THE NEXT WAVE

Investment Strategies for Plastic Free Seas

TRASH FREE SEAS ALLIANCE®

Ocean Conservancy®

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A LETTER FROM ANDREAS MERKL, CEO OF OCEAN CONSERVANCY

For more than 30 years, Ocean Conservancy® has brought together more than 11.5 million volunteers from 153 countries to participate in our annual International Coastal Cleanup™. In that time, volunteers have picked up nearly 100 million kilograms (220 million pounds) of trash from the world's beaches and waterways. We're proud and humbled by the combined accomplishments of Cleanup volunteers, but it's clear that with 8 million metric tons of plastic trash entering our ocean every year, and the prospect of 250 million metric tons of plastic in the ocean by 2025, cleanups alone will not suffice. We must tackle plastic waste's leakage from all points in the pollution pathway.

Around the world, there are exciting initiatives that are combating the problem at the local level. From local plastic substitution initiatives to exemplary zero-waste communities, great work is being done to keep our ocean and communities clean. Every effort adds up to make an important impact, and there is no single solution that will end plastic pollution on its own. Yet, after 30 years of experience and accumulating scientific research and analysis, we believe that we must focus on a long-term, systemic and global strategy to combat the rising tide of plastic waste before it enters the ocean.

Clearly, that long-term strategy is an economy designed to eliminate waste and pollution. This is a major undertaking — a huge cultural and economic shift. It will require decades to fully accomplish the substantial and complex collaboration across industries, the product and process innovations and redesign, the new definition of material and environmental standards, and the creation of entirely new markets. There can be no doubt that we also need to address the problem of plastic waste leakage in the shorter term.

Integrated, locally appropriate waste management solutions are needed now. This is not in conflict with the longer-term goals of waste elimination. To the contrary, good waste management — including proper collection and separation — is an essential condition for a future of steadily diminishing waste. To enhance the robust debate that is needed on this issue, we would like to offer the following general points about this report:

1. Waste reduction and waste management strategies are equally important. It is not possible to eliminate waste flows to the ocean by relying on just one or the other. Both consumption and production levels of plastics are exploding, and we need to think hard about how plastics are designed, used and then managed post-consumer use.

2. This report is principally concerned with only the waste management aspect of the solution set. This is because it is written from an ocean perspective, and we need fast action to keep plastic waste out of the ocean.

3. Waste management can do its job only if waste treatment technologies are significantly improved — landfills and incinerators are rarely a sustainable answer. Where technical innovation is concerned, the past is a poor predictor of the future — significant opportunities exist today to accelerate the commercialization and performance of new technologies. Any commercialization of new technologies must occur under technical, environmental and regulatory conditions that can ensure environmental and community health.

4. The solution will require the joint efforts of many sectors: cities, national governments, the private sector, private investors, development finance institutions, civil society and others. In the spirit of that sorely needed partnership effort, we welcome dialogue to help find sustainable solutions, based on the merits of this report.

Furthermore, we strongly believe that integrated waste management performed at the highest levels of environmental and social responsibility deliver benefits that improve public health, economic development and ocean health — this is necessary for any solution, either short-term or long-term, to be truly viable. The principles governing our work on marine debris therefore mandate that any proposed waste management option must meet the following criteria:

- Benefit both environment and people
- Be environmentally and socially responsible
- Be adaptable to changing waste conditions and technologies (i.e., minimize lock-in)
- Emphasize principles of circularity (waste reduction, recycling, waste repurpose, etc.)
- Be politically viable and locally appropriate, working within national, provincial and municipal laws, whenever possible, and respectful and supportive of national and local laws
- Address areas of high ocean plastic waste leakage

This report has been authored by members of the Trash Free Seas Alliance®, a coalition of industries, civil society organizations and academics focused on stemming the flow of plastic waste into the ocean. Informed by field research, interviews with local and global experts, and best-available, peer-reviewed science; it is focused on rapidly developing economies in Asia Pacific, in particular Indonesia, the Philippines and Vietnam, where some of the most significant leakage of plastic waste into the ocean occurs.

The analytics and recommendations mapped out in this report represent an ambitious plan to systematically reduce the amount of plastic waste entering our ocean annually by half over the next decade. The road ahead will not be easy, but it is attainable through a reinvigorated commitment by the private sector, civil society, scientists and the broader development community. And, with a renewed sense of united vision, we can achieve this ambitious goal and in the process significantly improve the health of the ocean, the planet and the diverse communities that depend on it.

Join us in our next wave as we continue our pursuit of trash free seas.

Sincerely,

Andreas Merkl

IN SUPPORT OF THE NEXT WAVE

"The Asian Institute of Technology is committed to playing a leading role in the sustainable development of Southeast Asia and its integration into the global economy. For such reason, we welcome 'The Next Wave', its thinking and the nine policy and practice recommendations recently endorsed by APEC Member Economies that will lead to more sustainable development and a greater harmony of waste management policies throughout all of Asia Pacific."

Osamu Mizuno, ***Director, Regional Resource Centre for Asia and the Pacific, Asian Institute of Technology***

"Finding value in waste to create new products is what the Closed Loop Fund is all about. That's why we are proud to have contributed to the analysis behind The Next Wave and its solutions. The report is a great step forward in helping to create a more sustainable and circular economy that contributes to improving the health of our ocean."

Rob Kaplan, ***Co-Founder and Managing Director, Closed Loop Partners***

"Litter is a global problem affecting our oceans and waterways. At Coca-Cola, we recognize how challenging and complex this issue is and it requires many actors to implement effective solutions. We also recognize we must all do more to reduce the likelihood of waste ending up where it shouldn't be. As one of the world's most recognized brands, we are concerned about what happens to packages after our beverages are consumed and the impact of improper disposal. As a founding member of the Trash Free Seas Alliance, we are proud to support the thinking introduced to improve waste management in developing economies where our products are available. By supporting these efforts, we can work with governments and across industries to eliminate marine litter."

April Crow, ***Senior Director, Environment & Sustainability, The Coca-Cola Company***

"Danone's mission is bringing health through food to as many people as possible and packaging has an important role to play by protecting the nutritional benefits and quality of our products. However, packaging also presents some challenges. It uses valuable resources in its conception and generates waste when not recycled. To address this challenge Danone aims to source its packaging materials from sustainable resources and create a second life for all plastics. We want to move to a circular model where packaging waste becomes a resource. In long-term Danone's commitment is to recycle more than we use. This is why we support the work of Ocean Conservancy and the Trash Free Seas Alliance and their findings in The Next Wave. Working together, we will combine our talents with them and others to move toward a more circular economy that captures the value in waste."

Charlie Cappetti, ***President Director, PT Tirta Investama (Danone AQUA)***

"There is a popular misconception that doing good and making a profit are mutually exclusive. At Encourage Capital we believe this is a myth. Indeed, we have seen and been involved in investments that have provided good returns to investors and helped address important social or environmental issues. But it goes further than that, we strongly believe that without private capital, without investment, we will not be able to address many of the world's most pressing problems, including plastic pollution in the Oceans. For this reason, we are proud to have contributed to The Next Wave, and we stand strongly behind its basic premise and its approach to finance and modeling. Indeed, we believe that this report will help provide some important insights and will show how bringing investment capital and a diverse group of investors to bear may be one of the best (if not the only) ways to improve the health of the ocean and the communities that depend upon it."

Ricardo Bayon, ***Partner and Co-Founder, Encourage Capital***

“As the global middle class continues to grow, lifting millions of people out of poverty and improving their lives, the critical issues of waste that confront us today will need to be addressed more quickly and holistically than ever before. This is especially true of rapidly developing Asia-Pacific economies that may have special challenges due to their limited land space or high degree of coastal access. The Next Wave is a much welcome take on the issue of identifying greater opportunities for reducing and better managing waste from an important point of view – the ocean. ISWA is proud to support the thinking introduced in The Next Wave particularly with our project on closing dumpsites, and we look forward to working with Ocean Conservancy and others in the private and public sectors as we move forward with our work to promote resource efficiency through sustainable production and consumption.”

Hermann Koller, ***Managing Director, International Solid Waste Association ISWA***

"Waste management in and of itself can be especially challenging when economies are industrializing and growing rapidly, as they are in the Asia-Pacific region. To attract investment, it will be important to regard waste management systems as an asset class just as we do for other infrastructure. One of the key aspects in financial markets which enables global investors to consider investment in new asset classes is the emergence of a "new normal" in the financial environment after the global financial crisis. But one of the great challenges of sustainable development is identifying new value in existing infrastructure models and assigning risk to new asset classes, such as waste management. With The Next Wave, Ocean Conservancy and the Trash Free Seas Alliance have done precisely that for APEC. Their work to identify new models showing the value of investing in the waste stream will have positive effects for investors, businesses, communities, and the environment in Asia and beyond. The challenge is for economies to see the benefits of prioritizing waste management, and for investors to respond.”

