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301: Accounting Systems, Modeling, and Economic Incentives

Kate Krebs, National Recycling Coalition
Jeff Morris, Sound Resource Management
Evan Edgar, Edgar and Associates
Lisa Skumatz, Skumatz Economic Research Associates
Joshuah Stolaroff, U.S. EPA Headquarters

Webinar #3

West Coast Webinars on Climate Change, Waste Prevention, Recovery, and Disposal

August 5, 2008

Climate Change & Recycling

2008 California Resource Recovery Association Conference

EPA Region 9 and 10 Webinar

Kate Krebs
Krebs & Company

Climate Change & Recycling

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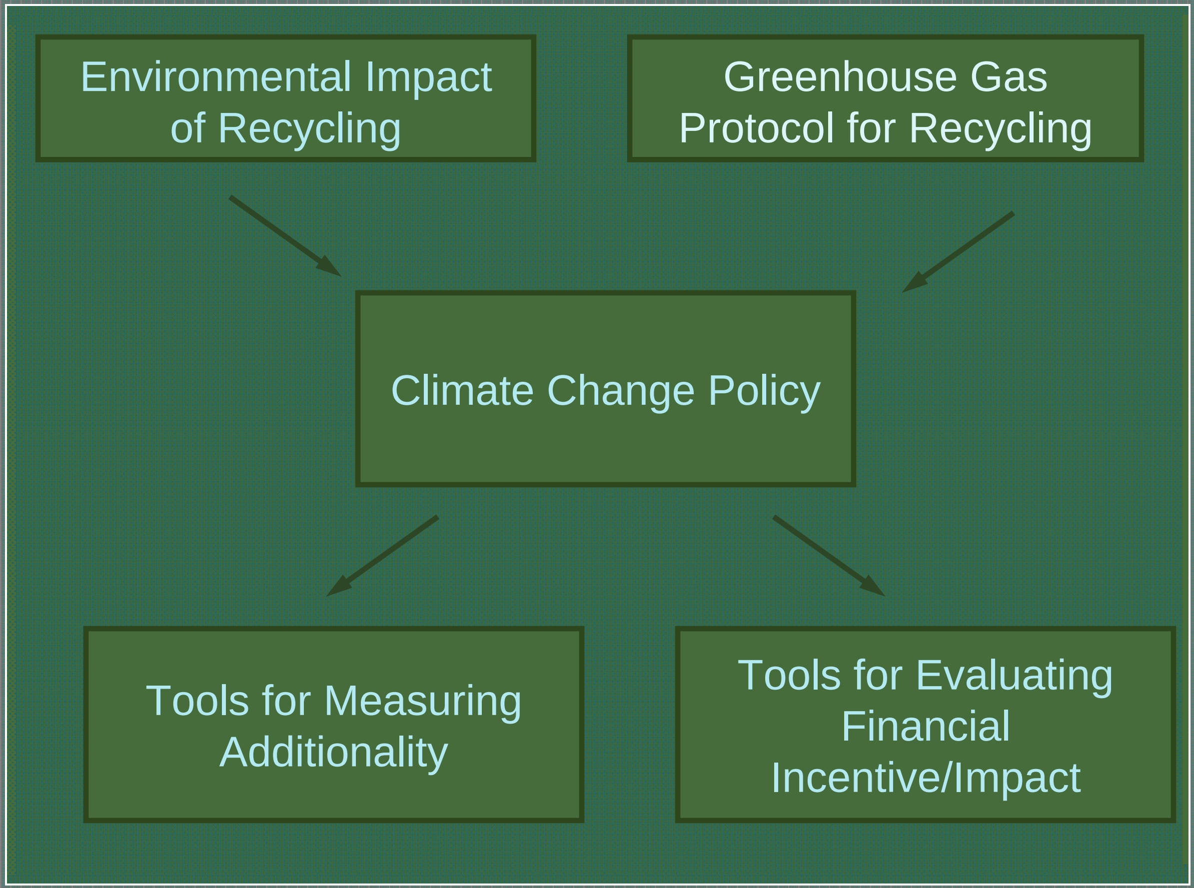
An image that galvanized our movement

Climate Change & Recycling



A singular opportunity to re-energize investment in recycling infrastructure

Climate Change & Recycling

Recycling Impacts

EPA

- Emissions from manufacturing, transporting, using and disposing of products & packaging
- Non-energy related manufacturing
- Carbon sequestration

Recycling Protocol

Credible Third Party

- Define activities and boundary of recycling project
- Establish baseline metrics
- Apply reasonable emission factors
- Meet additionality test

Climate Change & Recycling

- Federal Trade Commission Green Guides – Climate Claims
- House Energy & Commerce Committee
- Senate Manager's Amendment – Environment and Public Works Committee

- A NEW ADMINISTRATION

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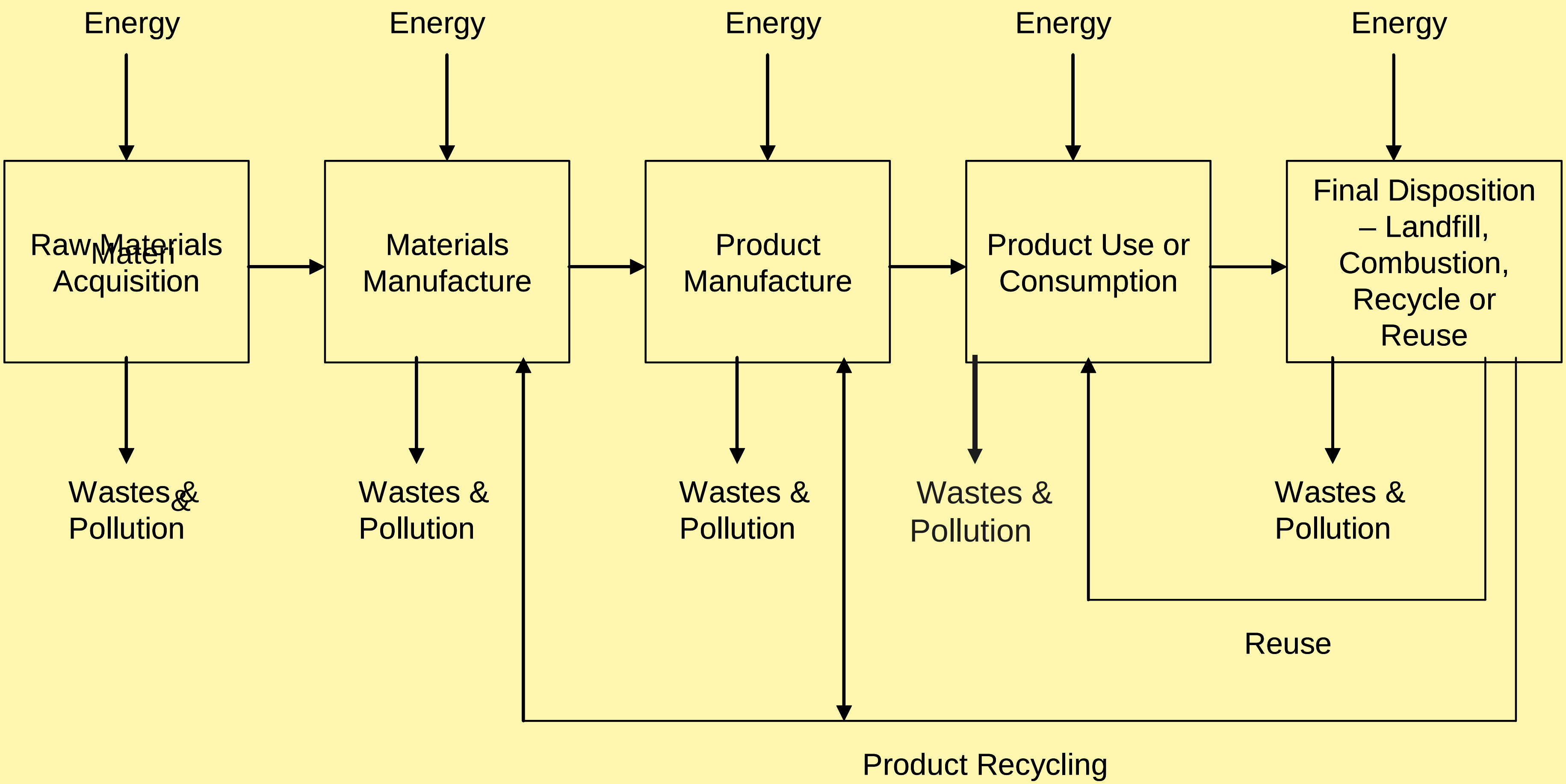
Measuring the Environmental Impacts of Discards Management: Models, Methods, & Results

Dr. Jeffrey Morris
Sound Resource Management

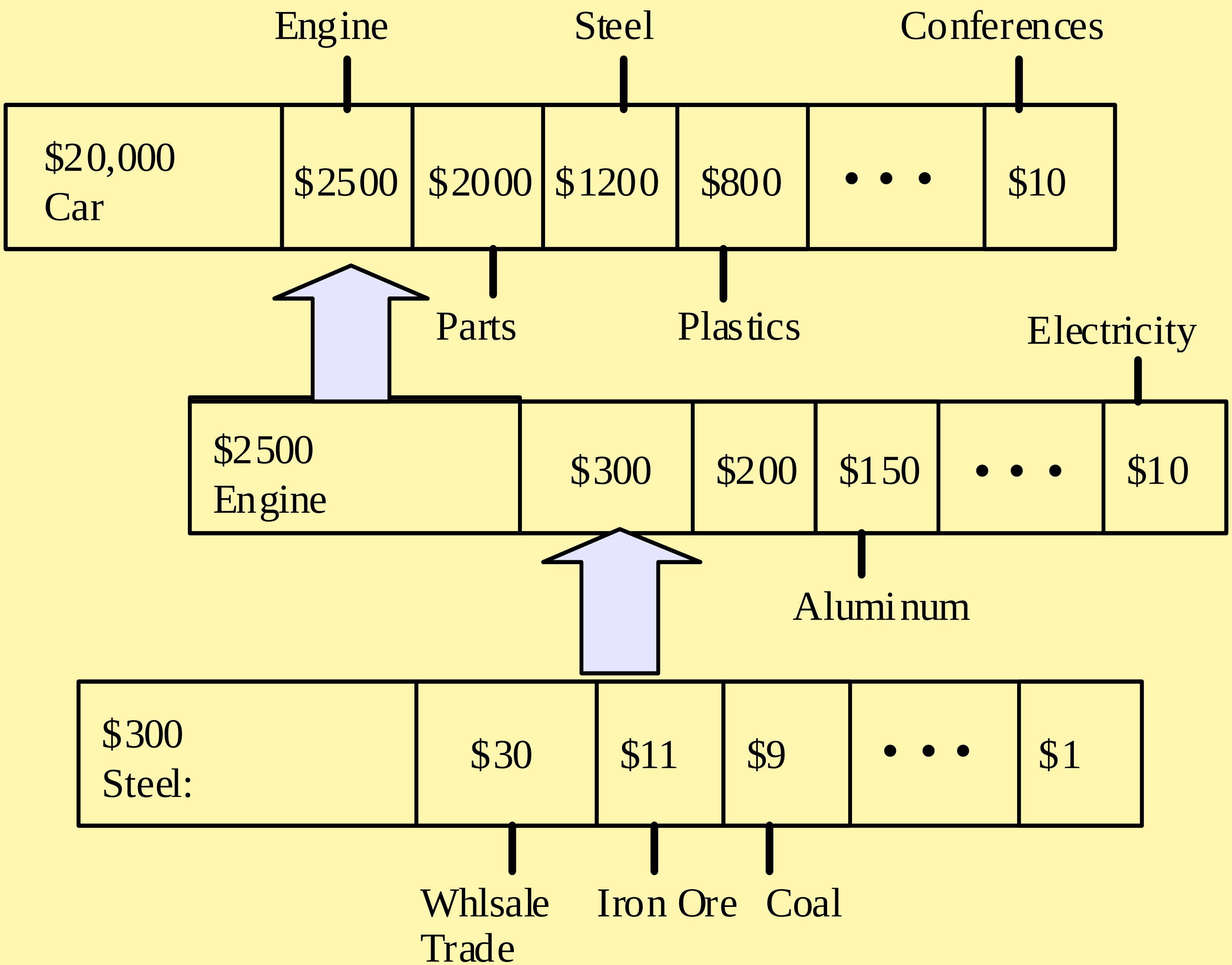
EPA Webinar live at CRRA - August 5, 2008

Life Cycle Analysis (LCA)



One or limited number of return cycles into product that is then disposed – open-loop recycling. Repeated recycling into same or similar product, keeping material from disposal – closed-loop recycling.

Automobile Supply Chain



Life Cycle Impact Categories

- Climate Change
- Human Health – Particulates
- Acidification
- Eutrophication
- Human Health – Toxics
- Human Health – Carcinogens
- Ecosystems Toxicity
- Ozone Depletion
- Smog
- Habitat Disruption
- Biodiversity Depletion
- Ecosystem Services Degradation
- Resource Depletion

Available Models

1. **ICLEI Clean Air Climate Protection (CACP)** (www.iclei-usa.org/action-center/tools/cacp-software)
2. **U.S. EPA Waste Reduction Model (WARM)** (www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html)
3. **Municipal Solid Waste Decision Support Tool (MSW-DST)** (Research Triangle Institute)
4. **Carnegie Mellon Economic Input-Output Life Cycle Assessment (EIO-LCA)** (www.eiolca.net)
5. **National Institute of Standard and Technology Building for Environmental and Economic Sustainability (BEES)** (www.bfri.nist.gov/oae/software/bees/model.html)
6. **U.S. EPA Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI)** (www.epa.gov/nrmrl/std/sab/traci/)
7. **Morris Environmental Benefits Calculator (MEBCALC)** (Sound Resource Management)
8. **National Recycling Coalition (NRC) Calculator** (www.nrc-recycle.org)
9. **Northeast Recycling Council (NERC) Calculator** (www.nerc.org)
10. **Consumer Environmental Index (CEI)** (www.zerowaste.com)

Issues with Various Models

1. No upstream impacts.
2. Cover only a single environmental impact.
3. No capital equipment production impacts.
4. No upstream composting impacts.
5. Energy offsets reflect average energy fuel source instead of marginal.
6. Based on process LCAs (supply chain coverage limited).
7. Not current and/or small sample emissions data.
8. Aggregate emissions only for climate change impact indicator (into carbon or carbon dioxide equivalents) even when non-GHG emissions are in the model.
9. Not very user friendly; very complex.
10. No method for comparing different environmental impacts.
11. Characterization factors (aggregation weights) for toxics, carcinogens, and ecosystem toxics are in flux.

