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Comparison of Green House Gas Impacts of

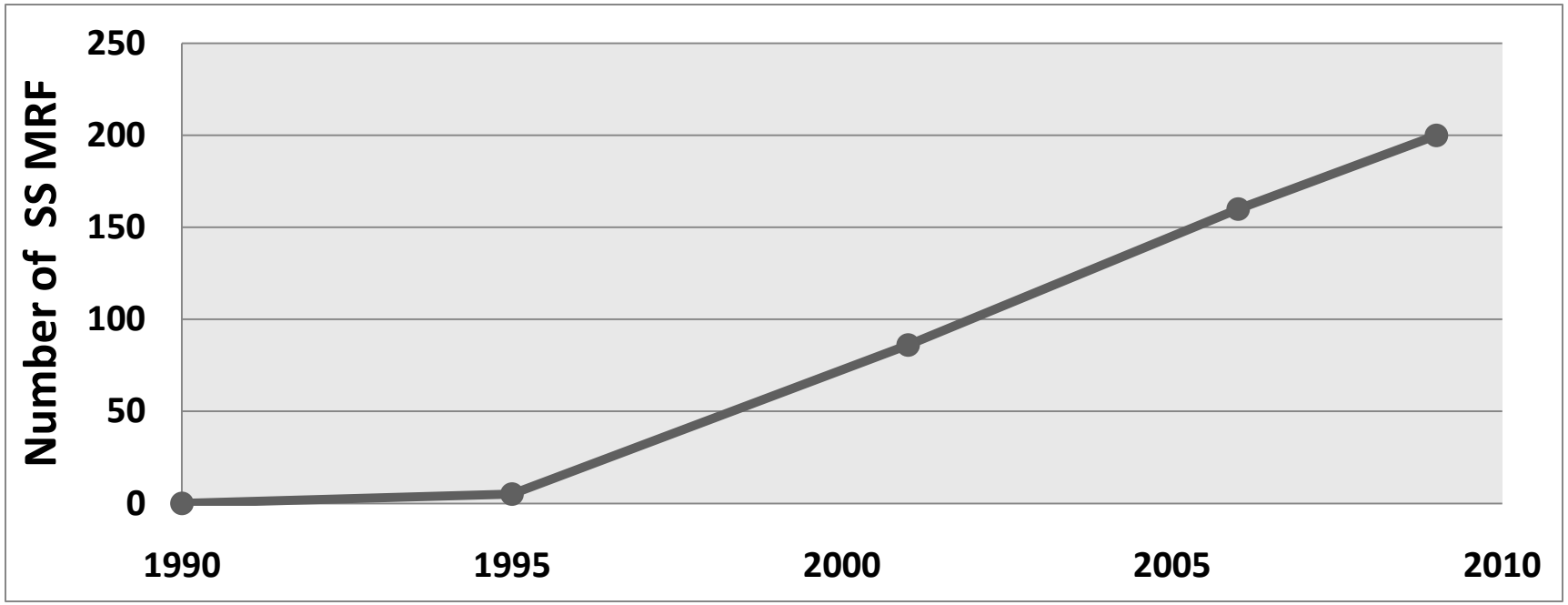
Dual Stream vs. Single Stream Collection and Processing of Recyclables

A study for Waste Management, Inc. by

Objective

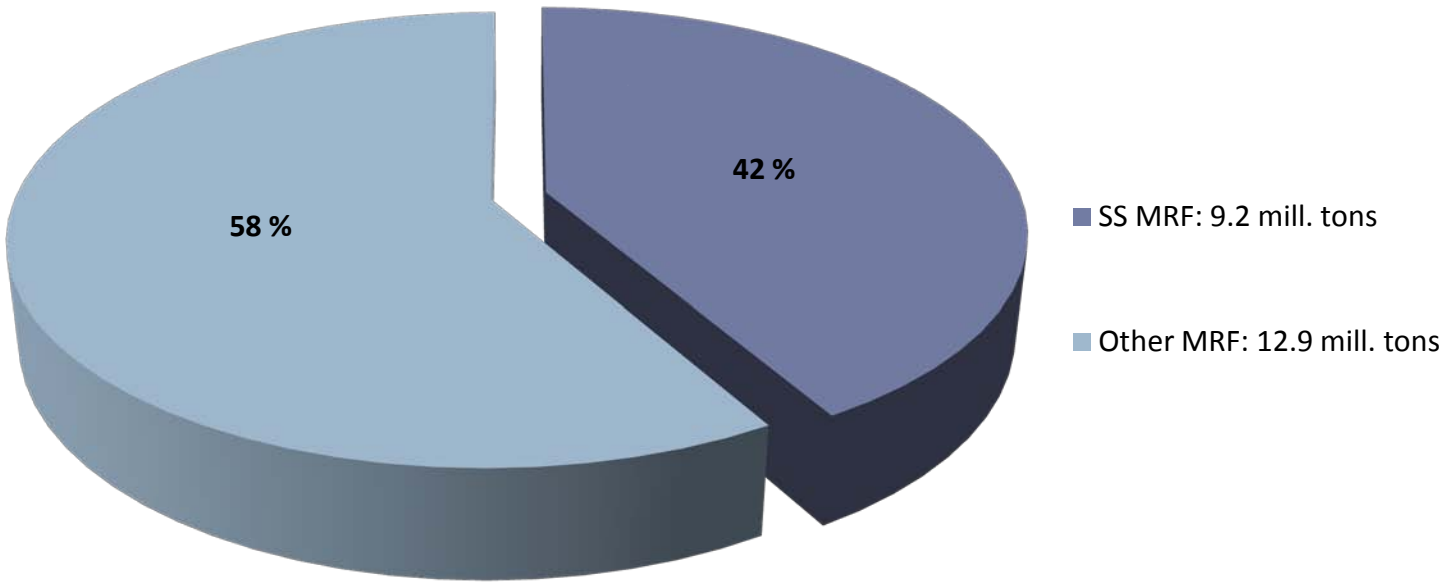
- Quantify the greenhouse gas (GHG) impacts of changing the collection and processing of recyclables in communities from dual stream (DS) to single stream (SS)
- **Dual Stream (DS) collection:**
  - paper fiber
  - mixed plastic, metal, and glass (PMG)
- **Single Stream (SS) collection:** PMG and paper fiber are collected together

Increase in number of SS MRFs since 1990



- Number of SS plants has increased dramatically between 2001 (70) and 2006 (160)

SS and DS collection and processing



- U.S. Single Stream capacity in 2006 was 9.2 million tons
- This corresponded to 42% of the total MRF capacity of 22.1 million tons

Capital costs of SS and DS MRFs

	Average MRF capacity (tons/day)	Average capital cost	Capital cost per daily ton of capacity
DS MRF	152	$4,907,000	$105,690
SS MRF	206	$7,551,000	$66,630

