REUSE, RECYCLE . . . REBOUND?
PROMISES AND PITFALLS OF THE CIRCULAR ECONOMY

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RESEARCH AND ANALYSIS

A Market-Based Framework for Quantifying Displaced Production from Recycling or Reuse

Trevor Zink, Roland Geyer, and Richard Startz

Keywords:
avoided burden
displaced production

Summary

The most significant environmental benefit of recycling or reusing a wide range of products

RESEARCH AND ANALYSIS

Toward Estimating Displaced Primary Production from Recycling

A Case Study of U.S. Aluminum

Trevor Zink,[1] Roland Geyer,[2] and Richard Startz[3]

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FORUM

Common Misconceptions about Recycling

Roland Geyer, Brandon Kuczenski, Trevor Zink, and Ashley Henderson

Keywords:
closed-loop

Summary

RESEARCH AND ANALYSIS

Circular Economy Rebound

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Keywords:
circular economy
closed loop recycling
economics
industrial ecology
reuse
rebound effect

Summary

The so-called circular economy—the concept of closing material loops to preserve products, parts, and materials in the industrial system and extract their maximum utility—has recently started gaining momentum. The idea of substituting lower-impact secondary production for environmentally intensive primary production gives the circular economy a strong intuitive environmental appeal. However, proponents of the circular economy have tended to look at the world purely as an engineering system and have overlooked the economic part of the circular economy. Recent research has started to question the core of the circular economy—namely, whether closing material and product loops does, in fact, prevent primary production. In this article, we argue that circular economy activities can increase overall production, which can partially or fully offset their benefits. Because there is a strong parallel in this respect to energy efficiency rebound, we have termed this effect "circular economy rebound." Circular economy rebound occurs when circular economy activities, which have

FORUM

Material Recycling and the Myth of Landfill Diversion

Trevor Zink[1] and Roland Geyer[2]

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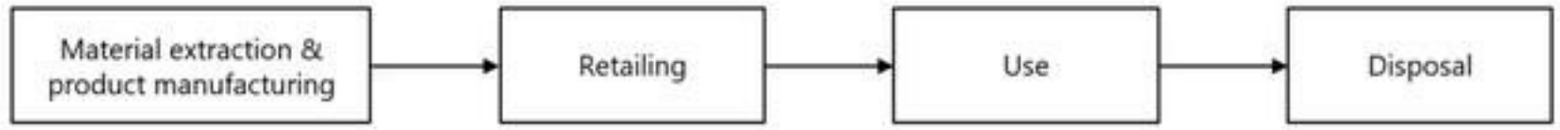
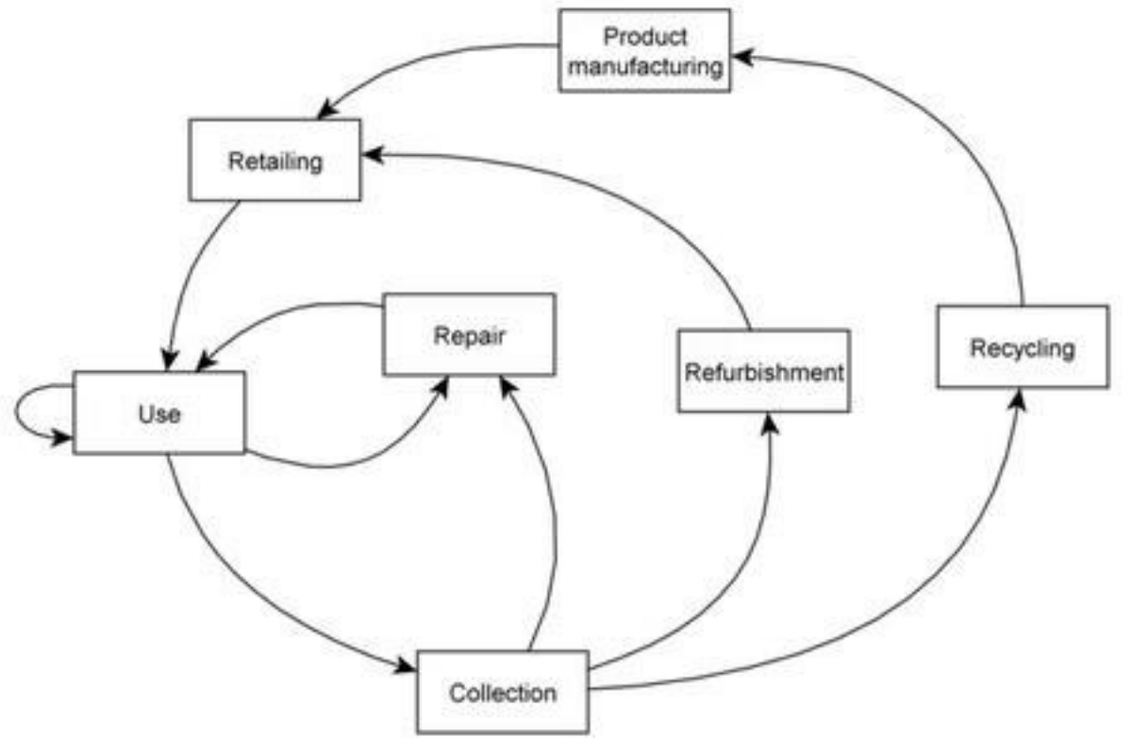
THE "CIRCULAR ECONOMY" (CE)