Additional Data Used in MEBCALC &CEI

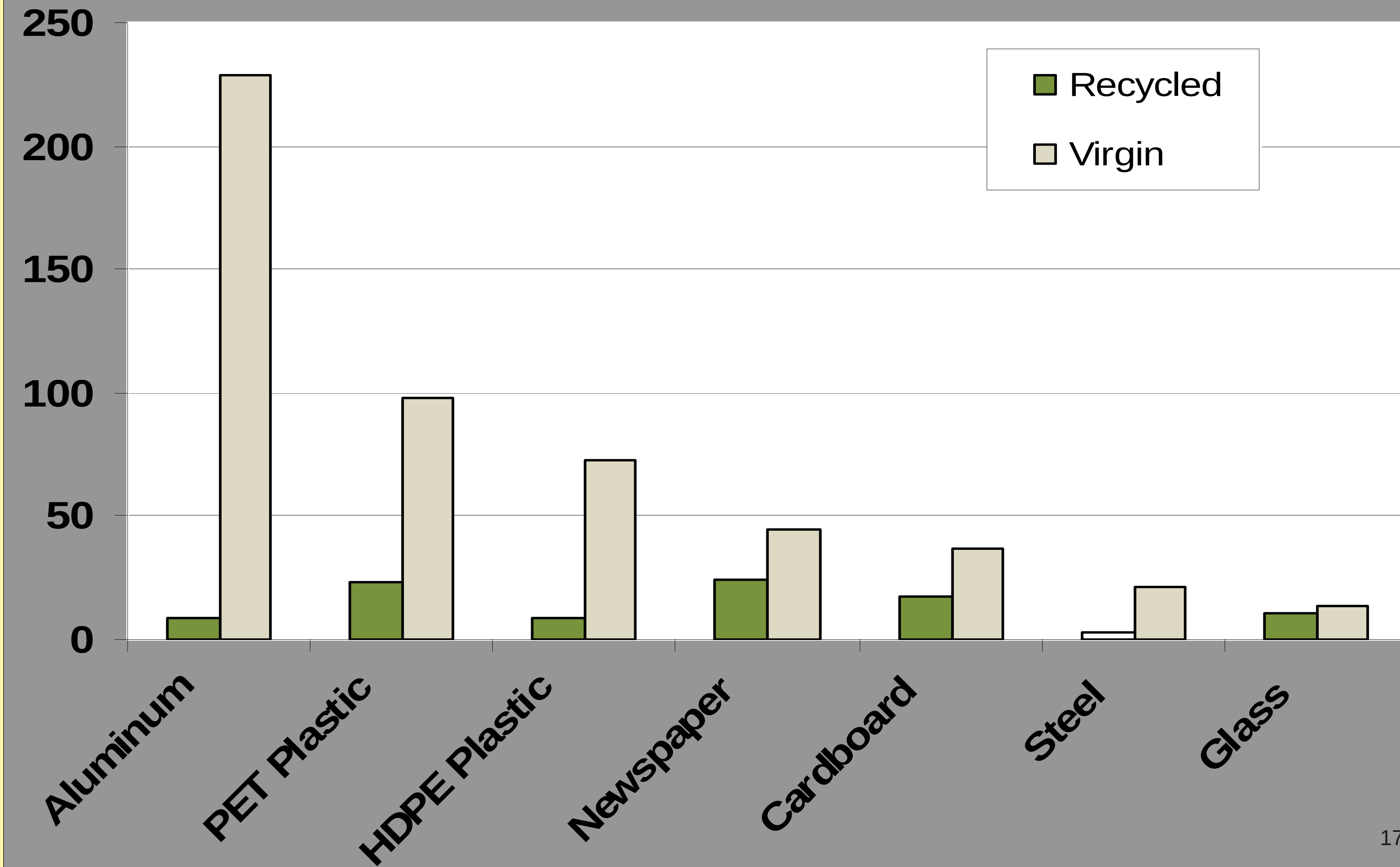
- **EPA AP-42** emissions data (www.epa.gov/ttn/chief/ap4)
- **WA Department of Ecology** vehicle and home fuels air emissions data
- **Scholarly books & peer-reviewed articles** – Hendrickson *et al* (2006), Morris (2005), Wihersaari (2005), and Morris and Bagby (2008)

Definitions of Terms on Graphs

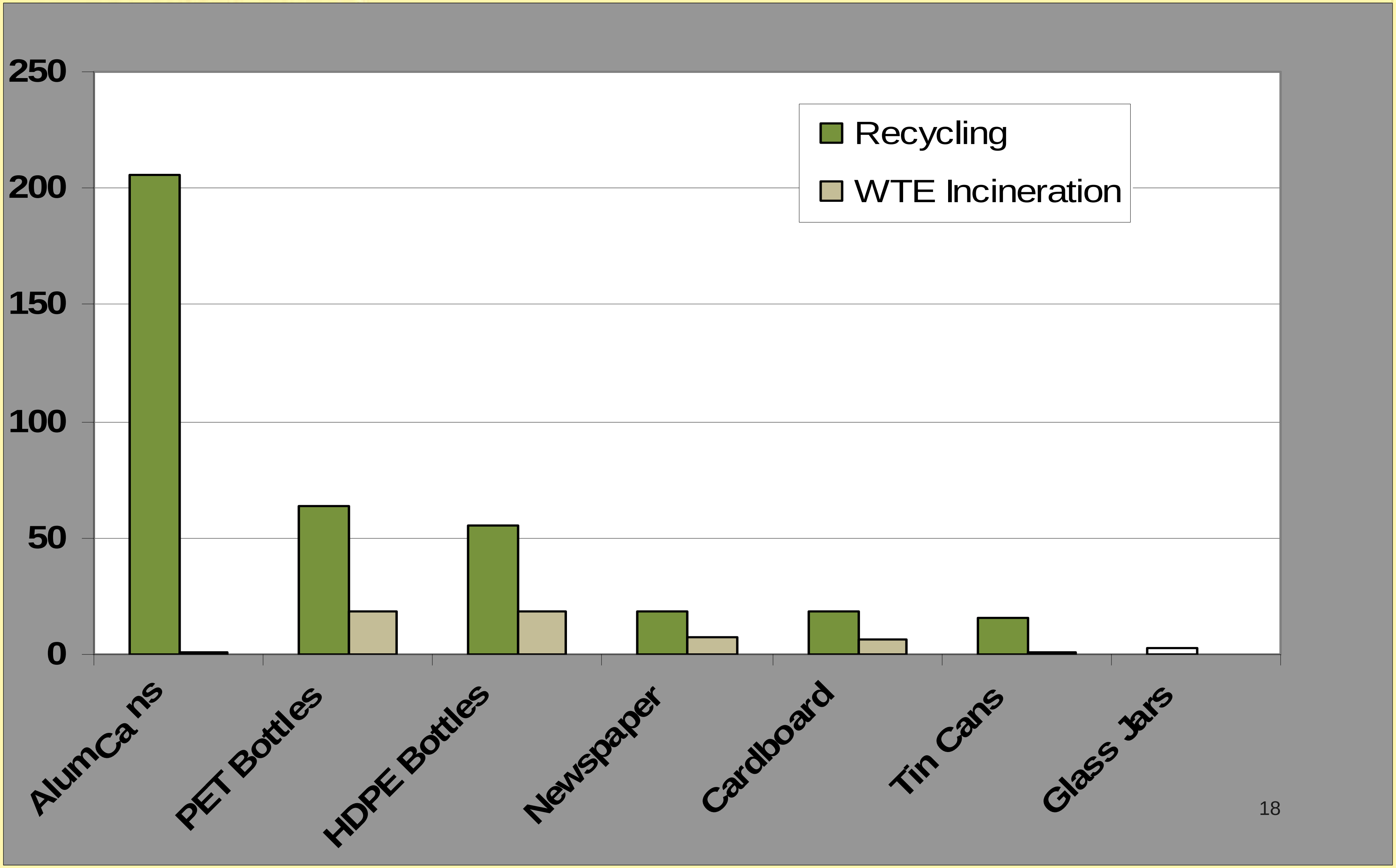
Model used for all graphs: MEBCALC Calculator

1. Recycling: closed loop material recycling
2. Composting: aerobic composting
3. WTE Incineration: mass burn thermal conversion/ advanced thermal recycling (offset to natural gas powered electricity generation)
4. Gasification/Pyrolysis: averages for advanced thermal conversion technologies (offset to nat. gas electricity)
5. Landfill+Energy: 75% methane capture & conversion to electricity via an internal combustion engine (offset to natural gas electricity)
6. Recycled: closed loop discarded-materials-content products
7. Virgin: newly extracted raw-materials-content products

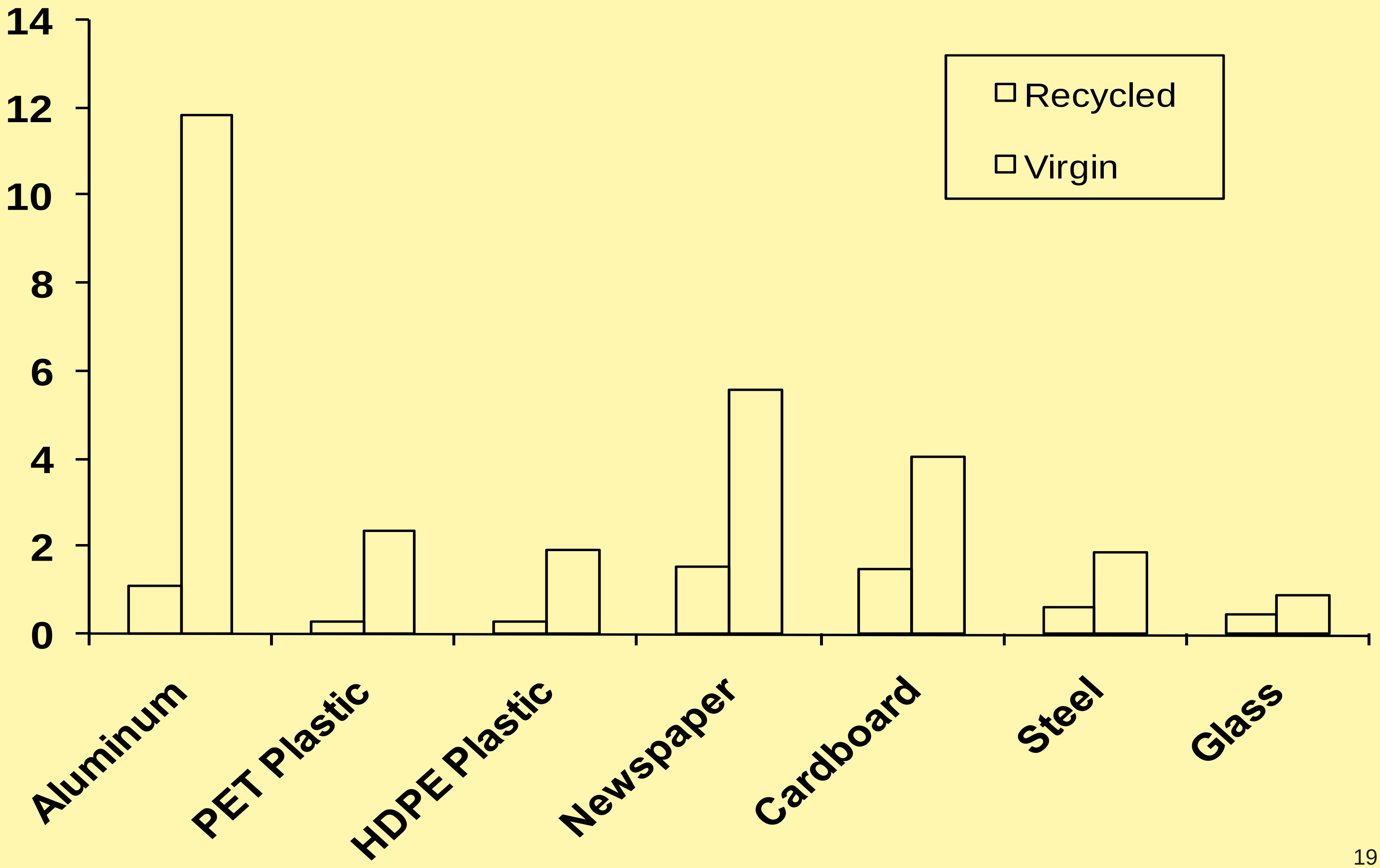
Energy Use: Recycled & Virgin Content Products (million Btus/ton)



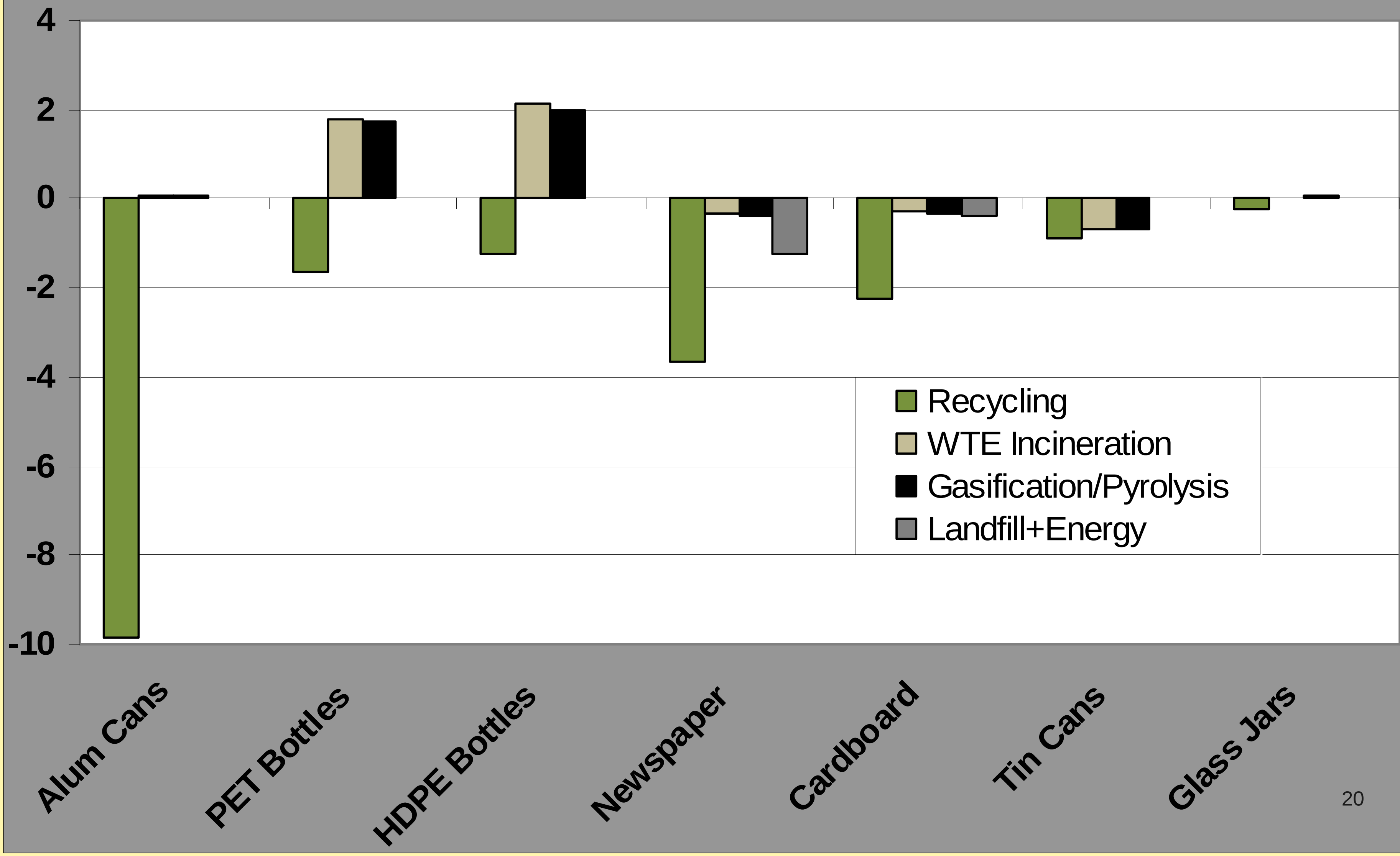
Energy Savings: Recycling vs. WTE Incineration (million Btus/ton)



