METHODOLOGY DOCUMENT

Trash Collection Automation ROI Calculator

A defensible 10-year total-cost-of-ownership model for manual rear-load vs. automated side-load residential collection.

VERSION	ISSUED	PREPARED BY
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CONTENTS

What's inside this document

Twelve sections covering the model's architecture, every formula, the conservative defaults, and known limitations.

01

SECTION 01
Overview & Purpose

The Trash Collection Automation ROI Calculator estimates the 10-year total cost of ownership for a residential curbside-collection operation, under two service models: traditional **manual rear-load** collection with a driver plus one or more helpers per truck, and fully **automated side-load** collection with a single operator per truck and uniform wheeled carts at each home.

The model produces a small set of headline figures — annual savings, break-even year, 10-year nominal cumulative savings, and 10-year Net Present Value (NPV) — together with a year-by-year cash-flow detail, a cost-per-home trajectory chart, and an auditable derivation for every formula in the model.

It is intended for: (1) Best Equipment Co. sales engineers building cost-justification packages for municipal prospects, (2) those prospects' finance and procurement reviewers who need to verify the math, and (3) any third party — a city council, an auditor, an outside consultant — who is asked to evaluate the proposal.

What this document is

A reviewable record of every formula, default value, and methodology decision baked into the calculator. If a customer's CFO asks "where does this number come from?" the answer lives here.

What this document is not

A guarantee of any specific result, a substitute for the customer's own actuals, or a substitute for engagement with their finance team. The model is only as accurate as the inputs it is given.

Conservative bias on defaults. Every default that affects savings direction has been set conservatively — lower labor escalation, higher discount rate, higher automated-maintenance premium, soft savings off by default, and reduced soft-savings values when toggled on. The intent is for the customer's own actuals to *improve* the projection rather than degrade it. If the calculator with default inputs produces a positive NPV, the customer's real-world outcome will almost certainly exceed that figure.

02

SECTION 02

Model Architecture

The model proceeds in five stages. Each stage is deterministic; given the same inputs, the same outputs always result. There is no stochastic component.

STAGE	INPUTS CONSUMED	OUTPUTS PRODUCED
1 · Waste volume	Households, pickups/wk, lbs per home, density	Weekly tons; per-truck payload capacity
2 · Fleet sizing	Stops/truck/day, trips/day, work days/wk	Working trucks (stops vs payload binding), plus backups
3 · Monthly cost build-up	Wages, employer-cost %, hours; truck cost & APR; container cost & APR; maint/truck	Year-1 monthly Labor, Equipment PMT, Container PMT, Mainte
4 · 10-year cash flow	Labor / maint / soft-savings escalation rates; finance term	Year-by-year manual annual, auto annual, hard Δ, soft Δ, cumula
5 · Financial summary	Discount rate	Nominal cumulative; NPV; nominal & PV break-even years; cost

The calculator runs the full pipeline on every input change. An audit-trail panel inside the tool reveals each derivation step in plain text for the current scenario.

03

SECTION 03
Fleet Sizing

A residential route must satisfy two physical constraints simultaneously: each truck must service all assigned stops within its work day, and the fleet collectively must haul the weekly tonnage to disposal. The model computes both constraints and takes the stricter as the recommended working-truck count, then adds user-configurable backup trucks.

STOPS CONSTRAINT

```
trucks_stops = ⌈ (households × pickups_per_week) ÷
   (stops_per_truck_per_day × work_days_per_week) ⌉
```

PAYLOAD CONSTRAINT

```
payload_per_load = body_capacity × compaction_ratio × density
weekly_tons = households × pickups_per_week × lbs_per_home ÷ 2000
trucks_payload = ⌈ weekly_tons ÷
   (payload_per_load × trips_to_dump_per_day × work_days_per_week) ⌉
```

FLEET TOTAL

```
working_trucks = max(trucks_stops, trucks_payload)
total_fleet = working_trucks + backup_trucks
```

Both constraints can be overridden manually — for example, when an existing fleet has more trucks than the constraints require for route flexibility, half-day shifts, or staffing absences. The override fields preserve the model's arithmetic while letting the analyst match an actual operational footprint.

Waste density (loose, uncompacted) defaults to 0.35 tons per cubic yard, consistent with typical residential municipal solid waste.

04 Labor Cost

SECTION 04

Labor is the largest cost line and the largest source of automation savings. The model computes a fully-loaded monthly labor cost for each fleet by combining hourly wages, an employer-cost multiplier, and monthly working hours.