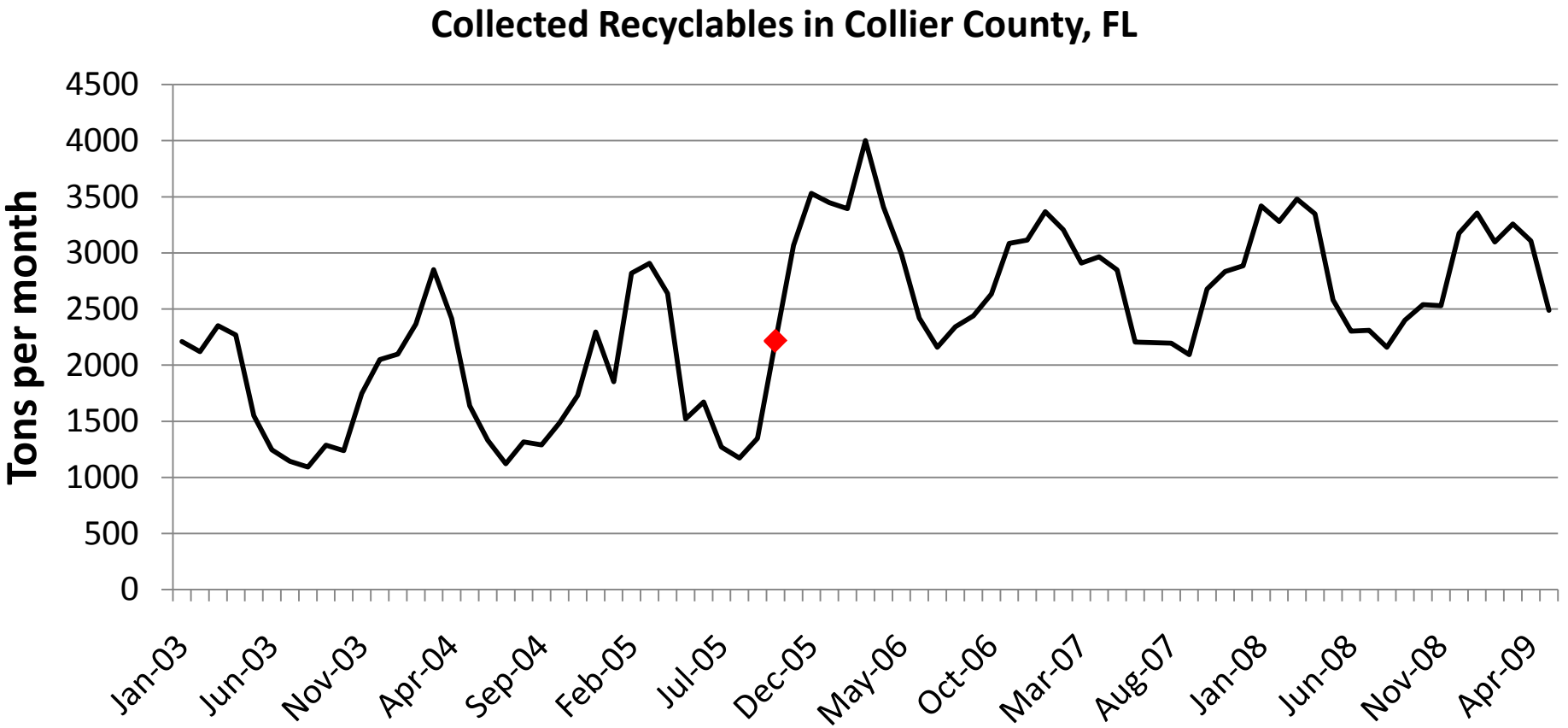
- SS MRFs are costlier to build
- However, on a per ton basis, the SS capital cost is only 60% that of a DS plant

Population of communities examined

Avon, MA	4,500
East Grand Forks, MN	8,000
Vadnais Heights, MN	10,000
Hopkins, MN	17,000
Township of Ocean, NJ	28,000
Mankato, MN	33,000
West New York, NJ	46,000
Blaine, MN	55,000
Burnsville, MN	60,000
Springfield, MA	151,000
Chula Vista, CA	221,000
Madison, WI	230,000
Collier County. FL	315,000
Dakota County, MN	390,000
Miami-Dade Co., FL	2,500,000

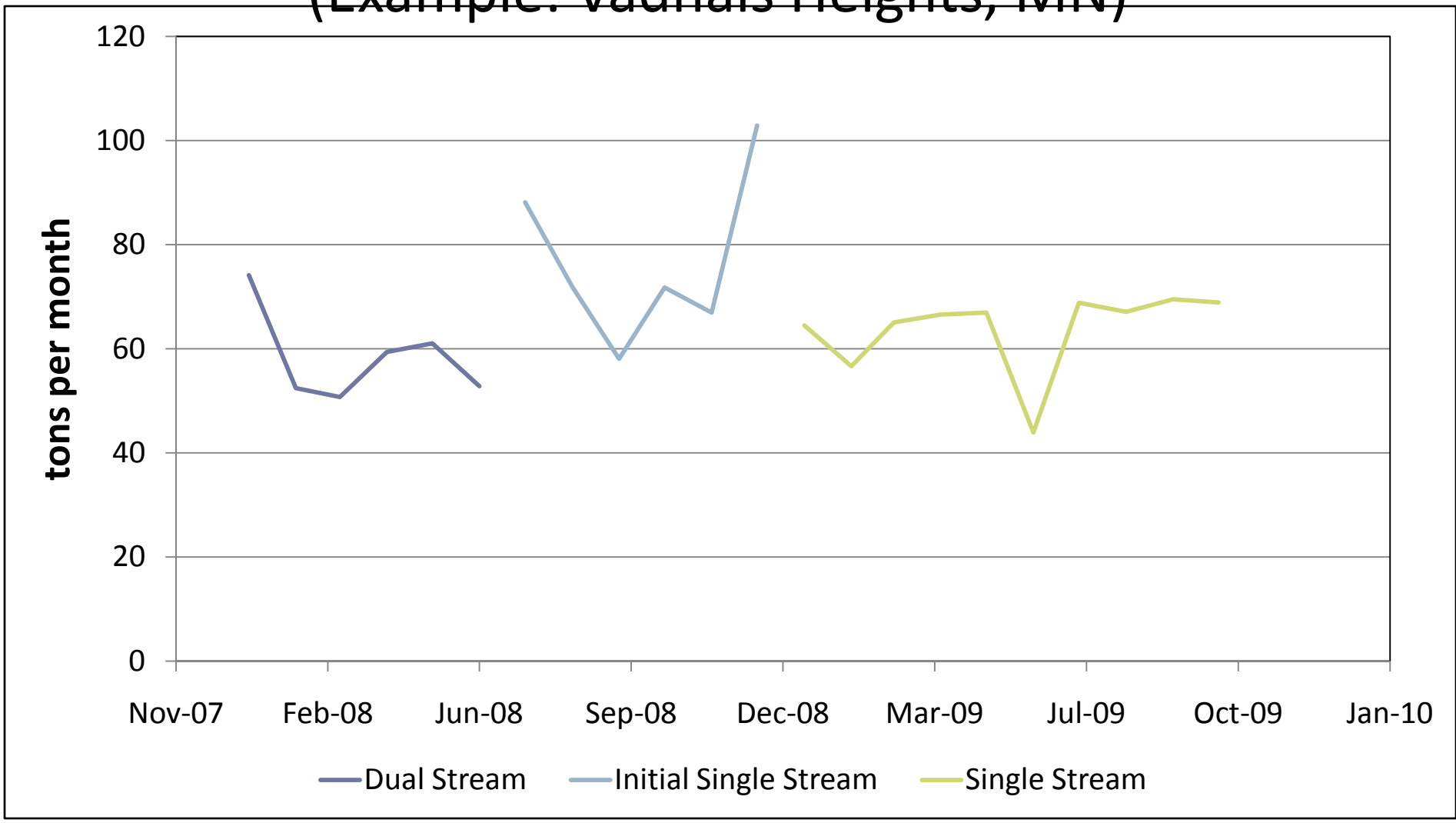
Change in collection rate (example: Collier County, FL)

