Environmental Research & Education Foundation™

Lighting the way towards a more circular economy

Elements Impacting Recycling Programs & End Markets

Presentation for

NATIONAL ACADEMY OF SCIENCES

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Why Recycle?

- **Reduce environmental burden**
  - Environmental burden: Activity affecting environment/human health that causes pollution, increases risk or depletes natural assets (especially those that are scarce)

    Examples:
    - Minimize use/extraction of raw materials
    - Global warming potential/emissions
    - Water use
    - Acidification
    - Eutrophication
    - Smog
    - Ecotoxicity
    - Human toxicity (e.g. respiratory, cancer, etc.)
    - Energy demand

- **Save money/make money?**
  - Value of a mixed recyclables = $80 - $90 / ton
  - Cost to recycle = $75 - $85 / ton
  - Landfill tip fees = $59 - $60 / ton

Recycling programs should have a clear justification/basis and set goals based on desired outcomes and measurable metrics.

Many state/city goals are just numerical goals without sound justification or clear metrics to quantify success.

Sources: EREF (2023) "Analysis of MSW Landfill Tipping Fees-2022"; NERC Recycling Report (May 2024)

Understanding the Limitations

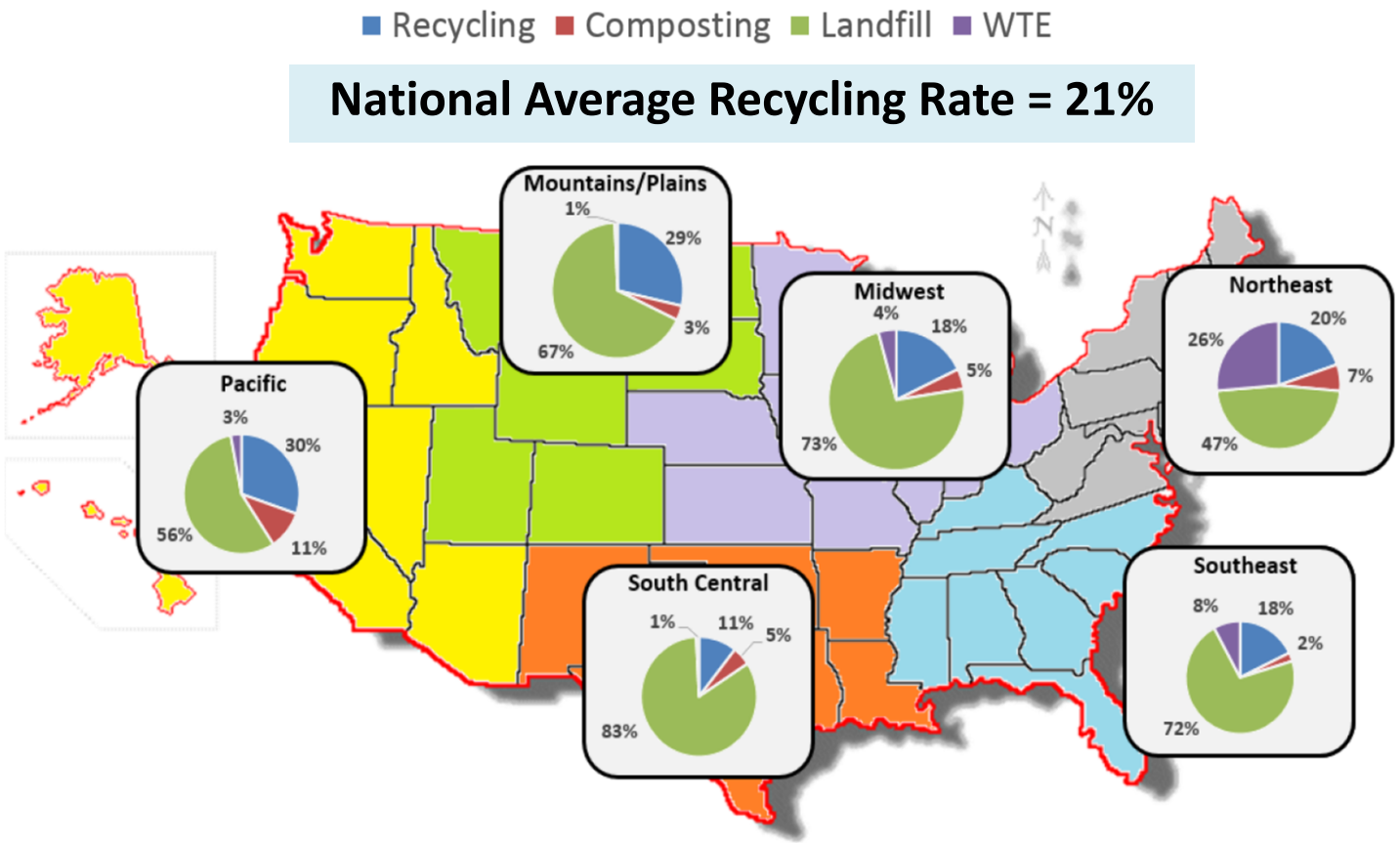
- Products manufacturers make what we buy, driven by consumer demand/preferences/need

