

Is Waste a Good Source of Energy?

Dr. Jeffrey Morris

Sound Resource Management Group, Inc.

Olympia, WA 98502

jeff.morris@zerowaste.com

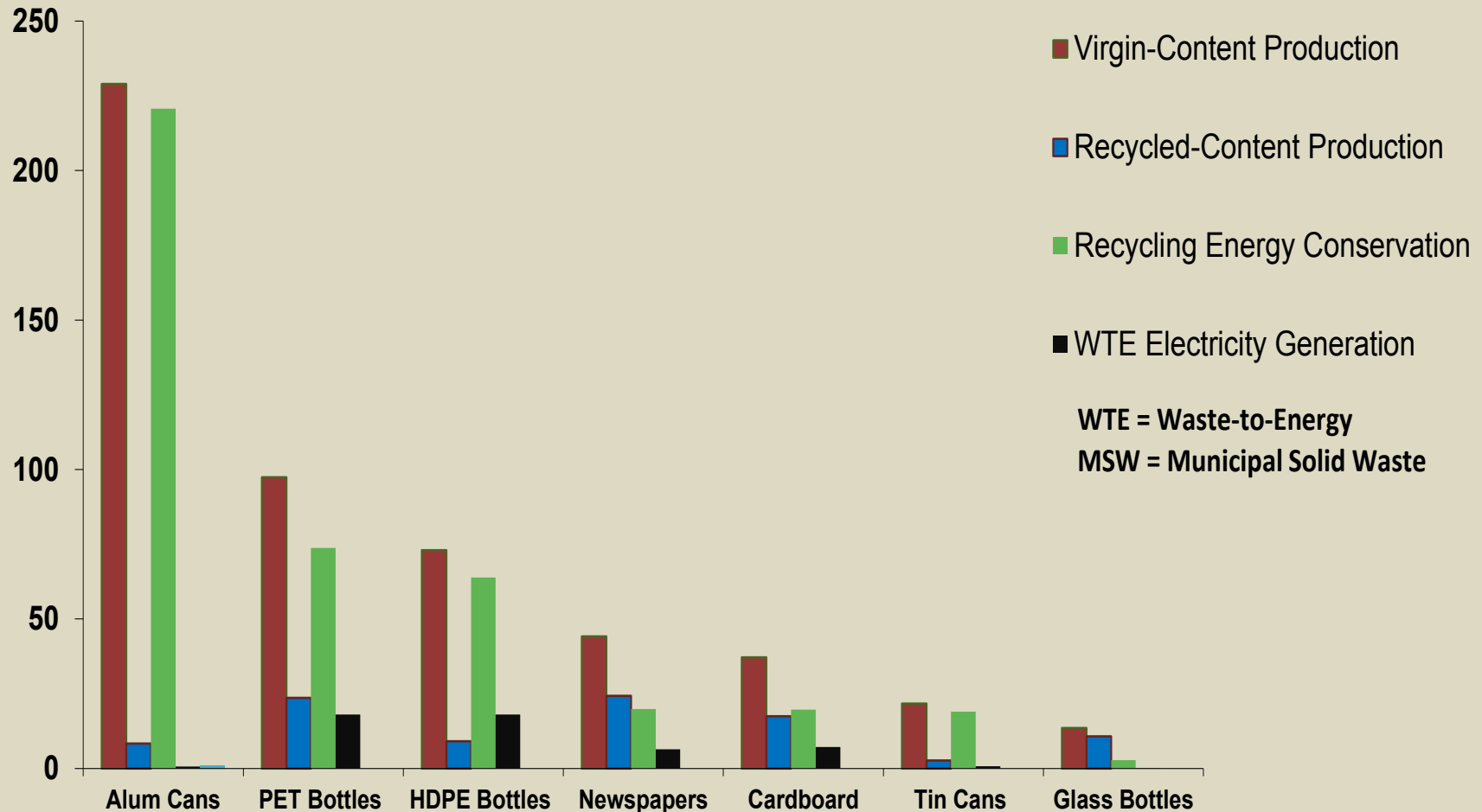
Tel 360.867.1033



Earth, Wind & Fire Energy Summit -- Oct 4, 2014

Energy Savings from Recycling vs. Energy Generated from Combustion/Gasification of MSW Materials

