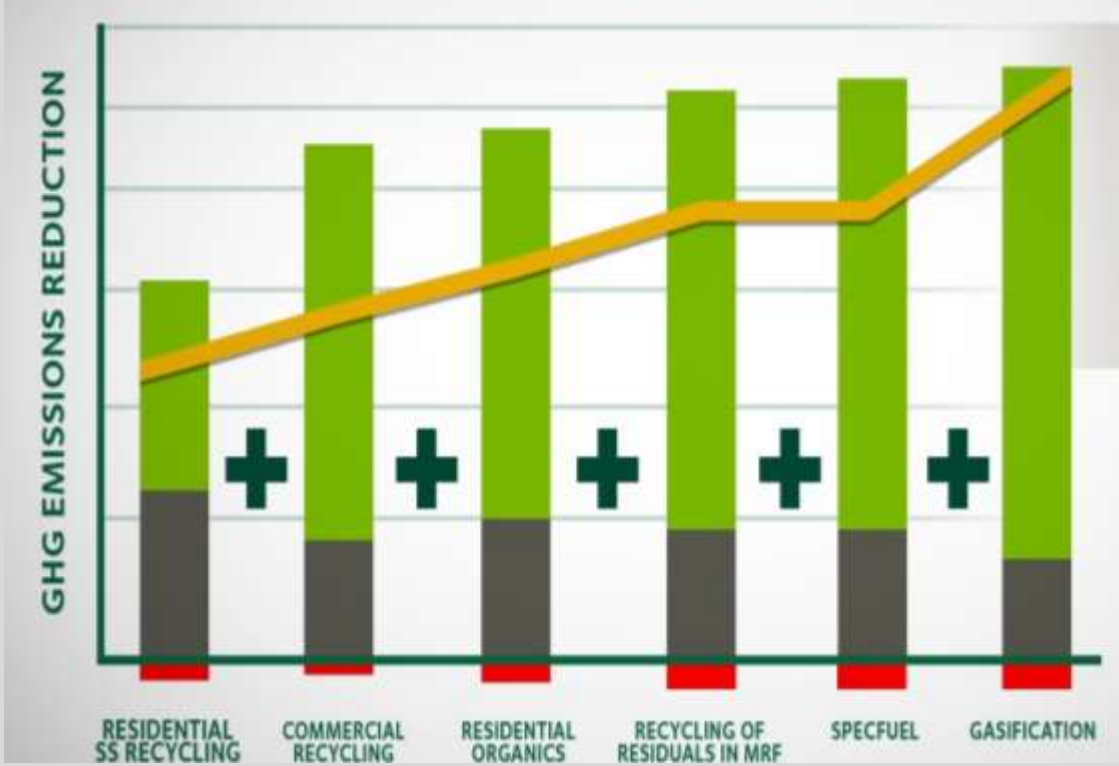
Looking Beyond Tons: Economics of GHG emissions reductions in the Environmental Services Industry



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Waste Management
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Project Overview

- Evaluated a range of environmental services, creating scenarios for each
- Analyzed the CO_2 emissions for each service
- Evaluated the cost per ton of emissions for each service
- Used mostly public information and industry-accepted data
- Created a “carbon abatement curve” for the solid waste/recycling industry.

Goal:
To review all services we provide to evaluate environmental impacts of the services we provide and cost of reducing emissions

Assumptions

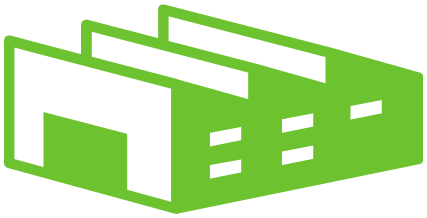
- US EPA 2014 Facts & Figures
- 254 million ton base
- Best practice recovery rates by generator type

- US EPA WARM Model
- GHG emissions focus

- National average disposal cost
- WM collection & processing cost
- 10-year average recycling values

- Incorporated data from 69 state & local waste char. studies across US
- Assumed Best Practice success for each scenario
- Assumed Traditional Recyclables = bottles, cans, paper & cardboard
- Recognized differences between residential and commercial