Hiroyuki Suzuki, ***Vice Chairman, Member of the Board, Nomura Research Institute, Ltd.***

“At P&G, we have a long-term vision to have zero manufacturing and consumer waste go to landfill and have conducted pilot studies in both the developed and developing world to understand how to eliminate waste while maximizing value recovery. We have been a leader in seeing the potential in better waste reduction and management, and that is why we are proud to support the Trash Free Seas Alliance®. The findings of The Next Wave lay a strong foundation for exploring collaborative efforts that can help bring meaningful and impactful waste management solutions to life.”

Jack McAneny, ***Director of Global Sustainability, The Procter & Gamble Company***

“This report shows that the barriers to dramatic reduction of plastic in the ocean are surmountable. The requisite technology, knowledge, and financial mechanisms exist and can be brought to bear in the rapidly developing Asia-Pacific region and beyond today. These solutions — which encompass reducing plastic use, recycling and reuse as well as efficient disposal of existing plastic waste — will clean our oceans and deliver multiple social and economic co-benefits. The United Nations Environment Programme and our International Environmental Technology Center in Osaka, Japan look forward to working with stakeholders reading this report to implement the solutions therein.”

Keith Alverson, ***Director, International Environmental Technology Centre, United Nations Environment Programme***

"“Helping countries sustainably manage their natural resources and fight environmental degradation is crucial to reducing poverty and long-term improvement of people’s wellbeing. The bold ideas outlined in The Next Wave could help harness the economic opportunities of waste to move coastal economies toward more sustainable development to improve the health of their communities and the ocean.”

Julia Bucknall, ***Director of Environment and Natural Resources, World Bank***

Plastic in the ocean is a problem that can be prevented. It won’t be easy, but it is critical to the health of our planet that we get this right. With The Next Wave we have a new model for creating a long-term solution that puts plastic in its place—fixing the problems with the systems on-land so we stop environmental contamination before it happens. The potential impact of this work is monumental and will help us move closer toward a future of trash free seas.”

Erin Simon, ***Deputy Director, Sustainability R&D, World Wildlife Fund***

ABOUT THE TRASH FREE SEAS ALLIANCE®

Ocean Conservancy founded the Trash Free Seas Alliance® (Alliance) in 2011. It unites leaders from industry, conservation and academia to create pragmatic, real-world solutions to combat the problem of marine debris. Building upon the growing body of science on plastic marine debris, the Alliance aims to reduce the amount of plastic waste leaking into the ocean annually by 50% by 2025. For more information, visit **www.oceanconservancy.org/our-work/trash-free-seas-alliance**.

ACKNOWLEDGEMENTS

This report has been produced by a project team, with guidance and support from a steering committee of committed partners from the Trash Free Seas Alliance, who take full responsibility for the report's contents and conclusions. Ocean Conservancy is deeply appreciative of their effort to produce this work, and their commitment to advancing solutions to keep trash out of the ocean.

The content of this report was also informed by the many technical advisors and organizations we consulted during its development. However, their participation does not necessarily imply their endorsement of the report's contents or its conclusion. We are greatly thankful for their contributions.

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Established in 1959, AIT plays a leading role in promoting the sustainable development and technological changes in the Asia-Pacific region through higher education, research and development, policy guidance, training and outreach. Regional Resource Centre for Asia and the Pacific (RRC.AP) is an institute-wide center of AIT that aims to bridge the gaps between the scientific understanding of sustainable development processes and sound policies at regional, national and municipal levels.

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Closed Loop Fund is a social-impact investment fund that provides cities access to the capital required to build comprehensive recycling programs with an aim of investing $100 million by 2020. Closed Loop Fund brings together the world's largest consumer product, retail and financial companies committed to finding a national solution to divert waste from landfills into the recycling stream in order to be used in the manufacturing supply chain.

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For more than 40 years, Ocean Conservancy has championed science-based policy solutions to protect ocean ecosystems. It provides leadership on the protection of special places, the restoration of sustainable fisheries, the reduction of human impacts on ocean ecosystems, and the need for comprehensive management of our nation's ocean resources. Informed by science, Ocean Conservancy's work guides policy and engages people in protecting the ocean and its wildlife for future generations.

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Plastics for Change is a social enterprise dedicated to reducing plastic pollution, increasing recycling rates and creating dignified livelihoods for the urban poor in developing countries. Plastics for Change has developed a deal process and mobile platform for providing waste pickers with fair market prices for the discarded plastics they collect.

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Waste2Worth Innovations seeks to catalyze the use of municipal waste as a resource for mitigating the larger social, economic and environmental impacts caused by municipal waste. Foundational to the Waste2Worth approach is the recognition of a locality's unique waste challenges toward the design of economically viable and environmentally sound waste infrastructure.

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Sustainable Waste Indonesia, *Indonesia*

SWI is an Indonesian company dedicated to bridging the global waste management challenge in Indonesia as well as to promoting local/indigenous knowledge and best practices. We underline the importance of a paradigm shift in Indonesia toward sustainable service delivery, the 3R principles and partnership of community, government and the private sector.

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EXECUTIVE SUMMARY

The critical and possible imperative to solve marine debris

An estimated 150 million metric tons of plastic waste are in the ocean today, and every year an estimated 8 million metric tons more are being added **[1]**. With oil prices at an all-time low, coupled with growing population levels and economic prosperity, plastic production and consumption are predicted to double over the coming decade. Without immediate intervention, 250 million metric tons of plastic waste could be in the ocean in fewer than 10 years **[1]**.

The goal suggested by the Trash Free Seas Alliance® is to **sustainably reduce the amount of plastic waste leaking into the ocean annually by 50% by 2025.** Although not easy, this goal is attainable if all stakeholders — government, development finance, the private sector, grant funders, private investors, academics, and civil society and community organizations — work together using all available means. Every lever must work effectively: from reduction and reuse to innovation in product redesign and the fundamental components of waste management — collection, recycling, treatment and landfill disposal. When these solutions meet, an enormous leap forward will be made in protecting the ocean, the climate and public health.

Given the aggressive 2025 timeline that coincides with regional and global goals such as ASEAN's Socio-Cultural Community Blueprint 2025 and Sustainable Development Goal 14, this report focuses primarily on waste management, both a critical mid-term solution and a key part of longer term interventions. The Trash Free Seas Alliance® fully supports the efforts of organizations like the Ellen MacArthur Foundation, which is rethinking plastic design, and others working toward waste minimization and no-value waste reduction. It also supports the work of so many local organizations engaging communities to address local waste issues. Waste management and waste reduction are essential, interdependent components of a single overarching strategy: one sets the stage for the other; waste management can stem the destructive tide of ocean plastic in the short-term, while waste reduction develops the systemic solution needed in the long-term.

This report does not have all the answers. It does not prescribe specific business models or technologies for specific places. It does lay out a blueprint for a collaborative effort to create the right conditions for sensible, innovative waste management in key cities and regions where ocean plastic inputs are currently largest. It also challenges some long-held beliefs with scientific evidence in order to achieve the ultimate goal of a 50% global reduction of plastic waste leaking into the ocean annually by 2025.

What's at stake

Plastic has become a ubiquitous part of daily living and can offer lifecycle benefits — both economic and environmental — for the products they protect. However, the very qualities that make plastic so useful — its unmatched strength, light weight and low cost — also make it problematic once it is discarded. Plastic waste is making its way into the world's ocean, where it can take centuries or longer to completely decompose. Once in the ocean, plastics merge with the biosphere. It has been documented that plastics affect nearly 700 species, from plankton to whales **[2]**. Not only do plastics harm animals externally, but plastic ingestion has also been shown to inhibit animal growth and make them more prone to tumor development, less successful in reproduction, and less able to detect and evade predators **[3]**. The potential impact on people from plastics moving up the food chain is an important question that is actively being researched.

To fix the plastic waste problem, and in turn ocean plastic inputs, the problem of waste management must be solved. Doing so improves more than ocean health. It can increase economic and job growth, make people healthier, and reduce emissions of toxic and greenhouse gasses:

- **Health:** Effective waste management prevents flooding and helps prevent the spread of infectious disease, reduces respiratory illnesses from the harmful emissions of open air burning of waste, and prevents food-chain contamination of both livestock and fish stock **[4]**.
- **Jobs:** The waste sector is estimated to employ 1% of the urban population in emerging economies **[5]**. Increased collection, recycling and treatment in the largest cities (with more than 2 million inhabitants) could increase employment in the formal waste management sector, generating around 76,500 extra jobs over 10 years in focal countries.

- **Climate:** Effective waste management can reduce an economy's overall greenhouse gas emissions by 10-15% **[6]**.
- **Economy:** Asia-Pacific Economic Cooperation (APEC) estimates that the cost of ocean plastics to the tourism, fishing and shipping industries is $1.3 billion in that region alone **[7]**.