Linear economy:



Circular economy:



WHY WE RECYCLE

Source: EAA

WHY WE RECYCLE

Misconception: Recycling 'reduces waste'

- Usually means: Recycling reduces landfill

81% *of Americans cited helping reduce landfills as an advantage of recycling*
– Call2Recycle

Source: EAA

WHY WE RECYCLE

Misconception: Recycling 'reduces waste'

Reality:

- Limited reuse
- Thermodynamic laws
- Recycling impacts higher than landfill

- Aluminum collection, sorting, and processing → 1.6 kg CO_2-eq. per kg

Source: EAA

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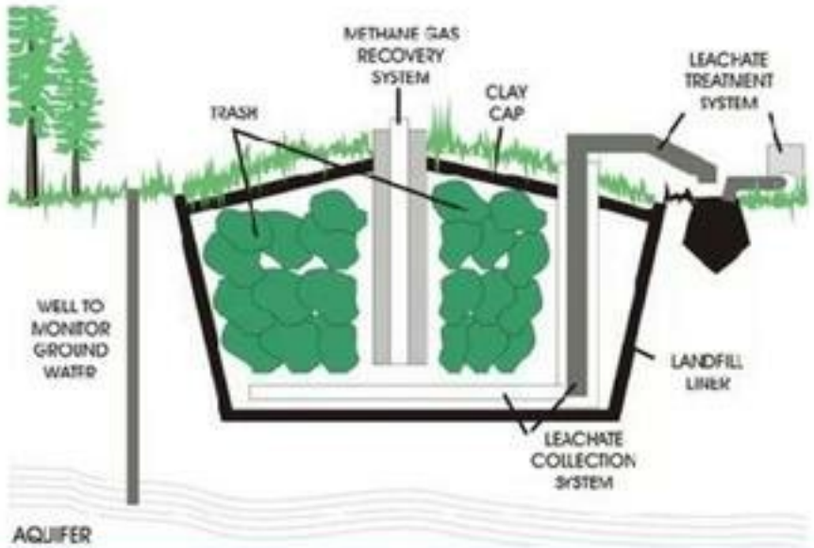

Aluminum collection, sorting, and processing → 1.6 kg CO_2-eq. per kg

Aluminum in landfill → 0.01 kg CO_2-eq. per kg

Source: EAA

WHY WE RECYCLE

Reality: The benefit is primary production "displacement"

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WHY WE RECYCLE

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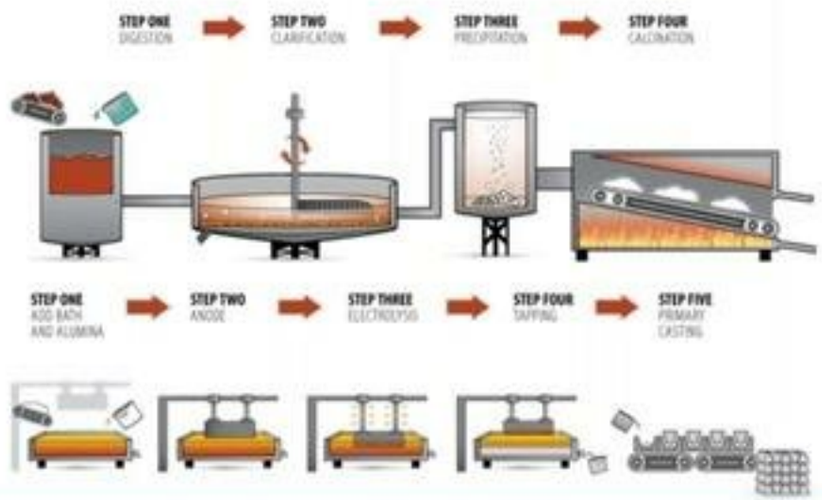