Scenarios

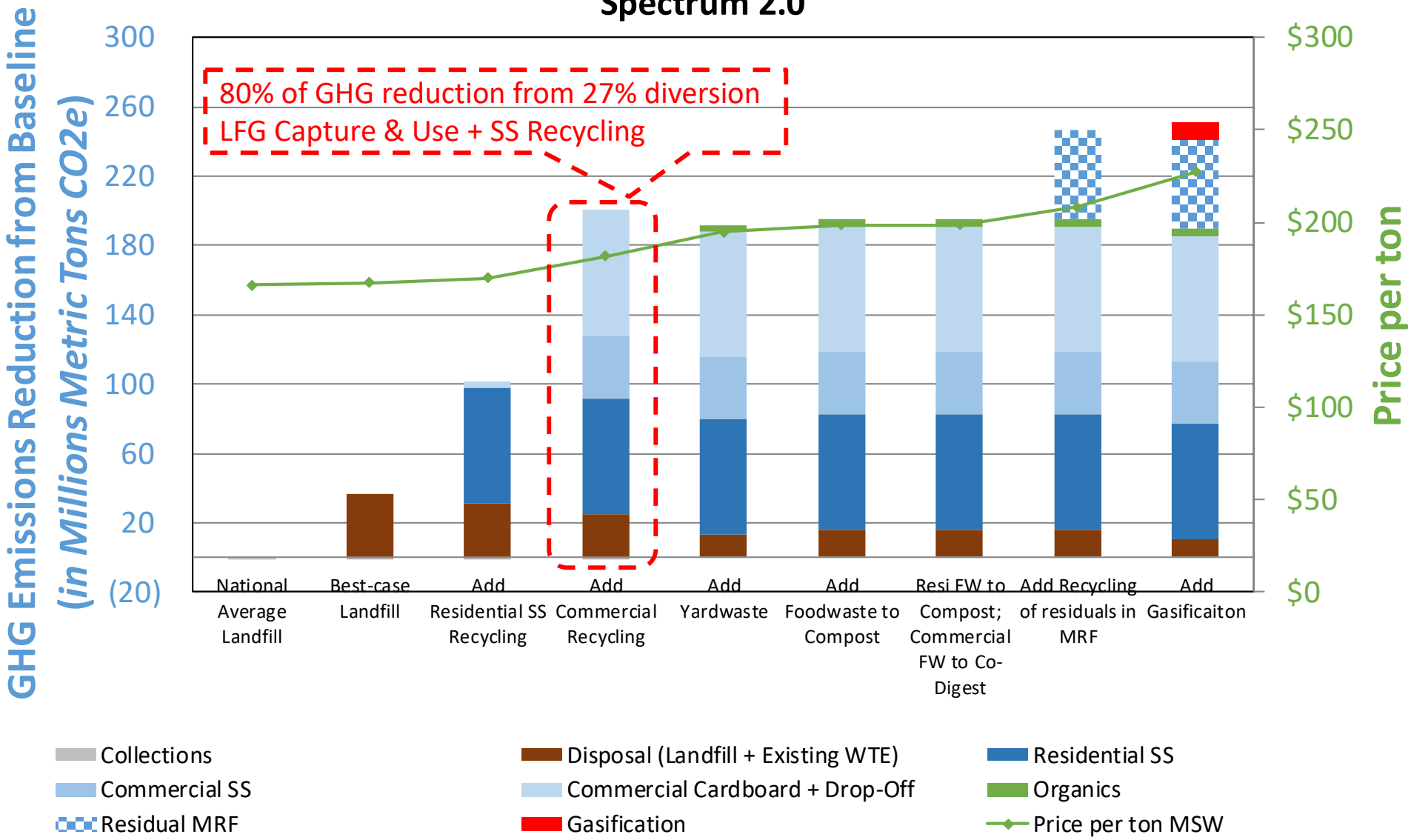


- **Base scenario:** 72% of MSW tons to landfills with LFGTE, 13% flare and 15% to LF with no LFG capture
- **Best Case Landfill scenario:** 100% of MSW to landfills with LFGTE. 75% gas capture.

- **RSS:** Best practice residential single stream recycling of paper, cans and bottles
- **CSS:** Best practice commercial singles stream recycling of paper, cans and bottles
- **YW:** Best practice composting of yardwaste
- **FW:** Best Practice composting / AD of foodwaste.

- **RMRF** Process all residual tons after recycling
- **Gasification:** All suitable post-recycling residuals material to gasification