An integrative approach

Good waste management begins at the product design stage, with a real priority on waste reduction and product end of use. Once a product is thrown away, the emphasis shifts to a carefully integrated waste management system. The front end (collection and separation) determines the technical and economic viability of the middle of the waste value chain (recycling and treatment) before final disposal at the back of the chain (landfill). Increasing the collection rate and quality increases the quality of feedstock for recycling and other technological solutions that create value from waste that would otherwise pollute landscapes, waterways and the ocean. Thus, the performance of the waste management system's technical, environmental and economic dynamics must be accelerated. The aim of future waste management systems is to maximize value and minimize costs in order to reduce the deficit of net cost areas of the waste value chain — collection, separation and landfill disposal — to the point that the system is economically sustainable, or until the deficit better matches people's willingness and ability to pay for it as a service.

Improving the economic fundamentals of waste management is essential in order to achieve the 2025 goal of reducing plastic waste leakage into the ocean annually by 50%. It is highly unlikely that government funding alone will be sufficient to build the necessary infrastructure, but there are precedents in other areas for this kind of improvement. Technical innovations have transformed entire business sectors, from clean energy to the rapidly approaching future of driverless electric cars. The success of the energy revolution has relied on smart incentives, good policy, and deep public and private investment to improve cost performance considerably in the past decade alone. Though collection, recycling and treatment innovation are critical pieces to reducing plastic waste leakage dramatically, future innovations that may evolve in this space cannot be predicted. Instead, the right conditions for reducing barriers to innovation must be created, just as they were in the clean energy sector. Performance improvement will primarily be a function of the following investments, all of which are designed to increase the value of the waste stream significantly:

- Design and fund a collection and separation system with an eye to the recycling and treatment technologies of the future.
- Grow recycling demand by designing more products for profitable recycling, and provide both positive and negative incentives to increase the use of recycled feedstock where feasible in product manufacturing.
- Support programs for the social and economic inclusion of waste pickers into waste collection, material recovery facility (MRF), separation and treatment opportunities, thereby providing safer working conditions while maintaining or improving livelihoods.
- Accelerate development and commercialization of technologies that permit highly efficient conversion of nonlocally recyclable plastics into virgin-quality feedstock or other valuable commodities.

Each location, from large urban cities to small rural villages, will require a different solution to its unique waste management challenges and opportunities. Adaptation, evolution and innovation will be required over the coming decade and beyond. This report lays out a proposal for an international waste management marketplace — a partnership of government, cities, the private sector, investors and civil society organizations that develop, in key Asia-Pacific cities and regions, the conditions for investments in innovative, integrated waste management solutions.

The pace and uptake of innovation is greatly accelerated by a cooperative effort to organize collection and by a coordinated approach to financing innovation. The recent endorsement of policy and practice recommendations on waste management by the highest levels of APEC, listed in Appendix 1, will certainly help to elevate waste management as a greater developmental priority by the governments of APEC's Member Economies and lead to greater collaboration and innovation in the region in order to adequately address this problem. However, the cost of financing waste management is unlikely to be carried by the public alone in rapidly developing economies because of the competition for scarce public resources needed to address numerous areas of developmental concern. Sensible economic support for waste management is necessary for it to ultimately succeed.

The issue of plastic waste in the ocean is complex, but solutions built on robust science and the concerted efforts of individuals, businesses, governments and civil society organizations are at hand. This report examines some of the solutions and technologies currently available and looks forward to establishing a framework to generate greater collaboration and innovation toward long-term solutions.

1 WHAT IS AT STAKE

150 million metric tons of plastics in the ocean today could grow to 250 million metric tons in less than a decade if immediate action isn't taken. Plastic waste is harmful to marine life, takes centuries or more to decay, and attracts contaminants from the waters in which it floats. Effective waste management reduces plastics waste leakage, increases GDP, makes people healthier, creates jobs, and reduces emissions of toxins and carbon.

Marine debris

Every year, more than 8 million metric tons of plastics pour into the ocean — the equivalent of a loaded garbage truck dumping its contents into the ocean every minute **[8]**. Plastics are a workhorse of the modern economy, with unrivaled applications at a material level. But as plastic production and consumption are expected to double in coming years, mismanagement of plastic waste means the ocean could contain 250 million metric tons of plastic in less than a decade **[1]**.

The very qualities that make plastics so useful — their unmatched strength, light weight and low cost — also make them problematic once they enter the ocean. Over time, exposure to ultraviolet light from the sun (UV exposure), wind movement and wave action break plastic debris down into small fragments, which currently total as many as 51 trillion pieces of plastic **[9]**. These plastic fragments, which it is estimated will take more than a century to fully decompose, circulate around the globe through ocean currents and adsorb toxic contaminants like dioxins, PCBs (polychlorinated biphenyls, persistent organic pollutants), and PBTs (persistent, bio-accumulative, and toxic substances) from the waters they travel through **[10]**.

Plastics are accumulating not only in water but also in marine life. Unlike larger plastics that endanger animals through entanglement, plastic fragments are small enough for animals to ingest easily. In fact, nearly 700 species throughout the ocean food chain have been affected by plastic debris, from the smallest plankton to the largest whales **[2]**. A 2015 study found that 55% of fish species in Indonesian markets showed evidence of having ingested plastics **[11]**. Plastics of different concentrations and types have also been found in 28% of individual fish sold at markets in Makassar, Indonesia, and in 25% of fish from Half Moon Bay, California **[11]**. More research remains to be done on plastics ingestion within the food chain and its potential impact on people, especially considering that seafood provides 15% of the world's protein **[12]**.

Waste management

A critical first step for reducing plastic waste in the ocean is effective solid waste management (SWM), which would result in more plastics being collected, separated, recycled and treated. The continued lack of proper waste management practices, on the other hand, fosters not only plastic leakage, but it also fuels broader environmental problems and has profound health and economic consequences.

Environmental issues

In the absence of sound waste management practices, actions like dumping and open burning will continue to be practiced widely in many areas. (For more details, see **Importance of establishing a sound collection base**.) Dumping waste directly into waterways can exacerbate flooding **[4]**, and the decomposition of unsorted, untreated waste — whether collected or dumped — releases methane, a powerful greenhouse gas (GHG). Open burning also releases harmful emissions that contribute to climate change and its associated effects such as droughts, sea-level rises, floods and landslides, all of which can devastate poor coastal and agricultural communities.

Enforcing environmental performance standards within integrated waste management systems will help to avoid such costs and degradation to the environment. Research has found, for example, that over 70% of Indonesia's urban waste-related GHG emissions could be avoided through a combination of increased recycling and anaerobic digestion of organic waste **[13]**. Assuming a carbon price of $20 per ton of CO_2e, the economic value alone of this abatement in the largest Indonesian cities could be around $60 million annually. Abatement will also make a contribution to mitigating the overall impacts of global climate change, whereas the economic consequences of unmitigated climate change are potentially very severe in the focal region; the Asian Development Bank recently estimated that by 2100 the total costs of climate change could consume nearly 10% of Indonesia's GDP without concerted action **[14]**.

Health issues

Societies without effective waste management practices are more vulnerable to the spread of infectious diseases, experience higher instances of respiratory illnesses and see increased rates of food-chain contamination. Waste disposal sites can be breeding grounds for mosquitos, which spread diseases such as Zika virus, dengue fever and malaria. In Indonesia, these diseases are responsible for over 11,000 deaths annually **[15]**, and the aggregate costs of dengue alone were estimated to be $323 million in 2010 **[16]**. In areas where households burn or dump their waste in their yards, instances of diarrhea are twice as high, and acute respiratory infections are six times higher than in areas where waste is regularly collected **[17]**. Air pollution currently takes the lives of around 50,000 Indonesians annually, of which an estimated 27% are linked to biomass burning **[18]**. Uncontrolled waste collection also affects the health of waste pickers, who may suffer from high rates of disease **[19]**. In some areas, open dumps are easily accessed by foraging animals that may later be consumed by humans, posing potential health threats. Plastic waste in the ocean also affects the food supply, with as-yet unknown risks for humans.

But better waste management systems can support major improvements in public health and wellbeing through improved sanitation, reduced waste burning and removal of mosquito breeding grounds.

This can improve overall productivity and wellbeing by reducing morbidity and mortality, as well as reducing the cost of healthcare to the community. Saint Lucia, for example, saved an estimated $3 million (about $16/person) in healthcare-related costs in its first year with a new solid waste management system **[20]**. Trinidad and Tobago (population just over 1.3 million) saved an estimated $23 million (about $17/person) under similar circumstances **[20]**.

Economic issues

Inadequate management of the waste stream has enormous economic costs. In Indonesia, for example, an estimated $166 million is lost in tourism revenues due to sanitation conditions, including a lack of efficient waste management and other elements **[21]**. And Asia-Pacific Economic Cooperation (APEC) forum estimates that the cost of ocean plastics to the tourism, fishing and shipping industries is $1.3 billion in that region alone **[7]**.