Million Btus per Ton



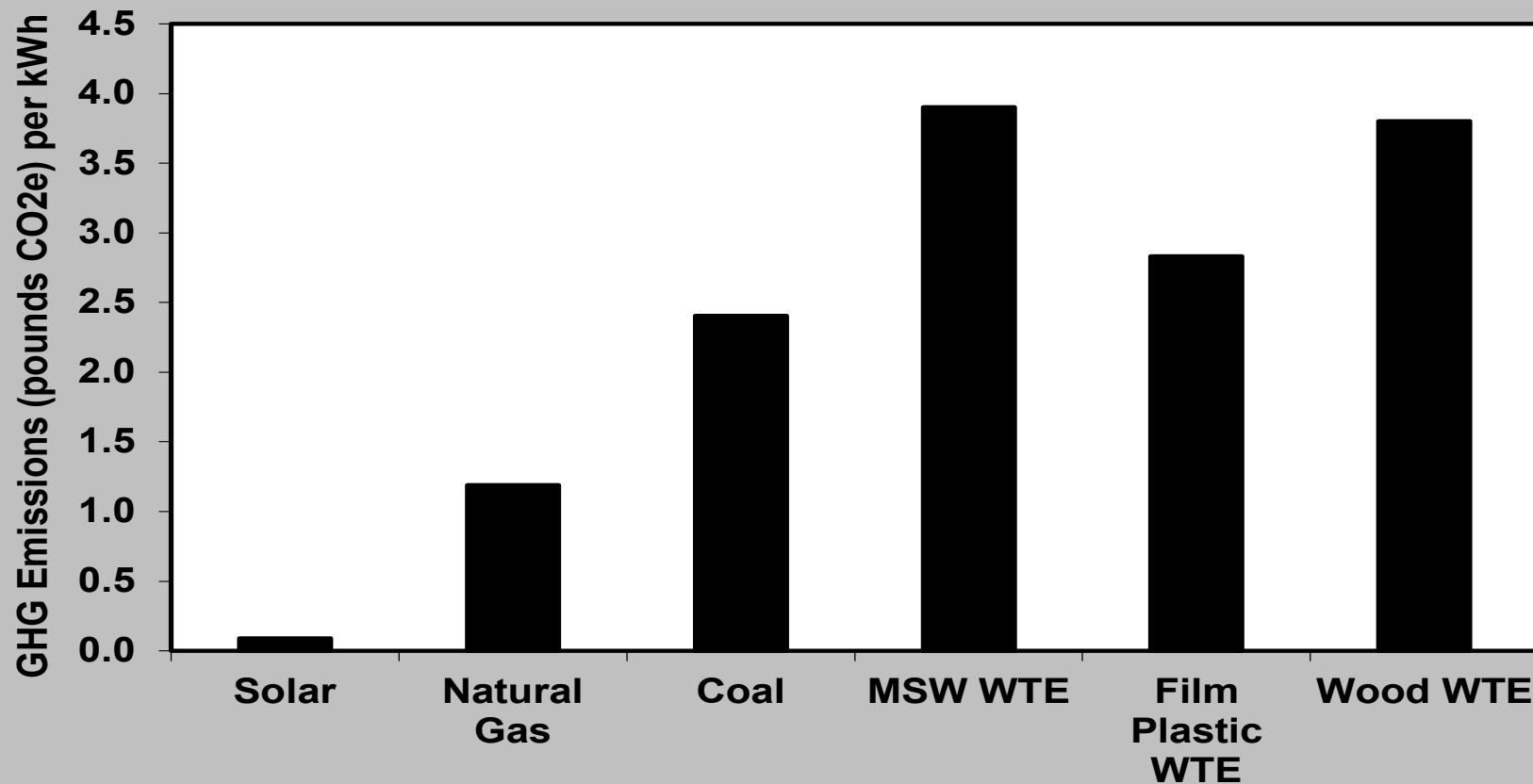
MSW WTE Facility, Spokane, WA



MSW WTE Pollution Control Equipment



Carbon Footprints for Electricity Generation

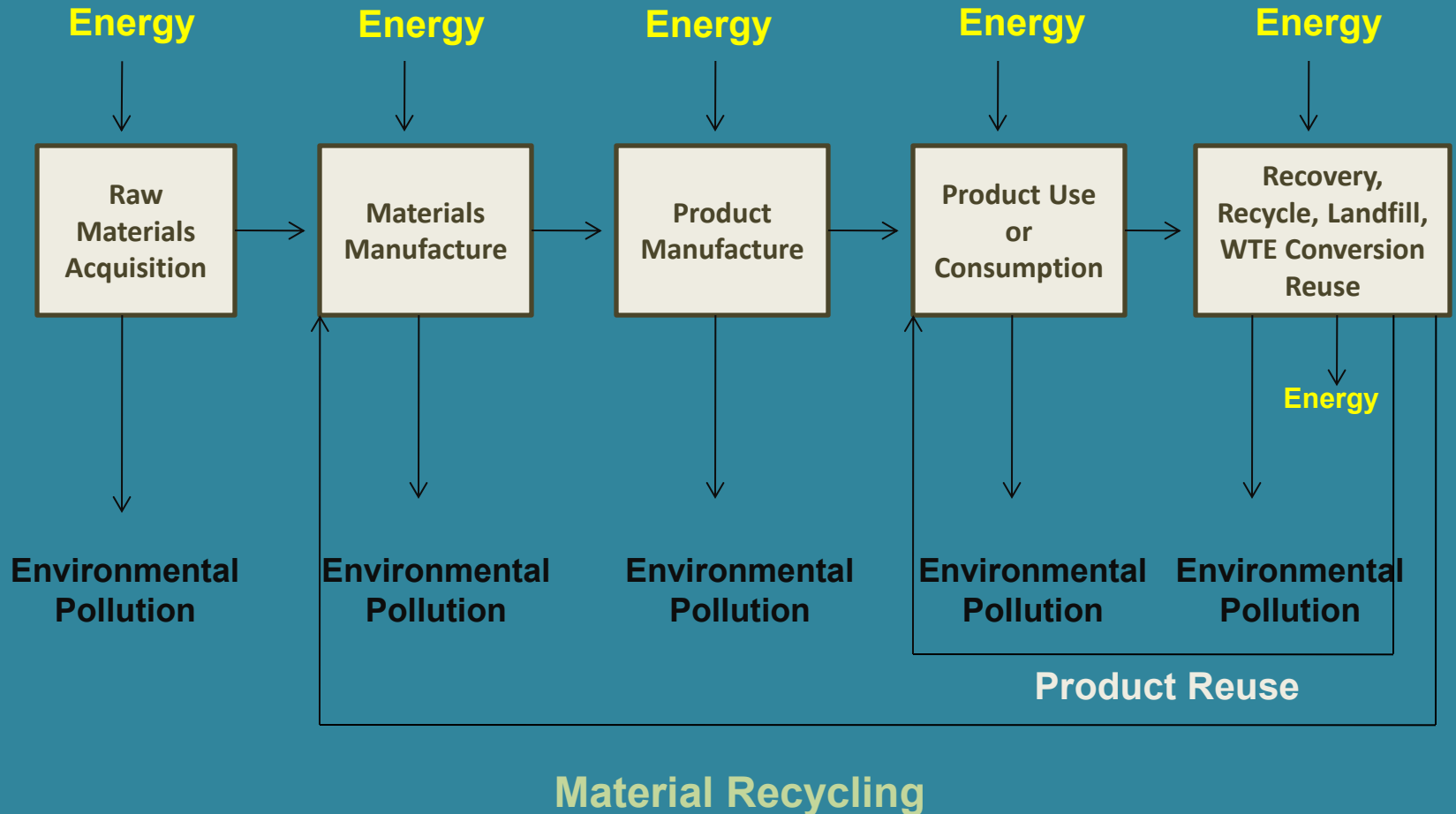


Sources: Kim, H. C.; Fthenakis, V.; Choi J-K.; Turney, D. E., 2012. Life Cycle Greenhouse Gas Emissions of Thin-film Photovoltaic Electricity Generation – Systematic Review and Harmonization. *Journal of Industrial Ecology* 16 (S1): S110-S121; Morris, J., 2010. Bury or burn North American MSW? LCAs provide answers for climate impacts & carbon neutral power potential. *Environmental Science & Technology* 44 (20): 7944-7949; Morris, J., 2014. Recycle, Bury, or Burn Wood Waste Biomass? *Journal of Industrial Ecology*, in peer review; and Whitaker, M. B.; Heath, G. A.; Burkhardt, III, J. J.; Turchi, C. S., 2013. Life Cycle Assessment of a Power Tower Concentrating Solar Plant and the Impacts of Key Design Alternatives. *Environmental Science & Technology* 47 (): 5896-5903.