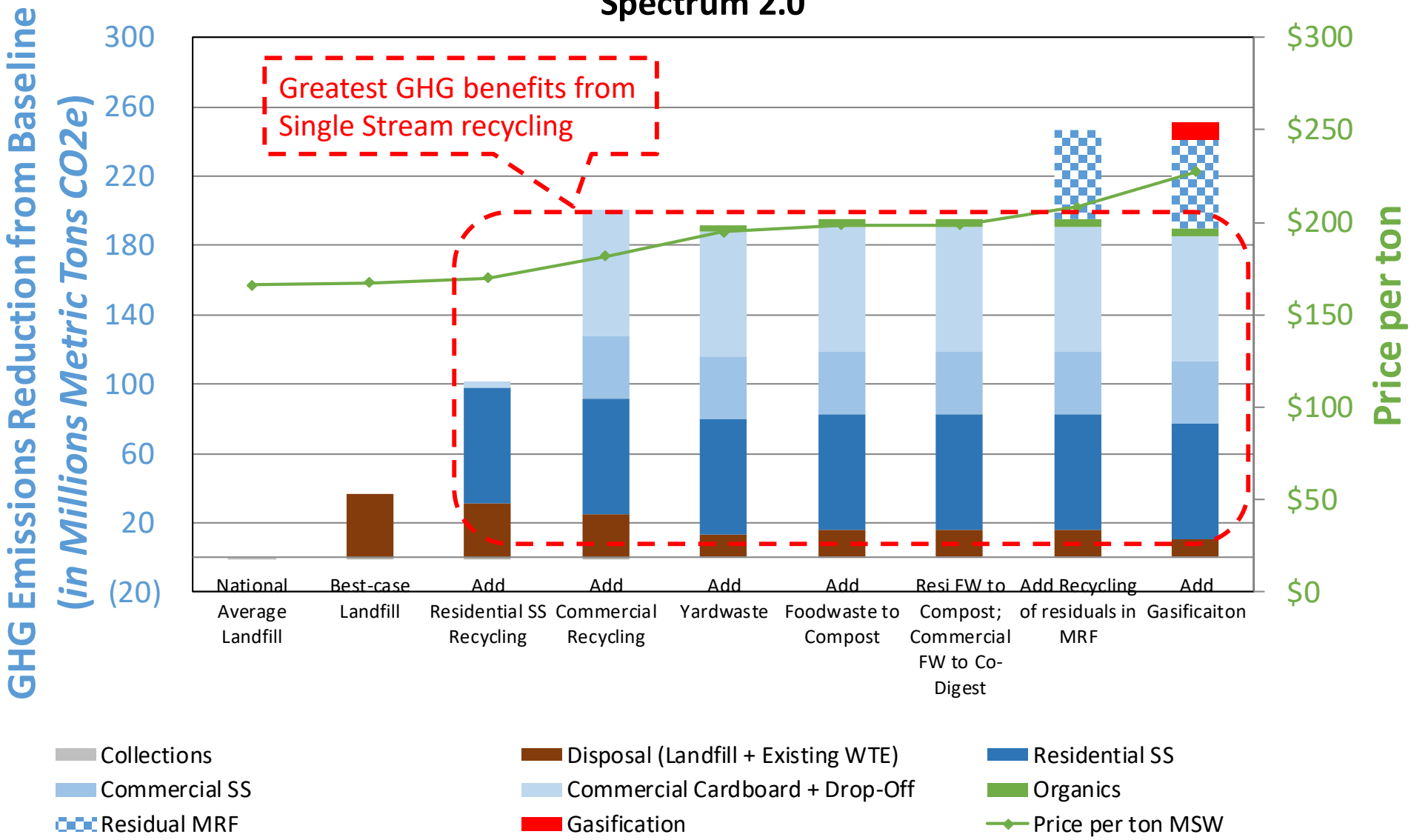
Spectrum 2.0



- **Scenarios build upon each other**
- **80% GHG benefit from aggressive LFG capture & use + recycling 27% of MSW**
- **More processing = high incremental cost for low incremental GHG reduction**

NOTE: LF Baseline emissions of 15 Million MTCO2e

Spectrum 2.0



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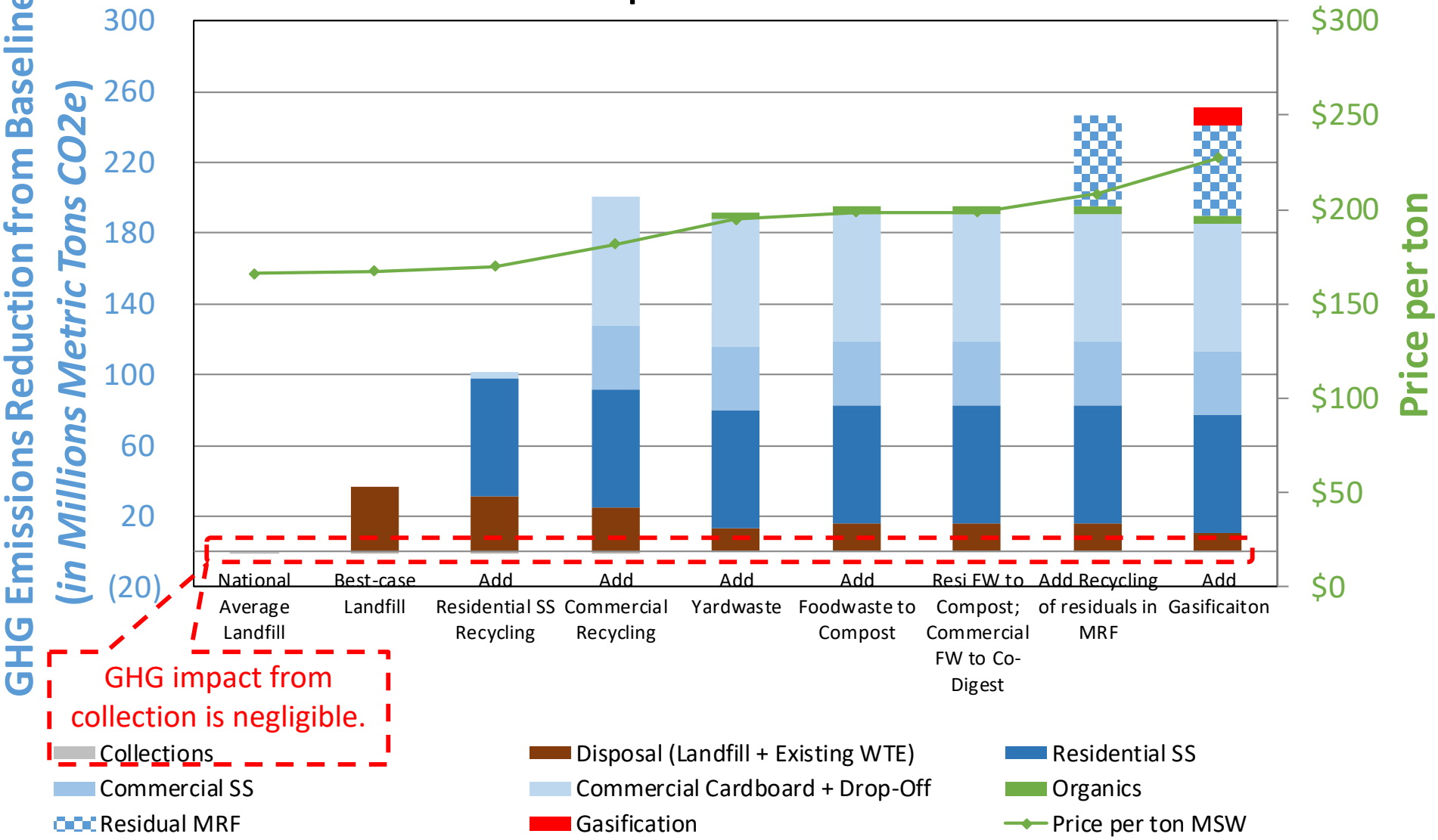