Better waste management systems will not only help these critical economic sectors to survive, but they will also help to create new jobs, increase wages and improve working conditions for those in the waste sector. In Indonesia's formal waste sector, for example, modelling indicates that increased collection and treatment in the largest cities (with more than 2 million inhabitants) can almost double employment in waste management, generating around 24,000 additional jobs over 10 years. For informal waste pickers, better training and tools can increase their productivity by up to 40%, which is likely to result in substantially higher wages. In developing economies overall, the informal waste sector is currently estimated to employ 15 million to 20 million workers **[22]**. Increased collection, recycling and treatment in the largest cities (with more than 2 million inhabitants) could increase employment in the formal waste management sector, generating around 76,500 extra jobs over 10 years in focal countries.

Waste management jobs extend beyond the collection workers, sorters, processors, tipping floor operators and others who typically come into contact with municipal solid waste (MSW). A significant amount of communication, outreach, customer care, auditing and public awareness campaigns must accompany new, integrated MSW systems to ensure successful implementation and monitoring of sound waste management practices, all requiring people to service these needs.

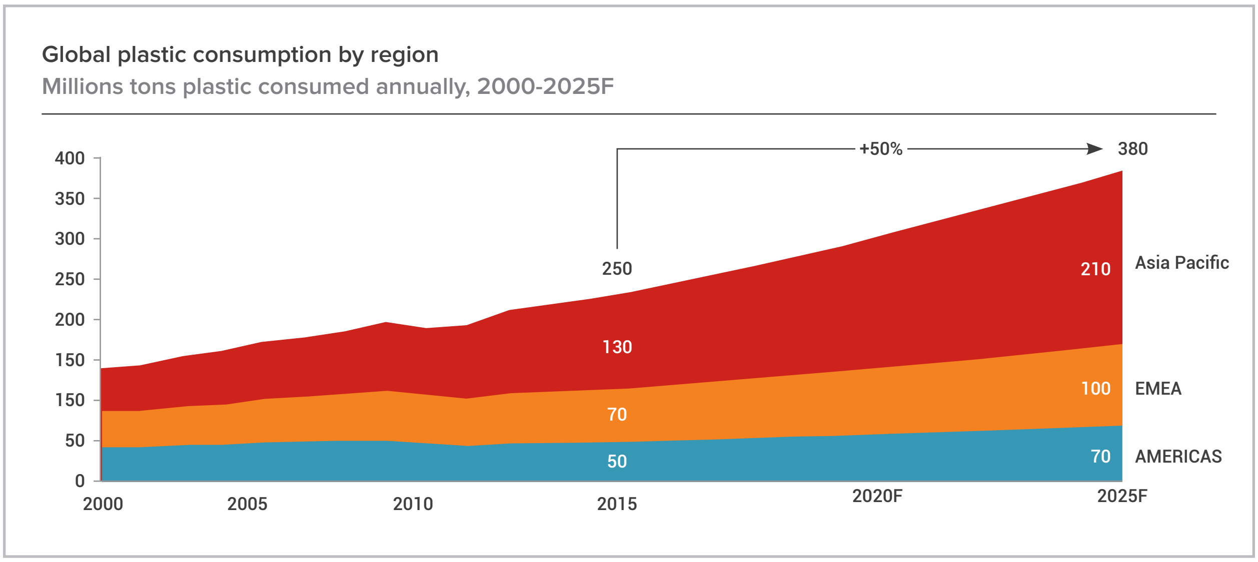
It is time for decisive action

> Plastic consumption and disposal is growing far faster than waste management infrastructure, with unacceptable implications for the ocean and public health. Given the lag time inherent in infrastructure development and product design, fast and decisive action is needed.

Waste — any discarded material such as household or municipal garbage, trash or refuse, food wastes, or yard wastes that no longer has value in its present form but may or may not be recyclable or otherwise able to be repurposed — is growing substantially worldwide, reaching an estimated 2 billion metric tons per year **[4]**. In fact, with two-thirds of the world's population, Asia Pacific alone is forecasted to generate 1.4 billion metric tons per year by 2030 **[23]**.

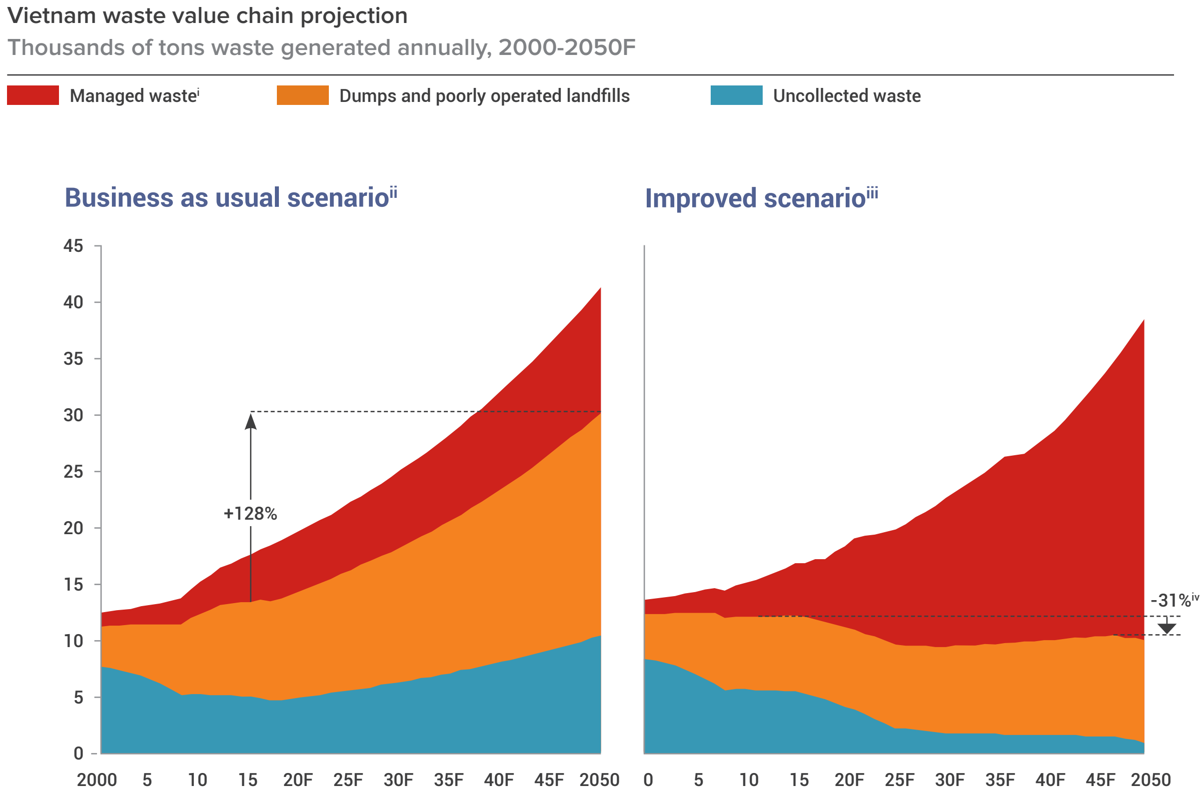
Plastic consumption growth is forecasted to reach 380 million tons in 2025 versus 250 million tons today, a 50% growth from 2015 levels, with the majority of that growth coming from the Asia-Pacific region (Figure 1) **[24]**. Plastics are being used in evermore applications, coupled with population growth, increasing urbanization, and growing levels of disposable income and associated buying pattern changes **[25]**. According to the best available research, four rapidly developing Asian economies — China, Indonesia, the Philippines and Vietnam — currently account for 50% of global plastic waste leakage to the ocean **[1]**. Tackling a problem of this magnitude and scale has to begin on land, where around 80% of marine debris originates **[12]**.

FIGURE 1. GLOBAL PLASTIC CONSUMPTION FORECAST [24]



Modeling in Vietnam reveals that if total per capita waste generation levels were reduced by 8% and significant improvements were achieved in collection, recycling, treatment facilities and sanitary landfill levels, there would be an inspiring 30% reduction in mismanaged waste. Still, 9 million metric tons would be considered "mismanaged" — waste that is either not collected or collected but then either dumped or stored in unsanitary dumpsites; all are significant contributors to marine leakage. The business as usual scenario paints a far drearier picture. Without intervention, mismanaged waste is expected to grow 130%, with 20 million metric tons forecasted to be mismanaged by 2050 **[26]** (Figure 2). These models illustrate the amplifying effect of waste generation growth against the ability to manage it. Clearly there is a need for fast action on a large scale.