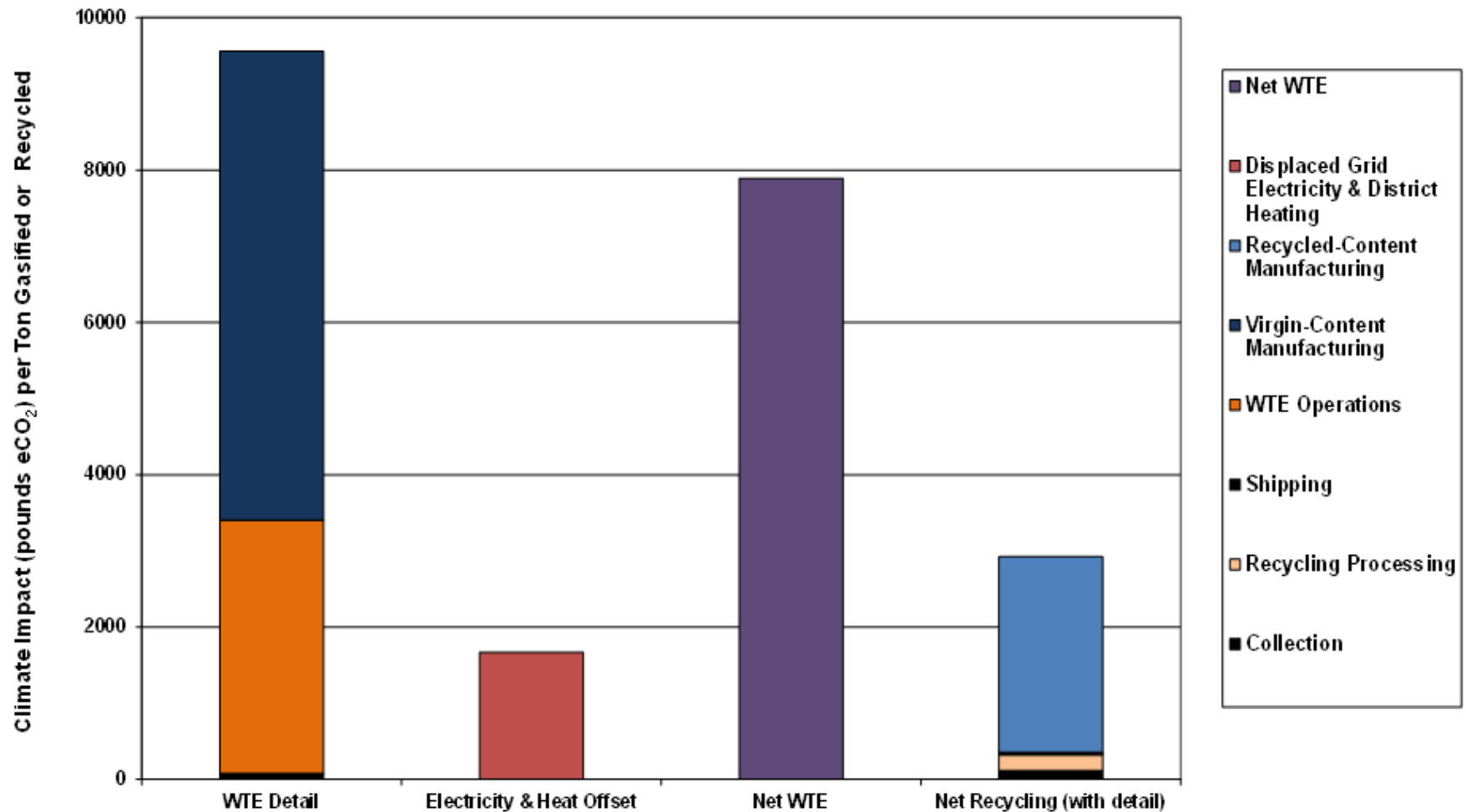
Motivations for Life Cycle Analysis (LCA)

- **Provide environmental performance assessments for competing products or services**
- **Evaluate environmental impacts that are otherwise not counted or are discounted in making choices**
- **Provide assessments of multidimensional environmental impacts in monetary units in order to compare against the economic bottom line**
- **Connect the dots in complex systems**