(transition to SS in October 2005)

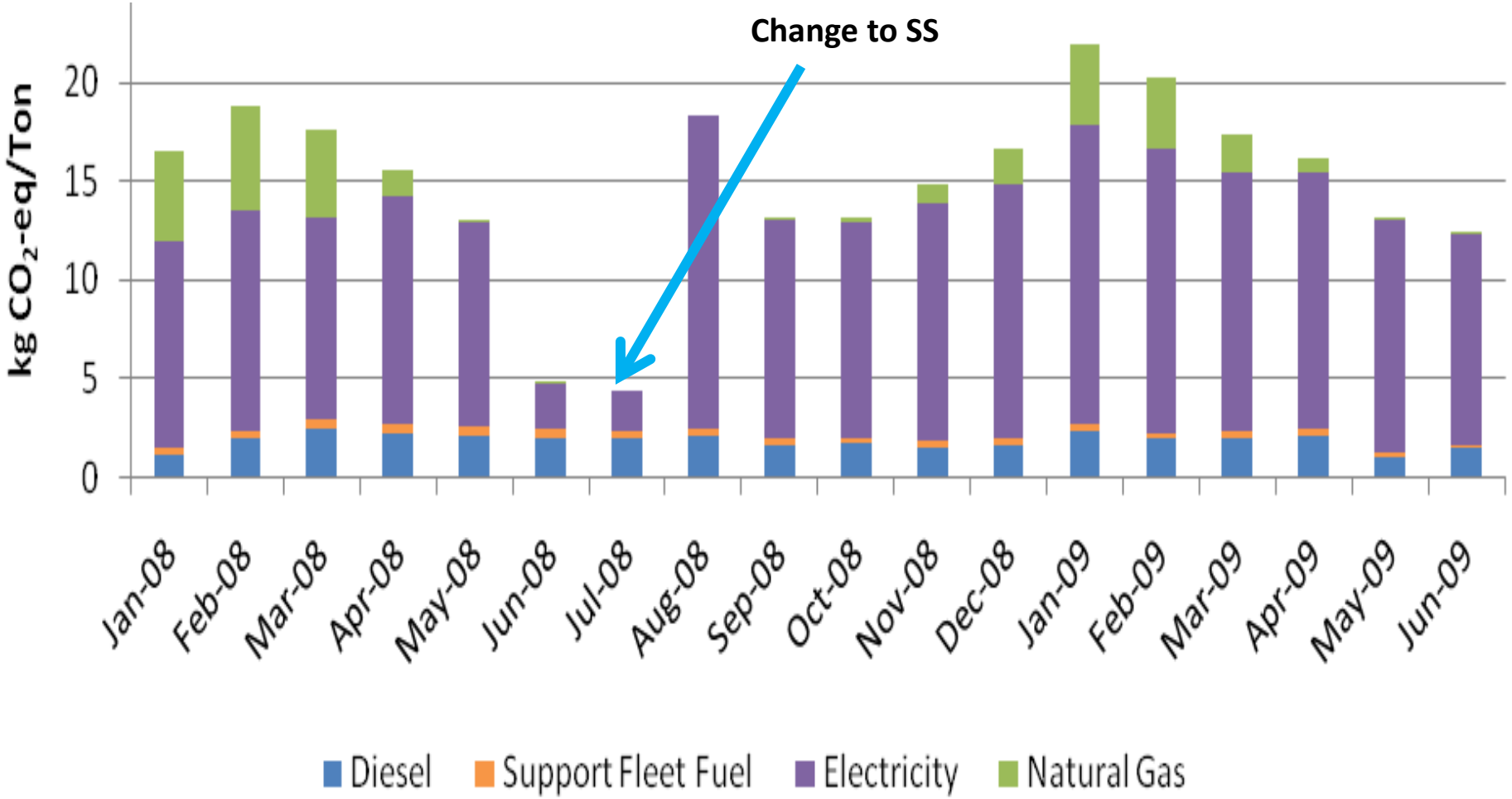


Fluctuation in monthly rate of collection

(Example: Vadnais Heights, MN)



Effect of DS to SS change on MRF GHG emissions (Avon MRF)



GHG Emissions Data for the Avon MRF normalized over inbound tonnage

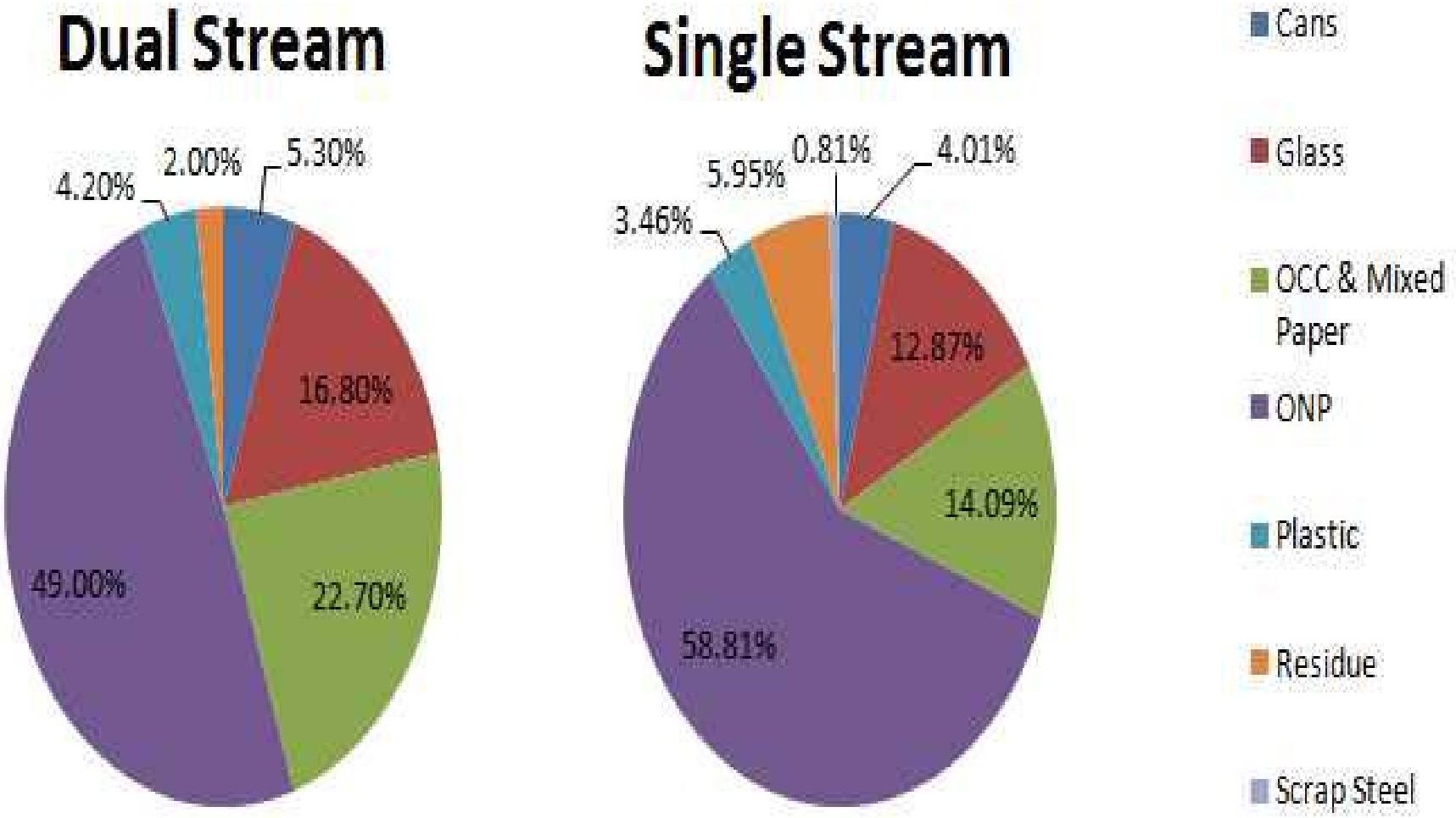
Increase in MRF capacity with change from DS to SS