FIGURE 2. COMPARISON OF IMPACT OF WASTE LEVEL GROWTH ACROSS TWO SCENARIOS IN VIETNAM [27]



i All landfills are the same size; sanitary landfills are in urban areas only and contain 7% of nonprocessed, collected waste prior to 2010 and 10% to 2020, 20% to 2030, 30% to 2040, 40% to 2050; dumpsites/landfills store remaining waste.

ii Business as usual scenario assumes urban waste growth is equal to forecasted urban population growth (3.1%) and rural waste growth is equal to historic growth levels (0.9%).

iii In the improved scenario, urban collection rates increase from 85% to 100% and rural from 43% to 90%.

iv Assumes 8% waste reduction per person.

2 WHY PARTNERSHIP IS NECESSARY

Individuals and organizations throughout the public and private sector all have compelling reasons to solve the challenge of post-consumer waste. However, the task is highly complex and requires the combined resources and capacities of all actors to address key challenges quickly. Potential opportunities for meaningful contributions by relevant stakeholders are presented as options to spark and sustain action and investment in waste management.

A problem for both public and private sectors

Governments, cities, development finance institutions (DFIs), the private sector, grant funders, private investors, academics, and civil society and community organizations all have strong reasons to engage in solving the post-consumer waste problem. In the public sector, national governments' interests include improving local economies, protecting the public health from groundwater contamination and the spread of mosquito-borne diseases, creating jobs, and delivering on international commitments such as Sustainable Development Goals and climate change agreements. At the local level, cities face immediate pressures of solving for rising waste costs, creating strong economic and green job growth opportunities, and reducing waste-related public health concerns and costs stemming from problems such as storm water drainage blockages. Provincial and regional governments stand to see economic benefits by facilitating smart cities.

In the private sector, incentives to contribute to effective waste management include opportunities for corporations to enhance brand value and reputation, improved access to and use of recycled content, and in some cases reduce compliance costs. DFIs and grant funders are looking for opportunities to deliver on infrastructure financing and health improvement mandates. Investors are looking for new, financially sound ways to use investment capital to solve critical environmental and social problems and to diversify their portfolios. Academics and scientists hope to provide innovations in recycling and treatment technologies, and they aim to create new business models to solve the challenging waste economics underpinning self-sustaining solutions. Local entrepreneurs and workers are looking for business and employment opportunities that a robust waste management sector could provide. And civil society and community organizations seek to protect the environment and improve the health, wellbeing and economic livelihoods of those in need.

Yet no single actor combines the resources, mandate and technical capacity to solve the challenge of waste. Waste management is highly complex: it involves redesigning products, organizing waste streams, raising billions of dollars and introducing new treatment technologies — and all of it has to be thoughtfully coordinated to avoid unintended consequences. Governments labor under competing and urgent priorities, with budgets that are insufficient to reach down to the capital-intense financing of waste infrastructure. Even where waste management is prioritized, the highly decentralized governance model of many countries means that ensuring widespread implementation can be a challenge unless technical and financial support and oversight happens nationally. Although there are strong examples of best-practice waste management in many cities, many cities in the focal countries may not have the capacity, technical know-how, or finances to design fully integrated waste management systems themselves. DFIs and private investors are faced with large perceived credit risks, high transaction costs and a lack of investment grade projects and a history of failed projects that make them weary of additional investment. The private sector does not yet understand how best to share their resources and expertise.

THE ROLE OF THE PRIVATE SECTOR

This analysis is supported by members of the Trash Free Seas Alliance (TFSA) – a collaboration of private sector, science and conservation leaders who share a common goal for a healthy ocean free of trash. Having previously identified a range of potential strategies in ***Stemming the Tide***, this work is intended to support the next steps, namely to identify and remove obstacles to financing needed investment in land-based waste management. TFSA hopes this work will encourage and catalyze engagement across these stakeholders. For the private sector, this includes identifying the most effective opportunities to partner in supporting and investing in solutions.

In addition to participation in the TFSA, various private sector actors have separately worked to advance solutions. For example, developing and financing innovative recycling and separation systems, creating funds to accelerate municipal recycling, and designing products to use less material and incorporate more recycled content. The TFSA's private sector members each have their own motivation for coming together to take the next steps, whether to enhance brand value, demonstrate a tangible commitment to sustainability, or simply to access more recycled content. Although the specific mechanisms for how each sector can contribute need additional development, these TFSA members recognize both an opportunity and a responsibility to play a part in maintaining a healthy planet and healthy communities. None of them want to see their products ending up as trash in the ocean.

This report outlines several areas of opportunity for impactful investment and participation from the private sector – including plastics makers, consumer goods companies, food and beverage producers, retailers, tourism related companies and others – to support waste management and resource efficiency goals. In some of these areas, models already exist, but all of these ideas will need further development in order to be tailored to the specific context and allow for a more detailed assessment of the proposed path forward. In addition, this report recognizes that to be effective, many of these approaches will require coordination across multiple private sectors as well as with other sectors including political commitments across multiple levels of government, and shared participation by investors, development banks and civil society organizations.

The members of the Trash Free Seas Alliance are committed to recruiting the necessary partners across these sectors, and taking the next steps to more fully develop and implement solutions. This report is offered as a beginning to that conversation.

Partnership as a way forward

The Brookings Institute, a Washington, D.C.-based nonprofit public policy organization, proposed a new theory on how to change the world after analyzing common threads across the last three major global agreements — the Addis Ababa Action Agenda, the Sustainable Development Goals (SDGs) and the Paris Agreement attained at COP 21 **[28]**. They found it is no longer enough to change the world through government policy and investment. Rather, government should play a catalyzing role through these actions while mobilizing business, civil society and community organizations, scientists, and others to deliver the change using their unique skills and resources. They contend that change is most sustainable if it meets these three basic elements:

- **Market making:** Use market forces to drive business toward scalable investments that simultaneously generate sustainable solutions to development challenges.
- **Data:** Create more data from more sources with more disaggregation, and make these more easily transparent and accessible, to drive toward evidence-based reforms and accountability.
- **Innovation:** Encourage innovations (technical, organizational and business-model) to drive the world away from business-as-usual.

A cooperative approach among multiple stakeholders is thus needed. Each waste stakeholder has the opportunity to carve out a meaningful role in solving waste management in developing economies. The role each player commits to will be developed with direct input from each stakeholder. A few initial suggestions for a possible way forward are offered in Table 1 as a starting point, beginning with the proposed APEC Policy and Practice recommendations. A multistaged approach to establishing such a partnership is suggested in the final section of this report, The Path Ahead.

TABLE 1. POTENTIAL ROLES OF WASTE MANAGEMENT STAKEHOLDERS

National governments	Provincial and regional governments	Cities
Establish policy conditions that invite (and de-risk) responsible waste investment. ▸ APEC PPR 1: Set ambitious yet attainable waste management targets at the economy-wide and municipal levels in consultation with affected stakeholders, consistent with the Sustainable Development Goals (SDGs) and, as appropriate, The Paris Agreement on Climate Change, and encourage regions or provinces to develop detailed action plans to reach agreed targets. ▸ APEC PPR 2: Build waste management performance indicators and methodology to track progress against economy-wide and municipal waste targets, maintain an economy-wide waste database, and encourage and acknowledge frontrunner cities for their overall waste and sanitation achievement through competitive award and certification. ▸ APEC PPR 3: Issue APEC guidelines on the development of definitions related to sustainable materials management (SMM) that facilitate trade in new technologies, and investment in recycling, recovery and other related SMM solutions. ▸ APEC PPR 4: Concentrate the majority of municipal solid waste responsibilities within a single government entity or independent department or agency, while clearly defining the waste-related roles and responsibilities of remaining institutions. ▸ APEC PPR 6: Where appropriate, enable the establishment of innovative, transparent funding approaches. These might include independent, blended pooled funding entities, and pay for performance delivery models. ▸ APEC PPR 7: Develop end-of-life incentive policy to stimulate recycling market demand and increase product recyclability; create conditions that encourage investments in waste collection, sorting and environmentally sound waste treatment. ▸ APEC PPR 9: Set strong environmental standards with reliable and transparent monitoring; consider community engagement strategies for transparency and accountability. *Increase funding available to pay for waste management.* ▸ APEC PPR 5: Increase dedicated financial support from domestic governments and encourage other stakeholders including the domestic and international financial community and other private sector actors to invest in local waste management. ▸ Apply for DFI funding for seed research and provide mechanism for cities to access funding.	▸ APEC PPR 1: Set ambitious yet attainable waste management targets at the economy-wide and municipal levels in consultation with affected stakeholders, consistent with the Sustainable Development Goals (SDGs) and, as appropriate, The Paris Agreement on Climate Change, and encourage regions or provinces to develop detailed action plans to reach agreed targets. ▸ APEC PPR2: Build waste management performance indicators and methodology to track progress against economy-wide and municipal waste targets, maintain an economy-wide waste database, and encourage and acknowledge frontrunner cities for their overall waste and sanitation achievement through competitive award and certification. ▸ Facilitate collective waste services like shared landfills or treatment facilities across cities. ▸ Facilitate best-practice learning and technical expertise support across cities.	▸ APEC PPR 8: Encourage the waste picker sector to assume new service roles in waste collection, recycling, composting and treatment through facilitation by NGOs and municipalities to improve health and safety while improving economic livelihoods. ▸ Fund best-fit collection and separation for an integrated recycling and treatment system. ▸ Reduce investor risk by making it difficult and expensive for changing regimes to default on long-term contractual agreements unless operators are not delivering as promised. ▸ Work with civil society and community organizations to ensure that health, wellbeing and economic livelihoods of waste pickers are protected and that proposed waste management system is environmentally sound.