- Consumer behavior during and after use are a significant driver of efficiency
  - The 5 R's:
    - REFUSE: refuse to use/purchase items that create waste in the first place
    - REDUCE: Reduce consumption or the generation of waste
    - REUSE: Reuse items to the extent practical
    - REPURPOSE: Find new ways to use items so they do not wind up as waste
    - RECYCLE: Recycle materials so they can be used again in a similar or different form

All are largely predicated by individual decisions

Consumers and manufacturers ultimately drive recycling as they define the starting material that can even be recovered in the first place.

Variability in Recycling: the National Picture



- Recycling varies geographically
  - Lowest = 3 - 4%
    - Montana (3%)
    - Idaho (4%)
    - Louisiana (4%)
    - Mississippi (4%)
  - Highest = 38 – 42%
    - Connecticut (42%)
    - Missouri (38%)
    - New Jersey (39%)
    - Oregon (38%)

- **How can we determine if this rate is reasonable and how much higher it can go?**

Source: EREF (2016) "MSW Management in the US"

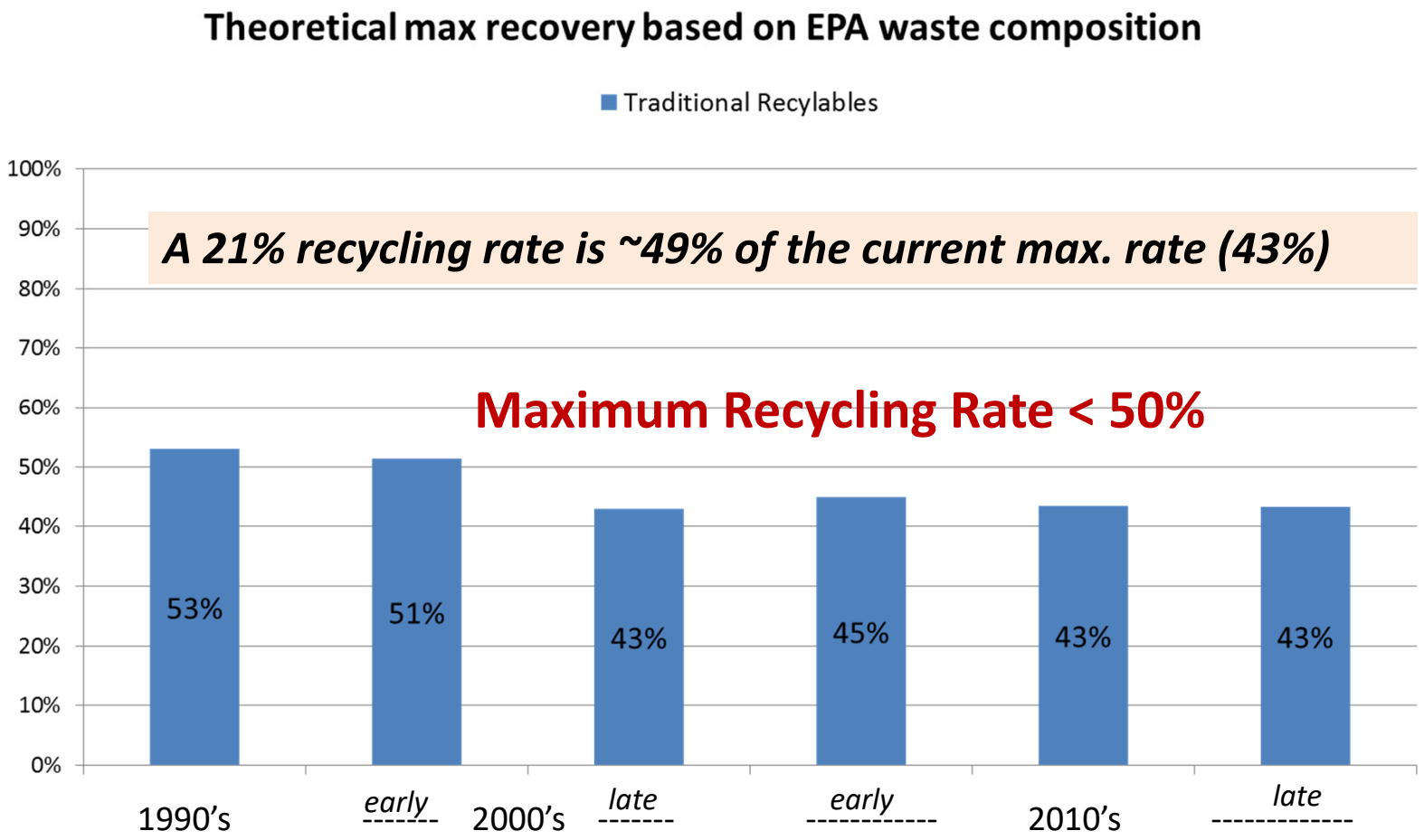
Theoretical Maximum Recycling Rate

What if we could recover 100% of every possible recyclable material from the waste stream?

- This would effectively remove the effects of consumer behavior and waste management operational efficiency.