Primary aluminum production (from bauxite) → **11.4 kg CO_2-eq. per kg**

Savings: 11.4 – 1.6 = 9.8 kg CO_2 / kg

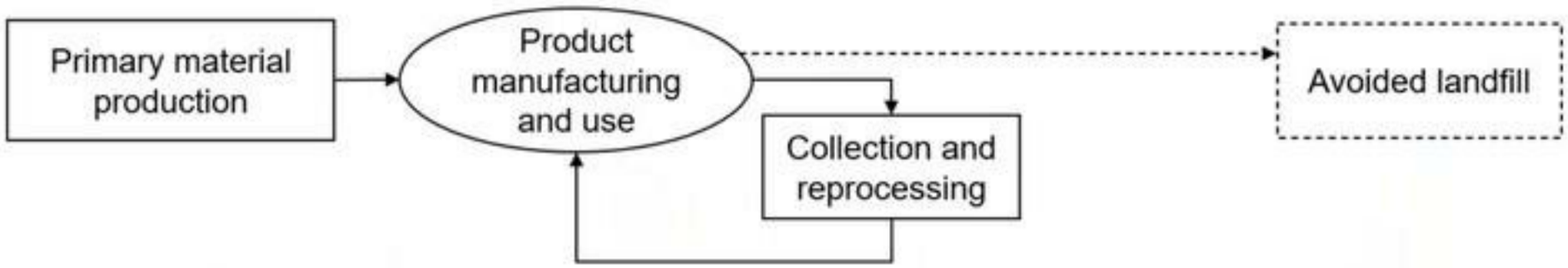
Source: EAA

THE BENEFIT OF RECYCLING

SAVINGS FROM RECYCLING = **AVOIDED PRIMARY IMPACTS** + **AVOIDED LANDFILL IMPACTS** − **REPROCESSING IMPACTS**

A BASIC RECYCLING SYSTEM

How it's commonly conceived – an engineering system



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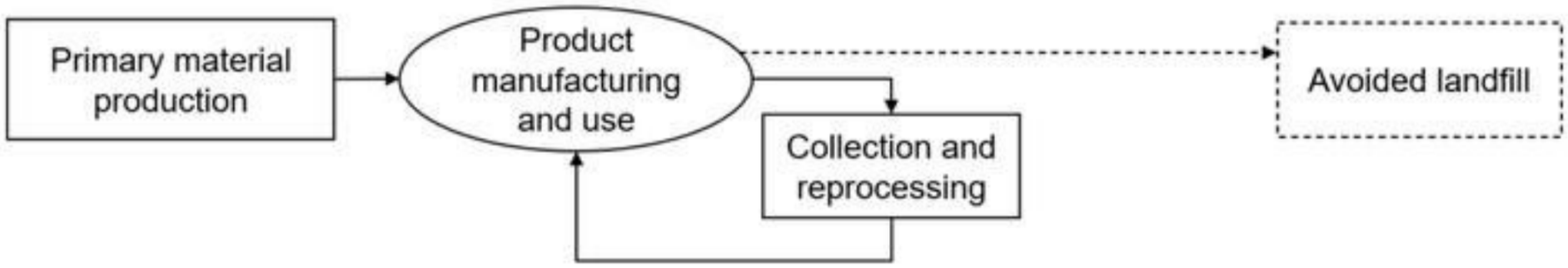
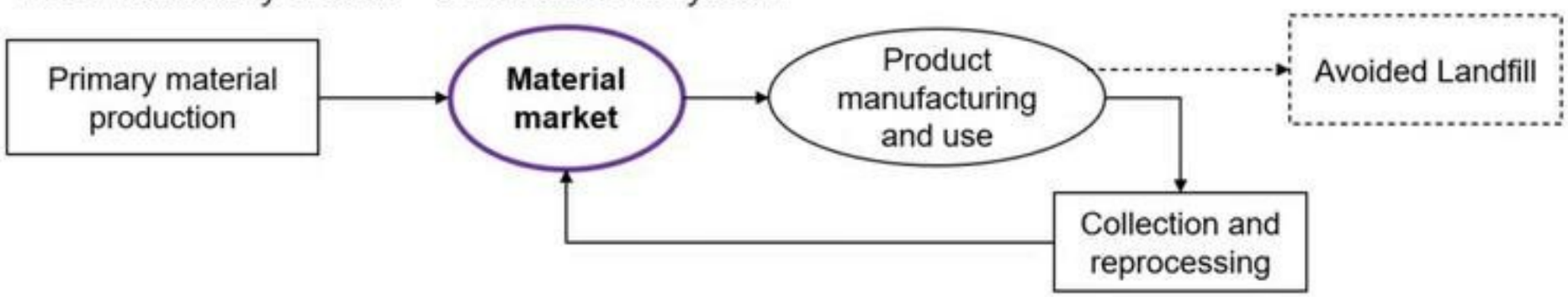