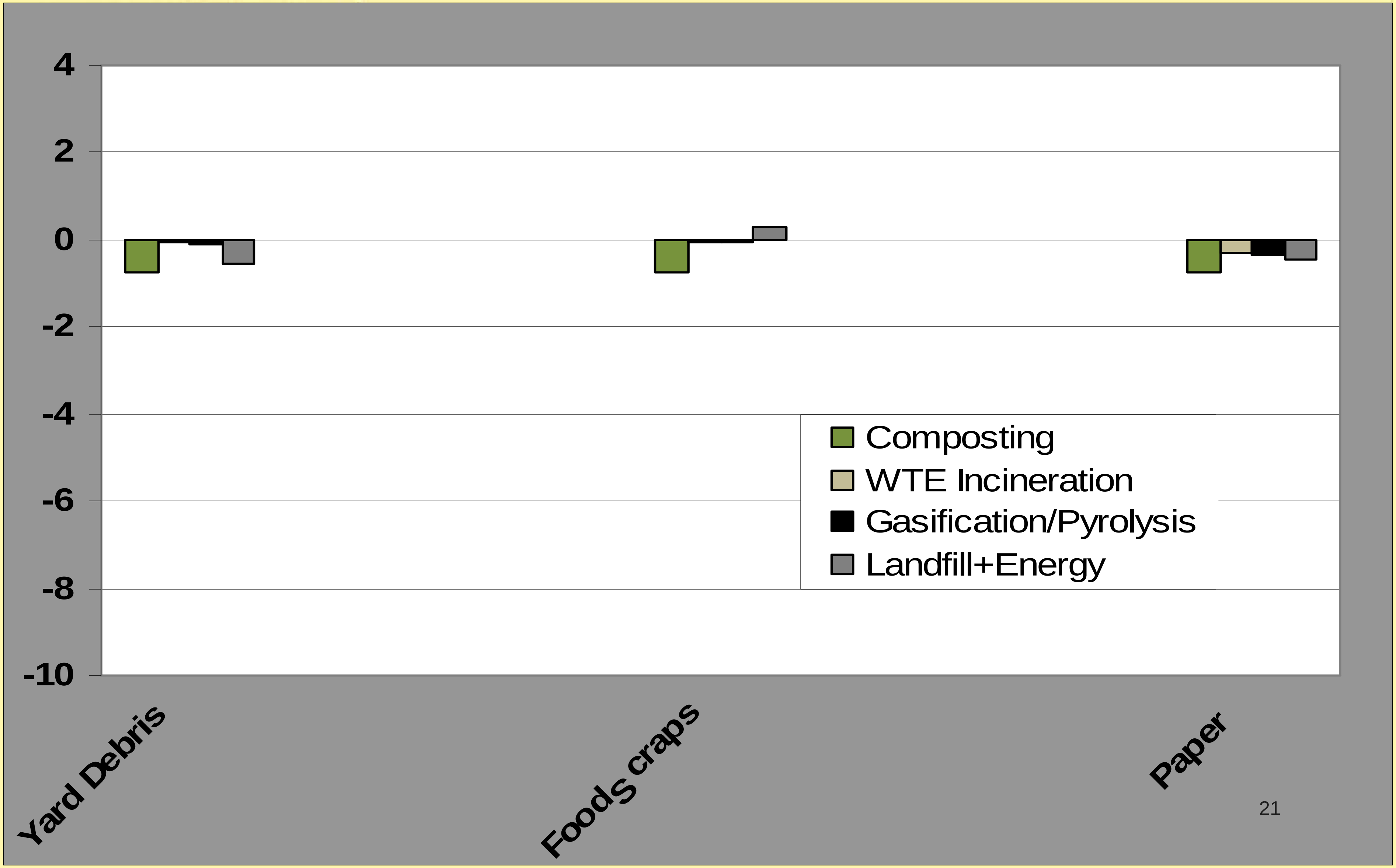
CO2 Emissions: Recycled & Virgin Content Products (tons eCO2/ton)



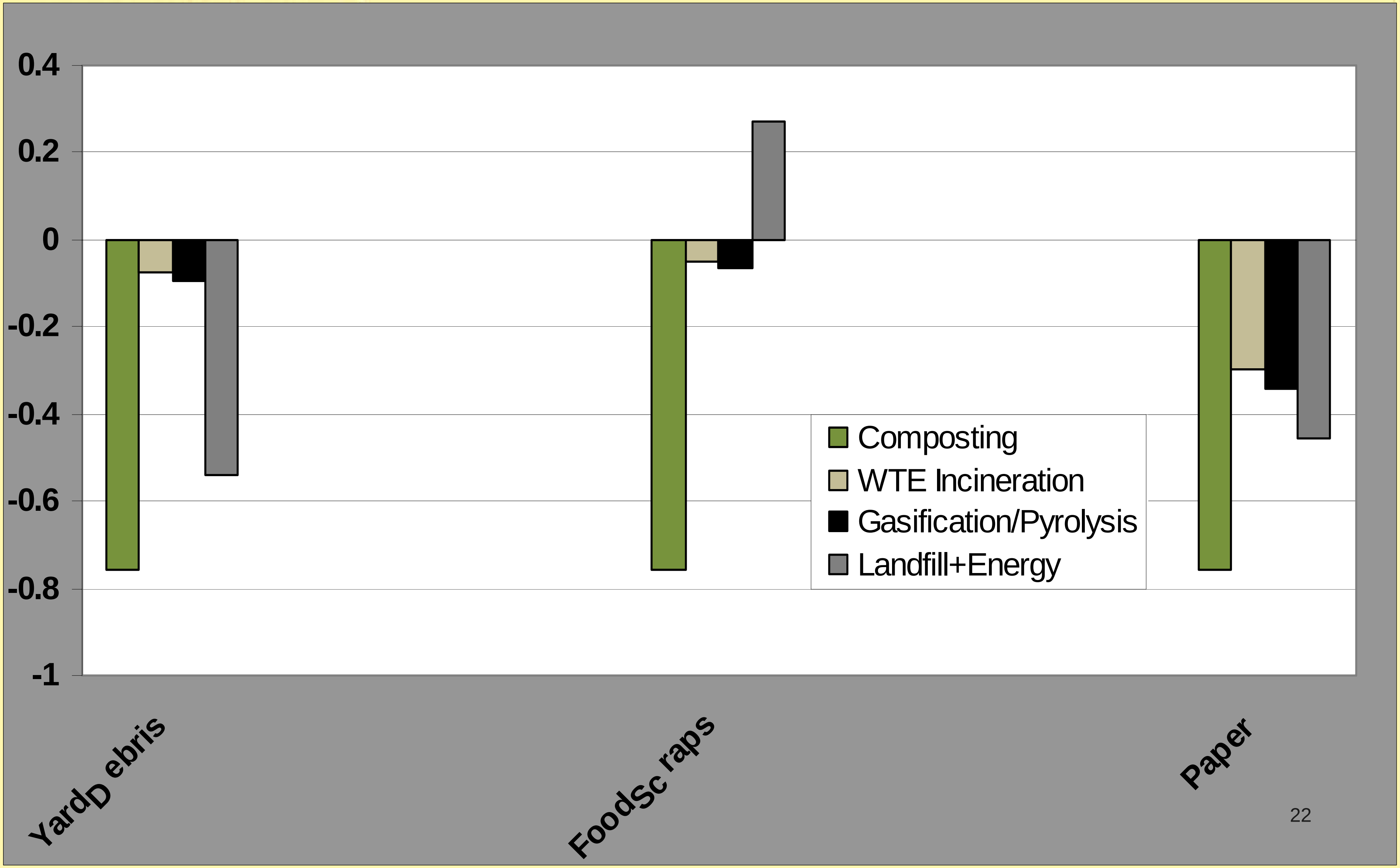
CO2 Emissions: Recycling vs. Disposal (tons eCO2/ton)



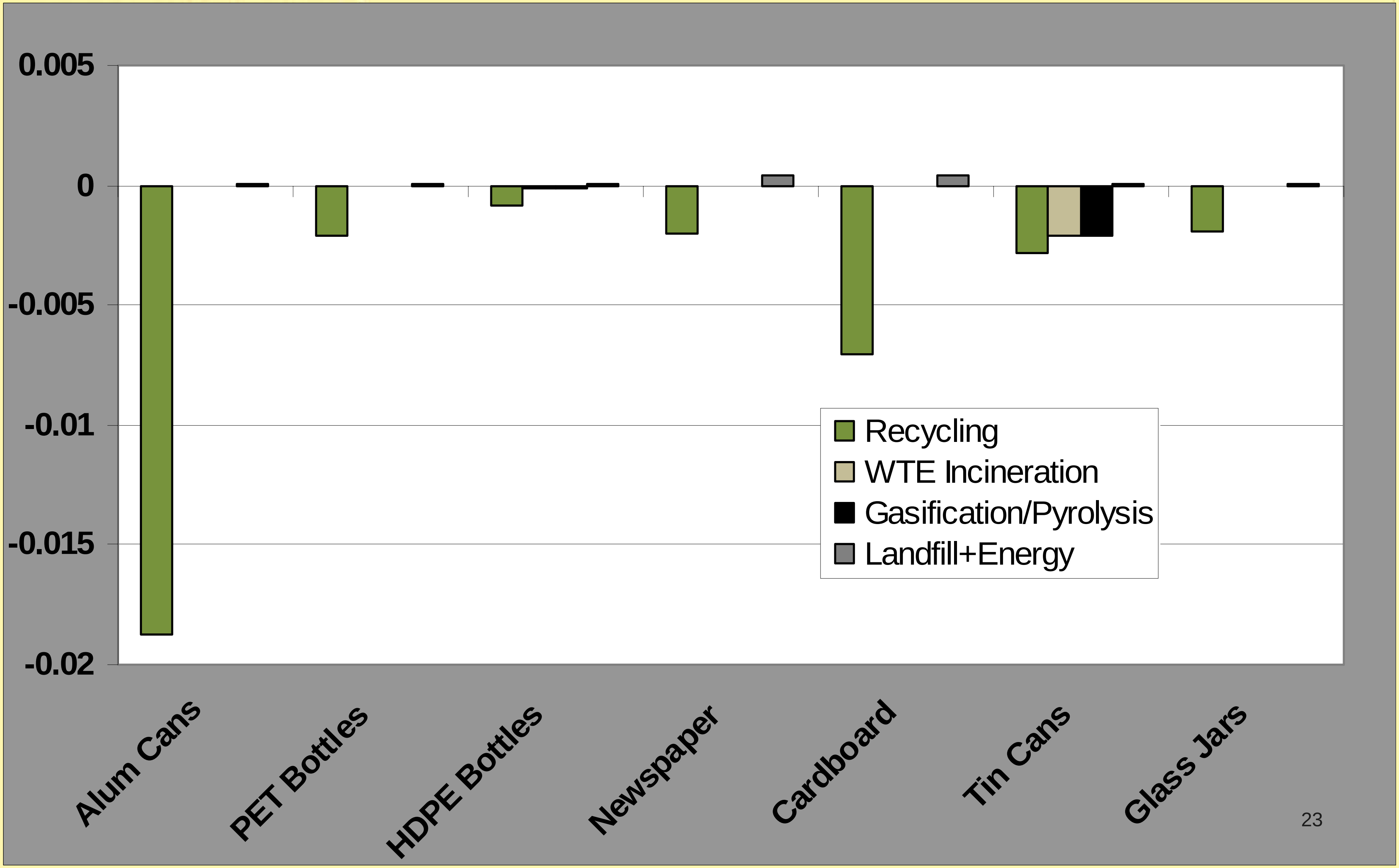
CO2 Emissions: Composting vs. Disposal (tons eCO2/ton)



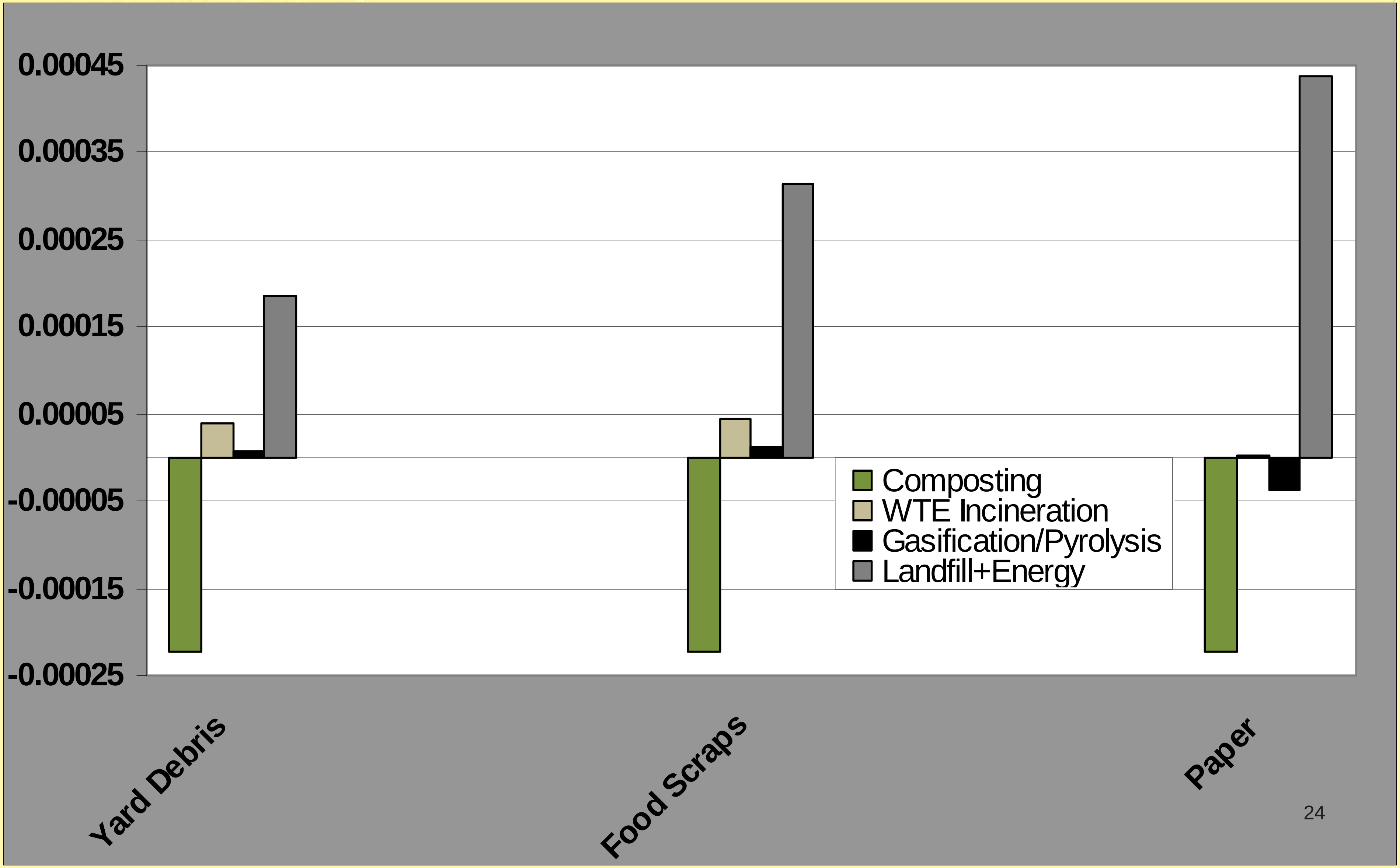
CO2 Emissions: Composting vs. Disposal – expanded view (tons eCO2/ton)