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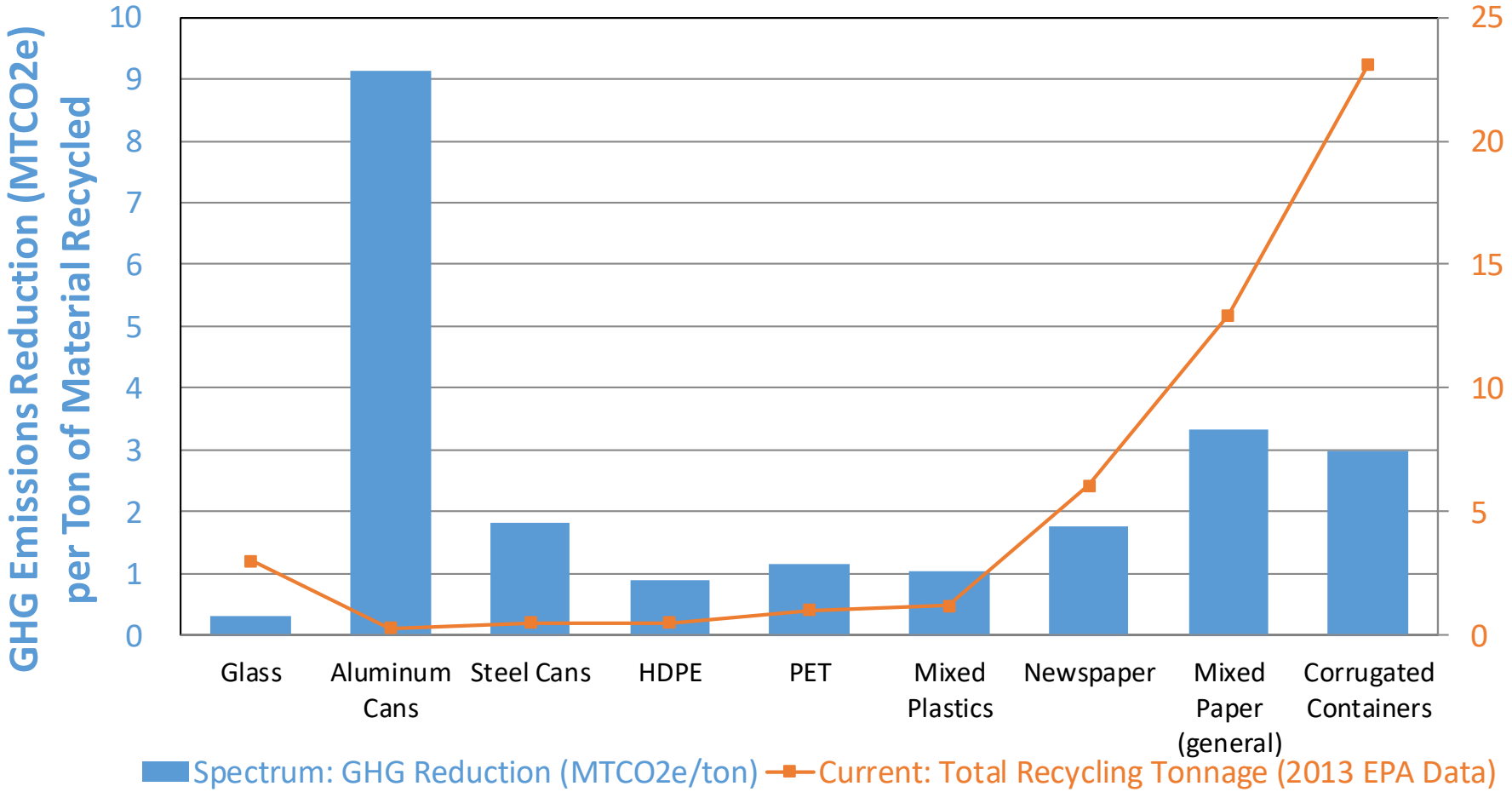
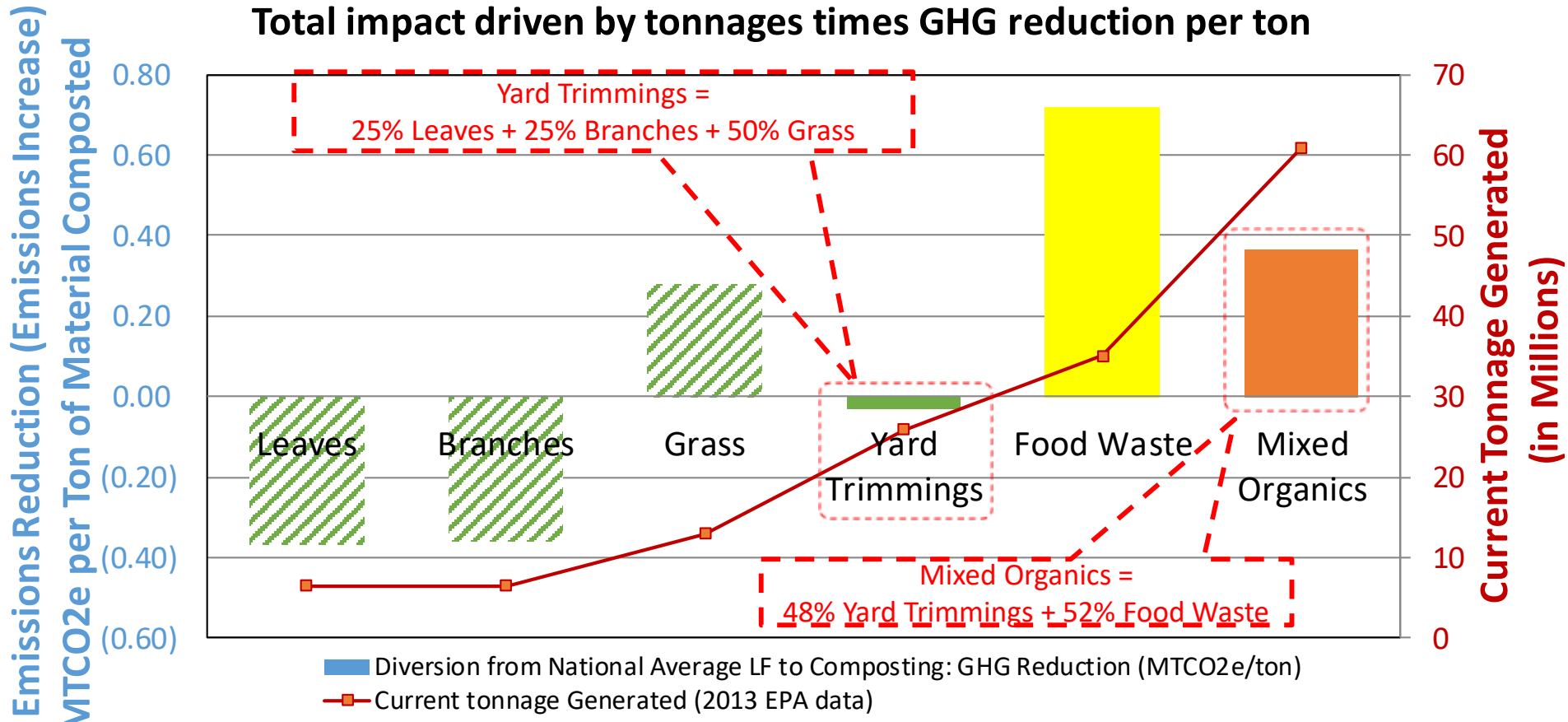
Total GHG reduction from recycling is driven by specific commodity tonnages times GHG reduction per ton



