Appendix

- Overview of key challenges inherent in system
- Ease of implementation scale and scoring
- Methodology and calculations used for solution set

In thinking through the portfolio of actions, we've tried to take into account the challenges inherent in the waste system (page 1 of 2)

Reduction

- Lowering quantity of plastic per unit reduces its value for any kind of treatment
- Redesigning product with different materials results in minimal gain within the parameters of cost and quality of the current system

Collection

- Waste collection and transportation is structured around **adverse incentives** that promote illegal dumping by haulers
- Waste **disposal at informal dump sites is financially attractive** for collection systems because of low capital-expenditure requirements (and consequent tipping fees) versus alternatives

Recycling

- Waste pickers are typically well-defined ethnic or social groups with limited expansion potential, and tend toward a **subsistence mind-set**: they would prefer more time off to more financial gain
- Products that are less attractive for recycling tend to have low levels of plastic content and low product homogeneity (for identification purposes) that yield lower returns for waste pickers, particularly in comparison to metals, cardboard, and paper
- Plastic **recycling is attractive only at aggregation points** in the collection system (eg, crowded urban areas, waste trucks, material-recovery facilities, and dump sites), and waste pickers ignore most uncollected plastic waste

SOURCE: 100+ expert consultations, team analysis

In thinking through the portfolio of actions, we've tried to take into account the challenges inherent in the waste system (page 2 of 2)

Conversion

- Economically viable **waste to energy depends on high electricity prices**/feed-in tariffs and subsidized delivery of free feedstock
- Recycling at **scale requires investment in material-recovery facilities (MRFs)** to sort all waste, most of which is organic with limited economic value
- Aggregation levels for **plastic treatment require a high population density**, with larger catchment areas requiring greater transport subsidies

Mitigation

- Waterway collection infrastructure needs to be cleaned frequently and sited near locations where it can be both effective and well maintained
- Cleanup drives affect only a small portion of marine debris—ie, the material that washes back up

SOURCE: 100+ expert consultations, team analysis

Criteria for scoring ease of implementation of different initiatives

Score	Implementation ease
1	Many decentralized implementation points needed; may require substantial shifts in consumer mind-sets and behaviors
2	Extensive institutional collaboration required for effectiveness; restrictions imposed, which need to be enforced; some substantial shifts in mind-sets and behaviors may be required
3	Multiple institutions involved; shifts in mind-sets and behaviors may be required but are adequately incentivized; constant monitoring and shifts required to prevent adverse incentives or outcomes
4	Multiple institutions involved; self-imposed restrictions are sufficient; shifts in mind-sets and behaviors may be required but are adequately incentivized
5	Relatively few implementation points required, but legislative action and executive enforcement necessary; decisions must be made at a local level; some shifts in mind-sets or behaviors required but adequately incentivized; initiative will require monitoring and upkeep to be effective
6	Relatively few implementation points required; decisions may be made at a centralized level; no major shifts in mind-sets or behaviors required; initiative may require monitoring and upkeep to be effective
7	Very few implementation points required; decisions may be made at a centralized level; does not require any shifts in mind-sets or behaviors; once installed, initiative upkeep can largely be automated

Rationale for ease-of-implementation scoring (1/2)

Initiative	Score	Rationale
"Pay as you throw" (PAYT) waste-disposal fees	1	PAYT requires large segments of consumers to pay extra for additional waste; in environments with poor waste regulation, implementation of this policy needs to be enforced at each individual collection point; poor enforcement will lead to larger amounts of uncollected waste as consumers circumvent waste systems to avoid paying fees
Product industry fees	3	Charge on plastic products implemented at point of sale requires cooperation of multiple retail outlets; however, there is potential to incentivize retailers with share in revenues; criteria for application will require constant refinement (eg, share of plastic required in a product in order to trigger the fee)
Product bans	2	Legislative action to curtail the use of plastic bags must be enforced at all points of sale in a highly fragmented market, large shares of which operate outside of official structures and formal economy
Sufficient street refuse bins	5	Street refuse bins primarily are an infrastructure rollout by local governments; however, they will require an education campaign or public-awareness drive to promote usage
Drop-off waste centers	3	Drop-off waste centers provide a small amount of remuneration to incentivize voluntary consumer waste drop-off, supplementing collection systems
Low-value-plastic subsidy	3	Additional extraction of selected low-value plastic products from the waste stream by waste pickers can be achieved with the help of a subsidy or incentives, but this may come at the cost of lower extraction rates for other plastic products in an environment where waste-picker capacity is circumscribed by membership of an ethnic or social group
Increased collection service	5	Expansion of collection services usually builds on existing service provision by the state, necessitating increases in operating or capital expenditures but mostly working within the context of existing legislature and mandates
Waste-exchange program	4	Exchange of waste leverages existing retail networks and incentivizes customer behavior with the help of different currency forms (eg, food stamps, supermarket vouchers)
Product redesign	3	Implementation requires coordinated action by large segments of consumer-packaged-goods industry in markets where much of this activity is fragmented; where this reduces quantities of plastic in product, initiative can go with the grain of industry trends; however, can also reduce quantity of plastic per product, making it less valuable to recycling economies
Packaging deposits	4	Deposits on packaging leverage existing product networks and incentivize customer behavior with help of financial remuneration for materials returned
Household presorting and separation	2	Successful separation at household level requires fundamental shift in entire waste-management system, with separation of waste by consumers and maintenance of separated state throughout the waste system by haulers and MRFs
Advance disposal fees	3	Deposit schemes such as advance disposal fees require uptake by a large cross-section of retail activity to be effective; which poses some challenges in markets with a high degree of retail fragmentation

Rationale for ease-of-implementation scoring (2/2)