How it actually works – an economic system



PRICE EFFECT REBOUND

When products are substitutes, a subsidy/supply increase of either good will…

- Result in reduced prices for both goods
- Result in higher consumption of both goods
- The resulting equilibrium (price/quantity for both goods) is difficult to know without specific data (and even with it), but
- The overall quantity of goods consumed will always be higher than before – fringe consumers will enter market, inducing greater supply

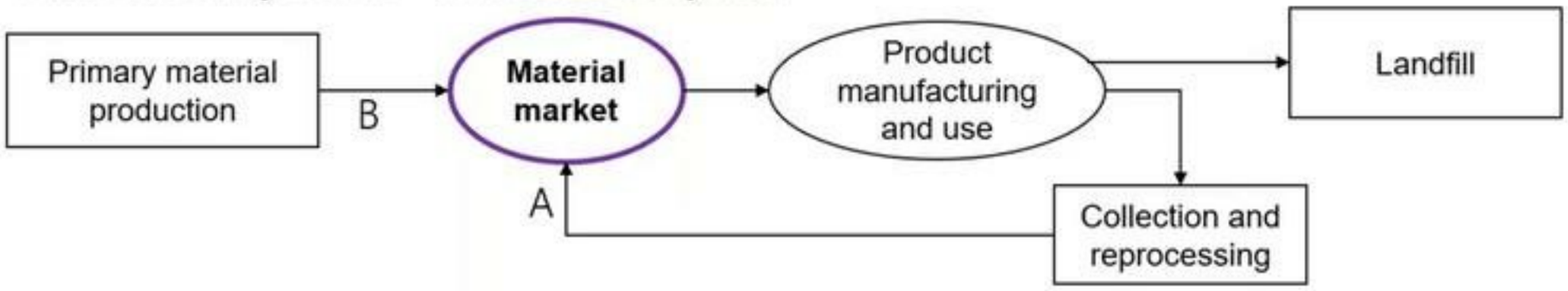
If consumers respond to changes in price (which they always do), increasing the supply of one good will not reduce consumption of its substitutes by the same amount

In reality, the primary and secondary versions are not the only substitutes

- Could compete with other materials (e.g. recycled aluminum may displace virgin or recycled steel or plastic)

DISPLACEMENT RATE

How it actually works – an economic system



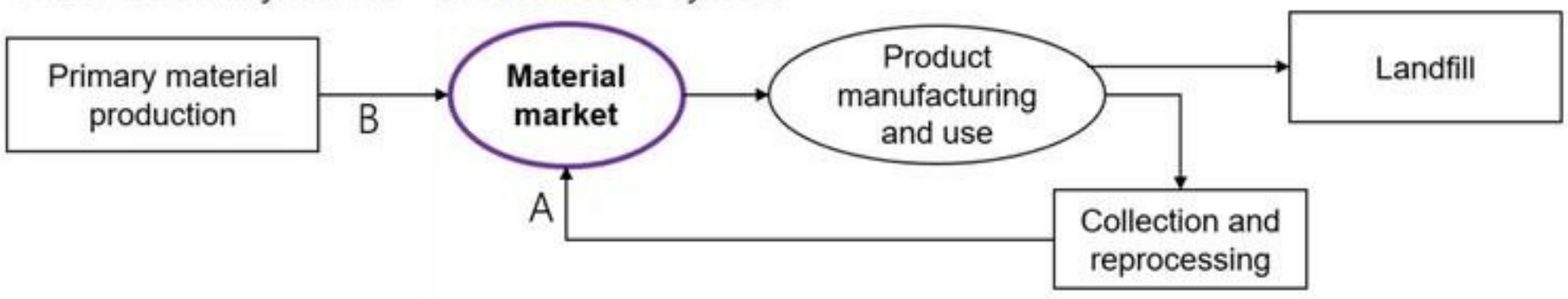
Displacement rate: $d = \frac{\Delta B}{\Delta A}$