NOTE: Tonnage assumes 2013 EPA data, base-case landfill with LFG Recovery for Energy & Aggressive Gas Collection

- **Bars are per ton GHG emissions benefits of each material types**
- **Red line: total tons**
- **Aluminum: high benefit but low tons**
- **Cardboard: high tons but decent benefit**

GHG impact from composting organics depends on specific material; Total impact driven by tonnages times GHG reduction per ton

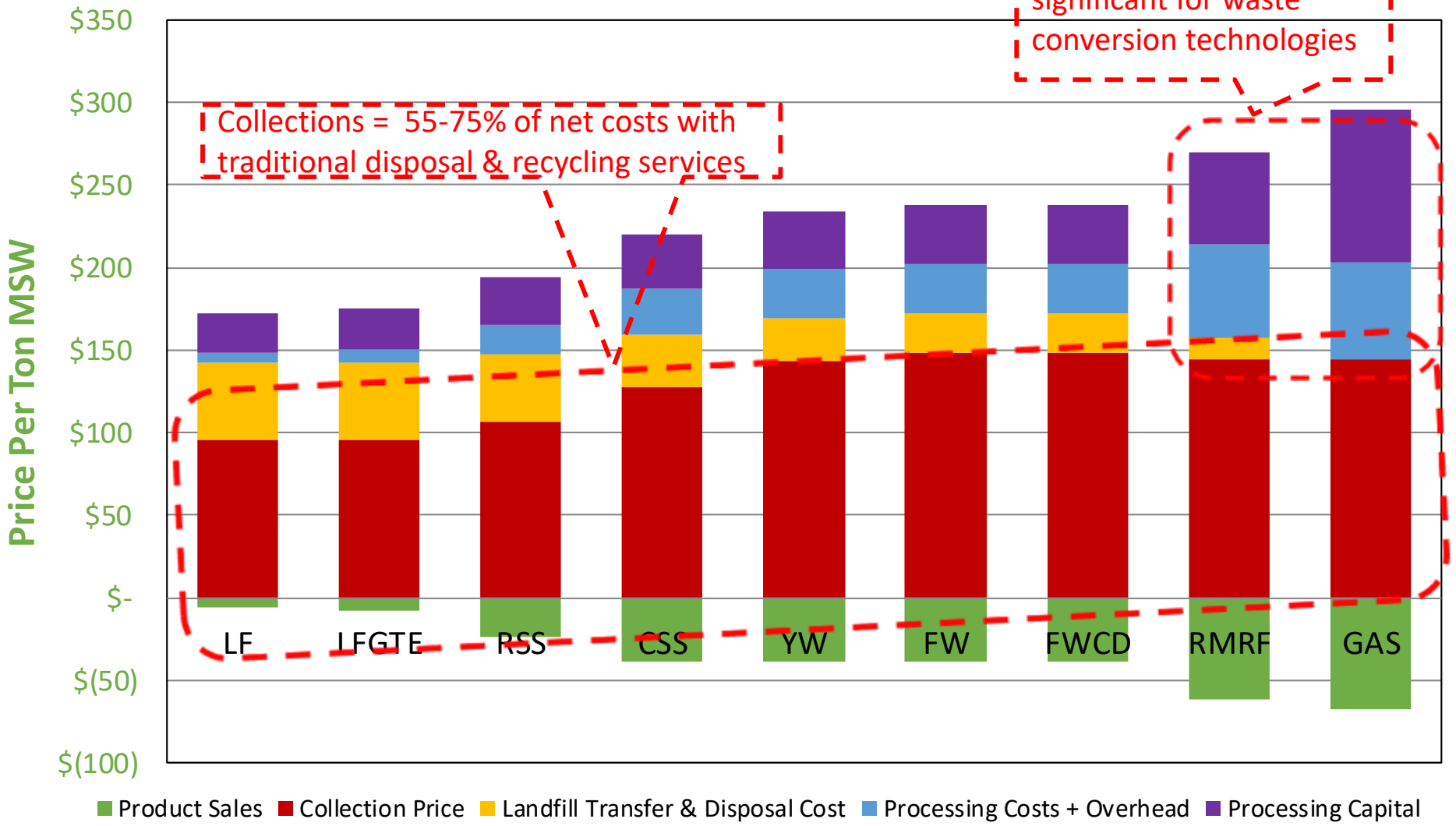


NOTE: EPA assumes Yard Trimmings = 25% Leaves + 25% Branches + 50% Grass; Mixed Organics = 48% Yard Trimmings + 52% Food Waste