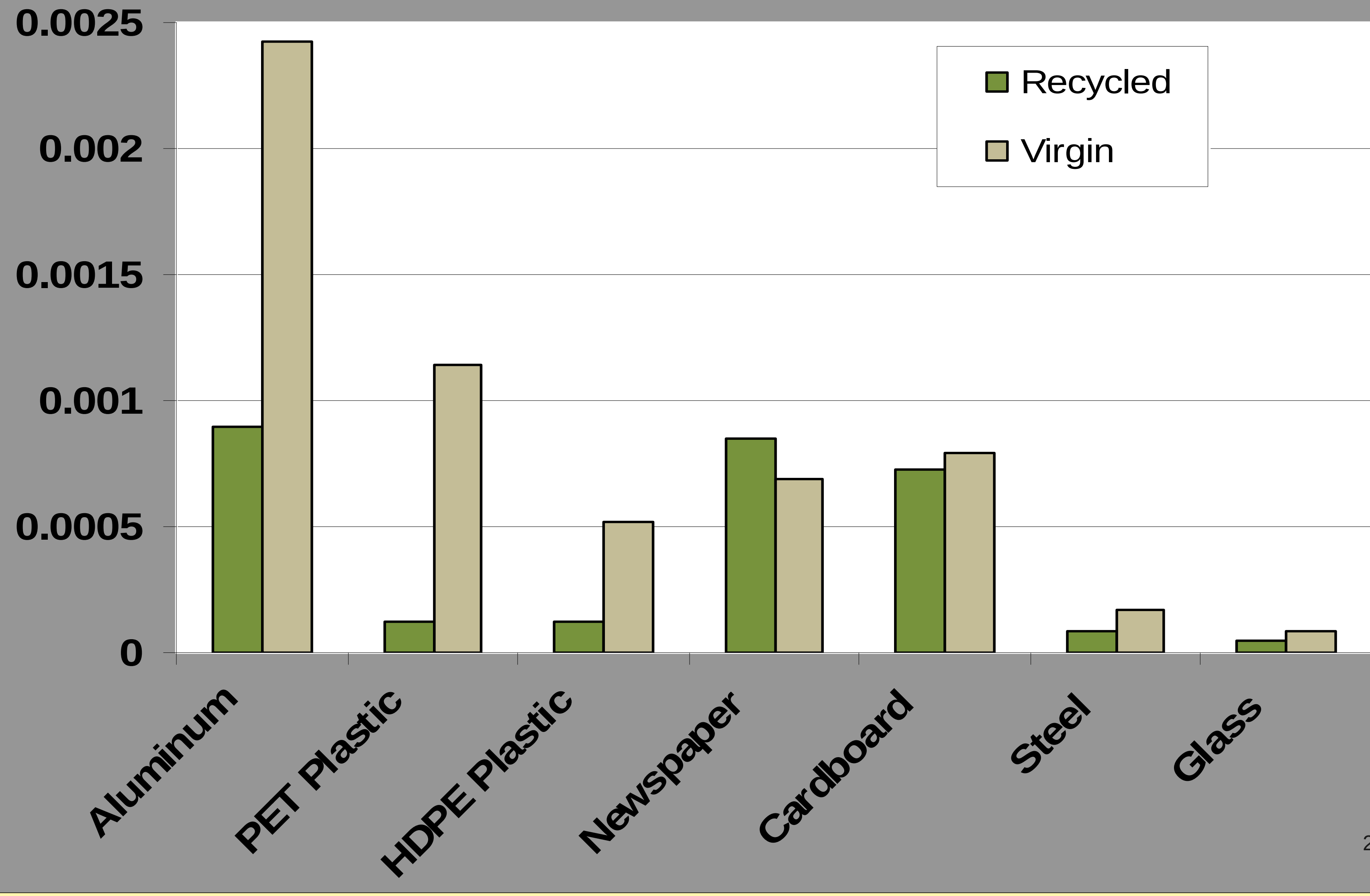
Particulate Emissions: Recycling vs. Disposal (tons ePM2.5/ton)



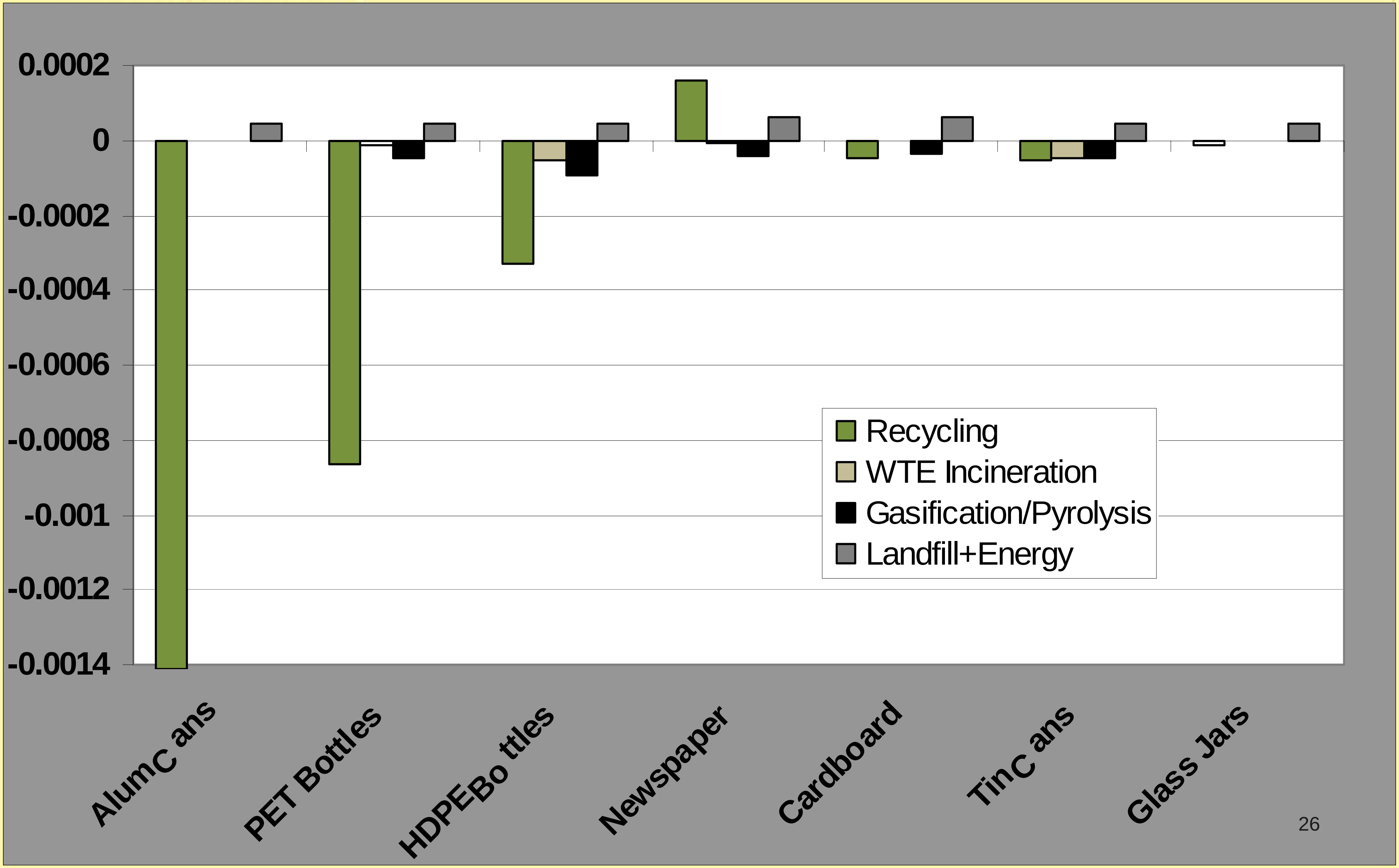
Particulate Emissions: Composting vs. Disposal - expanded view (tons ePM2.5/ton)



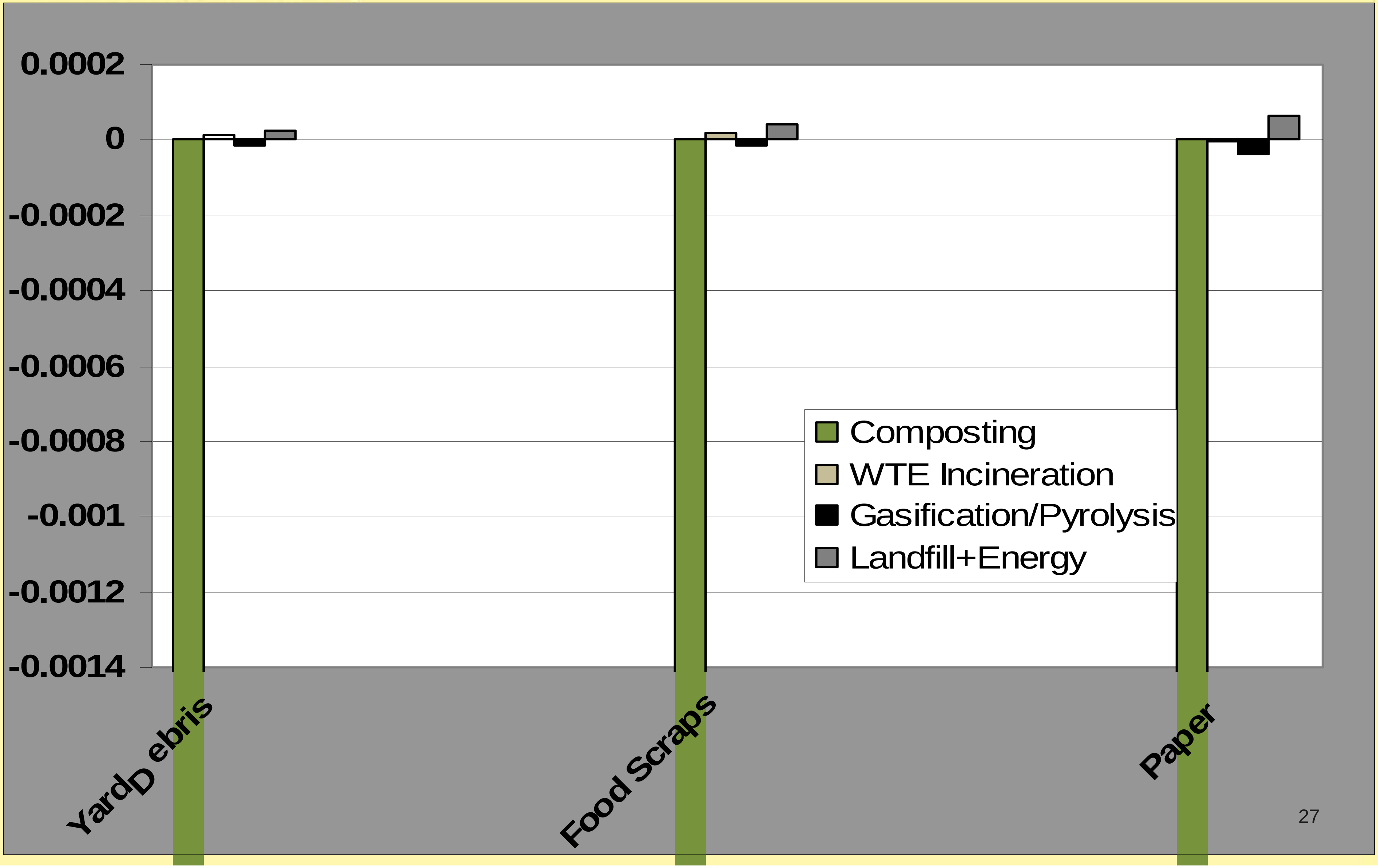
Eutrophying Emissions: Recycled & Virgin Products (tons eN/ton)



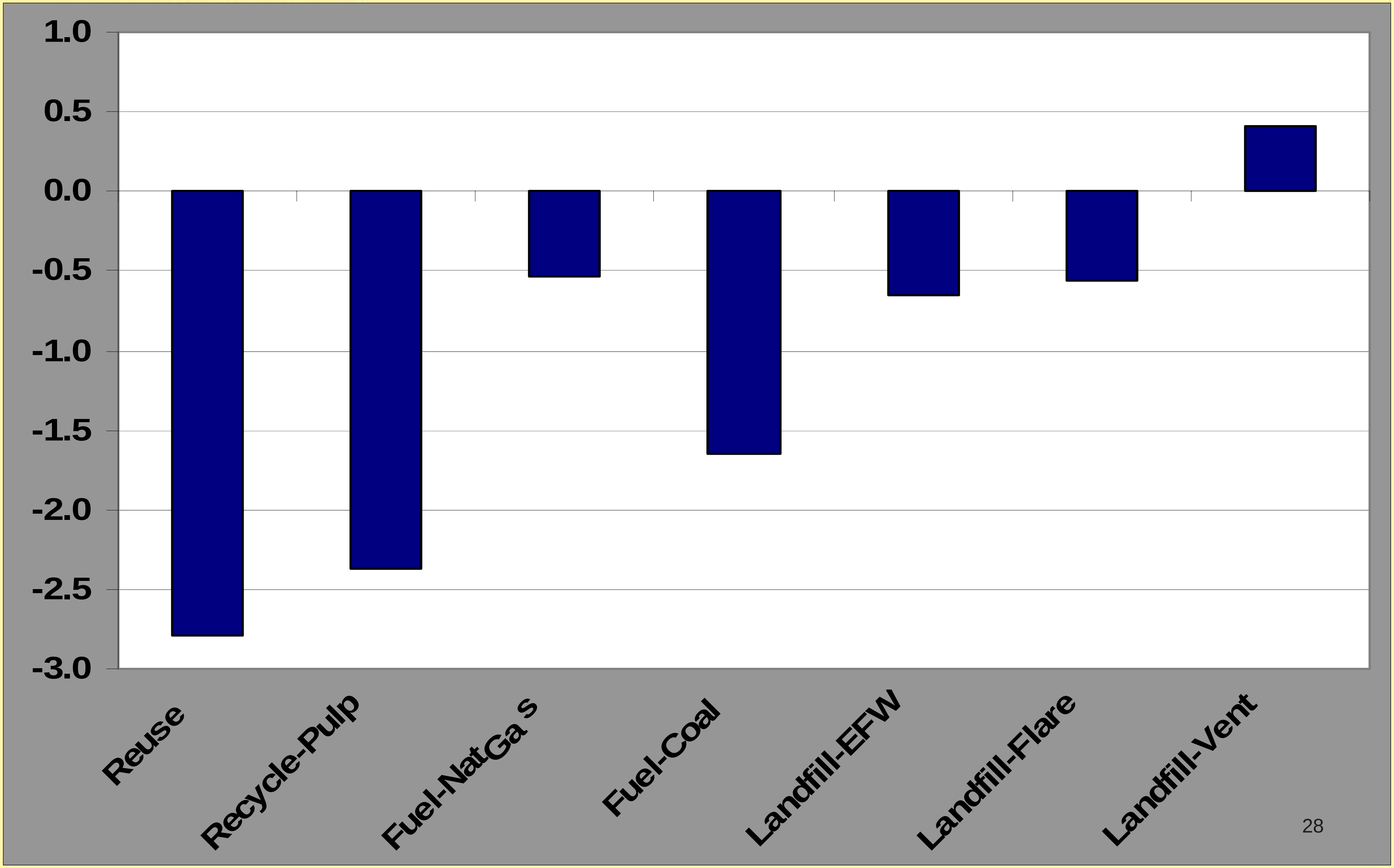
Eutrophying Emissions: Recycling vs. Disposal (tons eN/ton)



Eutrophying Emissions: Composting vs. Disposal (tons eN/ton)



CO2 Emissions: C&D Wood Scraps Management Options (pounds eCO2/ton)



Climate Cooling Benefits of Recycling (from WA CEI)

- **Gasoline & Diesel:** capturing 100% of household curbside recyclable materials equivalent to 60% cut in household vehicle fuel & oil use.
- **Electricity:** capturing 100% of household curbside recyclable materials equivalent to 10% cut in household electricity use.
- **Meat & Dairy:** capturing 100% of household curbside recyclable materials equivalent to 100% cut in household meat and dairy consumption.