Initiative	Score	Rationale
Littering fines	2	Fines require high level of coverage by law-enforcement authorities for enforcement itself to be effective; successful recoup of fines will suffer from any governance weaknesses inherent in law-enforcement systems of target location
Waterway infrastructure	7	Surface booms and trash traps are uncontroversial to install and, provided human resources are made available to clean and maintain them, can function with little or no hindrance
Hazardous-dump-site covering	5	Covering dump sites can be a straightforward public-civil-works initiative undertaken at either the central or the local level; however, success hinges on effective optimization of the overall waste-management system such that new dump sites do not surface in different locations adjacent to waterways
Hauler-system optimization	5	Successful optimization of the hauler system requires transparency initiatives at the local-government level, along with effective monitoring through GPS tracking systems and payment linked to desired performance
Hazardous-dump-site ban	4	Legislative action to close dump sites can be moderately effective (eg, 200 of 800 dump-site closures in Philippines following passage of RA 9003) but requires enforcement combined with creation of viable system alternatives for higher effectiveness
Product ban at dump site	2	Bans on specific plastic components can theoretically be enforced at dump sites with the allocation of sufficient human resources and monitoring procedures; in practice, however, this will hinge on a challenging process of manual identification of specific products in mixed waste streams
Mandatory recycled content	5	In an environment where waste-picker capacity is circumscribed by membership of an ethnic or social group, shift in demand for recycled resin will require enabling supply-side action, such as increased MRF facilities, which can be rolled out as relatively low-cost local-government infrastructure but require collaboration between formal and informal waste-collection systems
Refuse-derived fuel (RDF)	5	Production of RDF requires pretreatment in the form of waste segregation, which can be done through increased MRFs; these can be rolled out as relatively low-cost local-government infrastructure but require collaboration between the formal and informal waste-collection systems
Gasification	6	Gasification can be done at scale as a major infrastructure project led at either the central- or local-government level; with the exception of a steady stream of feedstock (the ease of implementation of which is represented in different initiatives), this requires a stable electricity rate or feed-in tariff; there may also be potential to leverage the private sector
Incineration	6	Incineration can be done at scale as a major infrastructure project led at either the central- or local-government level; with the exception of a steady stream of feedstock (the ease of implementation of which is represented in different initiatives), this requires a stable electricity rate or feed-in tariff; there may also be potential to leverage the private sector
Sanitary landfill	7	Basic sanitary landfills do not require sophisticated technology and are within the capabilities and experience of governments in our focus countries; they can effectively be rolled out centrally without requiring alignment of multiple stakeholders

We sized 21 initiatives

Initiatives

Reduction/elimination

- Product/material bans (bag bans)
- Resin/product industry fees
- "Pay as you throw" waste-disposal fees

Collection

- Increased collection services
- Sufficient street-level refuse bins
- Waste drop-off centers

Recycling

- Low-value-plastic subsidy
- Waste-exchange program
- Advance recycling/disposal fees
- Household separation bins
- Container deposits

Conversion/treatment

- Recycling-system upgrade (manual MRFs, RDF production, and mandatory recycled content)
- Gasification
- Incineration
- Sanitary landfills

Mitigation

- Hauler-system optimization
- Dump-site bans on hazardous dump sites
- Closing/covering high-risk dump sites
- Waterway infrastructure
- Dump-site bans on specific plastic types
- Littering fines

We faced a number of broad challenges in evaluating solutions for plastic leakage and made pragmatic assumptions where necessary

Challenges faced	Assumptions made
▪ Little to no local data available for any of our potential solutions	▪ Case studies from around the world used, with expected impact scaled down in line with level of economic development
▪ Cost, price information generally available only in US dollars or euros	▪ Cost, price information scaled in line with purchasing power parity (PPP)
▪ No available reference points for expected effectiveness at leakage reduction of some solutions (eg, hauler-system optimization and dump-site closure)	▪ Conservative assumptions made where expert input was unavailable

Solution methodology was used to calculate indicative rather than precise estimates for leakage reduction and net benefit

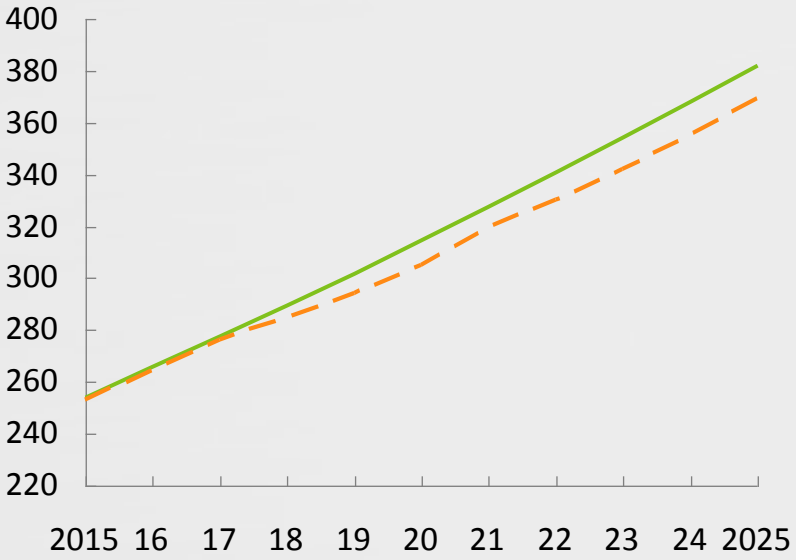
Contents

We used two approaches to evaluate the potential of product-redesign efforts and concluded they were not viable levers (1/15)

Without redesign
With redesign

Lightweighting products with less plastic only marginally slows plastic consumption growth . . .