National Average landfill (72% of MSW tons to landfills with LFGTE, 13% flare and 15% to LF with no LFG capture). Results in 64% lifetime gas
2013 EPA tonnage data

- **Not all organics are created equal:**
  - ✓ Foodwaste has greatest emission reduction potential, grass is next.
  - ✓ Leaves and branches have least emissions in Best Practices landfill (EPA)
- **Mixed Organics in EPA's Warm Model averages all blends of organics**:

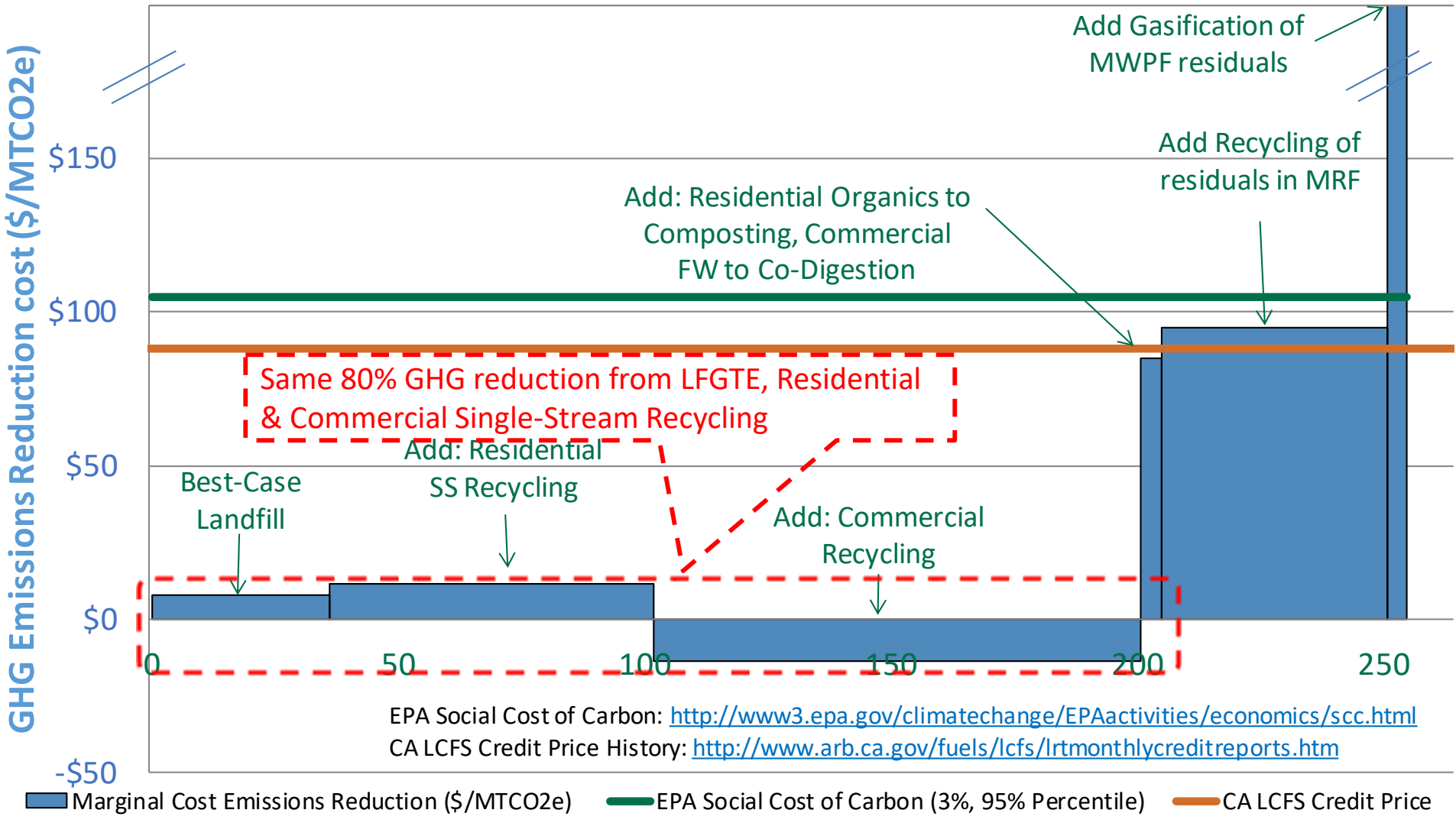
YW *= grass, leaves & branches.* ***FW*** *= all FW, including produce, diary, meats*