Private sector	Development finance institutions and grant funders	Investors
‣ Support best-fit collection and separation for an integrated recycling and treatment system. ‣ Collaborate among producers, brands and recyclers to review and improve the recyclability of plastic disposable products. ‣ Consolidate existing R&D efforts into a dedicated R&D fund for circular recycling and treatment options [29]. ‣ Fund recycling and treatment seed research with DFIs. ‣ Provide offtake agreement guarantees for waste-derived output, where applicable. ‣ Apply business expertise to improve waste management through interventions like improving logistics of waste management transport or using marketing prowess to change dumping and burning culture.	‣ Fund start-up operational costs (grant funders) and infrastructure for best-fit collection and separation for an integrated recycling and treatment system. ‣ Fund recycling and treatment seed research (i.e., feasibility study, technical assistance) with leveraged partner. ‣ Provide recycling and treatment capital expenditure investment funds for quality projects.	‣ Provide pay-for-performance financing mechanisms to accelerate achievement of national waste targets. ‣ Set up stacked funding mechanism for multiplayer participation in integrated waste system portfolio investments. ‣ Provide capital expenditure investment funds for quality projects. ‣ Consider funding recycling and treatment seed research with DFIs

Civil society and community organizations	Entrepreneurs and operators	Academics, engineers and scientists
‣ Offer credible insights on key cultural contexts to help make an integrated waste system strategy successful in local regions. ‣ Ensure transparency around financial flows, sector reform efforts, and technology and compliance monitoring of waste management systems and related policy and funding processes. ‣ Mobilize citizens, drawing on local traditions of coordination and cooperation to change waste culture and embrace agreed upon local waste strategies. ‣ Serve as implementation partners with cities and local governments. ‣ Administer small-scale microfinance programs, where applicable.	‣ Develop business plans for investable, vertically integrated waste management projects. ‣ Apply for seed financing. ‣ Build and run integrated recycling and treatment facilities.	‣ Provide R&D innovations in circular recycling and treatment technologies that enable currently "low-value" unrecyclable waste to become recyclable in environmentally sustainable ways. ‣ Develop new organizational and business models for collaborative waste efforts. ‣ Innovate on product and delivery system redesign. ‣ Conduct further research on the volume and impact of plastic marine leakage. ‣ Evaluate the impact of different policy and practice interventions.

3 AN INTEGRATIVE CHAIN OF WASTE ACTIVITIES MAXIMIZES VALUE

Around the world, the value of materials recovered from the waste stream is presently insufficient to pay for waste's collection and disposal costs. The aim of future waste management systems is to maximize value and minimize costs in order to reduce the deficit to the point that the system is economically sustainable, or until the deficit better matches people's willingness and ability to pay for it as a service.

Waste economics

If entrepreneurial market forces are more sustainable than ongoing funding support, then improving the economic fundamentals of waste management are essential to achieve significant waste management improvements at scale. However, while well-designed waste management systems can generate revenue, waste management operates at a net cost in countries across all income levels today — including Indonesia, Vietnam and the Philippines. To improve the financial equation, money must be spent at the front of the chain (collection and separation) to improve the value of what can be made in the middle of the chain (recycling and treatment) (Figure 3). Some countries are able to generate enough profits to defray some of the front end and back end costs. But on average, only 70% of total integrated waste management costs can be covered by the profits from recycling and other waste treatment **[30]**.

The goal of waste management systems in the future is to maximize value and minimize costs in order to reduce the deficit to the point that the system is economically sustainable, or until the deficit better matches people's willingness and ability to pay for it as a service. While the pure economics of waste value are limiting, the broader benefits in improved health, job growth, lower climate impact and avoided fishery, tourism and beach costs are significant **[4]**.

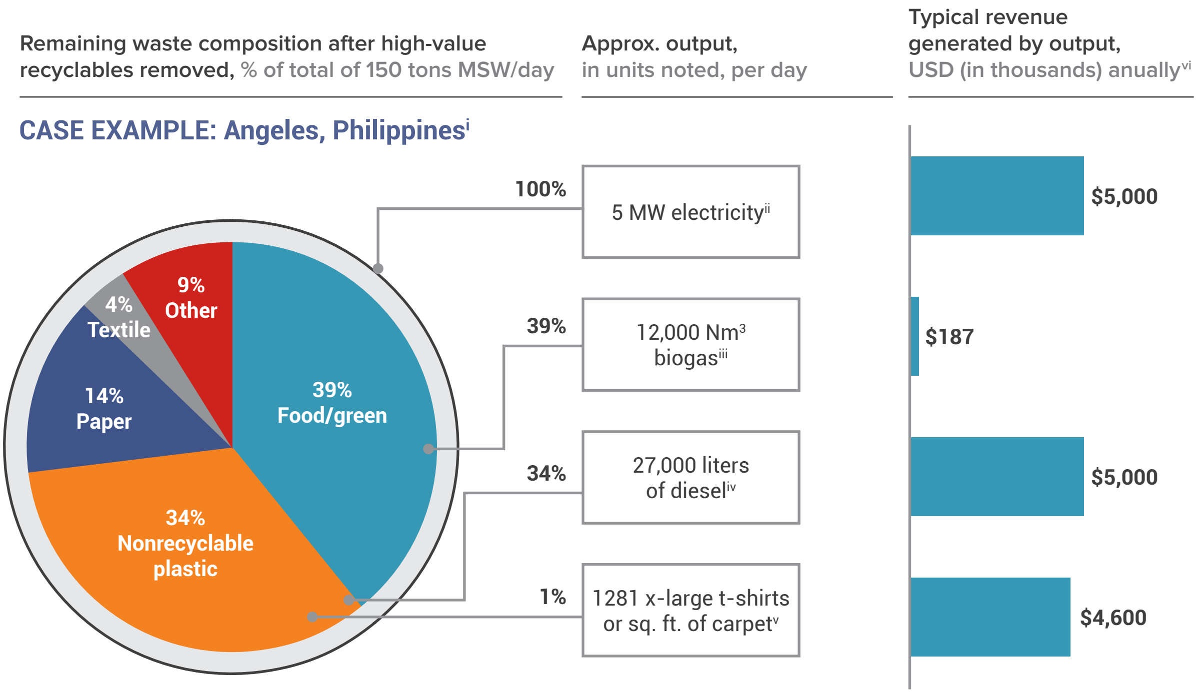
FIGURE 3. TRADITIONAL WASTE VALUE CHAIN

Front (net cost)	Collection ↓		Collection, generally carried out by municipal workers or privately paid haulers, involves collecting disposed waste from households and institutions and then transporting that waste to either a transfer station or landfill.
	Separation ↓		Waste can be sorted both before (source separation) and after collection at material recovery facilities (MRFs). Both source separation and MRFs increase the efficiency of recovering recyclables from municipal solid waste, but they require investments and other enabling conditions to work.
Middle (sometimes profitable)	Recycling *Plastics, metals, glass, cardboards*		Waste is minimized through the recovery and reprocessing of usable products that might otherwise be discarded. ↓
	Treatment		
	Organics	Anaerobic digestion	The biological conversion of organic materials (typically food/green waste) in the absence of oxygen via microorganisms.
		Compost	Decomposition of organic material (typically food/green waste) as a result of the action of aerobic bacteria, fungi and other organisms.
	Residual plastics, dirty cardboards	Waste repurpose	Numerous processes that take plastic waste as input material into other products such as road construction, railroad ties and building materials.
		Chemical recycling[i]	A catalyst and heat are used to break plastic polymer chains apart and create monomers. These monomers can then be "reassembled" into new polymers to create new plastic material that approximates virgin plastics.
		Pyrolysis/catalytic cracking[i]	Pyrolysis is the thermal decomposition of waste materials at high temperatures (200-800+ C, technology dependent) without the addition of air or oxygen resulting in solid and/or liquid residues as well as a gaseous mixture.
		Gasification[i]	Gasification is the thermal decomposition and partial oxidation of waste materials at high temperatures (400-800+C, technology dependent) using a limited amount of air or oxygen, resulting in solid residues and a gaseous mixture.
	↓	Incineration[i]	Incineration is the thermal decomposition and rapid oxidation of waste materials at high temperatures (230-800+C, technology dependent) with the addition of air or oxygen as sub-stoichiometric to excess levels, resulting in solid residues and a gaseous mixture.
Back (net cost)	Dumpsites and landfills *Inert (stones porcelain)*		Waste is disposed of in a pile that is usually underground and may be sanitary (i.e., measures taken to prevent leachate) or unsanitary (no prevention measures taken).

i Outputs from all thermal processes must be managed carefully in environmentally sound ways.