Plastic consumption, millions of metric tons



Assumes lightweighting by 10% across 15% of products with 3-year implementation period

. . . and redesigning products to include more value increases their price too much to be practical

CHINA AGRICULTURAL-FILMS EXAMPLE

Overview

In 2015, Chinese farmers consume 1.6 million tons of mostly LDPE-based mulching films,[1] preventing washout of soil nutrients and reducing need for pesticides. Their high contamination rates[2] make their recovery uneconomic, leading to illegal burning or burying of >50% of films[3]

Potential approaches

- **Option A:** If usage of thicker films became mandatory[4] to incentivize recovery, total costs would increase by about 150% from $3 billion to $4.6 billion
- **Option B:** Replacing films with biodegradable films would increase cost by about 220% from $3 billion to $6.6 billion

1 Based on extrapolation from 1.25 million metric tons in 2011 with compound annual growth rate of 7.1%.
2 Impurities such as soil and crop residues amount to about 80% of total weight.
3 In Spain, only 50% of mulching films are recovered, and half of them are landfilled.

SOURCE: Liu et al., "'White revolution' to 'white pollution'": Agricultural plastic film mulch in China," *Environmental Research Letters,* 2014; S. Guerrini, "Agriculture's Second Green Life," *Renewable Matter*, 2014; S. Chmela, "Mulching foils: Photochemical, hydrolytical and biodegradation," 2013, polymer.sav.sk

Initiative methodology (2/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Bag bans[1]

Leakage reduction, thousand metric tons/year
103

=

Expected reduction,[2]
%
90%

×

Banned channels,[2]
%
14%

×

Enforcement rate,[3]
%
49%

×

Total plastic waste, thousand metric tons/year
63

×

Share of bags in plastic waste,[4]
%
21%

×

Overall leakage rate,
%
12%

Product industry fees

Leakage reduction, thousand metric tons/year
45

=

Average price elasticity of demand of plastic products[5]
–1

×

Plastics tax,[6]
% of value
1%

×

Share of tax passed on to consumers,[7]
%
81%

×

1 – **Expected tax gap,**[8]
%
21%

×

Total plastic waste, thousand metric tons/year
63

×

Overall leakage rate,
%
12%

× –1

Operating profit (loss), $ thousand
(82,000)

=

Average value of plastic resin,[9] $/metric ton
1,000

÷

Share of raw-material value in total value chain,[10]
%
30%

×

Plastics tax,[6]
%
1%

×

Total plastic waste, thousand metric tons/year
63

+

Total plastic waste, thousand metric tons/year
63

×

Average price elasticity of demand, of plastic products[5]
–1

×

Plastics tax,[6]
%
1%

÷

Price level compared with initial value including VAT,[11]
%
112%

×

% of plastics in tax,
%
100%

×

Share of tax passed on to consumers,[7]
%
81%

×

1 – **Expected tax gap,**[8]
%
21%

1 Cost-neutral initiative—operating costs are assumed to fit into countries' existing enforcement infrastructure; 2 Based on Hong Kong and Ireland case studies. Includes supermarkets, convenience stores, and pharmacies as banned channels; 3 Assumes enforcement rates of 90% in urban, 60% in periurban, and 10% in rural areas; 4 Share based on Philippines data; 5 A measure of the responsiveness of demand to changes in price. At a figure of –1, this implies a 1% increase in price, leads to a 1% decrease in quantity demanded. Assumed to be –1 based on the soft -drinks market (ie, –0.8 to –1); 6 Tax assumed to be 1% of the end value of plastic in products; 7 Assumes that small-to-medium enterprises pass on full tax to consumers, while large caps pass on half the tax to consumers. Share of small-to-medium enterprises estimated based on share of employment; 8 Estimated by applying PPP to the UK VAT tax gap (ie, the estimated share of VAT tax bills avoided); 9 Weighted according to share of plastic in waste stream; 10 Assumes that value-added portion of the price of a plastic good is 70%; 11 Based on weighted-average VAT across the 5 target countries (~12%).

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations

Initiative methodology (3/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Pay as you throw (PAYT)

Leakage reduction, thousand metric tons/year
8

= **Reduction in plastic waste (based on US case studies),** %
2%

× **Ratio of difference between US and country group recycle rates,**[1] %
20%

× **Participation rate in PAYT,**[2] %
43%

× **Total urban plastic waste,**[2] metric tons/year
21,000,000

× **Collection urban waste leakage rate,** %
23%

Operating profit (loss), $ thousand
(82.1)

= **Total urban waste,** metric tons/year
166,000,000

× **Volume of waste per ton,** US gallons/metric ton
1,300

× **Participation rate in PAYT,**[2] %
43%

× **Price per gallon of waste adjusted for PPP,**[3] $/US gallon
0.0271

× [1 – [**Cost (bagging) per gallon,** $/US gallon
0.002

÷ **Price per gallon (PPP),** $/US gallon
0.0271]] − [**Total urban waste,** metric tons/year
166,000,000

× **Cost of collection/disposal,** $/metric ton per year
32

× **Participation rate in PAYT,**[2] %
43%]

1 US recycle rates at 35%, with group of 5 countries estimated at 7%; the ratio is used to apply the impact from the US case to the group of 5 countries.
2 PAYT assumed to be rolled out in highly urbanized areas, with participation in these areas equal to the urban waste collection rate (90%) .
3 Based on US case studies; cost scaled down according to PPP.