Avon (MA), Prince Georges County (MD) and St. Charles (Newark)

	Avon		PG County		St. Charles	
	Q1 08	Q1 09	Q4 06	Q4 08	Q1 07	Q1 09
	DS	SS	DS	SS	DS	SS
RESIDUE	6.3%	9.8%	3.6%	9.1%	7.8%	9.0%
Total Tons	21,102	26,009	15,866	29,230	23,476	35,170
% Increase in tonnage	23.3%		84.2%		49.8%	

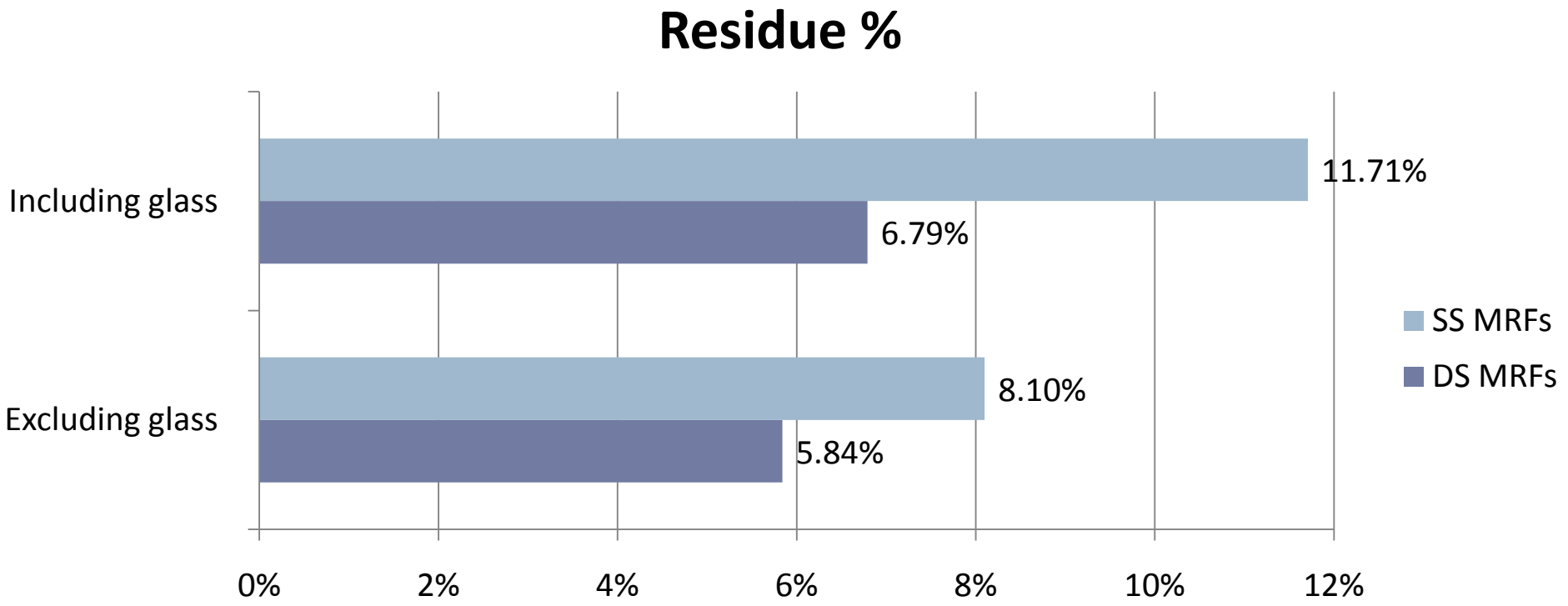
Change in MRF product streams

Estimated composition of recyclables in DS and SS collection in Vadnais Heights, MN



MRF Residue

- On the average, the DS plant residue is 5% of input
- On the average, the SS residue is 10% of input



Results

- More efficient use of truck volume; fewer truck trips and lower use of fuel per ton of material collected and decrease in truck hours. E.g., net annual costs of collection in Madison decreased 40% from $ 3.3 million to $ 2 million.
- DS to SS changes must be accompanied by structural changes to the recycling collection system, e.g.,
    - Change in receptacle size
    - Automated pickup

Results

- Increase in recycling rate can vary from only 10% (Vadnais Heights, MN) to 100% (Springfield, MA)
- Average increase in recycling is expected to be 50%
- Increase in MRF products is expected to be 40% (ave)
- Slightly smaller carbon footprint of energy use at SS MRF (-0.006 MTCE per ton processed than in the DS)

Results: GHG Benefits of SS over DS

GHG benefits (-) and impacts (+) of change

Contributing stage	Metric tons of CO_2e per ton of replaced DS collection
Collection of recyclables	-0.006
Processing of recyclables in MRF	-0.001
Effect of increased rate of recycling	-0.894
Total GHG benefit	**-0.901**

Major contributor to GHG benefits is increase in recovery of recyclable materials

Environmental benefit of change to SS collection and processing

A community that has in place a DS program collecting, for example, 100,000 tons per year, by switching to SS collection can expect to reduce its carbon footprint by about 90,000 tons of carbon dioxide