Under perfect conditions, most of the waste stream would be recycled and the remaining waste would be converted into compost or fertilizer, building materials, monomers, fuels, gases, or other useful commodities. For example, cities like Edmonton, Alberta, and San Fernando, Philippines, are able to derive value from 90% and 80% of their waste respectively, benchmarking what's possible **[31]**. Figure 4 shows potential conversion outputs and corresponding gross revenues for a typical peri-urban waste stream in the Philippines even after "high-value" recyclables have been picked out of the waste stream by the informal sector. This example does not account for the costs nor the complexities of the conversion technology, which in most cases significantly offsets the revenue generated (as explored later in **"Accelerating waste treatment innovation"**), but it does show that inherent value is present within even "low-value" waste.

FIGURE 4. EXAMPLE OF POTENTIAL REVENUE OF WASTE CONVERSION OUTPUTS FROM PREPICKED MUNICIPAL SOLID WASTE (MSW) [32]



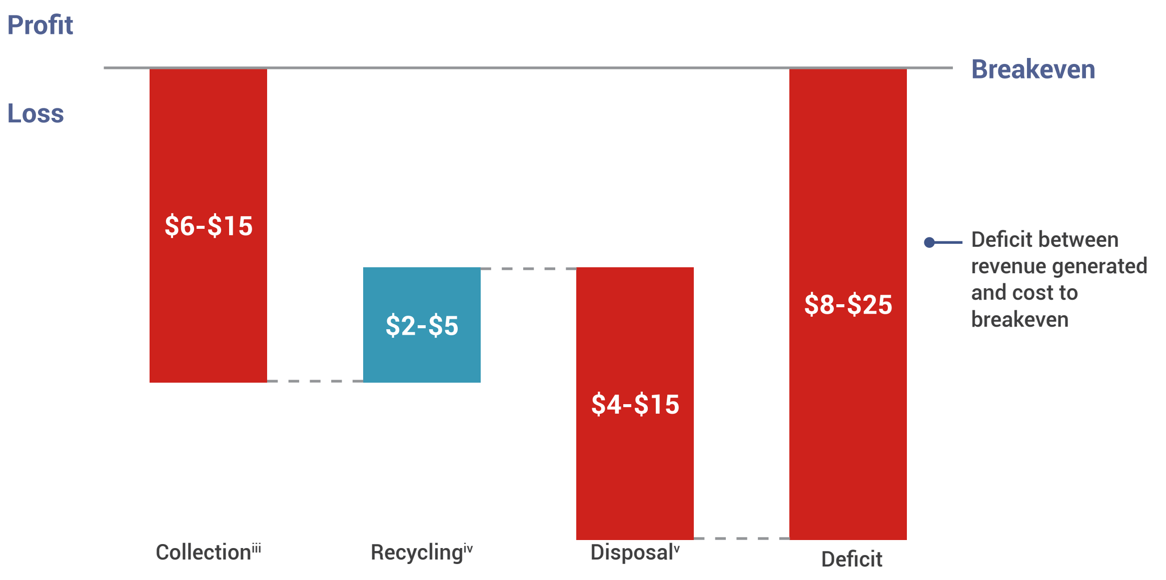
i Model case example based on a waste characterization study of Angeles, Philippines, pre picked MSW waste composition of 150 metric tons per day.
ii Assumes mechanical segregation of biodegradables from combustibles, then AD/gasification and conversion to energy; gross power.
iii Assumes biodegradables through AD; biogas composed of 60% methane and 40% carbon dioxide and others.
iv Assumes approximately 40 metric tons of handpicked plastic and a pyrolysis unit running at 60% efficiency.
v Assumes 0.6 metric tons of PET, and 19 20oz. bottles (weighing 24 g. each) to make 1 x-large t-shirt or 1 sq. ft. of carpet.
vi Assumes electricity at $0.14/kWh; natural gas at $1.93/MMBTU; diesel at $0.60/liter; t-shirts at $10 each.

But, in Indonesia, the Philippines and Vietnam challenges remain. Today, collection and landfill systems are often inadequately funded from household fees and city proceeds. Moreover, waste items such as metal, glass, paper and PET bottles are removed with great efficiency by informal recyclers ("waste pickers") and lost in the informal market, so these high-value items cannot reduce the net cost activities of the rest of the waste chain. The remaining low-value waste consists primarily of organics and plastic films that cannot be converted to higher value output without investment in waste separation (see box **Separation of waste into "wet" and "dry" fractions**) and costly, sometimes unproven, treatment technologies; it is therefore destined for landfills. In fact, the Ellen MacArthur Foundation's report, **"The New Plastics Economy,"** found that about 95% of plastic packaging material's value, or $80 to$120 billion annually, is lost to the economy after a short first-use cycle **[8]**.

Figure 5 shows a simplified example of today's typical waste chain economics, with collection and disposal costs surpassing any profits from waste recycling. Without structural improvements, these poor economics will continue to stymie the efforts of cities and agencies to pursue the private-public partnership arrangements necessary to tackle this problem, and investors will continue to feel waste management offers a return too low for the perceived level of risk.

FIGURE 5. WASTE SYSTEM DEFICIT [30]

Typical net cost/profit of waste value chain activities[i, ii]
$/ metric ton



i Model case example with all costs normalized over 313 metric tons.
ii Treatment is left out given as-is scenario and low treatment facility penetration today.
iii Collection costs exclude disposal tipping fees, which have been reallocated to disposal costs.
iv Recycling profit includes material recovery facility (MRF) costs.
v Landfill scenario includes open dump on the low range, given as-is scenario.

Designing the system for maximum value and minimum costs

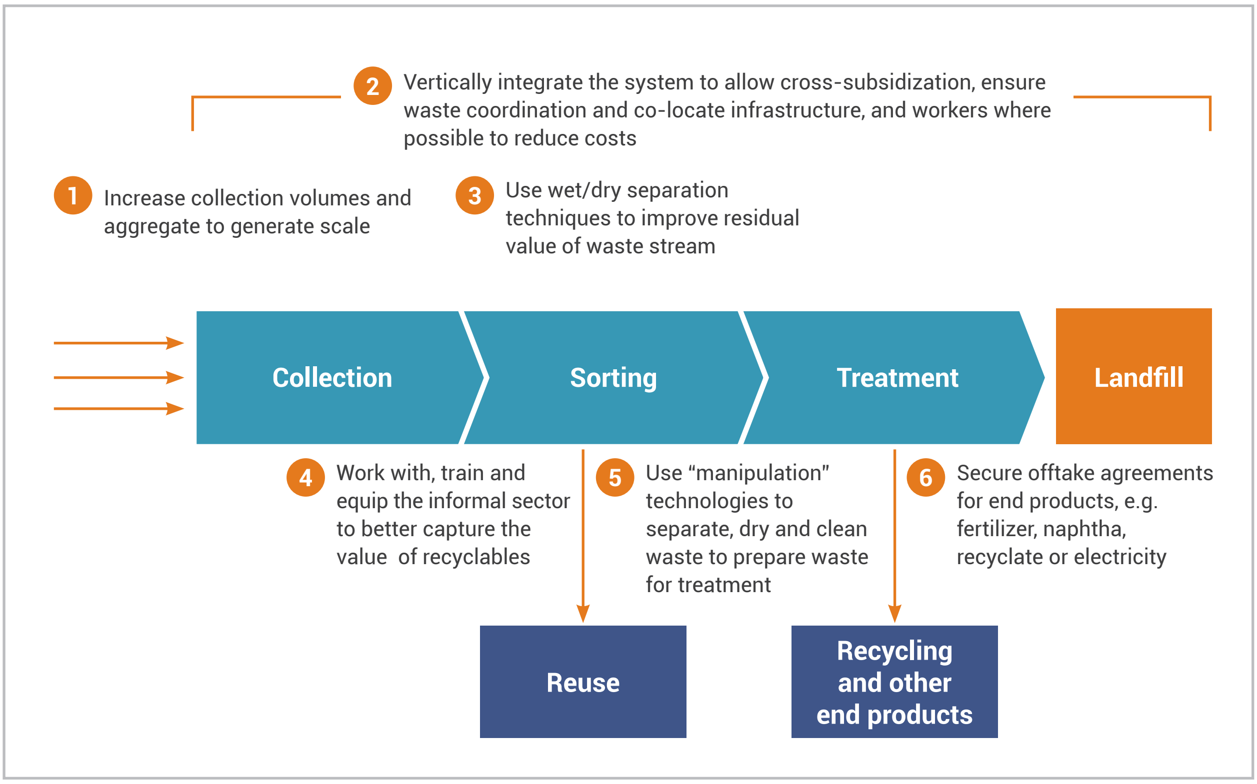
The central challenge is to make sound waste management financially sustainable long after initial seed investment has been given. Doing so requires designing the entire waste management system as one integrated whole, starting with establishing a strong collection foundation. In this type of "systems technology," many components are finely tuned to service one goal, and there is a high degree of dependency; decisions made in one part of the waste chain have ripple effects further along the chain. An increase in the collection rate and amount of waste that is separated into wet and dry streams increases the quality of feedstock for mechanical and chemical recycling solutions as well as other emerging technology options. This, in turn, prepares the way for favorable conditions for deriving value from an ever greater proportion of the waste stream.