Price breakdown - by Category



- **Collections is 55-75% of integrated costs until post processing options**
- **Infrastructure cost of new technologies is very high**
- **Commodity revenue is based on 10-year average blended value**

GHG cost abatement curve for the Environmental Services Industry



- **Costs plus environmental benefits create a single metric = $/ton of GHG**
- **Width of bars is GHG reduction, height is cost of GHG reduction**
- **Also includes LCFS & EPA social cost of carbon as proxies**

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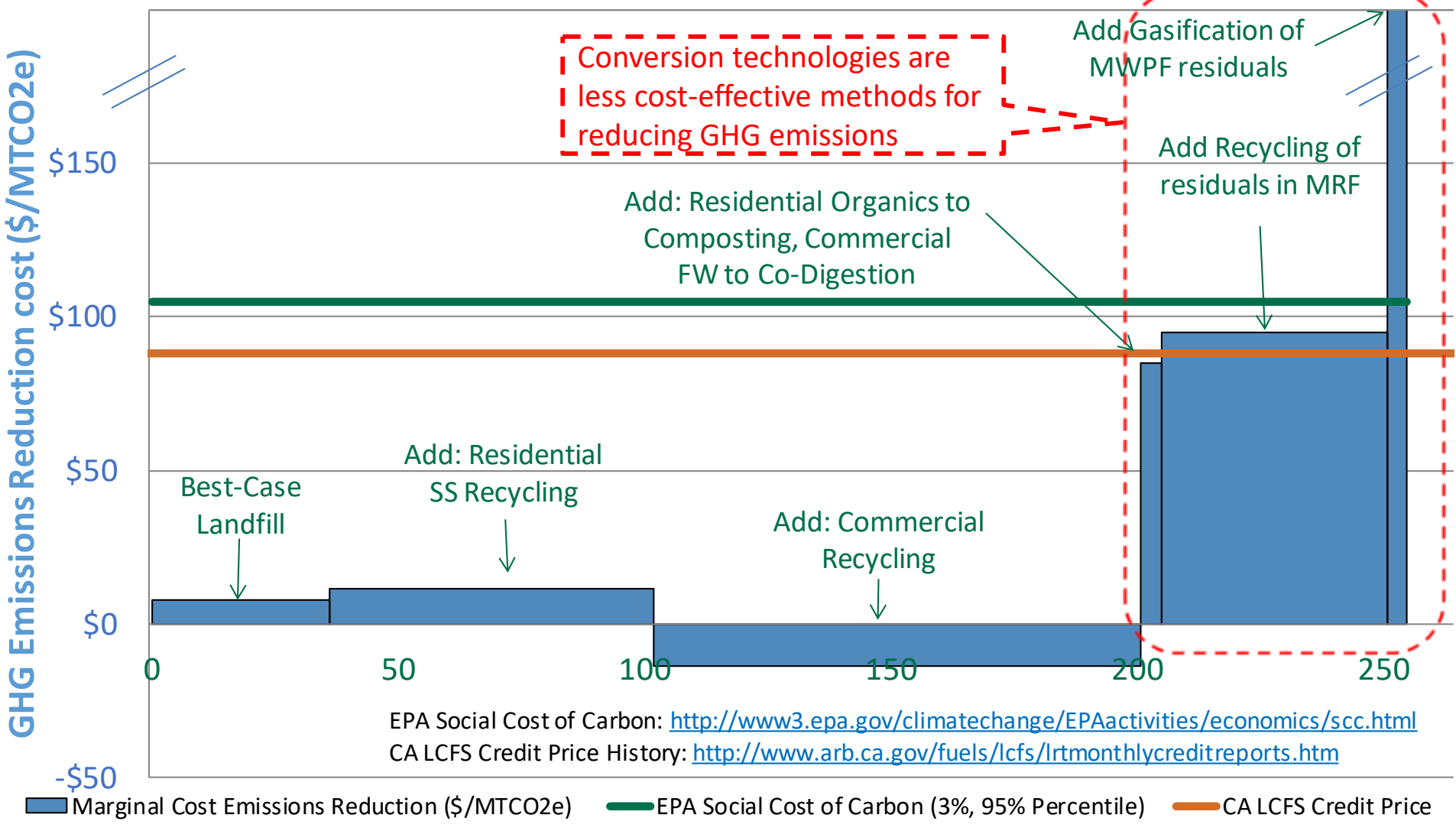