MONTHLY HOURS PER EMPLOYEE

```
hours_per_month = work_hours_per_day × work_days_per_year ÷ 12
```

EMPLOYER COST MULTIPLIER

```
employer_cost_mult = 1 + employer_cost_percent ÷ 100
```

MANUAL FLEET (DRIVERS + HELPERS)

```
manual_drivers = working_trucks
manual_helpers = working_trucks × helpers_per_truck
manual_labor_monthly = (manual_drivers × driver_wage + manual_helpers ×
helper_wage)
   × employer_cost_mult × hours_per_month
```

AUTOMATED FLEET (DRIVERS ONLY)

```
auto_drivers = working_trucks
auto_labor_monthly = auto_drivers × driver_wage × employer_cost_mult ×
hours_per_month
```

The automated model assigns one operator per working truck and zero helpers. Backup trucks do not carry permanent crew assignments; staff rotate to the backup truck when their primary truck is out of service.

The **employer-cost multiplier** covers employer payroll taxes (FICA, FUTA, SUTA), workers' compensation premiums, health and dental insurance contributions, paid time off, and other employer-side benefit costs. 31% is a commonly-cited composite for municipal field labor; individual employers should substitute their actual loaded-rate factor.

05

SECTION 05

Equipment & Container Financing

Trucks and (in the automated case) wheeled carts are financed using the standard amortization formula. Each truck — working and backup alike — incurs a level monthly payment over the finance term. After the finance term ends, the equipment line drops to zero in the model.

STANDARD PMT (LOAN AMORTIZATION)

```
r = annual_rate_percent ÷ 100 ÷ 12
PMT = principal × r × (1 + r)^n ÷ ((1 + r)^n − 1)
where n is the number of monthly payments (finance_term_months)
```

TRUCK PAYMENT

```
truck_payment_per_truck = PMT(truck_cost, truck_apr, truck_term_months)
total_truck_payment_monthly = truck_payment_per_truck × total_fleet_size
```

CONTAINER PAYMENT (AUTOMATED ONLY)

```
container_principal = container_cost_per_unit × households
container_payment_monthly = PMT(container_principal,
   truck_apr, container_term_months)
```

Containers are amortized separately from trucks because their useful life and finance terms commonly differ — heavy-duty wheeled carts frequently outlast a truck refresh cycle, and many municipalities finance them on different terms.

> The model assumes one cart per household. Routes with optional recycling or organics streams may require additional carts; if so, increase the container cost per unit accordingly, or run a separate scenario for each stream.

No down payment, no sales tax, and no trade-in residual is modeled. These can be added to the principal or treated as a separate Year-0 cash flow outside the calculator if material.

06

SECTION 06
Maintenance & Fuel

Maintenance and fuel are modeled as a single composite monthly figure per truck. The figure applies to every truck in the fleet — working and backup — under the conservative assumption that backup vehicles still consume fuel and parts during their reserve duty cycle, even at reduced utilization.

MANUAL

```
manual_maint_monthly = manual_maint_per_truck × total_manual_fleet
```

AUTOMATED (WITH PREMIUM)

```
auto_maint_per_truck = manual_maint_per_truck × (1 + auto_premium_pct ÷ 100)
auto_maint_monthly = auto_maint_per_truck × total_auto_fleet
```

The automated maintenance premium (default **35%**) reflects the higher unit cost of servicing automated arms, hydraulic controls, and the more complex electronics package on a side-loader. The conservative default sits above the industry midrange of 20–30% so that the projection errs toward overstating automated maintenance cost.

Fuel and maintenance are escalated together year-over-year (see Section 8). Major engine overhauls, mid-life refurbishments, and one-time replacement parts are absorbed into the escalating composite figure rather than modeled separately.

07

SECTION 07

Soft Savings

Beyond direct labor, equipment, and maintenance, automation produces a set of operational benefits that show up elsewhere in a municipal budget. The model quantifies four of them. **Soft savings are off by default** — the headline figure is hard cost savings only. Customers opt in to soft savings with their own actuals.

COMPONENT	FORMULA	CONSERVATIVE DEFAULT
Workers' comp premium reduction	crew_reduction × wc_per_job_annual	$4,000 / job / yr
Injury / lost-day claims avoided	baseline_claims_per_year × cost_per_claim × reduction_pct	1 × $30,000 × 50%
Reduced supervision overhead	flat annual figure	$4,000 / yr
Attendance / turnover improvement	crew_reduction × per_job_annual	$2,000 / job / yr

Defaults are deliberately conservative. Industry data commonly support larger reductions; the calculator allows the analyst to substitute the customer's actual experience modifier and claims history.

Workers' compensation rates for refuse collectors are classified by the National Council on Compensation Insurance (NCCI) under codes 9403 (rear-load collection) and 9410 (side-load collection). The rate differential between codes is one of the largest single drivers of soft savings and is typically verifiable directly from the employer's insurance carrier.

08

SECTION 08

Escalation & Net Present Value

A 10-year horizon spans long enough that two financial effects become material: input prices rise year-over-year (escalation), and future cash flows are worth less than present cash flows (discounting). The model handles both with standard corporate-finance formulas.