Climate Cooling Benefits of Composting (from WA CEI)

- **Gasoline & Diesel:** capturing 100% of household compostable materials equivalent to 30% cut in household vehicle fuel & oil use.
- **Electricity:** capturing 100% of household compostable materials equivalent to 5% cut in household electricity use.
- **Meat & Dairy:** capturing 100% of household compostable materials equivalent to 50% cut in household meat and dairy consumption.

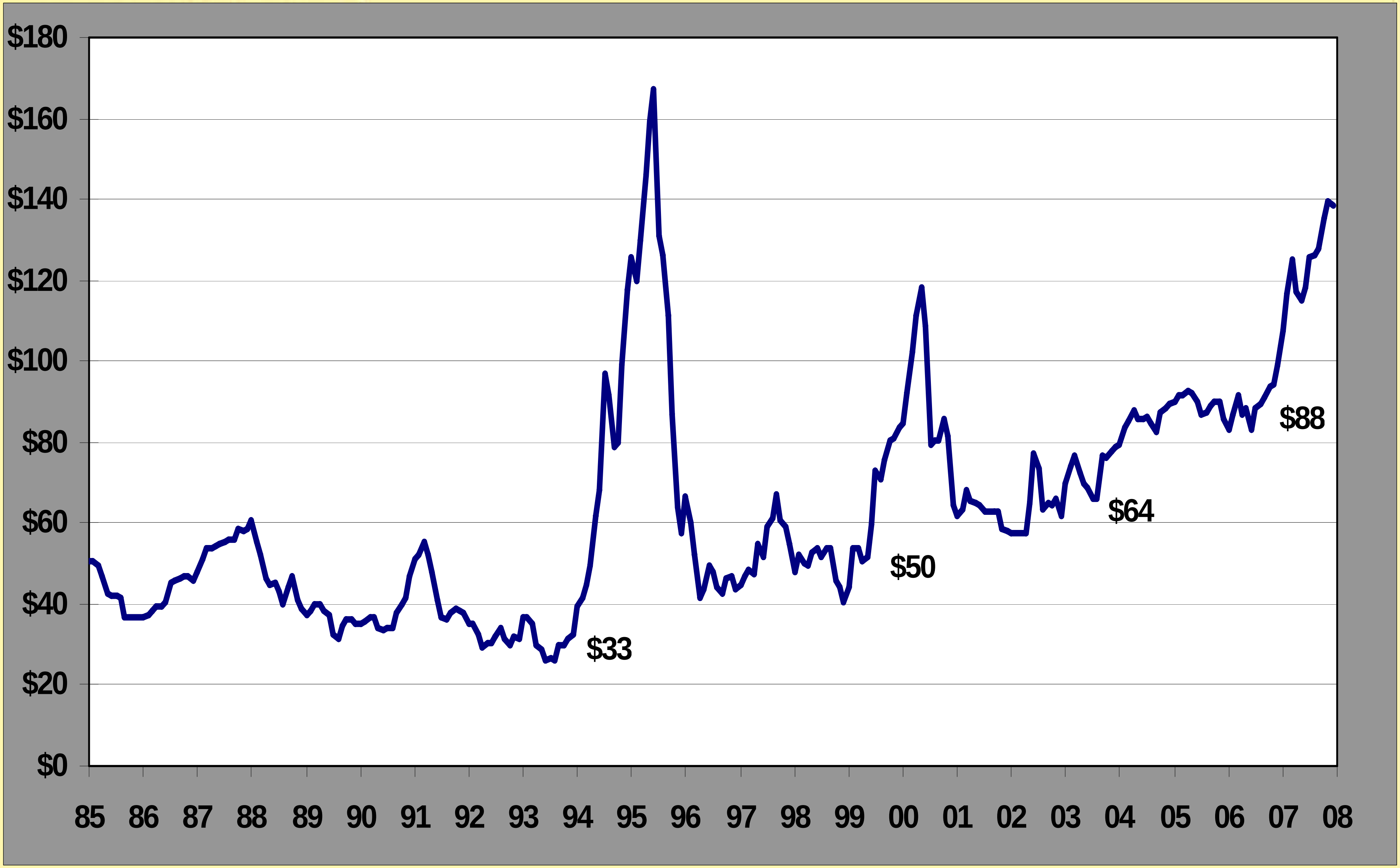
Value of Pollution Reductions

LCA Impact	Economic Cost (US$/ton)
Climate Change	$36 eCO2
Human Health - Particulates	10,000 ePM2.5
Human Health - Toxins	118 eToluene
Human Health - Carcinogens	3,030 eBenzene
Ecosystems Toxics	3,280 e2,4D
Acidification	661 eSO2
Eutrophication	4 eNitrogen

Value of Pollution Reductions from Recycling & Composting

Discard Type	Environmental Value (US$/ton)
Newspapers	$328-332
Cardboard	424-449
Mixed Paper	156-178
Glass Containers	53-54
PET Plastics	578-646
HDPE Plastics	202-279
Other Plastics	202-279
Aluminum Cans	1,456
Ferrous Cans & Scrap	14-63
Food Scraps	59-97
Yard & Garden Debris	58-67
Compostable Paper	49-71

Market Value of Recyclables – US Northwest (US$ per ton)



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The End

Thank you.

Presentation and Appendix File will be posted at:

http://www.epa.gov/region10/westcoastclimate.htm

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Policy Incentives, Climate Change & Resource Management Opportunities for the Recycling Collection and Processing System

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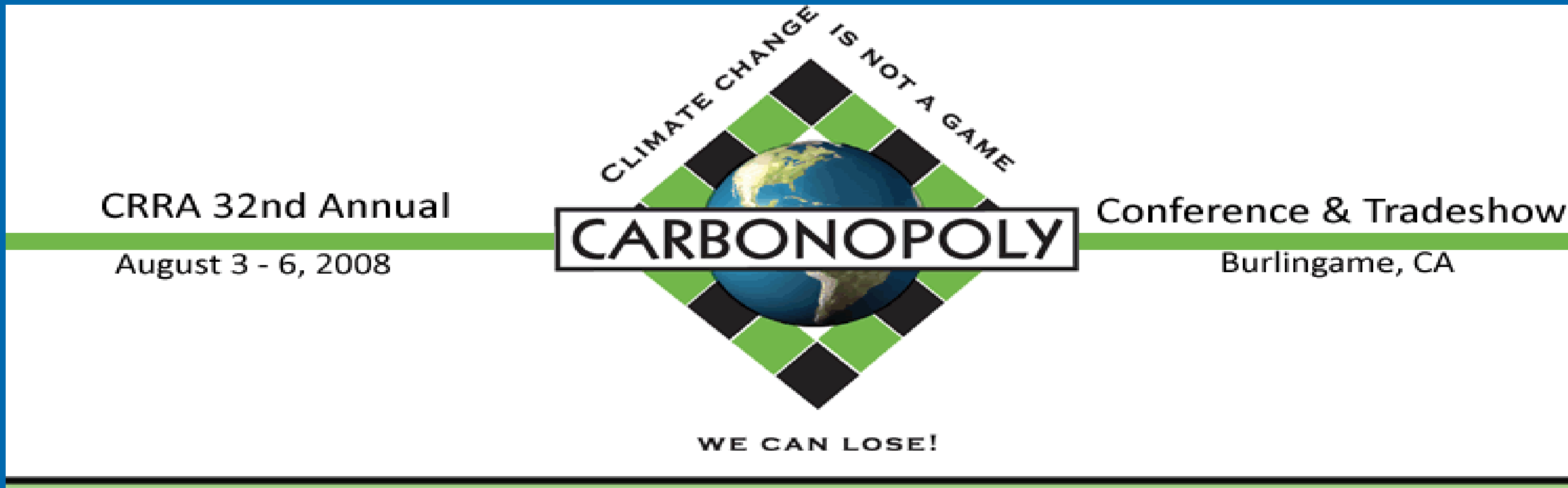


…. ………. or how to Pass Go and collect 200 tons of mandated commercial recycling, stay out of the Landfill Jail, promote the Community Chest of GHG benefits, take a Chance on biodiesel and ligno-cellulosic ethanol, use compost in Marvin Gardens, turn the Electricity Company green, and dream about being on Broadway and Park Place with carbon credits……….

Carbon Footprint Reductions Goals

- California needs a 30% reduction by 2020 from "business as usual", or almost 10% reduction by 2020 from the 2002-2004 baseline
- The Institute for Local Government – California Climate Action Network – draft Best Practices Framework calls for the recycling collection system footprint to be reduced
- Can the system reduce the carbon footprint? …and by how much
- "You can't manage what you don't measure"

4A's and 4F's

GHG Lingo

- Assessment
- Action
- Additionality
- Assignment of Carbon Credits

Recycling System

- Fleets – "Direct Emissions"
- Facilities – "Indirect Emissions"
- Feedstock Recycled – "Avoided Indirect Emissions"
- Future of Carbon Credits

What is the Carbon Footprint of a Recycling Collection and Processing System?

- Baseline GHG Emissions for typical solid waste and recycling collection/processing company with with a franchise, a fleet, and Material Recovery Facility (MRF) in a community achieving 50% recycling
- Baseline to assess any Early Action
- 90% are "direct emissions" from fleets fuel use
- 10% are "indirect emissions" from the electricity use at the MRF/offices
- 8 to 20x carbon negative due to "avoided indirect emissions" from recycling

Fleets – Policy Incentives

California Air Resources Board (CARB) Scoping Plan and the Low Carbon Fuel Standard (LCFS)

- 10% reduction in carbon intensity by 2020

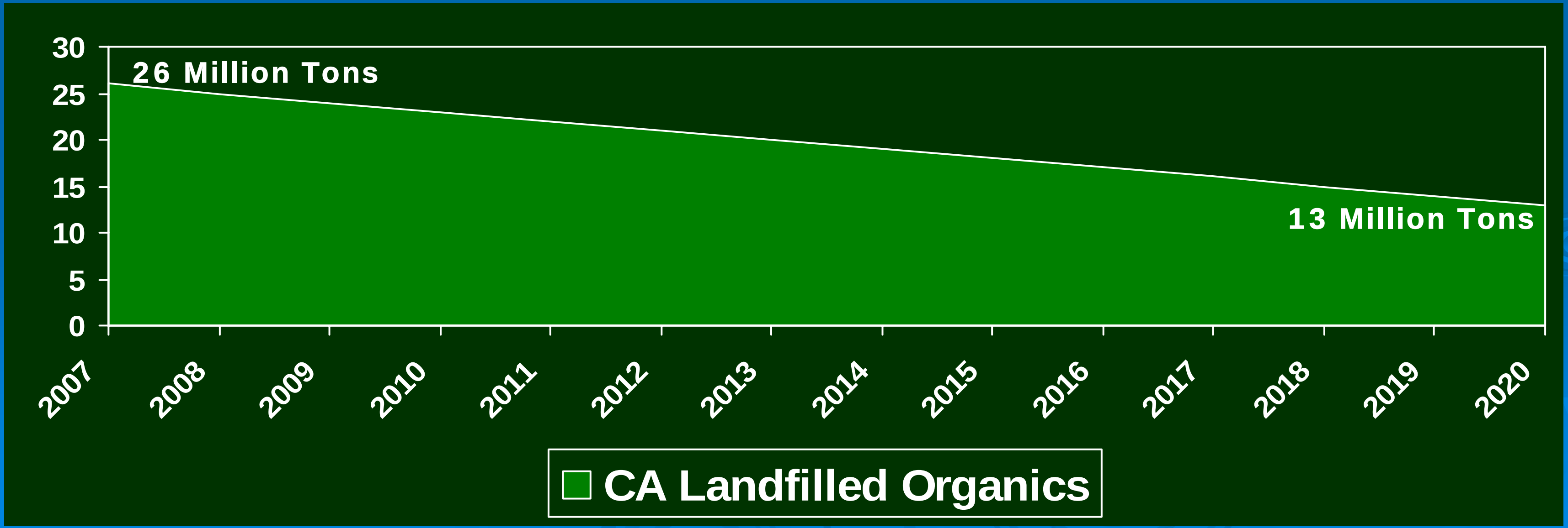
  16.5 $MMTCO_2E$ by 2020 – Top 4.

  - Low Carbon Fuel Standard Choices:
    B20/E15/LNG/CNG/HH
  - CARB Economic and Technology Advancement Advisory Committee - Ligno-Cellulosic Ethanol
  - California Climate Action Registry Biogenic Sources Policy
  - CA Integrated Waste Management Board (CIWMB) Strategic Policy Directive No. 6 or diverting 50% of organic by 2020.

One Million Tons Per Year

-- that's all we ask --

- 26 Million Tons of Organics in Landfills in 2007
- Reduce by 50% by 2020 – CIWMB Strategic Directive No. 6
- 13 millions TPY over next 13 Years
- "Million Tons Per Year Organic Reduction Plan"



Fleet's Biofuel Market Tons

CA Executive Order S-06-06 for Biofuels, the state shall produce a minimum of 20% of its biofuels within California by 2010, 40% by 2020.