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations

Contents

- Reduction/elimination
- **Collection**
- Recycling
- Conversion/treatment
- Mitigation

Initiative methodology (4/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Increased collection service

Leakage reduction,[1] thousand metric tons/year 1.9	=	**Total waste,** thousand metric tons/year 548	×	**Additional collection through initiative,**[2] % 35%	×	**Share of plastic in uncollected waste,** % 11%	×	**Difference in leakage rate between uncollected and collected plastic,** % 8%
Operating profit (loss), $ million (3.3)	=	**Total waste,** thousand metric tons/year 548	×	**Additional collection through initiative,**[2] % 35%	×	**Cost of waste collection,** $/metric ton 17		

Sufficient street refuse bins

Leakage reduction,[1] thousand metric tons/year 106	=	**Total rural waste,** thousand metric tons/year 253	×	**Increase in rural waste collection rates,**[3] % of total 4.4%	×	**Share of plastic in waste,** % 11%	×	**Difference in leakage rate between uncollected and collected plastic,** % 8%

1 May not match exactly with calculations in the methodology boxes due to rounded numbers in the methodology boxes.

2 Weighted-average increase in collection rates across 5 countries, with China, Indonesia , and Vietnam reaching a 77% collection rate, and Thailand and the Philippines reaching a 90% collection rate in line with collection rates for economic peer group.

3 Based on case examples from Stockholm and Toronto. Applied by finding their ratio of waste density to bin density and applying this as the standard for the group of 5 target countries to meet to increase their collection rates. The collection-rate increase is estimated by calculating the portion of the required increase in total bins (including household bins) that can be met by street refuse bins, and applying this ratio to the difference in current collection rates between the group of 5 target countries and those of Stockholm and Toronto.

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations

Initiative methodology (5/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Sufficient street refuse bins (cont.)

Capital expenditures, $ thousand (102.4)	=	**Cost per bin,** $ 24	×	**Total rural land area,** km² 5,400,000	×	**Additional bins required,**[1] number/km² 0.79		
Operating profit (loss), $ thousand (195)	=	**Attrition/replacement rate of bins,**[2] % 10%	×	**Total capital expenditures,** $ (102,400,000)	+	**Cost of collection per bin (PPP adjusted),** $/year (43.27)	×	**Total rural land area,** km² 5,400,000	×	**Additional bins required,**[1] number/km² 0.79

Waste drop-off centers

Leakage reduction, thousand metric tons/year 197	=	**Total number of urban/periurban households,** thousands 276	×	**Households incentivized to participate,**[3] % 11%	×	**Drop-off capacity per household,**[4] metric tons/year 0.0529	×	**Overall leakage rate,** % 12%
Operating profit (loss), $ thousand (83)	=	**Total number of urban/periurban households,** thousands 276	×	**Households incentivized to participate,**[3] % 11%	×	**Drop-off capacity per household,**[4] metric tons/year 0.0529	×	**Average subsidy,**[5] $/metric ton 52

1 Based on the ratio of waste density to bin density for Stockholm and Toronto. The number of additional bins required is assumed to equal the ratio from the difference in overall collection rates between the group of 5 and Stockholm and Toronto; 2 Assumes 1 in 10 bins will need to be replaced or repaired per year; 3 Calculated by estimating the total capacity of households to supply targeted plastics, valuing the capacity at sorted-plastic prices plus an assumed 20% subsidy, then taking the ratio of the value of the basket to households' average cost of recycling time. Participation is then scaled down further according to the estimated national unemployment-benefit claimant rate; 4 Estimated by finding the average plastic waste per household, multiplied by the share of targeted plastics in total plastic waste (PET, HDPE, LDPE, PP, PS, plastic bags), multiplied by an expected recovery rate of 80% (based on waste-picker collection rates of 90% for PET), and finally, multiplied by a 33% loss factor assuming that a household visits once every three weeks and only has two weeks' worth of trash; 5 Assumes a 20% subsidy on the value of targeted plastics.

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations

Contents

- Reduction/elimination
- Collection
- **Recycling**
- Conversion/treatment
- Mitigation

Initiative methodology (6/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Low-value-plastic subsidy

Leakage reduction, thousand metric tons/year	=	**Total plastic waste,** thousand metric tons/year	×	**Overall plastic recovery rate,** %	×	**% increase in recycling capacity as a result of subsidy**[1]	×	**Overall leakage rate,** %
210		63		14%		20%		12%

Operating profit (loss), $ thousand	=	**Total increase in recovered low value plastic,** thousand metric tons/year	+	**Current plastic bag recovery ,** thousand metric tons/year	×	**Subsidy offered for plastic bags,**[2] $/metric ton
(786.3)		1.7		372		379

Waste-exchange program[3]

Leakage reduction, thousand metric tons/year	=	**Number of urban households**	×	**% of households that break even on waste exchange**[4]	×	**Participation rate of breakeven households,**[5] %	×	**Recovered plastic per incentivized household,**[5] metric tons/year	×	**Overall leakage rate,** %
210		146,400		34%		79%		0.044		12%

1 Assumes that a subsidy offering on plastic bags would result in 20% additional waste pickers joining the market (based on expert input that per-picker capacity is static).
2 Estimated by finding subsidy needed for plastic bags to match recovery rates of PET on a wage-per-day basis.
3 Program is cost neutral, as all costs/benefits are managed by participating corporations.
4 Estimated by comparing the value of the capacity of households to supply targeted plastics on a weekly basis (PET, HDPE, LDPE, representing ~34% of plastics) at the selling price of junk shops with the cost of household recycling time to recover this plastic. Assumes a a recovery rate of targeted plastics of 90% based on Philippines waste-picker efficiency for PET.
5 Estimated based on expected claimant rate of unemployment benefits, extrapolated from UK data based on PPP; UK data sourced from the BBC.