YEAR-OVER-YEAR ESCALATION (K = 0 IN YEAR 1, K = 1 IN YEAR 2, …)

```
labor_year_k = labor_year_1 × (1 + labor_escalation_pct)^k
maint_year_k = maint_year_1 × (1 + maint_escalation_pct)^k
soft_year_k = soft_year_1 × (1 + soft_escalation_pct)^k
equipment_year_k = equipment_payment if k < finance_term, else 0
container_year_k = container_payment if k < container_term, else 0
```

Equipment and container payments are fixed by their respective loan amortization; they do not escalate. They drop to zero in the first year after the finance term ends. This is the source of the large step-down in automated annual cost that typically appears in Year 6 of a 60-month finance plan.

ANNUAL NET CASH FLOW

```
CF_year_k = manual_annual_year_k − automated_annual_year_k + soft_year_k
```

NET PRESENT VALUE

```
discount_factor_k = 1 ÷ (1 + discount_rate)^k
NPV = Σ from k = 1 to 10 of (CF_year_k × discount_factor_k)
```

The discount rate represents the customer's opportunity cost of capital. For municipal entities, this is usually approximated by their general obligation bond rate. The conservative default of **5.0%** sits at the upper end of typical U.S. local-government bond yields, which makes future savings less valuable in present-value terms.

A nominal cumulative break-even and a discounted (PV) break-even are reported separately. The PV break-even is later than the nominal break-even when the discount rate exceeds zero, because future savings are worth less in present-value terms.

09

SECTION 09

Cost per Home — 10-Year Trajectory

Municipalities bill residential customers per home per month, so the cost most directly relevant to a council member is the monthly per-household figure rather than the total fleet cost. The calculator's trajectory chart plots this value year by year for each fleet, highlighting the crossover year — the first year automation costs less per home than the current manual operation.

FORMULA (PER YEAR K)

```
cost_per_home_per_month_k = annual_fleet_cost_k ÷ 12 ÷ households
```

The manual line typically rises smoothly under the labor and maintenance escalation rates. The automated line begins higher in Year 1 because of financed equipment and container payments, drops sharply in the first year after the finance terms end, then climbs gently from escalation. The crossover year — visually annotated on the chart — is the year a customer can credibly tell their residents their bill stops rising and starts falling.

For municipalities that present cost-per-home as the headline metric in budget hearings, this chart is the single most defensible visualization in the calculator. It uses no assumptions beyond what the customer has already approved (the annual fleet costs they've reviewed) and renders them in the units they already use.

10 SECTION 10 Default Values & Sources

Every default value baked into the calculator is a mid-range industry figure intended to produce a reasonable first-pass estimate before customer-specific actuals are substituted. Defaults marked **"conservative"** have been intentionally stepped down (or up) from the industry midpoint to bias the projection against automation.

INPUT	DEFAULT	REFERENCE / RATIONALE
Driver wage	$29.00/hr	BLS OES code 53-7081, U.S. median, adjusted for municipal scales.
Helper wage	$24.00/hr	BLS OES code 53-7081, 25th-percentile band.
Employer costs (% of wage)	31%	Composite of FICA + FUTA + SUTA + workers' comp + benefits + PTO.
Helpers / manual truck	2	Standard rear-load configuration for residential service.
Work days / year	260	5 days/wk × 52 wks. Holidays and weather cancellations not netted.
Work hours / day	8	Standard shift; overtime not separately modeled.
Disposal rate	105 lbs/wk/HH	Typical residential MSW; varies with demographics and recycling.
Waste density	0.35 t/yd³	Typical loose (uncompacted) residential MSW.
Manual truck cost	$250,000	Mid-range new-build rear-loader, late-model chassis.
Automated truck cost	$375,000	Mid-range new-build automated side-loader.
Interest rate (manual)	3.5%	Indicative municipal lease rate.
Interest rate (auto)	4.0%	Slightly higher than manual to reflect financing premiums.
Finance term	60 months	Standard municipal equipment lease.
Container cost / unit	$70	Standard wheeled cart including delivery and assembly.
Container term	60 months	Most municipalities finance carts on the same cycle as trucks.
Maintenance (manual)	$2,500/truck/mo	Composite for parts, labor, tires, fuel.
Auto maint premium	+35%	Conservative — industry midrange is 20–30%.
Labor escalation	2.5%/yr	Conservative — closer to long-run inflation than recent wage spikes.
Maint escalation	3.0%/yr	Conservative composite for diesel & heavy-truck parts inflation.
Soft escalation	2.0%/yr	Conservative for medical-cost & insurance-premium inflation.