GHG Benefit per Ton of MRF Product

Material	Tons of material per outbound ton from SS MRF	GHG benefits, MTCE per ton of material	GHG benefits, MTCE per outbound ton of SS MRF
Paper fiber	0.65	0.8	0.520
Aluminum	0.008	4	0.032
Plastics	0.08	0.4	0.032
Ferrous metal	0.032	0.5	0.016
Glass	0.13	0.1	0.013
Residue	0.10	0	0
Total GHG benefit per metric ton of MRF product		=	0.61

- Principal materials contributing to GHG reduction are Paper Fiber, followed by Aluminum and Plastics

GHG benefits of Using Recycled Mtrls

- Highest for Aluminum due to high energy inputs required for its production from Bauxite
- Overall Reduction in GHG is highest for Paper fiber as it emits methane if landfilled

Recyclable commodities	Tons Recycled	Reduction in energy use for materials produced from recycled rather than "virgin" stock (mill. Btu)	Reduction in GHG by using recycled stock (MTCE)
Paper fiber (OCC, ONP, mixed)	1	-13.95	-0.83
Iron and steel scrap	1	-19.97	-0.49
Glass	1	-2.13	-0.08
Mixed Plastics (HDPE, LDPE, and PET)	1	-52.50	-0.41
Aluminum	1	-206.42	-4.03

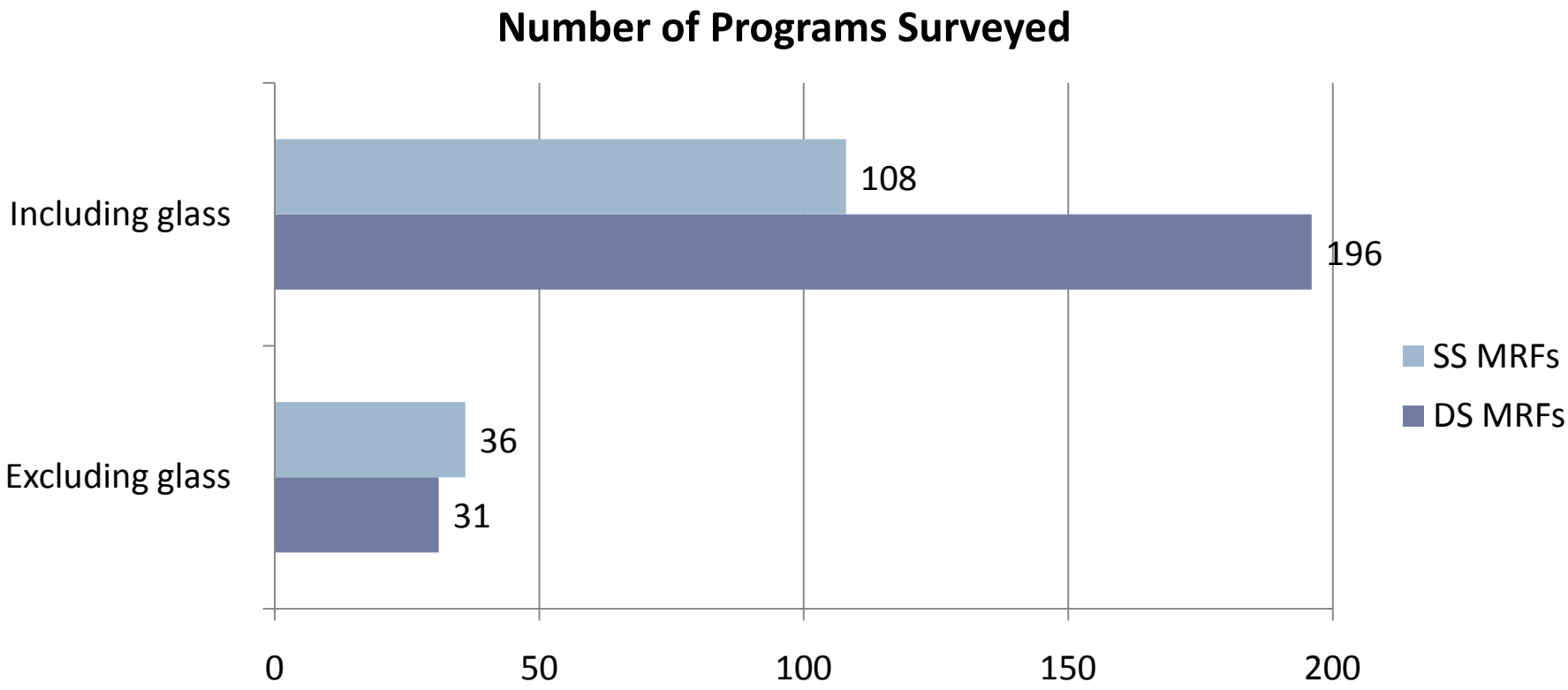
GHG Benefits: Recycling over Landfilling

- 64% of post recycling MSW in US ends up in landfills.
- Table shows Net GHG benefits assuming landfilling of Recyclables not collected by DS

	GHG Emissions Associated with Recycling ($MTCE^2$)	GHG Emissions if all Disposed ($MTCE^2$)	Net GHG Emissions if Recycled ($MTCE^2$)
Mixed Metals	-1.73	0.01	-1.74
Ferrous Scrap Metal	-0.49	0.01	-0.499
Glass	-0.076	0.010	-0.087
HDPE	-0.383	0.010	-0.394
LDPE	-0.467	0.010	-0.477
PET	-0.424	0.010	-0.434
Corrugated Cardboard	-0.748	0.077	-0.825
Magazines/Third-class Mail	-0.738	-0.120	-0.617
Newspaper	-0.950	-0.208	-0.742
Office Paper	-0.677	0.623	-1.300

Residue

- 36 out of 144 SS plants (25 %) exclude glass
- 31 out of 196 DS plants (13.6 %) exclude glass