- 1 tons of organic waste makes 77.5 gallons of ethanol (urban, forest, agricultural)
- 1 Billion gallons of ethanol used in CA in 2005 – 20% in-state reduction by 2010 – 200 million gallons from **2.5 million ton of organic waste**
- 2 Billion gallons of ethanol use in 2020 of the projected 20 billion gallons of fuel to be used, would need **10 million tons of organic waste** to produce 800 million gallons of ethanol – 40% in-state
- Note: Upstream GHG's from waste derived fuel issues

Fleets and Low Carbon Fuel Standard – 13% to 20% Footprint Reduction

Biogenic (i.e., plant) Sources from Low Carbon Fuel use counts as GHG reductions

- LCFS Standard of 10% reduction by 2010
- B5, B10, B20 to E15, E85
- Going B20 - 18% GHG reduction companywide
- Going E15 – 13.5% GHG reduction companywide
- Fuel Producers are lined up for the Carbon Credits

Anthropogenic Sources such as LNG, CNG, and Hydraulic Hybrid (HH) reduces GHGs

- LNG – 18% less of 90% is 16.2% companywide
- CNG – 23% of 90% is 20.7% companywide

Recycling Facilities
6% to 8% Footprint Reduction

- CARB Scoping Plan and a Million Solar Roof, Renewable Portfolio Standard (RPS), and Energy Efficiency
- 10% of a systems GHG are from “indirect emissions” from imported electivity.
- A MRF Solar roof top can be optimized to supply 67% of the on site power needs
- Energy Efficiency of office and the MRF can also reduce GHGs

Carbon Footprint Reduction Potential

Recycling and Processing System

- Fleets – 13% to 20%
- Facilities – 6% to 8%
- System – 19% to 28%

State and Local Goals

- CA Assembly Bill 32 – 30% by 2020 from "Business as Usual", 10% by 2020 from 2002-2004 baseline
- "Best Practices" – 10% by 2020?

Recycled Feedstock GHG Benefits

- Current Assessment Tools using the Federal EPA WARM Model customized for California
- 8x to 20x carbon negative from the "avoided indirect emissions" from recycling
- The Recycling System is "Carbon Negative" better than "Carbon Neutral"
- Communal GHG Benefits caused by local action from the curb, to the MRF, to the markets for remanufacturing
- Need updated and standardized GHG Assessment Tool for California

Policy Incentives for Increased Recycling and Composting

- Commercial Recycling – up to 6.5 MMTCO2E by 2020 (About 3.5 million tons of recyclables)
- Compost Use - 3.1 MMTCO2E by 2020
- Anaerobic Digestion – 2.2 MMTCO2E by 2020
- CA Senate Bill 1020 – 60% diversion by 2015, and 75% diversion by 2020 with mandated commercial recycling
- CARB Scoping Plan to develop “Recycling Protocols” for local government and business - Can’t be quantified
- Future Carbon Credits after 2012

GHG Assessment Tools

Develop Assessment Tools Today

- Standardized Federal WARM Model for California application now for Assessment
- Use for Program Design Now
- Use for CA Environmental Quality Act Assessment starting in 2009
- Do not delay the development of the Assessment Tool for rigorous Protocol Standards for future carbon credits
- Have the Assessment Tool be the foundation for future Protocol develop

Additionality for Carbon Credits

- Regulatory test beyond mandates
- Beyond business as usual
- Real
- Enforceable
- Permanent
- Transparent
- Independently verifiable

Carbon Credits for Recycling?

- Develop GHG Assessment Tools today to quantify the communal benefits of recycling
- Additionality varies over time – SB 1020
- Recognize the rigorous Protocol Development of 3 to 5 years for "carbon credits"
  - Complex measurement
  - Determination of "operational area"
  - Determination of Additionality
  - Avoid double counting
  - Renewable energy certificates (RECs) under Renewable Portfolio Standard (RPS) may trump GHG "cap and trade"

Who get's the Carbon Credit?

- Low Carbon Fuel producers selling over 10% blends are vying for carbon credits
- The domestic manufacturer using recycled glass, plastic, paper beyond minimum content laws wants the carbon credit
- Biomass energy facility want the carbon credits and RPS
- The compost producer that makes the compost wants the carbon credit, so do the farmers
- Should there ever be carbon credits, the benefits will be passed though the "value chain" where the recycling system benefits

Pass Go, Collect Recyclables

- Carbon Footprint reduction for “direct and indirect emissions” for the recycling collection/processing system - fleets/facilities
- AB 32 and the Scoping Plan represents many opportunities – LCFS/RPS/Pavely/Solar
- GHG Assessment Tools Now for recycling program design and CEQA Documents
- Do not delay Early Actions waiting for Recycling Protocols to obtain elusive carbon credits

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WHAT PROVIDES THE BIGGEST BANG?

Comparison of Carbon Footprint Effects and Costs from Recycling / Diversion vs. Energy Efficiency Programs

California Resource Recovery Association, August, 2008

U.S. EPA West Coast Waste Prevention, Recovery, and Disposal Webinar: 301

Lisa A. Skumatz, Ph.D.
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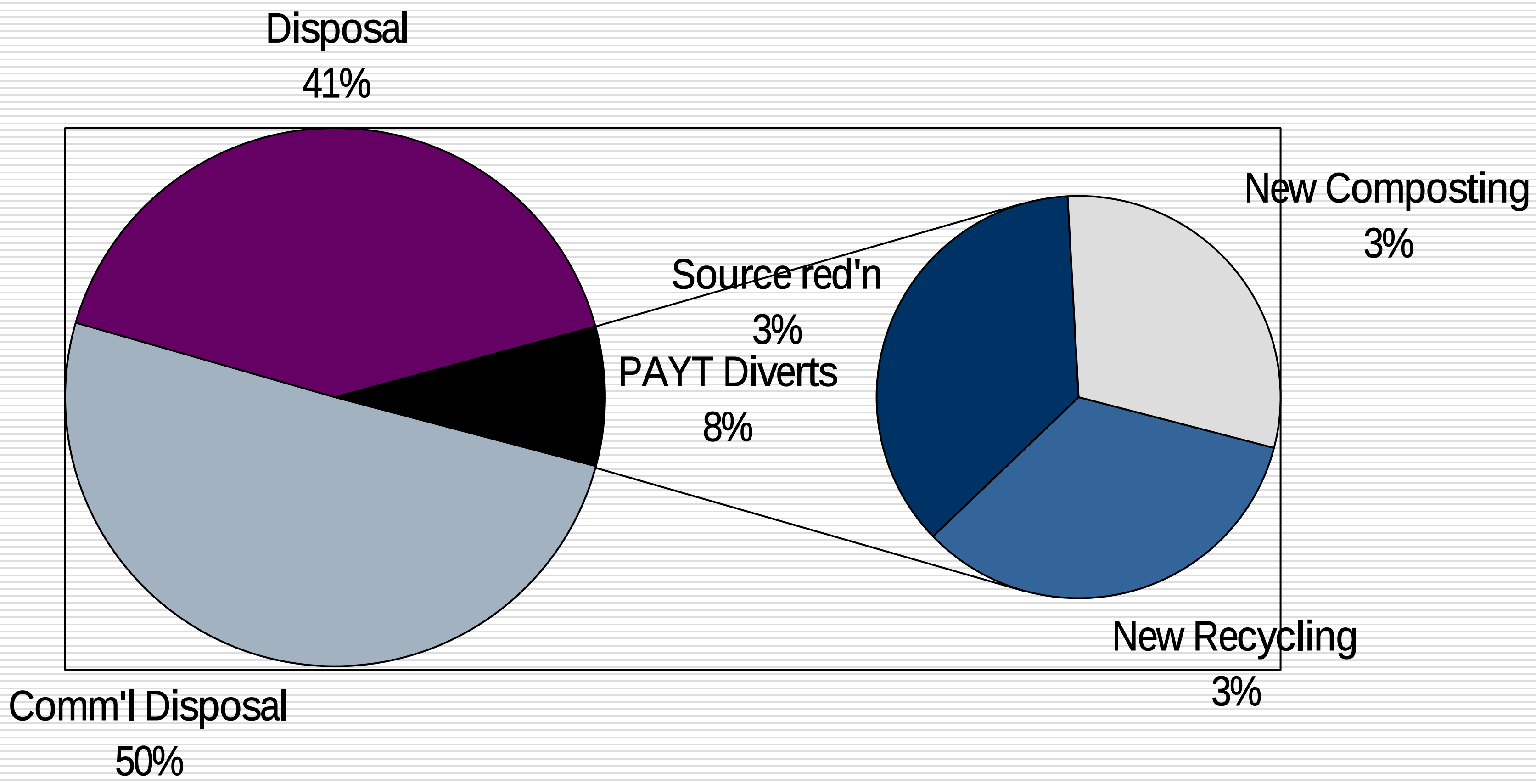
TOPICS

- Measuring value of emissions impacts
- Comparisons of cost to reduce 1 Metric Tons Carbon Equivalent (MTCE) from different initiatives
- Implications

MEASURING OMITTED IMPACTS FROM PROGRAMS

- Programs & activities deliver wide array of impacts accruing to:
  - Participant
  - Deliverer
  - Society
- Monetizing makes people pay attention…
  - Can include in fuller benefit-cost analyses, marketing
  - Examine “portfolio” approach to achieving goal
  - Allows step beyond “hand waving”
  - Start with Pay As You Throw (PAYT) example

PAYT IMPACTS ON MUNICIAPL SOLID WASTE DISPOSAL



(Source: Skumatz Economic Research Associates / SERA)

IMPACTS FROM PAYT

- Recycling:
  - 5–6 percentage points may be attributed to recycling (with similar increases for both curbside and drop-off programs);
- Composting:
  - 4–5 percent go to yard waste programs, if any;
- Source Reduction:
  - About 6 percent is removed as a result of source-reduction efforts, including buying in bulk, buying items with less packaging, etc.

Source: SERA publications

MONETIZING GREENHOUSE GAS (GHG) EFFECTS FROM PAYT

- Analysis of PAYT and associated source reduction (SR)
  - Analysis of environmental impacts (1999 SERA)
  - Follow-on from GHG/energy model and analyses (1994 SERA)
- Steps:
  - PAYT quantitative effects from SERA estimates (population covered, disposal tons, 17% reduction to recycling, composting, SR)
  - EPA's WARM (Waste Reduction Model) to estimate emissions changes from recycling, composting, SR
  - Valuations from Non-Energy Benefits (NEB-It) model (SERA)

RESULTS

- Monetized emissions from PAYT
  - Used regulatory and environmental values from more than 30 sources for emissions
- Results
  - Metric ton reductions in CO_2, CH_4, CF_4, C_2F_6 computed from WARM; first 2 components valued
- Premium value beyond landfill tip fee from PAYT adds $1-$6/ton (1999)
  - Conservative (direct, only landfill effects)

UPDATED 2006 PAYT / GHG ANALYSIS

- Tons affected:
  - PAYT in 7100 communities, 75 million population (SERA 2006)
  - Generation range from EPA and Biocycle
  - Tons diverted are 17% of residential generation (SERA)
  - Shares to recycling; compost; source reduction
- Emissions
  - The EPA WARM (WAste Reduction Model) to estimate carbon and BTU equivalents for baseline / alternative scenarios (with PAYT)
    - WARM model inputs / standard curbside mix, default landfill
  - Pros and cons of model (especially compost)/ improving

GHG RESULTS FROM PAYT

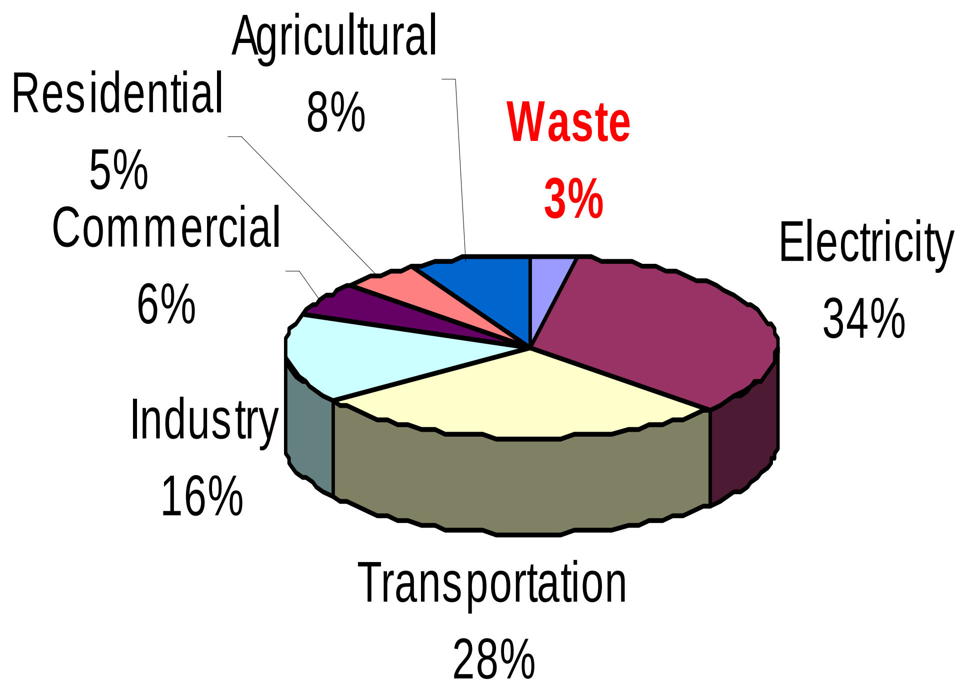
- With the PAYT adoption as of 2006, annual emissions reductions are equivalent to:
  - 61-109 million MBTU
  - 7.4-13.3 million MT CO_2 Equiv.
  - 2.1-3.8 million MT Carbon Equiv,

VALUING THE IMPACTS

VALUING THE EMISSIONS

- Worth computed based on dollar value of the reduced emissions in terms of carbon dioxide equivalents
  - Used prices from the Chicago Climate Exchange (CCX). As of late 2006, the CCX value for metric tons of CO2 was about $4.00-$4.15.
    - From www.chicagoclimatex.com. Other web sites like carbonfund.org suggest values of $5.50, for example.
  - 2006 value of $30-$55 million dollars annually
  - **About $4-$11/ton premium on landfill tip fee savings**

US GREENHOUSE GAS EMISSIONS (2005) - CONVENTIONAL



Source: USEPA

➔ HAS LED TO FOCUS OF ATTENTION ON ENERGY PROGRAMS…

- Depressing…
  - Spend half my time in energy –
  - Which more effective? Where balance?
- Preliminary estimates
  - Depends on type of program (of course)

DELIVERING EQUIVALENT GHG REDUCTIONS – ENERGY VS. DIVERSION…

ENERGY PROGRAM ANALYSIS - COST PER MTCO2E

- Assembled data on Cost/kWh for energy programs
  - Ranges of residential energy efficiency (EE) programs
  - Range of commercial EE programs
  - Wind; Photovoltaic
- Calculating emissions diverted from programs
  - Used national mix of generating plants (including coal, natural gas, average age / models)
  - Used NEB-It model with secondary data to model GHG impacts and costs
  - Generated cost per MTCO2E