Schematic of a Product's Life Cycle

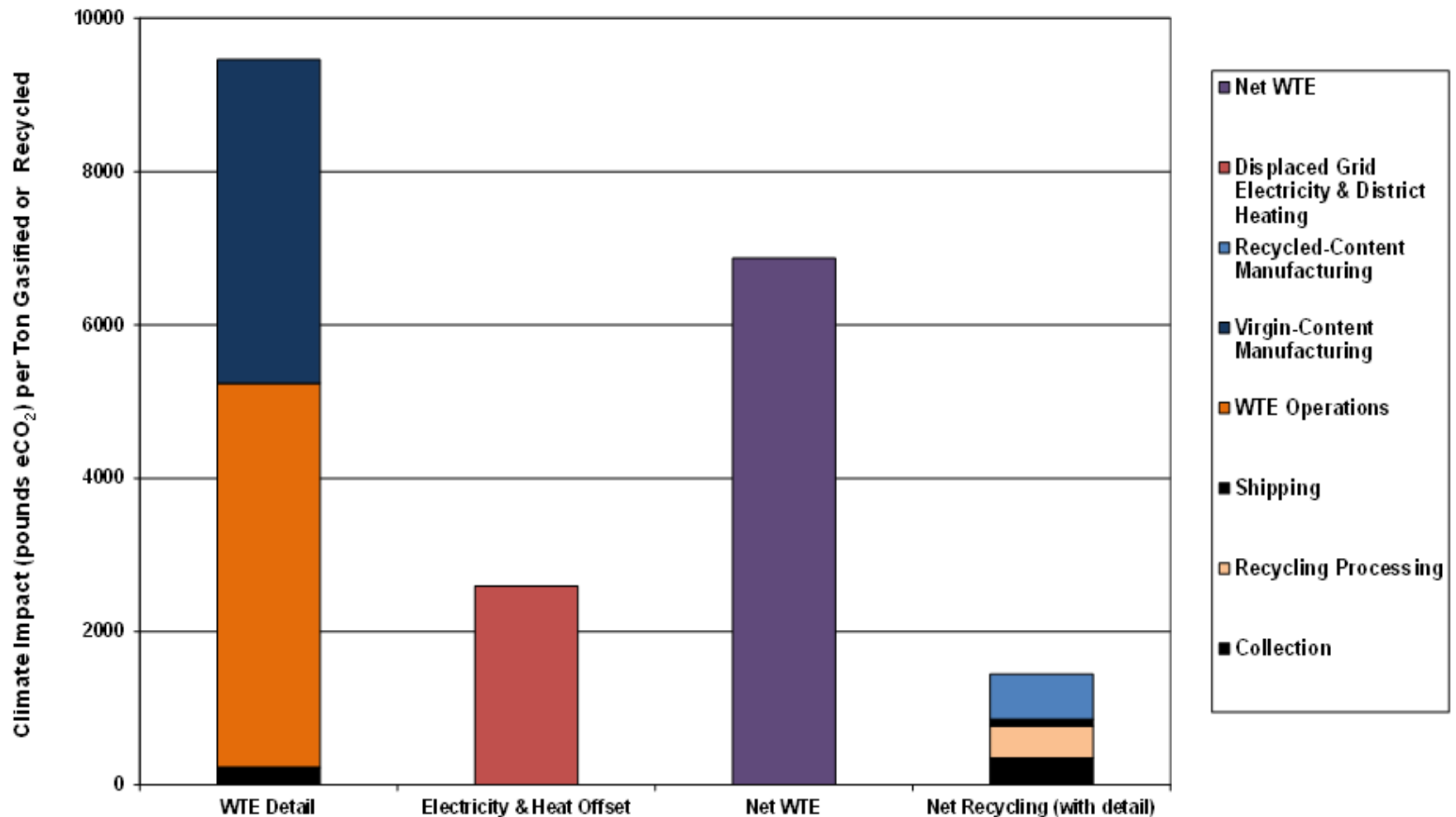


WTE vs. Recycling Climate Impacts Paper & Cardboard



WTE vs. Recycling Climate Impacts

Film Plastic (LDPE)