Benefit of recycling = d × (Avoided primary + avoided landfill) – reprocessing




DISPLACEMENT RATE

How it actually works – an economic system



Displacement rate: $d = \frac{\Delta B}{\Delta A}$

$0 = d_{be} \times$(Avoided primary + avoided landfill) – reprocessing

d_{be} = reprocessing/(avoided primary + avoided landfill)

For aluminum: d_{be} = 14%

Estimated US aluminum displacement rate
~10% (source)

For steel: d_{be} = 23%

Estimated US steel displacement rate
~63%

BEHAVIORAL REBOUND

When recycling is an option…

- People took 32% more pens
- People used 44% more scratch paper
- People used 19% more wrapping paper
- People used 28% more sample cups

…and felt better about it!

Sun & Trudel 2017
Ma, et al. 2019

CHECKING IN…

The circular economy is reuse, repair, refurbishment, and recycling

We recycle in hopes that we prevent more harmful primary production

There's no guarantee recycling does that

- Can increase overall consumption
- Can displace something else less harmful

Recycling can cause us to consume more

REFURBISHMENT

What is the potential benefit?

REFURBISHMENT

What is the potential benefit?

- E.g.: 7 kg CO2 for refurbished smartphone vs 15 kg CO2 for primary smartphone

What is the potential problem?

- Are refurbished phones substitutes for new?
- Used clothes?
- Used cars, refurbished buildings?

Will refurbished products *actually* displace primary alternatives?

REUSE

What is the potential benefit?

- If it's not displacing anything, it's not helping

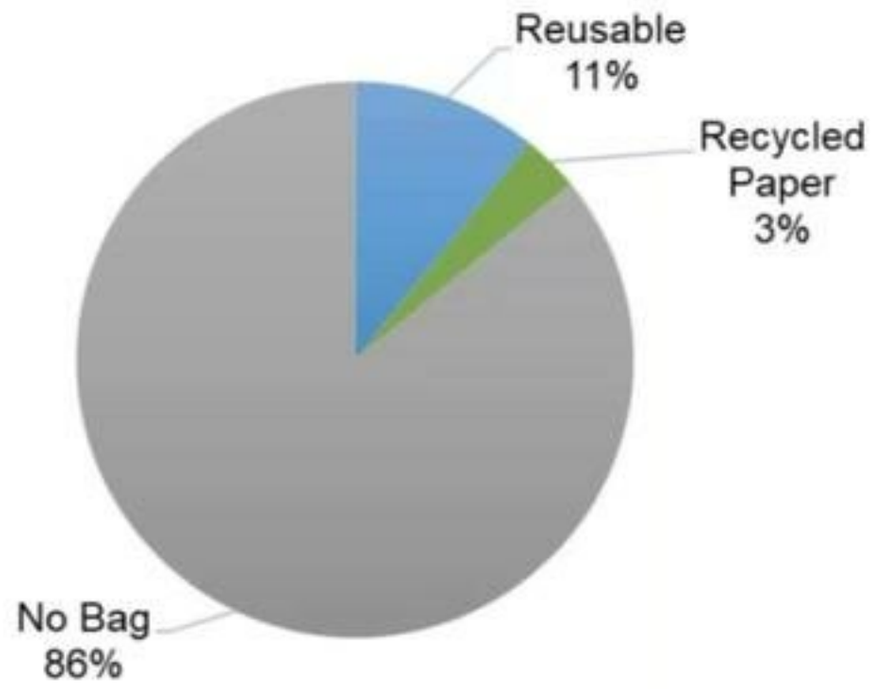
What is the potential problem?

- Reusable items are bigger, heavier, include more material
- They incur an impact "debt" at production that must be "worked off" over time by displacing single-use items
- What if they aren't used enough?

MISSING THE POINT ON REUSABLES

Impacts of making a reusable bag are 11-33x higher than a single-use plastic bag.