Source: SERA 2007/2008

DIVERSION PROGRAM ANALYSIS - COST PER MTCO2E

- Computed cost per MSW ton diverted
  - Used national SERA database on costs for solid waste programs
  - Costs and tons for Curbside recycling
  - Costs and tons for PAYT
- Used WARM model results (direct landfill diversion only)
  - Computed MTCO2E from program diversion

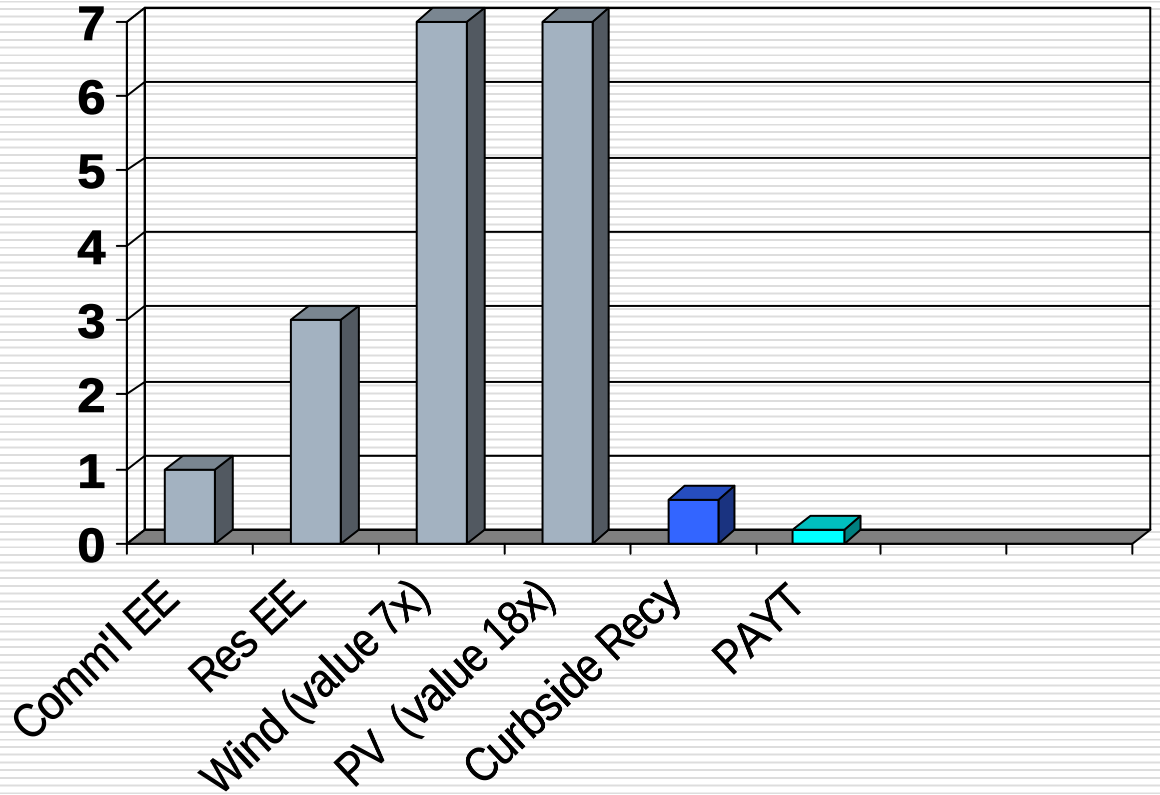
Source: SERA 2007/2008, preliminary

RELATIVE COST (PER MTCO2E) AND COVERAGE – "RECYCLING" VS ENERGY EFFICIENCY

	Normalized Multiplier for Cost per MTCO2E (SERA)	Speed to implement and full scale implementation coverage
Commercial Energy Efficiency	1.0 – baseline	1-3 years; fraction of customer base
Residential Energy Efficiency	3 times as expensive as com'l EE	1-3 years; fraction of customer households
Wind	7-8 times as expensive as com'l EE	TBD
PhotoVoltaic (PV)	18-25 times as expensive as com'l EE	TBD
Curbside Recycling	0.6-0.7 time the cost of com'l EE	6 months – 2 years; covers all households in area
Pay As You Throw (PAYT)	0.2-0.3 times cost of com'l EE	3-9 months after political approval; covers all single family households in area
Prevention & reuse		
Yard Waste program		

NOTE: Direct effects only (Source: SERA 2007-2008; DRAFT)

RELATIVE COST PER MTCO2E FOR SOLID WASTE, ENERGY PROGRAMS



Draft results show MSW programs cheaper to reduce CO2 than EE!

Conserative: Direct landfill emissions effects only – no “upstream” effects

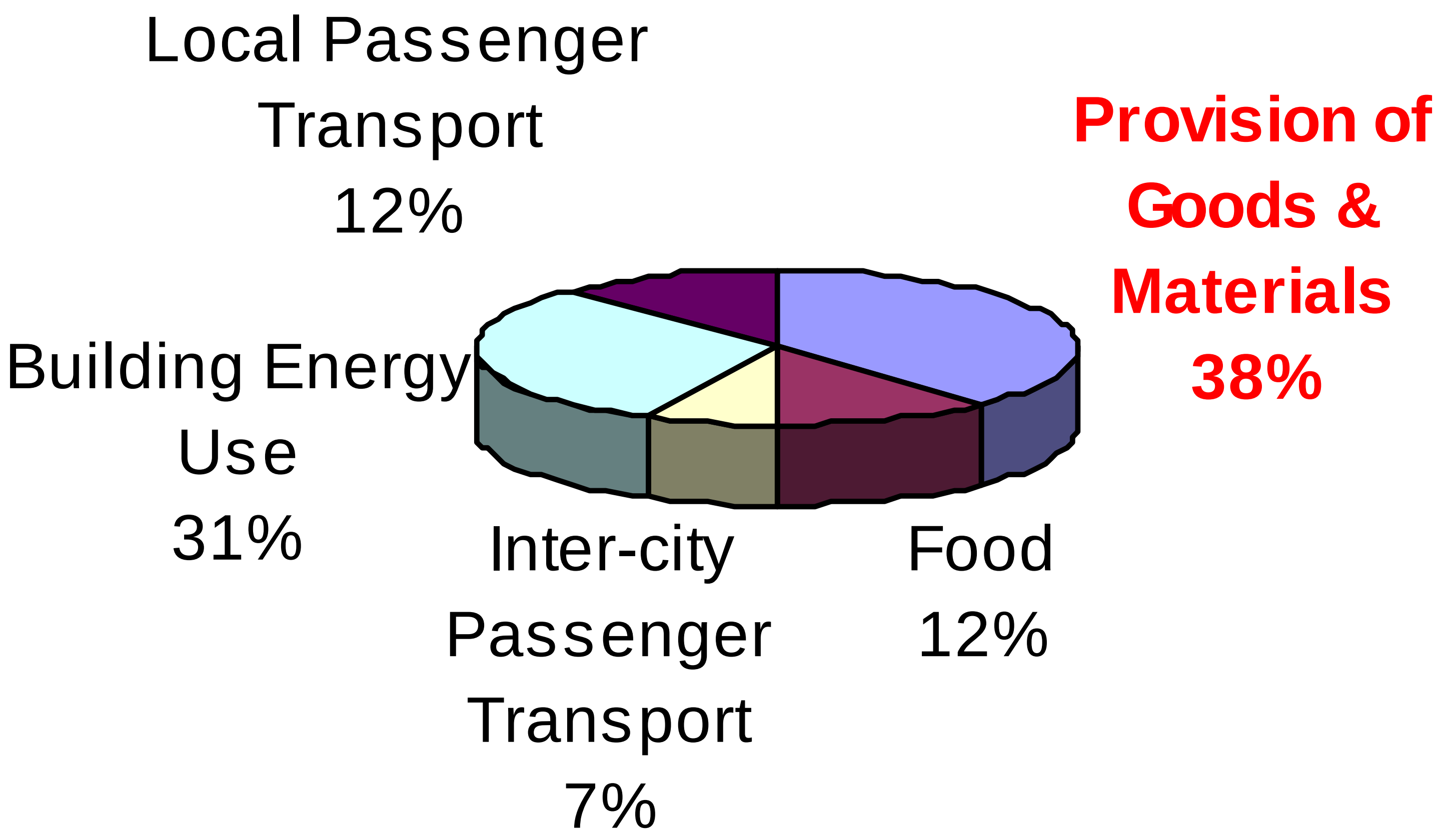
SPEED / COVERAGE / AUTHORITY – ADVANTAGES FOR SOLID WASTE PROGRAMS

- Speed / Timing
  - Implementation FASTER for recycling / diversion than for many EE programs (and practically all transportation measures)
    - Examples / Results in achieving city GHG goals
- Coverage
  - PAYT, recycling immediately covers ALL households (businesses) in area – unlike slow buildup of energy programs
- Authority
  - Cities / counties often no authority over energy…
- Retention…

GOING BEYOND "DIRECT" IMPACTS

- ***BEYOND*** DIRECT effects... Evidence
  - Methane impacts important – and front-loaded
  - Production emissions MUCH (many times) more important than DISPOSAL emissions (Allaway (ORDEQ) / USEPA) – more dramatic view than "save 95% of energy for aluminum"
  - Energy savings due to recycling MUCH more important than Landfill diversion
  - Revised accounting to "provision of goods and services" changes balance (USEPA prelim) and international effects

US GREENHOUSE GAS EMISSIONS (ALTERNATIVE VIEW)



Source: USEPA (Prelim); from Allaway (ORDEQ)

UPSTREAM PRODUCTION SAVINGS EVEN MORE DRAMATIC - EVIDENCED THROUGH LONG-HAUL BREAK-EVEN FIGURES (Allaway,ORDEQ)

Material	Production Savavings (MMBTU/ ton coll'n)	Break even-Truck	Break even-Rail	Break even - Freighter
Aluminum	177	121,000	475,000	538,000
LDPE	61	41,000	162,000	184,000
PET	59	40,000	157,000	178,000
Steel	19	13,000	52,000	59,000
Newspaper	16	11,000	43,000	49,000
Corrugated	12	9,000	33,000	38,000
Office pap	10	7,000	27,000	31,000
Boxboard	6.5	4,400	17,400	19,800
Glass (to bottles)	**1.9**	**1,300**	**5,100**	**5,800**

Break even: transport energy = energy saved displacing virgin feedstock

CONCLUSIONS

- Can measure impacts from GHG reductions
  - Preliminary work shows millions in savings and premiums per ton diverted.
- Can compare cost to achieve GHG reductions from array of programs
  - Recycling cheaper than energy conservation for some programs (& cheaper than renewables)
  - Faster to implement / greater coverage / have authority – early "big bang" programs
- Broader economic context… "making the case" for diversion…
  - We're NOT 3%, we're faster / cheaper… Should be the #1 program for cities with climate change goals

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Materials Management and Greenhouse Gas Emissions

California Resources Recovery Association

2008 Annual Conference

August 5th, 2008

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AAAS Science and Technology Policy Fellow
Office of Solid Waste and Emergency Response
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Materials management and land management have influence over a large share of greenhouse gas (GHG) emissions

+

Materials and land management approaches can make significant GHG reductions.

Materials management and land management have influence over a large share of greenhouse gas (GHG) emissions

+

Materials and land management approaches can make significant GHG reductions.

green design

energy efficiency

Materials management

Prevention-oriented approaches

industrial ecology

design for environment

sustainable consumption

… tend reduce emissions at low cost and with environmental co-benefits (compared end-of-pipe controls)