- It would reflect the recyclability potential of generated waste, providing the ***maximum recycling rate possible*** for a given waste composition.

Maximum Recycling Rate



Validating Florida's 75% Recycling Goal (a case study)

- Florida's 2020 Recycling goal = 75%
- Theoretical Maximum Rate *(derived by EREF)* = 51.6%
  - EREF stated publicly in 2015 the 75% goal was unachievable
- Recycling rate they achieved in 2020 (Florida DEP, 2021):
  - 50% *(but this includes renewable energy credits which is NOT actual recycling)*
  - 25% for commodity recyclables
- Represents a 48.4% recovery of commodity recyclables

Source: EREF and Florida and the 2020 75% Recycling Goal - Final Report

Which material should be a focus?

Recyclable Material Emissions and Value (per ton)

Material	1000kg CO_2 Reduction	% CO_2 Reduction	Commodity Price ($/ton)
Aluminum	9.11	82%	$1450
Ferrous	1.85	50%	$222
PP	1.51	97%	$145
PET	1.25	56%	$320
HDPE	1.02	65%	$480 - $690
Mixed Fiber	0.51	43%	$62.5 - $110
Glass	0.31	53%	$11 - $58

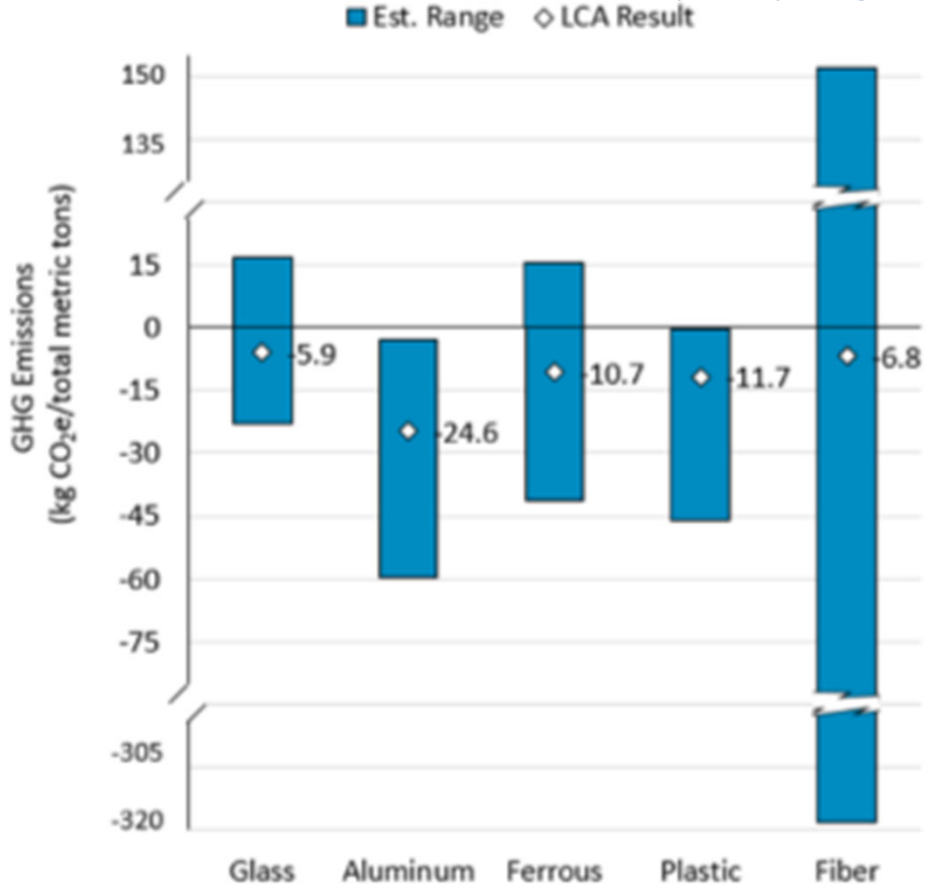
- % reduction is used widely, but this is typically less useful
- Economic value and environmental benefit may not always align.
- Higher economic value doesn't necessarily equate to the higher emissions reduction