What if the 11% of reusable bags used were all new bags?
Impacts increase 100-300%



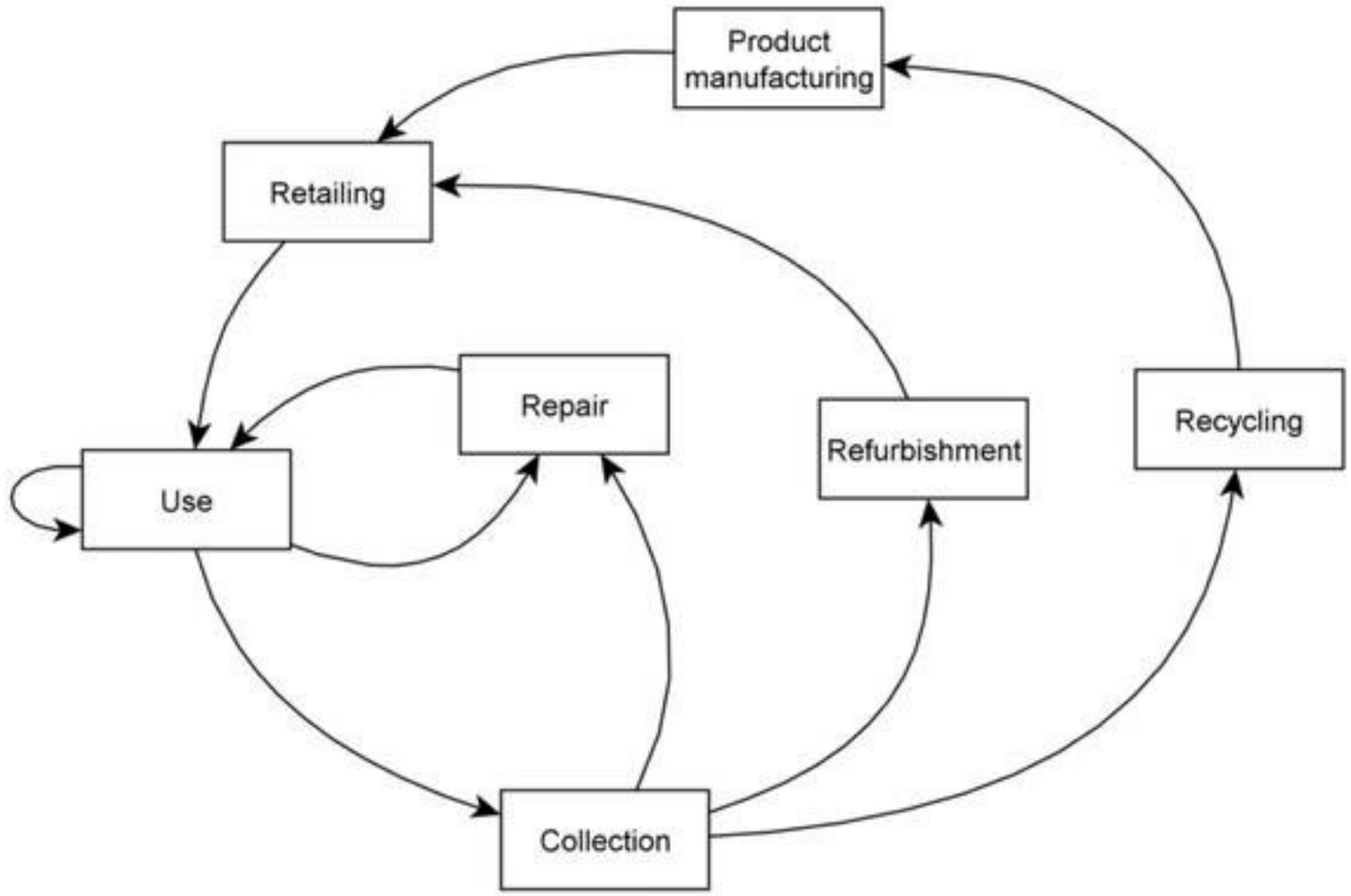
Source: CalRecycle

MISSING THE POINT ON REUSABLES

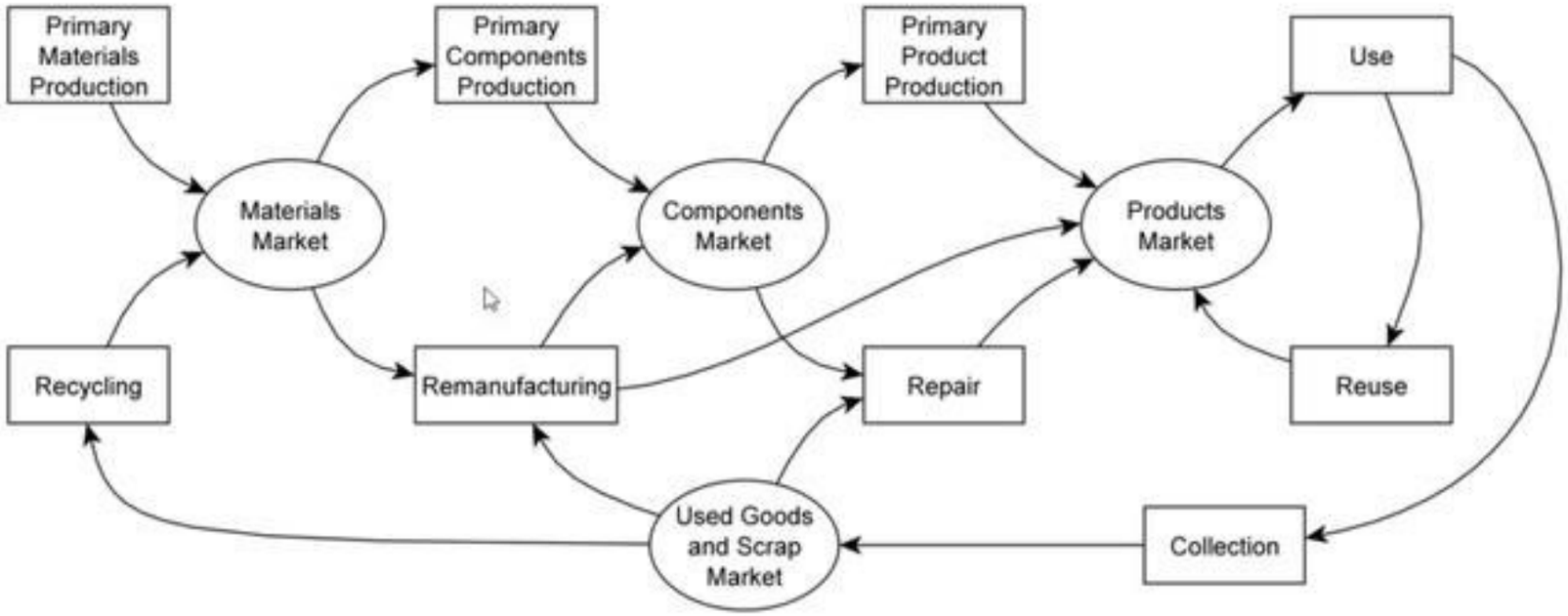
"Using this reusable bag keeps hundreds of disposable plastic bags out of landfills and from littering our cities, rivers, and oceans."

- Only if it actually displaces single-use bags
- Disposal is not the problem—focus on production
- Why are the bags ending up outside landfills?