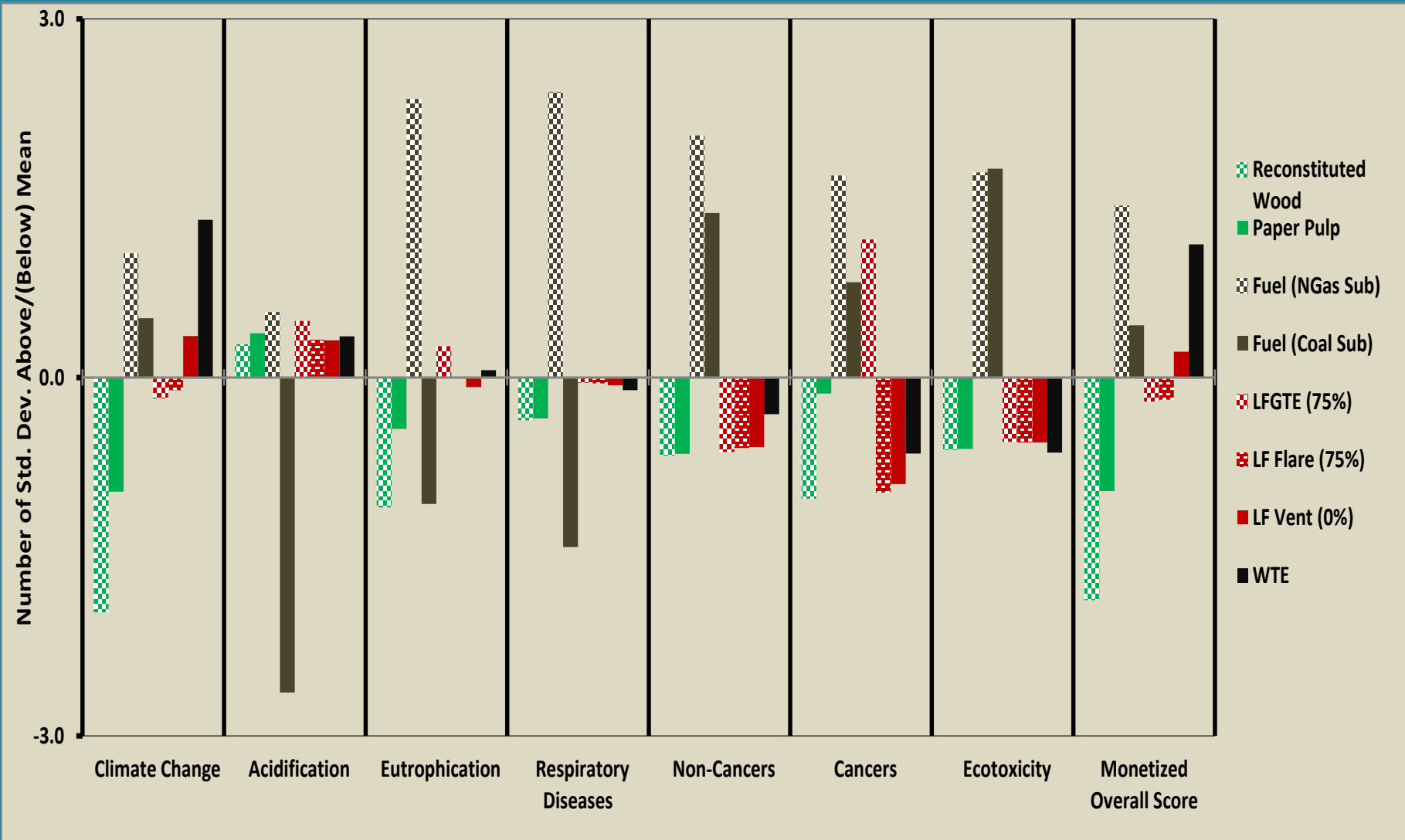


Wood Chip Piles, 49 MW Biomass Plant Anderson, CA



Source: Dr. Mary Booth, Partnership for Policy Integrity, www.pfpi.net

Life Cycle Environmental Impacts for Clean Wood Waste – Recycle, Bury or Burn



Monetization Estimates

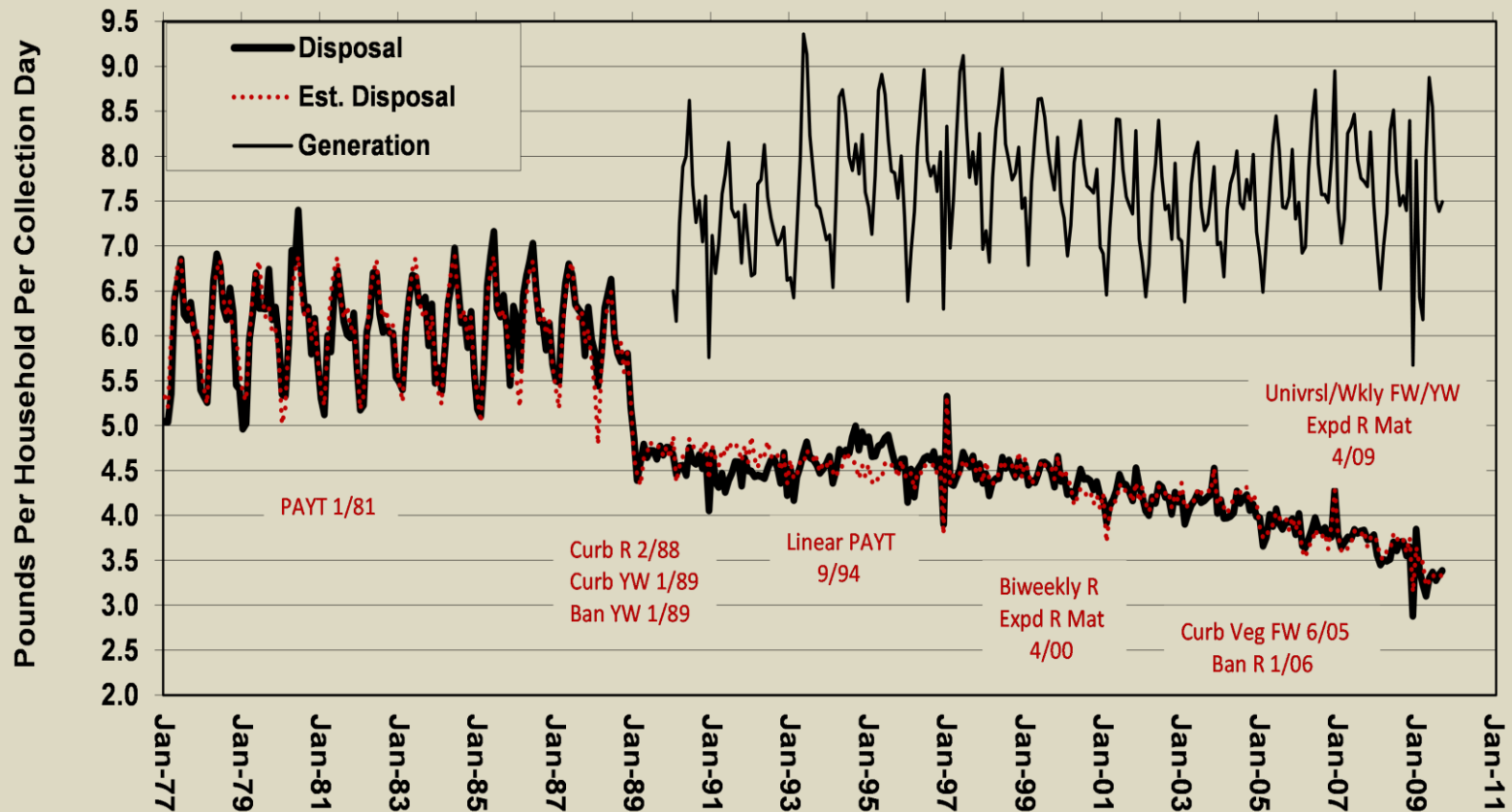
- Climate Change – eCO₂ @ \$50 per ton
- Acidification – eSO₂ @ \$290 per ton
- Eutrophication – eN @ \$4 per ton
- Human Health-Respiratory – ePM_{2.5} @ \$10,000 per ton
- Human Health-Non-Cancers – eToluene @ \$30 per ton
- Human Health-Cancers – eBenzene @ \$3,030 per ton
- Ecotoxicity – e2,4-D @ \$3,280 per ton

Source Separated Recycling Rates (Seattle 2012) vs. Multi-Family Mixed Waste Processing Recovery Rates