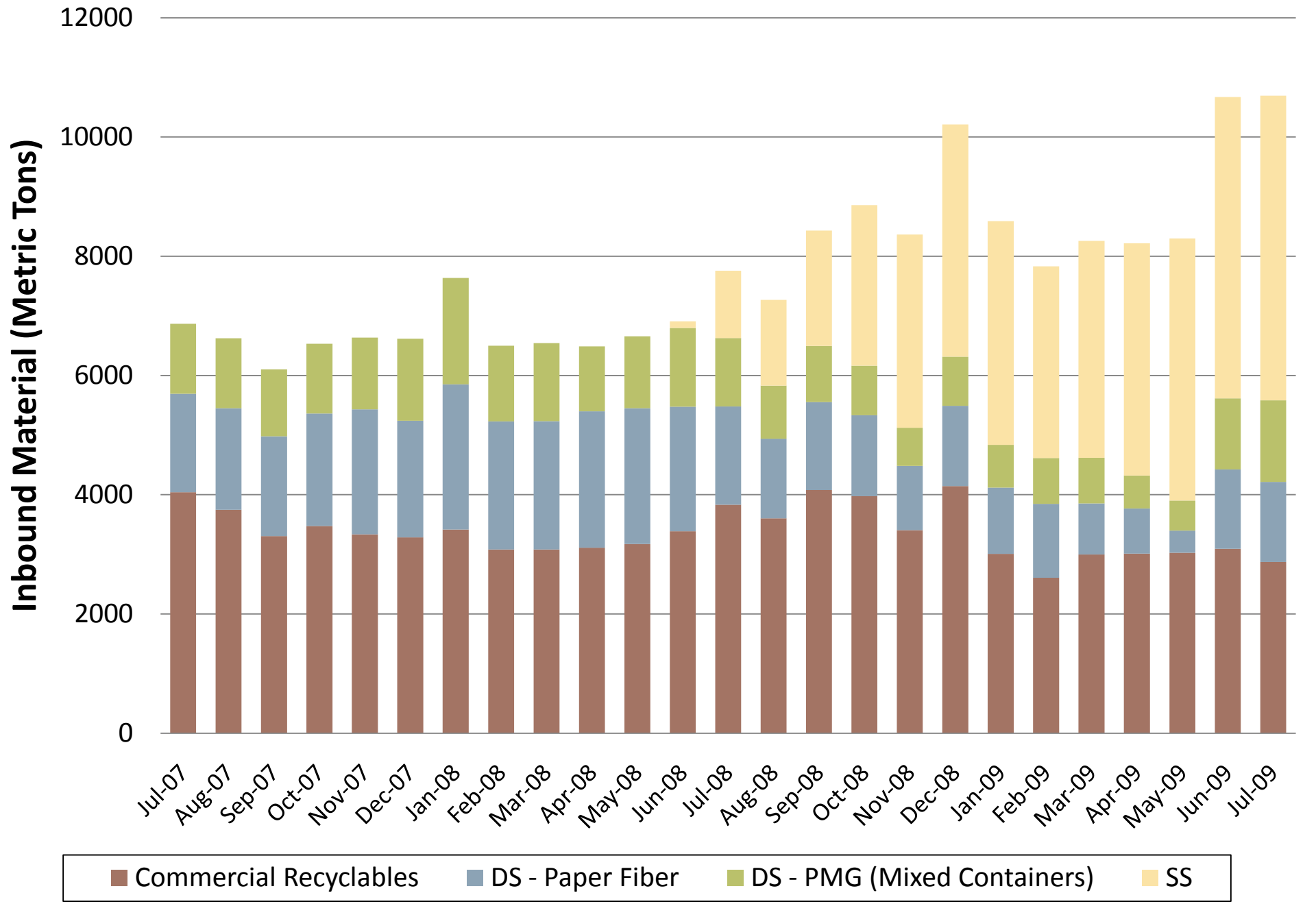
Community 1: Avon, MA

A DS plant was retrofitted in July 08, to facilitate both SS and DS operation

- GHG emissions for SS were 10.33 kg CO_2e per ton—a 9.4% decrease in carbon intensity

Energy type	Units	Absolute consumption			Consumption intensity, per ton processed		
		DS	SS	% change	DS	SS	% change
Electricity	kWh	69600	110000	58%	10.5	12.8	23%
Natural Gas	Therms	2621	1941	-26%	0.39	0.23	-41%
On-site Diesel	Gallons	1295	1501	16%	0.19	0.18	-10%
Fleet Fuel	Gallons	275	275	0%	0.04	0.03	-22%