Discount rate	5.0%/yr	Conservative — higher rate discounts future savings more heavily.
Soft savings	OFF	Off by default; hard cost savings carry the full headline.
Workers' comp / job	$4,000/yr	Conservative — lower tail of NCCI 9403/9410 differential.
Injuries / yr (manual)	1	Conservative — count only well-documented OSHA recordables.
Cost / injury claim	$30,000	Conservative — industry midrange is $35–50k.
Injury reduction (auto)	50%	Conservative — observed reductions commonly exceed 70%.
Supervision savings	$4,000/yr	Conservative — reduction in route-supervisor allocation.
Attendance / turnover	$2,000/job/yr	Conservative — backfill & recruiting cost reductions.
Cart distribution (Yr-1)	$15/HH	One-time cart delivery & route assignment. Industry midrange $10–25/HH.
Public outreach (Yr-1)	$25,000	One-time campaign: mailers, social, public meetings, FAQ pages.
Driver training (Yr-1)	$5,000/op	One-time per automated operator: equipment training, certifications.
Other one-time (Yr-1)	$10,000	Route restructuring, GIS work, signage, miscellaneous transition.

Best Equipment Co. encourages sales engineers and customers to override every default that the customer has direct knowledge of — actual wages, actual maintenance history, actual injury logs — before treating any output as a committed figure.

11 Limitations & What Is Not Modeled

SECTION 11

The model is intentionally a simplified, transparent representation. The following effects are real but are deliberately excluded for clarity. Where they are likely to matter, they should be modeled as separate one-time or recurring adjustments outside the calculator.

Truck replacement / refleeting cycles

The model assumes trucks remain in service for the full 10-year horizon after the initial 5-year finance term ends. Real fleets replace trucks roughly every 7–10 years, which would re-introduce equipment payments after Year 7 or so.

Trade-in residual values

Trade-in proceeds at end of useful life are not modeled. A 10-year-old rear-loader typically retains 5–10% of original value; an automated side-loader often more.

Recycling, yard waste, bulky-item streams

The model represents a single waste stream. Multi-stream operations should be modeled as separate scenarios and summed.

Driver overtime and split shifts

Labor is modeled at straight-time hourly rates. Operations with significant overtime should inflate the driver wage figure or model overtime separately.

Fuel-price volatility

Diesel inflation is approximated by the maintenance escalation rate. Customers with strong views on fuel prices should test alternative escalation values.

Carbon, environmental, community benefits

Automated collection produces fewer route miles and lower employee injury rates, but no monetary value is assigned to these.

Cart replacement / loss rate

Carts wear out and are lost or stolen. The model assumes the initial cart fleet lasts the full container finance term.

12 SECTION 12 Glossary

Plain-language definitions for every term used in the calculator and this document.

Automated side-loader	A collection truck with a robotic arm mounted on the side of the body that lifts and dumps standardized wheeled carts, allowing single-operator service.
Backup truck	A reserve vehicle in addition to the working fleet, sized to absorb downtime from maintenance, breakdowns, or peak demand.
Body capacity	The volumetric capacity of a collection truck's hopper, measured in cubic yards. The compaction ratio determines how much raw waste fits into that volume.
Break-even year	The first year in which cumulative savings cross from negative to positive — i.e., the year by which the initial premium for automation has been fully recovered.
Compaction ratio	The ratio of raw waste volume to compacted volume inside the truck body. A 4:1 ratio means 4 cubic yards of raw waste compresses into 1 cubic yard of truck capacity.
Employer costs	Employer-paid costs above the base wage: payroll taxes (FICA, FUTA, SUTA), workers' compensation premiums, health/dental insurance, retirement contributions, paid time off, etc. Expressed as a percentage of base wage.
Hard savings	Direct, easily-verified cost reductions: lower labor headcount, lower fuel and maintenance bills, etc.
Crew reduction	The difference between the manual fleet's field crew size and the automated fleet's. A positive number reflects field staff no longer needed for the route; in practice these workers are frequently redeployed to other municipal functions rather than separated.
Manual rear-loader	A traditional collection truck loaded from the back by a crew of one driver plus one or more helpers.
NPV (Net Present Value)	The sum of future annual cash flows discounted back to today using the discount rate. A positive NPV means the investment yields more than the discount rate.

PMT	Standard loan-amortization formula for a fixed monthly payment given principal, interest rate, and term.
Soft savings	Indirect benefits that are real but harder to quantify exactly: workers' comp premium reductions, supervision overhead, attendance, turnover.
Stops per day	The number of household collection stops a single truck can complete in a working day, accounting for travel time, dump trips, and unload time.
Working trucks	The number of trucks actively running routes on a typical day. Distinguished from backup trucks (in reserve) and total fleet (working + backup).

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For questions or to request the source workbook, contact your Best Equipment Co. sales engineer.