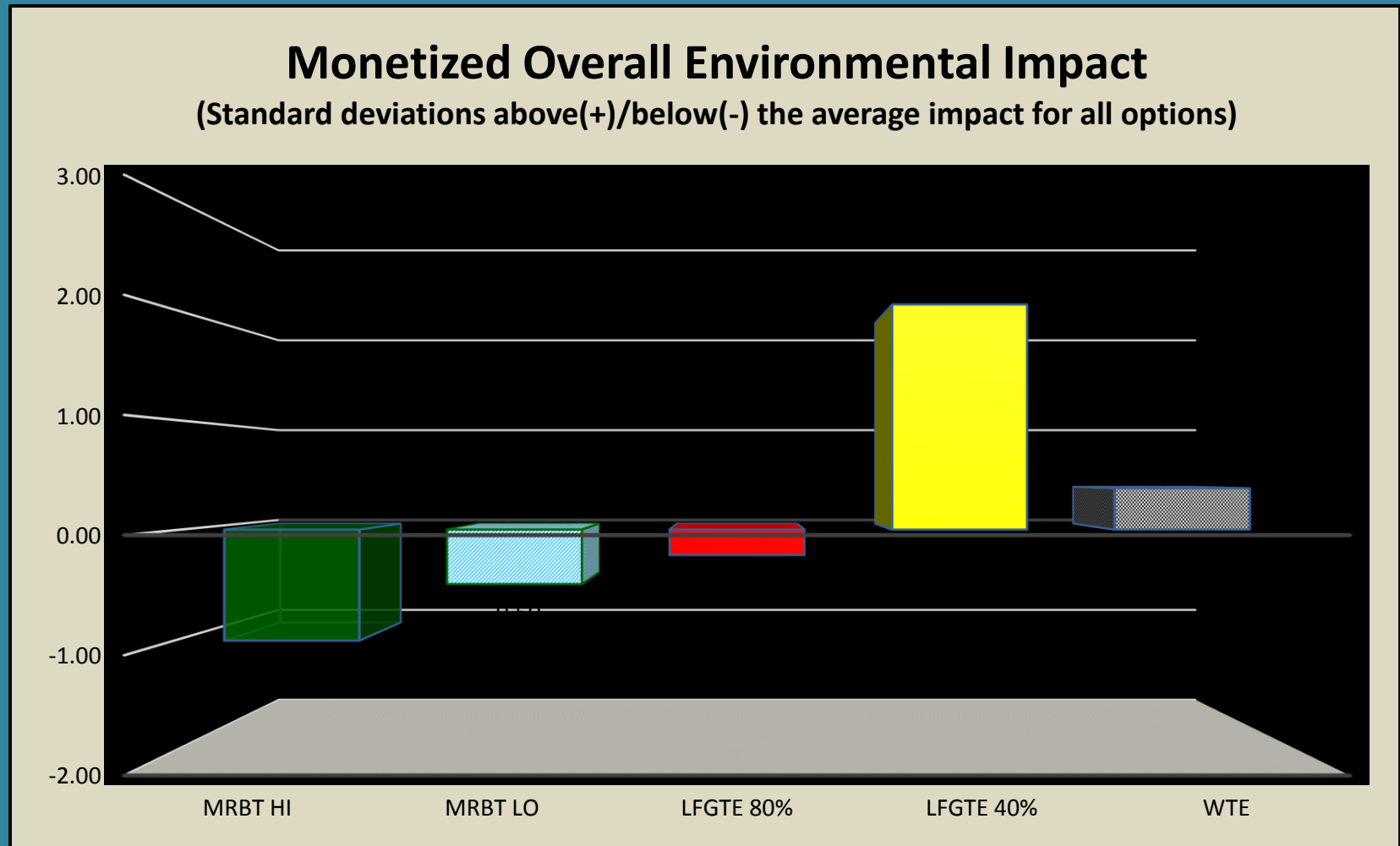
	Single-Family	Multi-Family	Commercial	Self-Haul	Total		Multi-Family Dirty MRF
Newspaper	96%	83%	79%	18	86%		35
Cardboard	92	80	88	34	86		75
Mixed Paper	87	67	74	5	72		35
Plastics	29	14	15	1	16		50
Glass	92	76	77	20	82		30
Metals	55	22	72	57	62		75
Wood	0	0	0	0	0		?
Yard Debris	99	56	93	79	94		?
Food Waste	62	9	55	0	51		?
Total	71%	32%	61%	11%	55%		25% + ?%

Source Separated Recycling & Composting Trends for Seattle, WA

City of Seattle Residential Waste Generation & Disposal



What Do We Do with Residual Wastes as They Decline – MRBT, LFGTE or WTE?



Sources

- Morris, J., 1996. Recycling versus incineration: An energy conservation analysis, *Journal of Hazardous Materials*, 47 (1-3 Special Issue on Energy-from-Waste): 277-293.
- Morris, J., 2005. Comparative LCAs for curbside recycling versus either landfilling or incineration with energy recovery. *International Journal of Life Cycle Assessment*, 10(4): 273-284.
- Morris, J., 2010. Bury or burn North American MSW? LCAs provide answers for climate impacts & carbon neutral power potential. *Environmental Science & Technology* 44(20): 7944-7949.
- Morris, J., Matthews, H.S., Morawski, C., 2013. Review and meta-analysis of 82 studies on end-of-life management methods for source separated organics. *Waste Management* 33: 545-551.
- Morris, J., 2014. Recycle, bury or burn clean wood waste. *Journal of Industrial Ecology*, in peer review.

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