Sources: EREF (2022) "LCA of Curbside Material Recovery"; NERC Recycling Report (May 2024), Current Recycling Commodity Pricing - 2024 (wv.gov)

Recycling's Benefit Differs By Material and Situation

- Negative values indicate emissions savings compared to landfilling
- In some scenarios, recycling results in higher emissions than landfill for glass, ferrous and fiber materials
- Factors that influence this include:
  - Product design/configuration/formulation
  - Energy grid
  - Transport distance
  - End Use
- Similar variability may occur for other burdens
  - E.g., water use to re-process plastics tends to be significantly higher than virgin material processing

Emissions from Closed Loop Recycling



Source: EREF (2022) "LCA of Curbside Material Recovery"

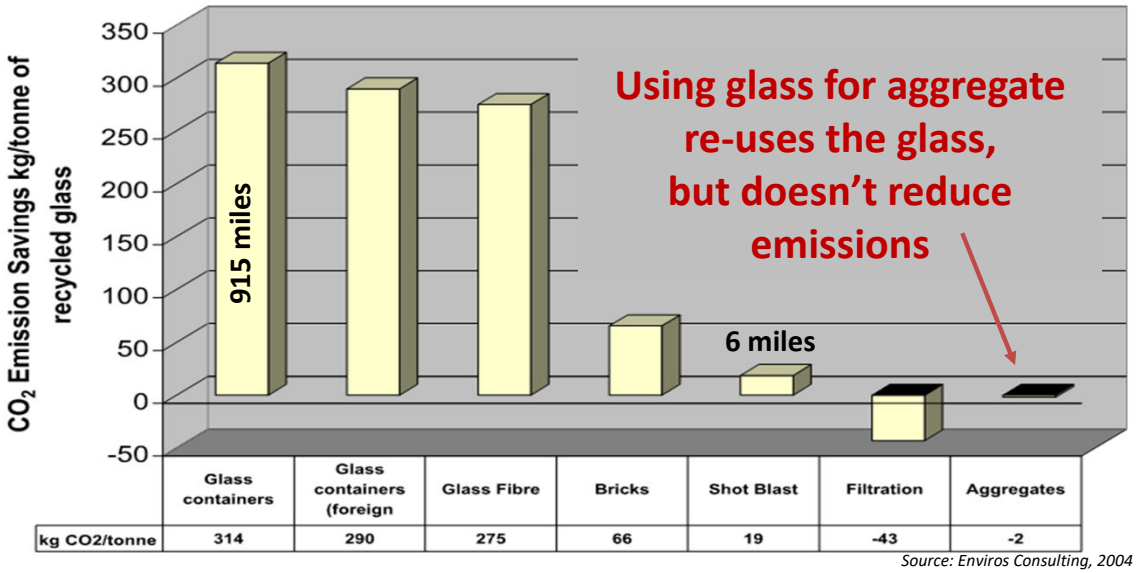
Not All End Markets are Created Equal

Recovered PET End-Uses		# of Recycles
41%	Fibers	1 – 2?
31%	Bottle-to-bottle	Many
15%	PET sheet	1
8%	Strapping Tape	1
1%	Other	~ 1

Source: NAPCOR (2019)

- Only 1/3 of recovered PET is closed loop

Glass End Uses & Estimated Emissions Savings



Source: Enviros Consulting, 2004

- Glass has ~7 end uses but roughly ½ of them offer emissions savings

- ***Majority of recoverable materials are not closed loop and go to different end uses***
- ***Each end use has a different level of sustainability benefit/impact***

Key Takeaways

1. Product manufacturers and consumers define what can be and is recycled, so they ultimately drive the long term effectiveness of a recycling program
2. Recycling rates are inconsistent and vary widely across the U.S.
3. On a national basis, the maximum recycling rate (upper limit) is likely 45 – 55% currently based on known waste compositions. Increases to this will be dictated by product manufacturers.
4. Many established recycling goals are difficult to measure, overly ambitious, or even unjustified.
5. Recyclable materials exhibit substantial differences in economic value, environmental benefit.
6. End uses can vary widely and which in some cases can negate the environmental benefit relative to landfilling.
7. Many recycled materials go to end uses that are NOT closed loop.

Thank You

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Lighting a path to sustainable waste management practices