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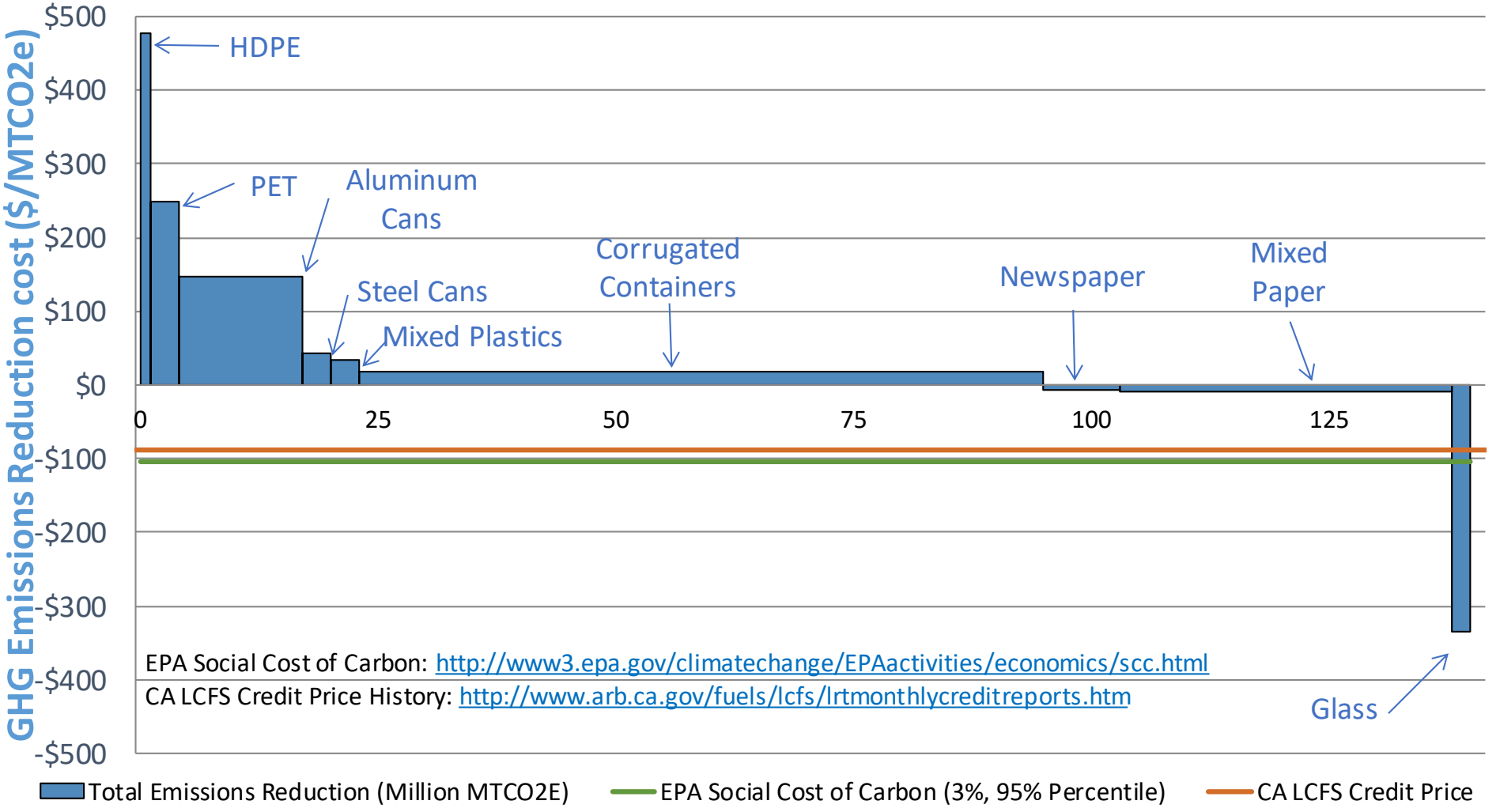
GHG cost abatement curve for the Recycling (RSS+CSS)
PRODUCT - INCREMENTAL COLLECT - PROCESSING + AVOIDED DISPOSAL



- **Environmental benefits & cost per ton of carbon reduction for recycling only**
- **Includes collection, processing and commodity values**
- **Results show the benefits of recycling paper, metal and plastic bottles**

Thank you!