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, BBC, 100+ expert consultations

Initiative methodology (7/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Advance disposal fee

Leakage reduction, thousand metric tons/year	=	**Expected reduction,**[1] %	×	**Banned channels,**[2] %	×	**Enforcement rate,**[3] %	×	**Total plastic waste,** thousand metric tons/year	×	**Share of bags in plastic waste,**[4] %	×	**Overall leakage rate,** %
103		90%		14%		49%		63		21%		12%

Operating profit (loss), $ thousand	=	**Remaining plastic bag consumption,**[5] metric tons/year	×	**Plastic bags per ton**	×	**Price of bag,**[6] $	−	**Cost of bag,** $
224.3		92.4		147,000		0.0265		0.01

Household separation bins

Leakage reduction, thousand metric tons/year	=	**Total plastic waste,** thousand metric tons/year	×	**Share of MSW**[7] **from households,** %	×	**Urban collection rate,** %	×	**Household participation rate,**[8] %	×	**Plastics recovery rate,**[9] %	×	**Leakage rate of collected plastic,** %
67		63		60%		57%		7%		65%		7%

1 Expected reduction source from Hong Kong and Ireland case studies in supermarkets, convenience stores, and pharmacies; 2 Initiative assumed to be rolled out in the same channels as Hong Kong for the bag ban fee launched (by share of volume); 3 Assumes enforcement rates of 90% in urban, 60% in periurban, and 10% in rural areas; 4 Share based on Philippines data; 5 Calculated by deducting the expected reduction in channels across which the ban is levied from the total plastic-bag waste; 6 Based on Hong Kong and US plastic-bag charges of $0.05 adjusted for purchasing power parity; 7 Municipal solid waste; 8 Assumes that bins will be rolled out in urban areas only, that only 25% of the most affluent households will participate, and that all affluent households live in homes that enable access to separation bins; 9 Assumes 80% recovery rate of plastics for recycling, with 19% of collected plastics not recyclable (based on share of unrecyclable plastics in the plastic waste stream).

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations

Initiative methodology (8/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Household separation bins (cont.)

Capital expenditures, $ thousand (658.7K)	=	**Total households,** thousands 546	×	**Household participation rate,**[1] % 7%	×	**Capital-expenditure cost per household,**[2] $ 17		
Operating profit (loss), $ thousand (314.4)	=	**Attrition rate of bins,**[3] %/year 10%	×	**Total capital expenditures,** $ thousand (686)	+	**Extra cost of collection from separated bins,**[4] $/metric ton per year 31	×	**Total waste collected through bins,** metric tons/year 8,000,000

Container deposits[5]

Leakage reduction, thousands of metric tons/year 15	=	**Number of urban households,** thousand 146.4	×	**Household participation rate,**[6] % 9%	×	**Capacity per household in supplying plastic packaging waste,**[6] metric tons/year 0.041	×	**Expected commercial participation rate,**[7] % 40%	×	**Leakage rate for collected plastic,** % 7%

1 Assumes that bins will be rolled out in urban areas only, that only 25% of the most affluent households will participate, and that all affluent households live in homes that enable access to separation bins; 2 Assuming an average size of bin of 16 gallons, with 3 bins provided for separating waste (into general, organic, and recyclables); 3 Assumes that 1 in 10 bins will have to be replaced every year; 4 Estimated by accounting for time savings in dropping off waste at MRFs, which tend to be closer to urban areas than landfills (17.5% cost saving), although with a 3-times increase in the time spent during door-to-door collection due to separated waste (240% cost increase); starts from a $17 cost of collection based on cost of conventional collection system; 5 Cost neutral as all costs/benefits are managed by participating corporations; 6 Estimated by comparing the value of the capacity of urban households to supply plastic packaging (representing ~32% of plastics) at the sorted value of junk plastic to the cost of household recycling time to recover this plastic. Assumes a recovery rate of 90% based on Philippines waste-picker efficiency for PET; 7 Assumes only large corporations will participate (40% of market according to national employment share).