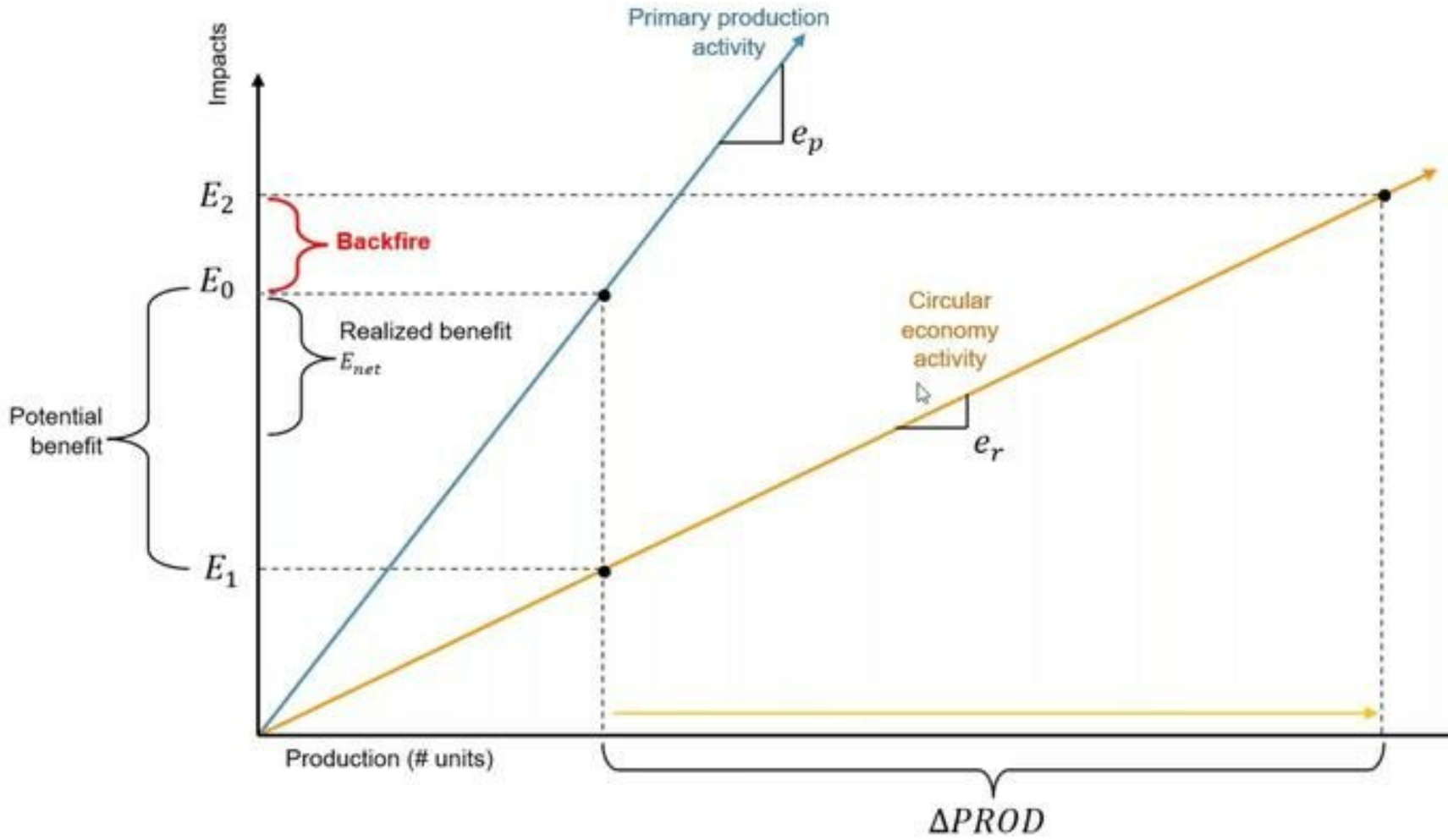
THE ENGINEER'S DIAGRAM



THE ECONOMIST'S DIAGRAM



CIRCULAR ECONOMY REBOUND



MORE GENERAL LESSONS

CE activities can either raise or lower production and use impacts

CE activities can either raise or lower the level of production or number of uses

		Secondary impacts relative to primary production	
		Lower	Higher
Change in production quantities	Higher	**Q1: Circular Economy Rebound** Recycling Video on demand Recoverable rocketry (SpaceX) Refurbished phones	**Q2: Higher net impact**
	Lower	**Q4: Lower net impact** Product lifetime extension (ceteris paribus)	**Q3: Potential shortfall** Reusable bottle Reusable grocery bag

CHECKING IN…

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There's no guarantee recycling does that

- Can increase overall consumption
- Can displace something else less harmful

Recycling can cause us to consume more

Refurbished items may not displace new items

Reused items must work off a debt by displacing single-use alternatives

A high risk of "circular economy rebound"

AVOIDING REBOUND

Don't seek to maximize recovery or 'circularity'

- Measures of "resource circularity" miss the point

Maximize *displacement potential*

Stagnate or reduce overall material consumption

AVOIDING REBOUND

Don't seek to maximize recovery or 'circularity'

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Maximize *displacement potential*

Stagnate or reduce overall material consumption

However...

- Means selling less or the same amount of stuff
- McKinsey & Co. advises clients to market secondary products and components in a way that does *not* cannibalize existing sales (i.e. does not displace primary production)
- Probably requires a stagnant economy, which isn't feasible under a capitalist model
- Time for something new?

TAKEAWAYS

The only potential benefit of recycling/CE is avoiding primary production
- Disposal is not the main concern – production is
- No guarantee of displacement

Stop recycling / circular economy?
- For now, probably—but that's not the point

Improve recycling / circular economy?
- Options are limited within a profit-maximizing/growth framework

Don't view CE as a "silver bullet"

Recycling *does not* make up for consumption
- The green bin is *just as bad* as the black bin
- Damage mostly comes from production, not end-of-life
- The option of recycling can induce impact-increasing behavior

Reuse/repair is usually a good option
- But, must be sure to work off the environmental "debt"!

The inconvenient solution: Source reduction (buy less stuff!)

The hard problem: How to make that work realistically?