Total Inbound Tonnage to Avon MRF



Detailed breakdown of outbound tonnage from MRFs

	Avon		PG County		St. Charles	
	Q1 08 DS	Q1 09 SS	Q4 06 DS	Q4 08 SS	Q1 07 DS	Q1 09 SS
GLASS: Beneficial Use	0%	5.6%	0%	11.4%	45.9%	12.5%
GLASS: Clear	0%	4.8%				
GLASS: Three Mix	11.1%	1.5%	46.0%	8.8%	3.6%	26.3%
METAL: Steel Cans	1.7%	1.7%	0.9%	1.1%	7.4%	4.7%
METAL: UBC (Aluminum)	0.1%	0.2%	0.3%	0.6%	2.2%	1.2%
MIXED: Baled Recyclables					3.9%	0%
PAPER: High Grade	6.3%	3.8%	0.5%	0%		
PAPER: Mixed	1.2%	7.4%	0.1%	2.9%	0.2%	1.1%
PAPER: OCC	39.0%	28.7%	18.4%	17.7%	7.5%	14.5%
PAPER: ONP	29.8%	32.9%	25.5%	44.9%	5.4%	22.2%
PLASTIC: 1 through 7	4.4%	0.1%	4.7%	3.5%	16.0%	4.9%
PLASTIC: HDPE	0%	1.5%			0%	0.9%
PLASTIC: Mixed Other					0%	2.7%
PLASTIC: PET	0%	2.0%			0.1%	0%
PLASTIC: Polyfilm	0.1%	0%				
RESIDUE	6.3%	9.8%	3.6%	9.1%	7.8%	9.0%
Total Tons	**21,102**	**26,009**	**15,866**	**29,230**	**23,476**	**35,170**
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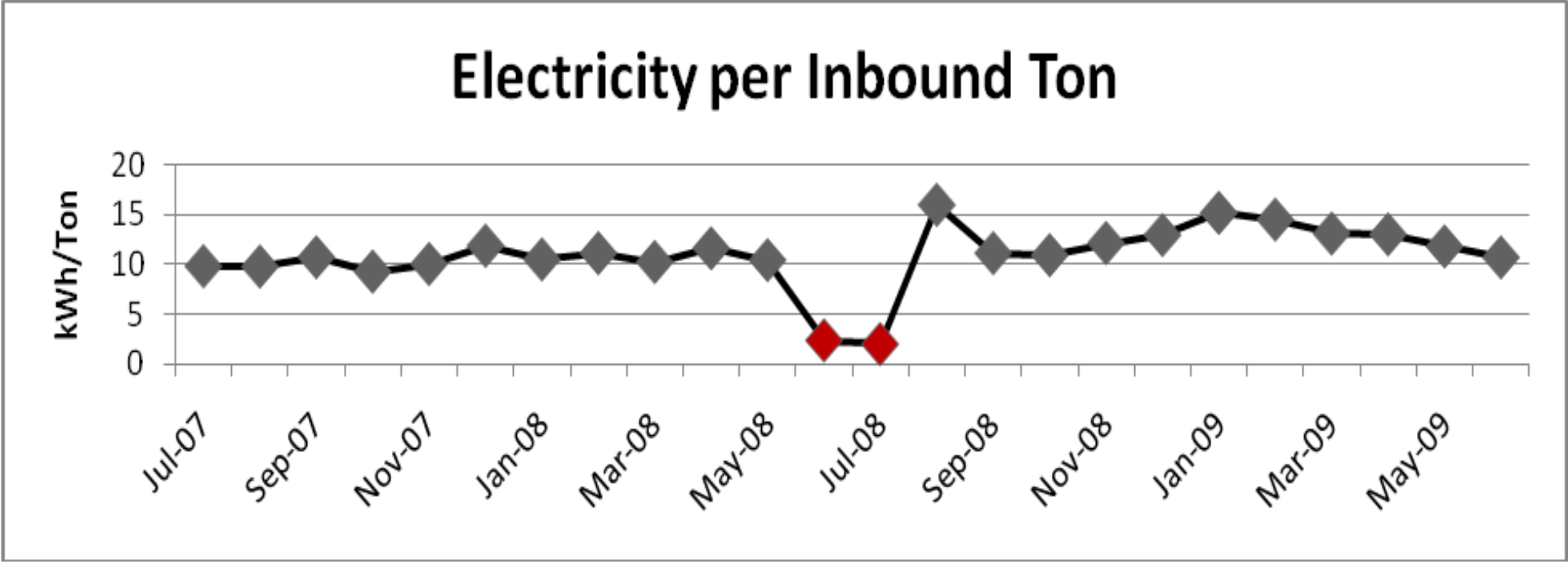
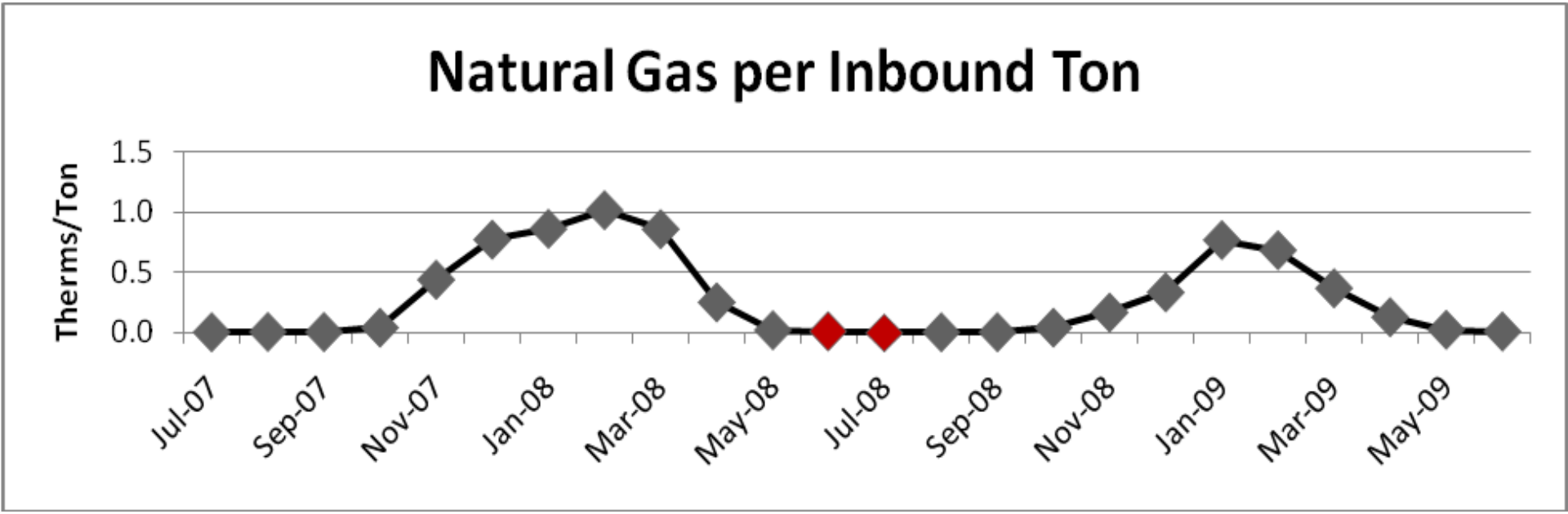
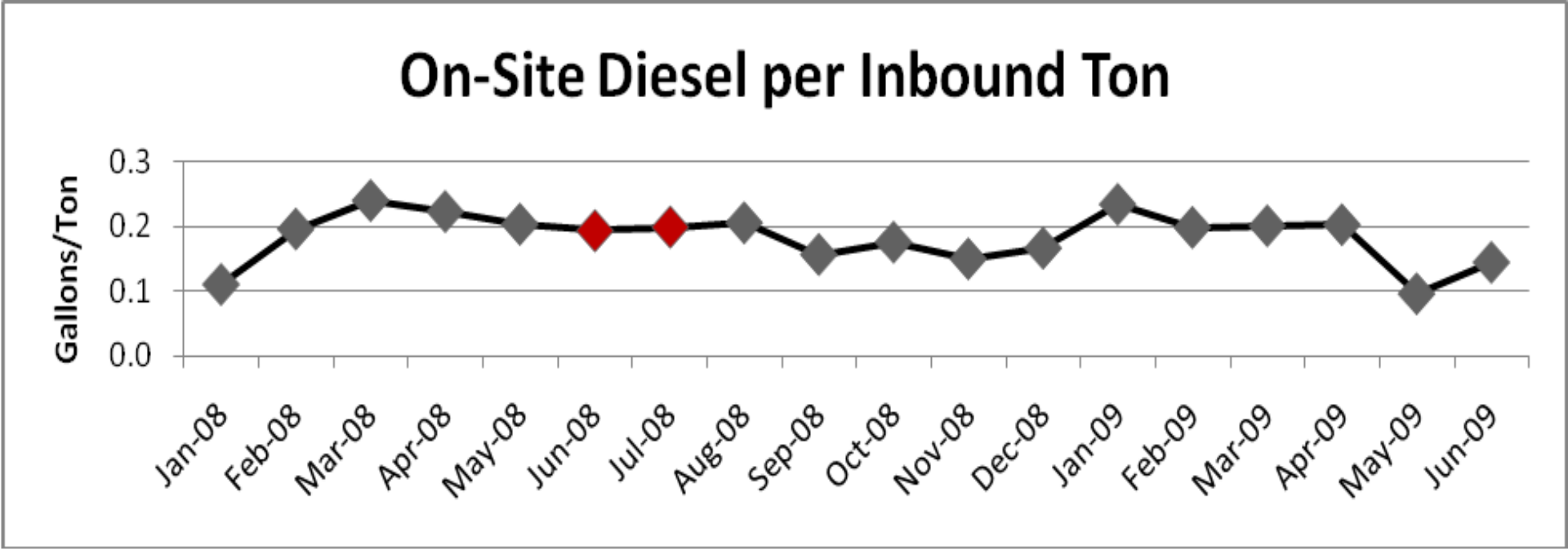
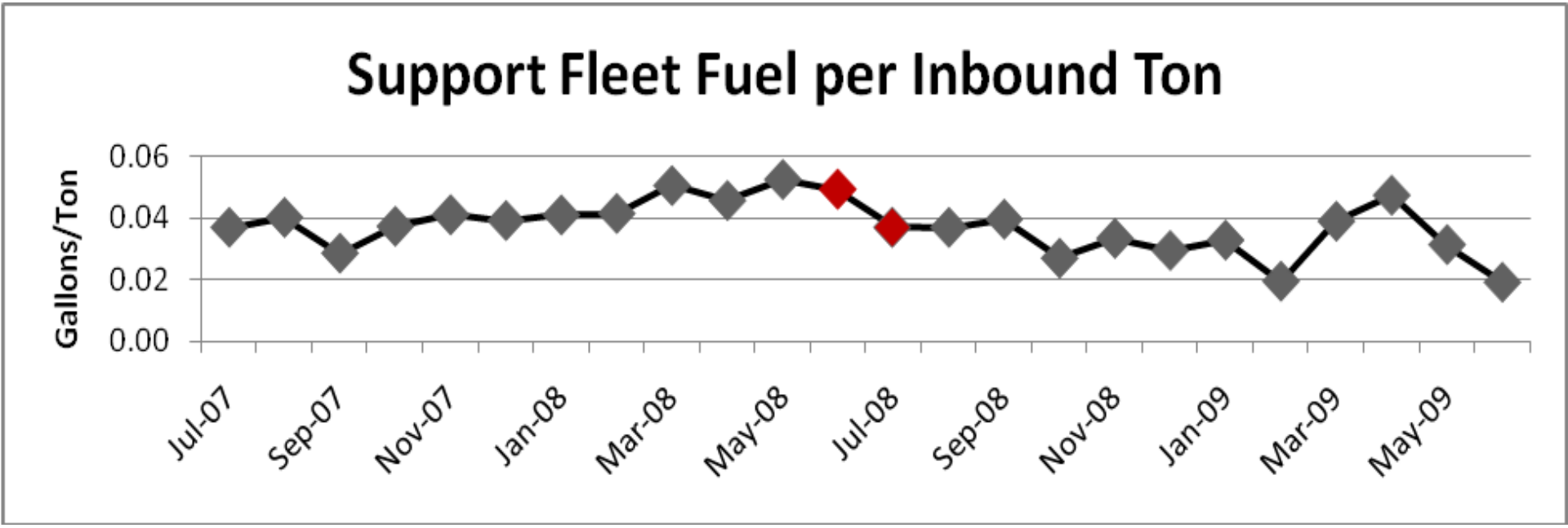