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations

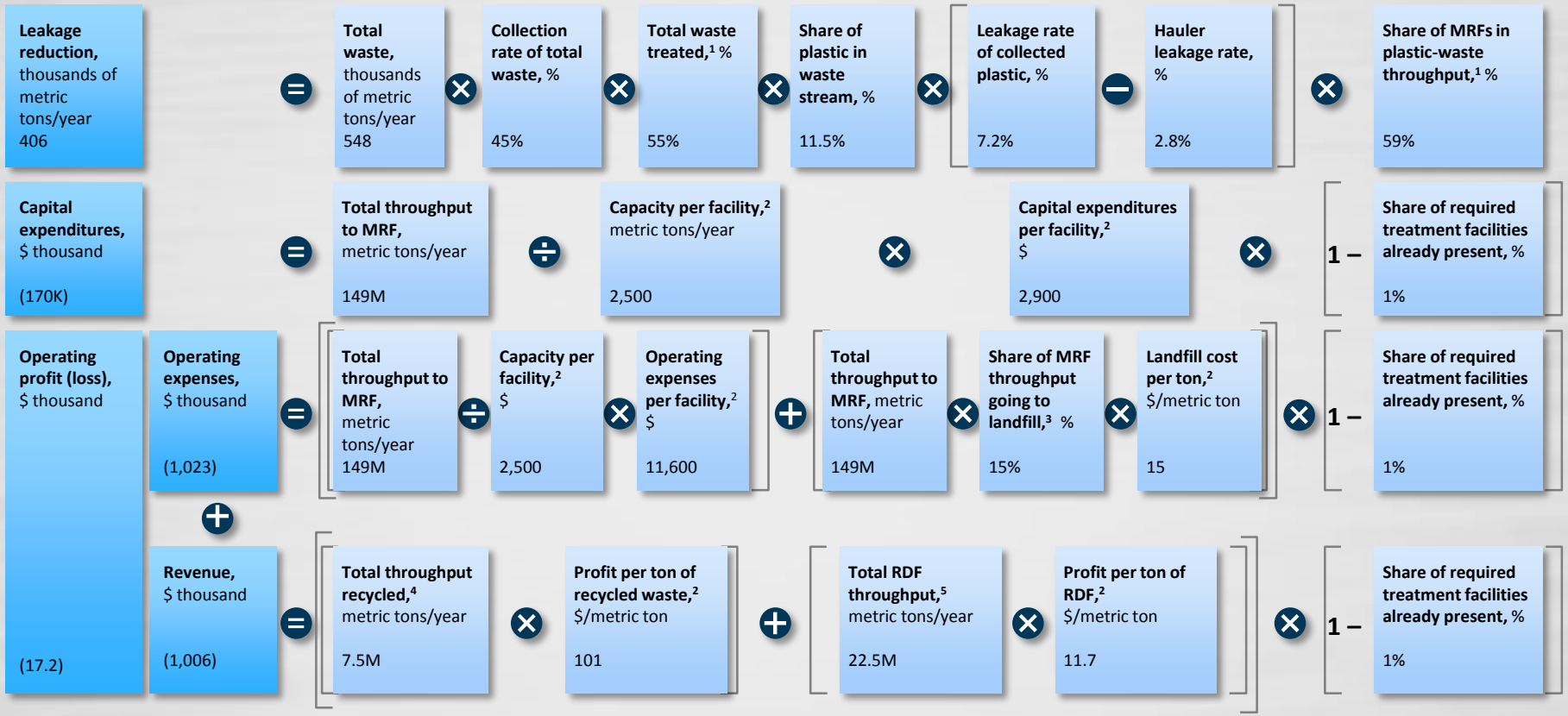
Contents

- Reduction/elimination
- Collection
- Recycling
- **Conversion/treatment**
- Mitigation

Initiative methodology (9/15)

NUMBERS MAY HAVE ROUNDING ERRORS

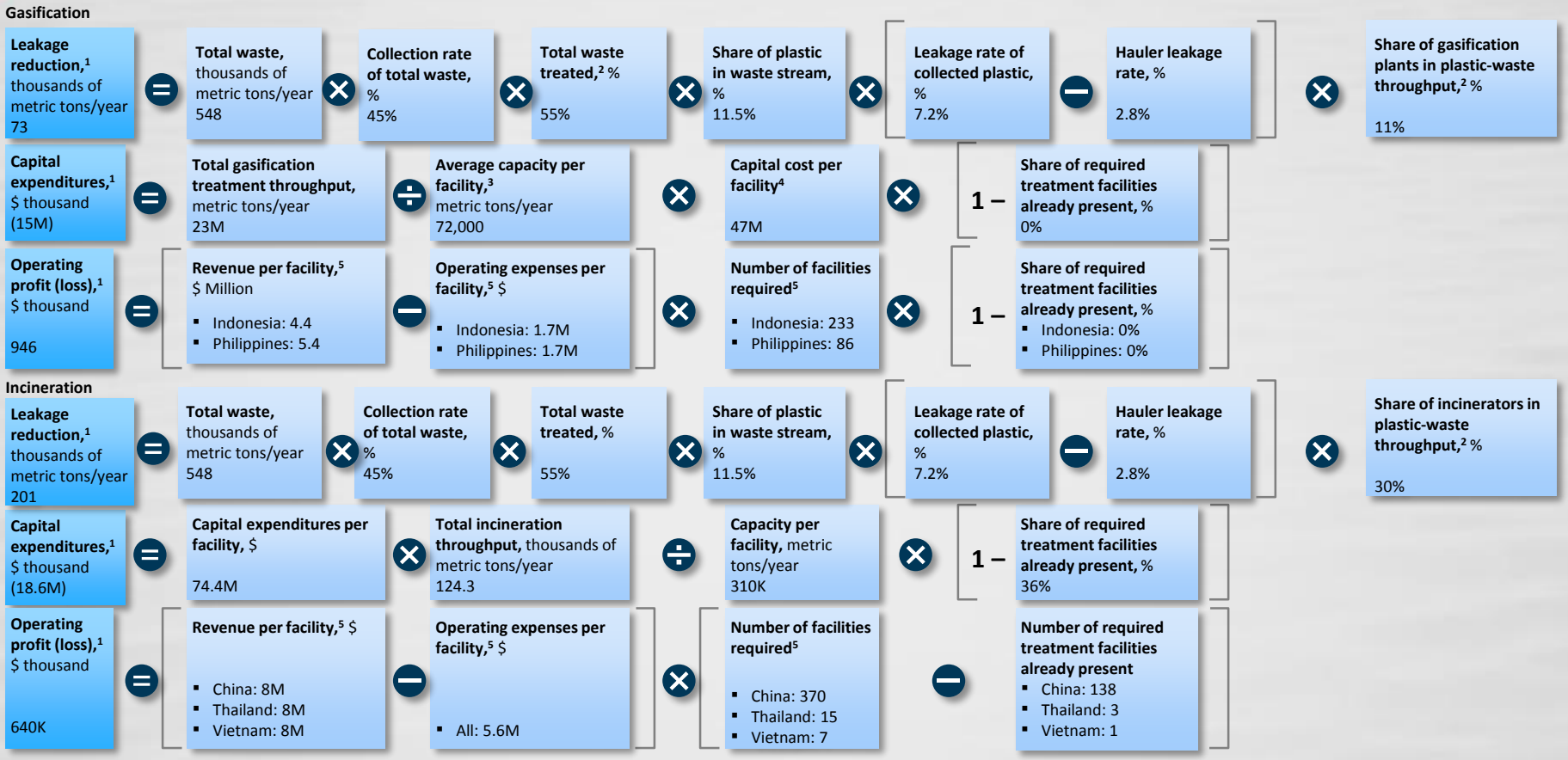
Mandatory recycled content and refuse-derived fuel (RDF)



