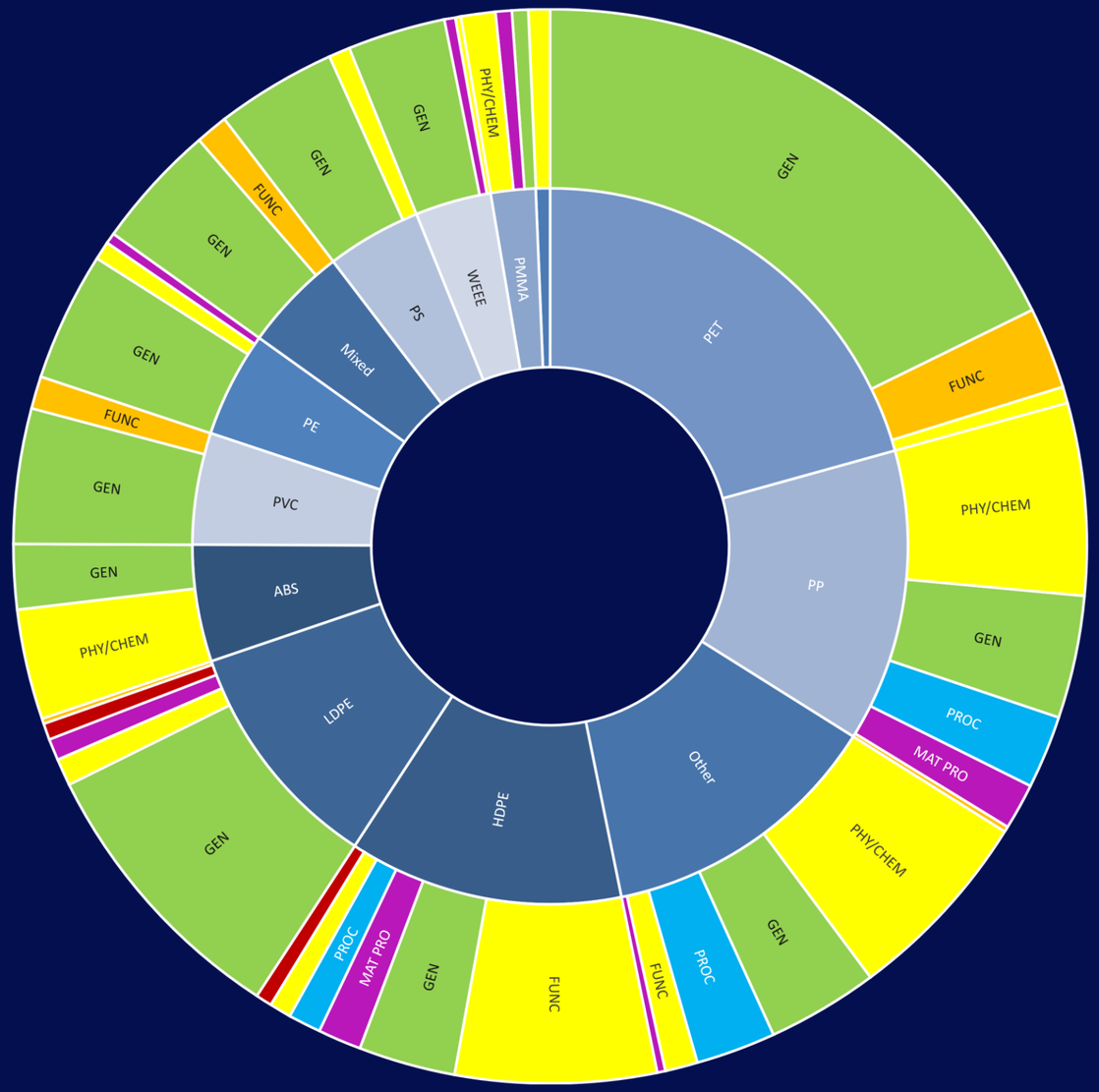

Quality Assessment

What LCI databases were used?

All versions of data within date range of study compiled in data base

Pedigree matrix applied to each updated version of a node

Ranked data highest to lowest quality

Highlighting where in the scope additive data is highest quality

Highlight where improved additive data is needed