Energy and fuel consumption data for the Avon MRF normalized over inbound tonnage





Energy and fuel consumption data for the Avon MRF normalized over inbound tonnage

Community 2: Springfield, MA

- **Population:** 151,000
- Tested SS collection in a pilot program of 800 households
- Recyclables collected from that area doubled
- City purchased 95-gallon, wheeled containers for 14,000 additional households at the cost of $750,000
- Plans to provide such containers to all 37,000 homes in the city

Community 3: West New York, NJ

- **Population:** 46,000
- An exception to the general finding that the amount collected increases with SS ranging anywhere from 20-50%
- High density population and street parking did not allow for the use of automatic side loaders
- No significant change in collected tons when switched from DS to SS

Community 4: Chula Vista, CA

- **Population:** 221,000
- Switched from four-stream (newsprint, mixed paper, cardboard, and mixed containers) to SS in 2002
- 18-gallon containers of the old system were replaced by one blue 96-gallon cart
- Recycling rates more than doubled to 1,500 tons per month (162 lb per capita)
- Residue at the SS MRF also doubled to about 9%

Community 5: Hopkins, MN

- Switched from weekly curbside DS collection to bi-weekly curbside SS recycling
- Overall collection costs decreased by a net amount of $20,500

	DS (2002)	SS (2003)	change DS to SS
Curbside recycling, tons	867	1,007	+16%
Curbside trash, tons	3280	2624	-20%
Cost of collecting recyclables	$80,649	$87,188	+$6,539
Cost of collecting trash	$127,921	$100,890	-$27,031
Cost per ton of recyclables	$93.02	$86.58	-6.92%
Cost per ton of trash	$39.00	$38.45	-1.41%

Summary of Hopkins, MN recycling data

Community 6: Dakota County, MN

- Has five SS and two DS communities
- Not a before and after scenario
- Difference in material collected is 16.6 %

Collection Type	Communities	Number of homes	Tons collected	Lb. collected per home
DS	Apple Valley, Inver Grove Heights	86,688	488	22.5
SS	Burnsville, Eagan, Lakeville, Rosemount, West St. Paul	115,431	1514	26.2
% difference of material collected in SS over DS collection			16.6%	

Community 7: Mankato, MN

- **Population:** 33,000
- Gross operating cost of the SS program is $34.90 per ton lower than the DS program

Cost or revenue item	Difference of SS from DS
Loading & transportation of recyclables to MRF	+$1.14
MRF operating expense	-$34.90
Net cost	**-$33.76**

Community 8:
Blaine, MN and Burnsville, MN

- Blaine, the recyclables collected increased by 89%—from 7,000 to 13,260
- Burnsville they increased by only 6%—from 12,400 to 13,200
- Blaine, collection truck productivity increased substantially from 0.62 to 1.06 tons per driver hour (+71%)
- Burnsville, it increased from 0.7 to 0.98 tons/hour for (+40%)

Community 8:
Blaine, MN and Burnsville, MN

- Fuel consumption decreased by nearly 40%

	Blaine		Burnsville	
	DS	**SS**	**DS**	**SS**
Driver hours	11,533	12,730	17,690	13,359
Tons collected	7,103	13,553	12,390	13,190
Fuel, gallons/hour	3.5	3.5	3.5	3.5
Fuel use, gal/ ton	5.7	3.3	5.0	3.5
Equivalent GHG emissions, kg CO_2 e per ton	57	33	50	35
Fuel saving by switch to SS collection, gal/ton		2.40		1.45

Blaine and Burnsville, MN Data for change from DS to SS collection

Community 9: Vadnais Heights, MN

- Converted from DS recycling collection scheme to SS in July 2008
- DS collection occurred every week and utilized 18 gallon bins
- SS collection occurs every other week, using 64 gallon carts

	DS collection	SS collection	% Change DS to SS
Yearly route mileage	6105	2819	-54%
Yearly mileage to MRF	8923	4461	-50%
Total miles travelled	15028	7280	-52%

Mileage driven by collection fleet in Vadnais Heights, MN for DS and SS collection

Community 10: East Grand Forks, MN

- Transition from SS in a bin to SS in a cart sometime in early to mid 2009
- Isolates the effect of increased cart size on collection volume

Month	2008 (tons)	2009 (tons)	% increase
Aug	30.66	44.54	45.2%
Sep	33.82	54.03	59.8%
Oct	36.89	51.01	38.3%
Nov	32.07	46.87	46.1%
Dec	35.52	70.02	97.1%
AVERAGE	33.79	53.29	57.7%

Change in recyclable tonnages for East Grand Forks, MN due to a change in bin volume

Community 12: Miami-Dade

- Adopted SS at the end of June, 2008
- 92% greater collection per month (tpm) than one year earlier

Community 13: Township of Ocean, Monmouth County, NJ

- Major benefit is cost savings of about $140,000 per year
- Due to the elimination of one route, automated pickup, larger recycle and trash bins and a rewards program for waste diversion

Other Benefits of SS

- In Madison, WI, switch to automated collection led to a 36% reduction in on-the-job injuries Decrease in Employee injuries during processing
- Automated processing of the recyclables also decreased job-related injuries by 69%
- Worker's compensation cost decreased by 25% to $93,000 when recycling collection was automated
- And by 61% to only $36,000 when both refuse and recycling collection systems were automated