1 Based on capacity of various regions and cities to meet minimum required scale for treatment option.
2 Based on expert interviews and case examples from China and the Philippines.
3 15% is the remaining throughput allocated to MRFs after 5% of throughput is allocated for recycling as part of the mandatory recycled content (see footnote 4), 15% is allocated to RDF (see footnote 5), 55% is assumed to be biodegradable (based on the Philippines MRF waste mix), and a final 10% is assumed to be other recyclables (eg, wood, based on Philippines MRF waste mix).
4 5% of total throughput to MRF due to impact from mandatory recycled content, as per the impact of the California plastic-container law.
5 15% of total throughput to RDF; includes paper, cardboard, plastics (proportion based on the Philippines waste stream).

Initiative methodology (10/15)

NUMBERS MAY HAVE ROUNDING ERRORS

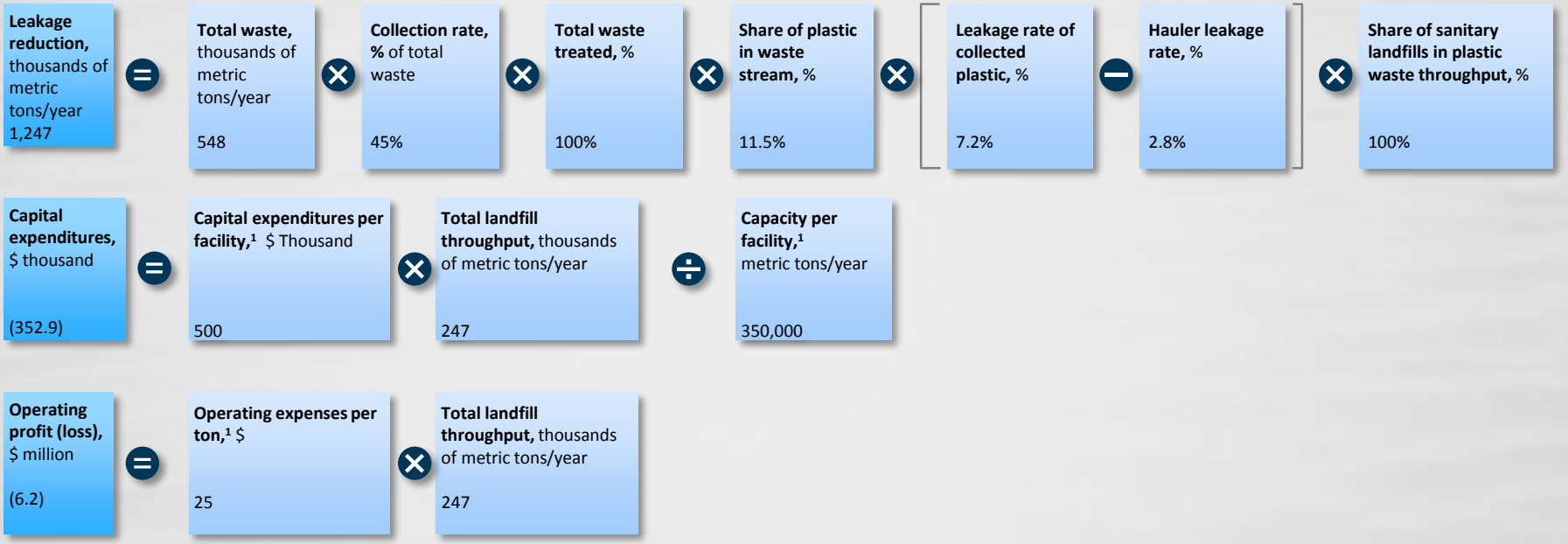


1 Not including contributions from existing facilities.
2 Based on capacity of various provinces to meet minimum required scale for treatment option.
3 While actual capacity is 90,000 metric tons per year, plant is assumed to operate at ~80% capacity in line with best practice.
4 Based on expert interviews and examples from China and the Philippines.
5 Separated calculations by country are added to reach overall operating profit. Differences in economics (ie, revenue and operating expenses per facility) result from differences in electricity feed-in-tariff at national level; revenue figures differ between countries, although rounding of the numbers hides this.

Initiative methodology (11/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Sanitary landfill



1 Based on expert interviews and benchmarks from Belize, Jordan, Kazakhstan, South Africa, and Uzbekistan.

Contents

Initiative methodology (12/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Optimize hauler transport system

Leakage reduction, thousands of metric tons/year 699	=	**Total plastic waste going through hauler system,**[1] metric tons/year 27.3M	×	**Hauler leakage,**[1] % 2.8%	×	**Effectiveness,**[2] % 90%						
Operating profit (loss), $ thousand (16.4)	=	**Total waste going through hauler system,**[1] metric tons/year 234.2M	×	**% dumping following initiative**[3] 0.3%	×	**Share of dumping caught by monitoring system,**[4] % 45%	×	**Fine per ton of dumping,**[5] $ 100	−			
		Total population size 1.8 billion	÷	**Number of people per GPS system** 1 million	×	**Number of FTEs per system**[6] 3	×	**Average annual wage per FTE,**[7] $ 8,300				
Capital expenditures, $ thousand (680)	=	**Total population size** 1.8 billion	÷	**Number of people per GPS system** 1 million	×	**Cost of GPS system (PPP adjusted),**[6] $ 371,000						

1 Calculated; 2 Assumes GPS monitoring system combined with dumping fines are able to reduce hauler dumping with a 90% effectiveness; 3 Calculated by multiplying the 2.8% hauler-leakage figure by 1 minus the 90% effectiveness ratio; 4 Assumes GPS tracking system is able to track 45% of dumping incidents; 5 Based on cost of cleanup of ~$170 (scaled down to $100 for group of 5 countries). Sourced from Water Health Educator; 6 Based on Dallas, Texas (US), case study. FTE is full-time equivalent employee; 7 Based on the Philippines.