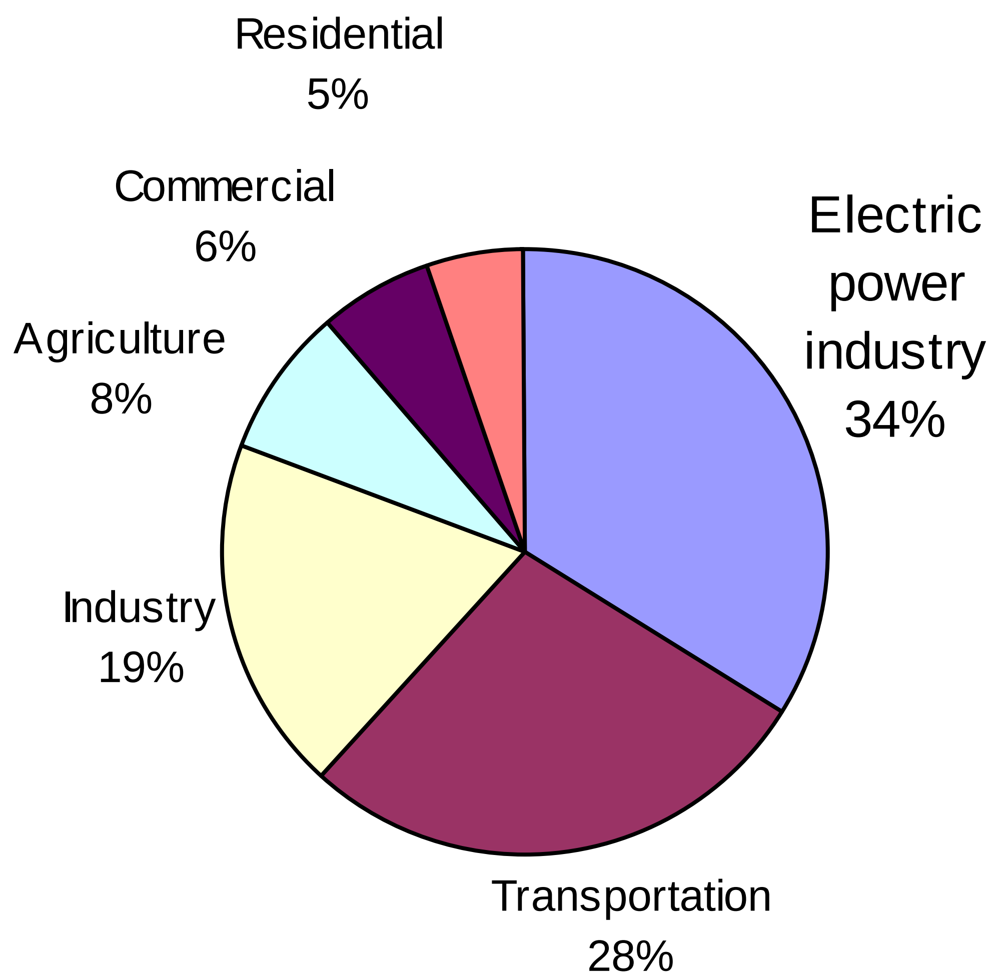
Prevention-oriented approaches

Systems thinking

Life cycle analysis

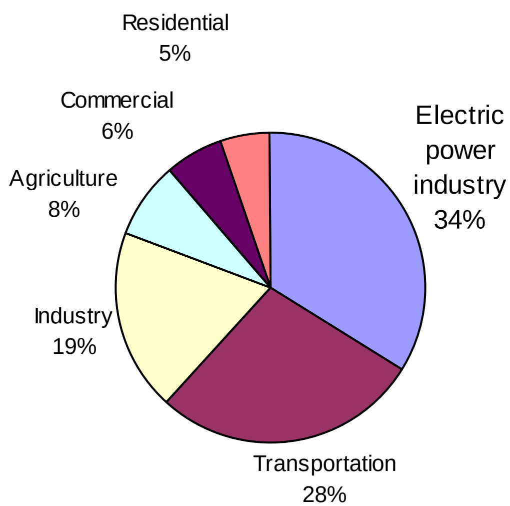
Consumption-based accounting

US GHG Emissions 2005: Sectors View



Source: EPA (2007). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005.*

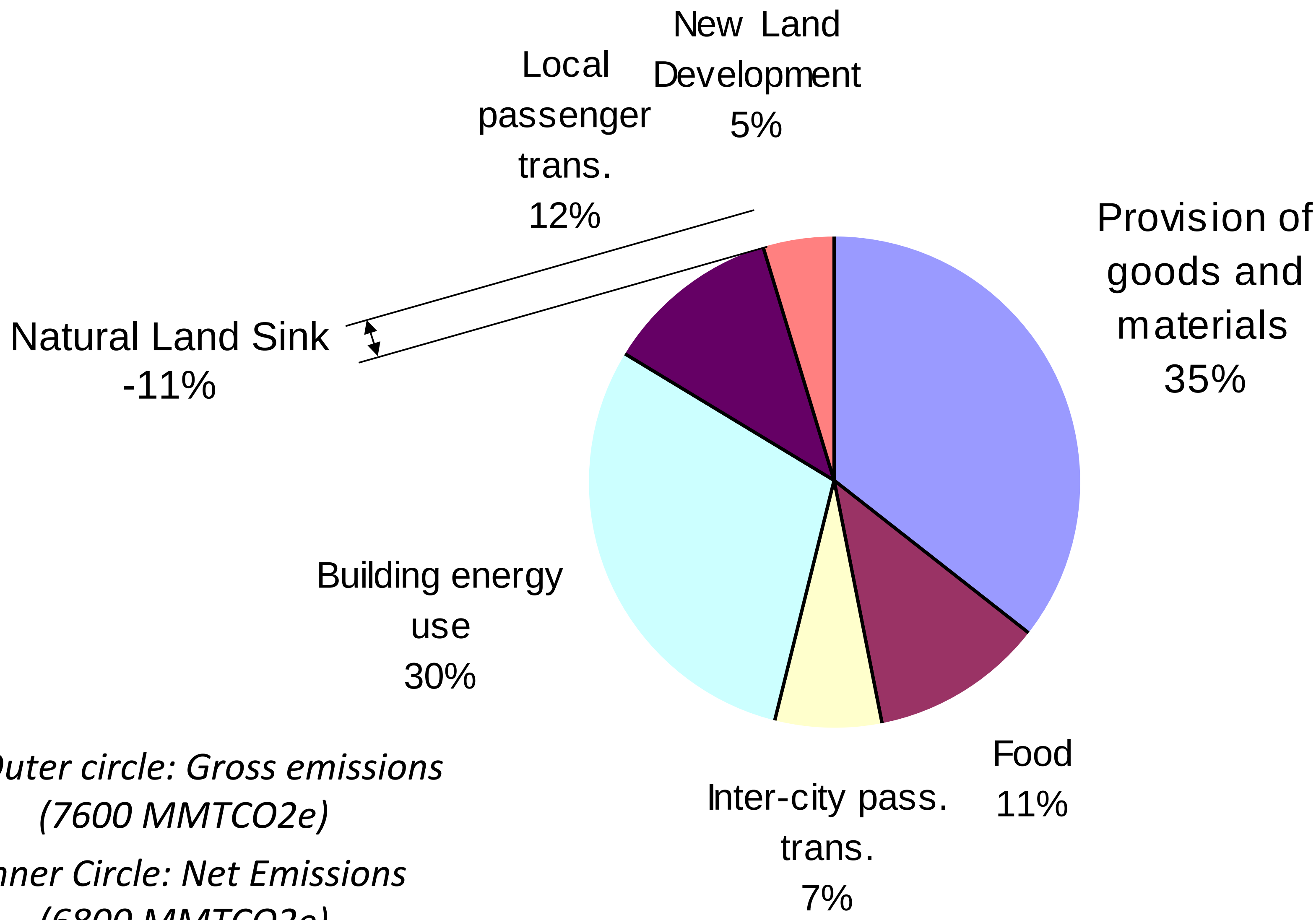
US GHG Emissions 2005: Sectors View



This view:

- shows share of emissions by point of emission
- is useful for targeting **end-of-pipe solutions** (e.g. carbon capture at power plants) and **technology substitution** (e.g. hybrid-electric vehicles

US GHG Emissions 2005: Systems View

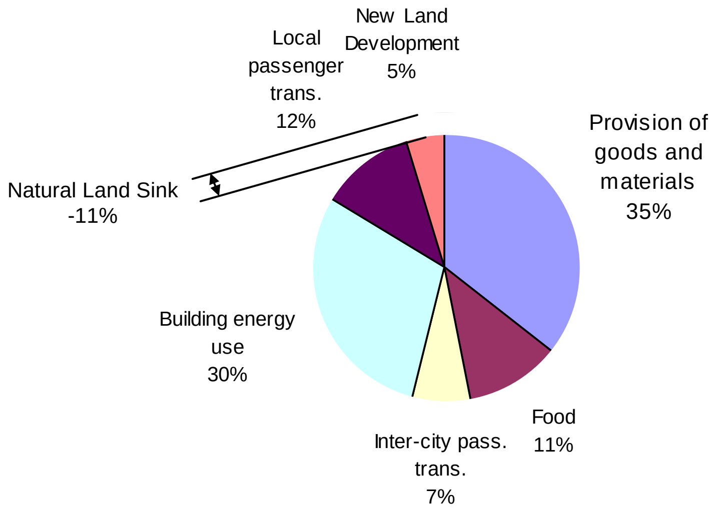


Outer circle: Gross emissions (7600 MMTCO2e)

Inner Circle: Net Emissions (6800 MMTCO2e)

Source: Draft analysis by EPA OSWER Center for Program Analysis

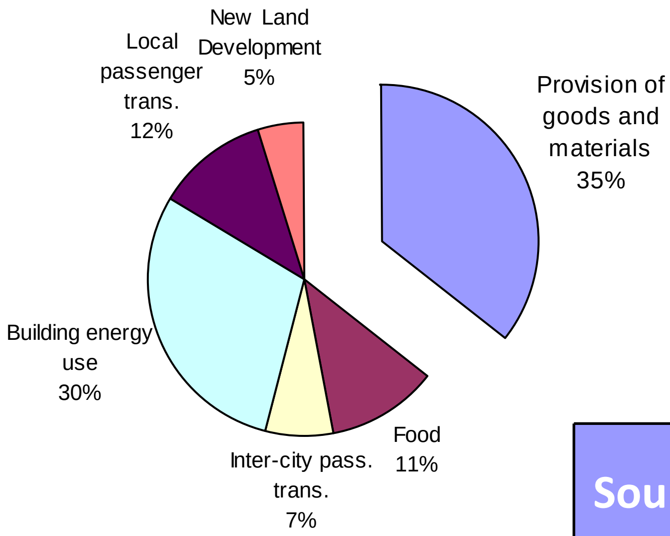
US GHG Emissions 2005: Systems View



This view is:

- one perspective (among many possible) of emissions by system or **category of use**
- chosen with land and materials management in mind
- useful for targeting **prevention-oriented** mitigation solutions (e.g. materials source reduction and land reuse)

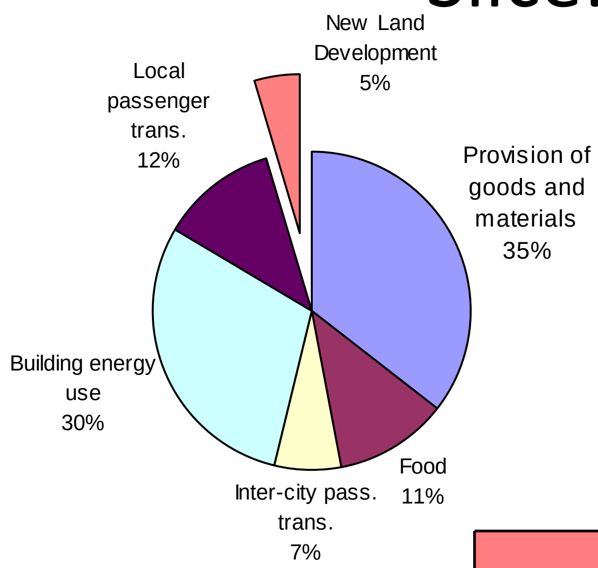
Slice: Provision of Goods and Materials



Draft analysis by EPA OSWER Center for Program Analysis

Source	Emissions [MMTCO2E]
Industrial sector fossil fuel combustion	840
Industrial sector electricity use	735
Other industrial emissions	680
Freight	514
Emissions from Waste	187
Total	**2,955**
Adjustments to correct for emissions counted under other slices	(285)
Revised Total	**2,670**

Slice: New Land Development



Draft analysis by EPA OSWER Center for Program Analysis

Source	Emissions ($MMTCO_2E$)
Lost Soil Carbon	202
Lost Biomass Carbon	81
Lost DOM Carbon	31
Highway, Street, Bridge, and Tunnel Construction	31
Water, Sewer, and Pipeline Construction	9
Total Annual Emissions Resulting from New Land Development	**354**

Example materials management activities

Activity	**Technical Potential Reduction [MMTCO2e/yr]**
Source reduce 25% of cans, glass, plastic, and consumer paper	31 – 110
Reduce packaging use by 50%	147
Extend the life of personal computers by 50%	51
Recycle all construction materials	160
Increase national MSW recycling rate to 50%	36
Capture and recover all methane at U.S. landfills	130
Compost all food scraps	21

Source: Draft analysis by EPA OSWER Center for Program Analysis

EPA-tracked Contaminated Land in the US

Category	Area [acres]
Federally-listed brownfields	37,000
Non-Federal CERCLIS Proxy Sites	2,200,000
Federal CERCLIS Proxy Sites	2,500,000
Non-Federal RCRA Sites	1,000,000
Federal RCRA Sites	11,000,000
Total Acreage of Contaminated Sites	**17,000,000**

Acreage Considered Urban/Remote		
Urbanized Area	2,800,000	17%
Urban Cluster	340,000	2%
Remote	13,600,000	81%

Source: Draft analysis by EPA OSWER Center for Program Analysis

Example land revitalization activities

Activity	Technical Potential Reduction [MMTCO2e/yr]
Revegetate 3.2 million acres of former mine lands	81
Develop all solar class 6 and 7 contaminated land as utility-scale solar	888
Develop 0.5 million acres of contaminated land as utility-scale wind	31
Optimize the top five NPL treatment technologies	4.6

Source: Draft analysis by EPA OSWER Center for Program Analysis

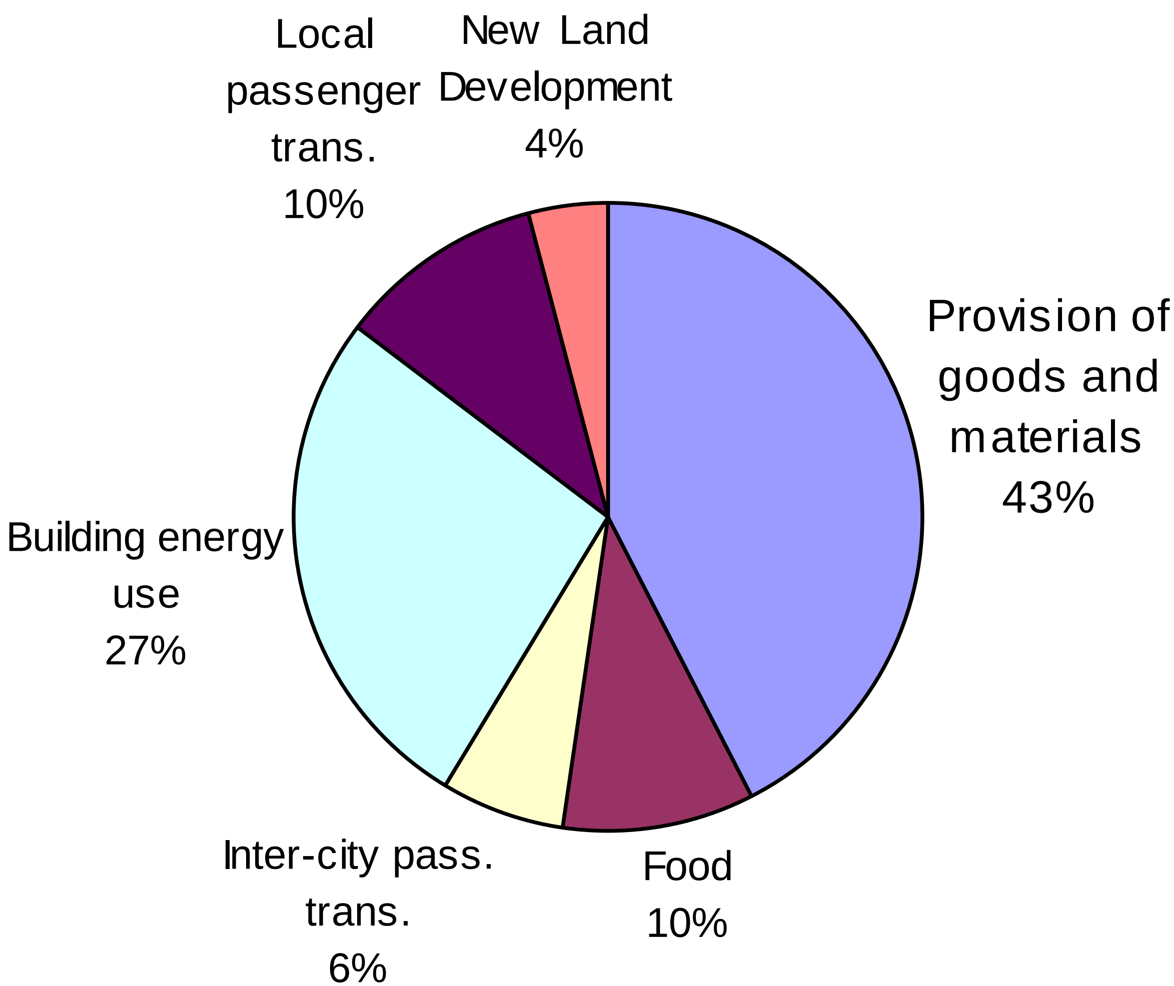
Extending the framework

Systems-oriented accounting can help target **prevention-oriented** mitigation options.

Technical potential calculations can identify **biggest opportunities** for impact.

The analysis can be done at **many levels** (local, state, individual) and for **many types** of systems.

Example: extending scope to international emissions



- Food emissions decrease slightly
- Goods and materials increase by 1/3
- Overall emissions increase by ~12% (4-18%)

Sources: Weber and Matthews (2007). *Environ. Sci. Technol.,* 2007, 41, 4875-4881

Draft analysis by EPA OSWER Center for Program Analysis

Systems thinking puts more emissions and more mitigation opportunities on the table.

Materials and land management opportunities are best understood within a systems framework.

Contact me at *stolaroff.joshuah@epa.gov* or 202-566-2642.

Question & Answer

Webinar #3

West Coast Webinars on Climate Change, Waste Prevention, Recovery, and Disposal

August 5, 2008