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations; case studies (Dallas)

Initiative methodology (13/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Dump-site ban on specific products[1]

Leakage reduction, thousands of metric tons/year	=	Total plastic waste arriving at dump sites,[2] metric tons/year	×	Share of target plastics in ban in total plastic waste,[3] %	×	Dump-site leakage rate,[2] %	×	Effectiveness,[4] %
110		12.3M		25%		7%		50%

Closing/covering hazardous dump sites

Leakage reduction, thousands of metric tons/year	=	Current leakage from hazardous dump sites,[2] metric tons/year	×	Reduction effectiveness,[5] %			
841		1.2M		70%			
Capital expenditures, $	=	**Number of hazardous dump sites**[2]	×	**Cost of covering landfill in United States,**[6] **$**	×	**PPP adjustment**	
(2.6M)		1,300		3.8 million		0.53	
Operating profit (loss), $ thousand	=	**Number of hazardous dump sites**[2]	×	**Cost of maintenance per landfill cover in United States,**[7] $	×	**PPP adjustment**	
(179.5)		1,300		262,600		0.53	

1 Cost neutral, as costs of enforcement assumed to fit within existing policing infrastructure; 2 Calculated; 3 Calculated; assuming that PET, HDPE, LDPE, and LLDPE are banned; share based on Philippines plastic waste-stream mix; 4 Assumes that 50% of the leakage can be reduced in the target plastics from a ban; 5 Assumes that 70% of hazardous dump sites can be covered; 6 Based on Dallas , Texas (US), case study; 7 Press search, adjusted for PPP; based on a Dallas case study.

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations, case studies (i.e. USA)

Initiative methodology (14/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Waterway infrastructure

Leakage reduction, thousands of metric tons/year 81	=	**Number of principal rivers**[1] 2,000	×	**Number of traps**[2] **per river**[3] 2.5	×	**Annual trash capacity per trap**[4] 52	×	**Capture efficiency of traps**[5] 86%	×	**% of plastic in leaked waste** 35%
Capital expenditures, $ thousand (419.7)	=	**Cost per ton of capacity,**[6] $ (1,600)	×	**Number of principal rivers**[1] 2,000	×	**Number of traps**[2] **per river** 2.5	×	**Annual trash capacity per trap**[2] 52		
Operating profit (loss), $ thousand (948.6)	=	**Annual maintenance cost per ton of capacity,**[7] $ 3,600	×	**Number of principal rivers**[1] 2,000	×	**Number of units per river** 2.5	×	**Annual trash capacity per trap**[2] 52		

1 Major rivers that can sustain marine travel used as a proxy for the route plastic follows to the ocean; 2 Modeled based on trash traps, but approach could also apply to booms and other infrastructure;
3 Assuming that each principal river has 130 metric tons per year of waste that could be intercepted by infrastructure, estimated based on assuming a capacity of 2–3 traps per river multiplied by the capacity of each trap; 4 Capacity of single trap is 1 ton of waste. Annual capacity is reached assuming trap is cleaned out once per week; 5 Based on US case examples; 6 Based on total cost of ~$82,000 (adjusted from US cost according to PPP) divided by annual trap capacity; 7 Based on 11% operating-expense-to-capital-expenditure ratio (adjusted for PPP) from US case examples, scaled up for increased frequency of collection (ie, 2–3 per year in US case example, versus 52 times in group of 5 target countries).

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations

Initiative methodology (15/15)

NUMBERS MAY HAVE ROUNDING ERRORS

Dump-site ban on hazardous dump sites[1]

Leakage reduction, thousands of metric tons/year	=	**Total waste arriving at dump sites,[2]** metric tons/year	×	**Share of waste leaked through hazardous dump sites,[2]** %	×	**Effectiveness (based on Philippines)[3]**
82		3.36M		7%		25%

Littering fines

Leakage reduction, thousands of metric tons/year	=	**Total plastic waste,** thousands of metric tons/year	×	**Litter rate,[4]** %	×	**Reduction in litter rate from fine,[5]** %	×
20		63		2%		10%	
		Leakage rate of uncollected plastic, % 16%					

Operating profit (loss), $ thousand	=	**Number of littering instances,[6]** millions	×	**Average fine rate,[5]** %	×	**Litter fine,[7]** $
193.8		38.8		0.5%		1

1 Cost neutral, as costs of enforcement assumed to fit in line with existing policing infrastructure.
2 Calculated.
3 A ban on hazardous dump sites resulted in fall of illegal dump sites in Philippines from 800 to 600 (based on RA9003). Effectiveness ratio assumed to be same if initiative is applied to group of 5 target countries.
4 Sourced from *Science* journal estimate.
5 Assumes current enforcement system will catch 1 in 200 litterers.
6 Based on total mass of trash littered divided by assumed average weight of trash of 260 grams (assumes 3–4 pieces of trash per littering incident caught; average weight of littered trash estimated based on data from Ocean Conservancy beach cleanups).
7 Based on Colorado (US) fine of $25; scaled down based on differences in GDP per capita.

SOURCE: National Solid Waste Commission of the Philippines, *China Environmental Statistics Yearbook*, World Bank, 100+ expert consultations