The entire waste stream — high-value recyclables, organics, residual plastics and waste, inert materials, and hazardous materials — must all be addressed. Plastic waste leakage cannot be solved in isolation.

The following six levers (shown in Figure 6 and discussed in greater detail in sections 4 and 5) will need to be implemented in a coordinated approach to increase the value that can be derived from the waste stream:

1. Increase collection levels and aggregate waste volumes to generate scale. Most recycling and treatment technologies require sufficient scale to justify capital investment.
2. Build vertically integrated waste systems to allow cross-subsidization, ensure waste stream coordination and co-locate infrastructure where possible to reduce land, transport and overhead costs.
3. Use wet/dry separation techniques to ensure residual value of the waste stream. Wet/dry separation allows for higher recycling rates and better quality, more homogenous feedstocks for treatment options.
4. Use "manipulation" technologies to separate, dry and clean waste to prepare waste for further treatment.
5. Give the informal waste picker sector the opportunity (but not the mandate) to work with the formal integrated waste system in an entrepreneurial way.
6. Integrate with or develop markets for end products with secure, long-term offtake agreements.

FIGURE 6. IMPROVING THE ECONOMICS OF WASTE MANAGEMENT [33]



System profitability has been achieved over the past decade for solar and wind power, where smart incentives, good policy and deep public-private investment have dramatically improved costs and performance. The energy revolution is on the path for success because it was realized early on that the entire system — not just a specific technology — needed to be optimized and recalibrated. The same can be accomplished in waste management.

Making the waste management system sustainable will require funding of a collection infrastructure that accelerates modern waste treatment and recycling methods; provides convenient access to aggregated, separated materials; accelerates development and employment of new treatment technologies; provides for inclusion opportunities for waste pickers to participate in formal waste management; and steadily increases the proportion of plastic products that are profitably recyclable. Therefore, building a more sustainable waste system in Indonesia, the Philippines and Vietnam consists of two key strands of action: 1) fixing the front end of the waste system by building a modern waste collection and separation system, and 2) fixing the middle by accelerating recycling demand and waste treatment innovation while ensuring nonprocessed waste is disposed of safely in sanitary landfills at the back of the chain. To complement this approach, recently endorsed APEC policy and practice recommendations have been highlighted in nine priority areas where Member Economies are able to take specific action.

The funding gap in waste management

Waste management is costly to governments, and waste management is often not a high priority. Waste management costs are forecasted to nearly double to $376 billion annually in 2025 from $205 billion annually in 2010 **[34]**. Globally, there is a revenue gap of $40 billion annually in financing for the MSW sector **[35]**. The World Bank estimates that upper middle income countries spend approximately $25 billion annually on waste management, and that high income countries spend roughly $160 billion annually — more than six times as much **[36]**.

There are established models for covering those costs, typically by combining municipal revenues from taxes and direct fees paid by households to haulers. However, funding levels in many developing economies are inadequate. According to the **UNEP and ISWA Global Waste Management Outlook report**, for economies aiming to increase collection rates to levels of 95% or higher, spending 1% of gross national income (GNI) is considered best practice **[37]**. In Indonesia, 1% of GNI would translate to about $70-$130/metric ton of waste generated **[38]**. Yet many economies spend far less than 0.5% **[4]**.

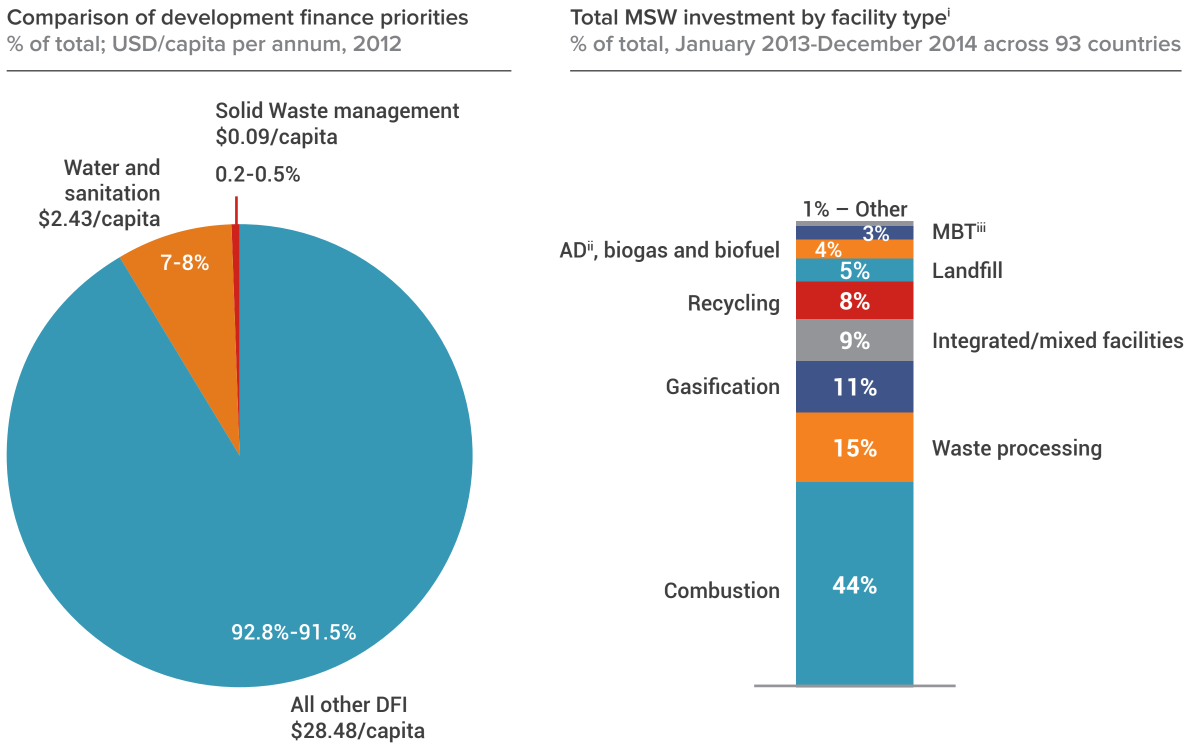
Cities with competing priorities for already constrained budgets have tended to keep collection levels low in order to reduce waste expenses and extend landfill life. The untaxed, informal economy is significant, and city revenues from land and property taxes, utility tariffs, turnover taxes and vehicle taxes are limited, especially in small cities and rural areas with high unemployment and low income tax bases. Some countries' national regulations restrict borrowing, and the poor financial condition of local governments decreases their creditworthiness.

In addition, many households either cannot afford collection fees or by virtue of cultural norms do not place enough value on collection to pay a fee for the service, especially when the alternatives of dumping, burning or burying trash is culturally acceptable, poorly regulated and free **[39]**. Affordability is a real challenge when 60% of households in Jakarta, Indonesia, spend one-third of their income on water and electricity, with little disposable income leftover for other necessities like waste disposal **[40]**.

While national waste budget data is difficult to secure, in 2014, the Indonesian Directorate General of Human Settlement's budget for waste management was $105 million, 0.1% of the national tax revenue and 0.01% of GNI. Although additional funds were leveraged from a grant from the German government **[41]**, Indonesia still lacks the budget necessary to meaningfully assist local regions with funding shortages.

DFIs also generally underspend on waste management. Despite the demonstrated human health, economic and environmental impact, less than 0.3% of total DFI lending went to waste management in 2012, as compared to 8% for water infrastructure (Figure 7). An increase to just 1.5% would create $3 billion of additional funding for waste management **[42]**. In addition, DFI contributions are generally at the national level, which makes it challenging for cities to access them. Funded programs are targeted at treatment infrastructure, particularly sanitary landfills and waste to energy, rather than collection. Thus, the system is unbalanced, making follow-on investment more not less risky.

FIGURE 7. DEVELOPMENT FINANCE FUNDING INTO WASTE MANAGEMENT AND WASTE MANAGEMENT INVESTMENT BY FACILITY TYPE [43]



i Municipal solid waste (MSW) investment covers $85 billion in MSW facility development projects between July 2013 and December 2014 across 93 countries. Figure may underrepresent smaller, lower technology projects such as landfill investment. Some projects will not pass feasibility and therefore the total active project value is higher than ultimate amount invested.

ii AD is an abbreviation for anaerobic digestion.

iii MBT is an abbreviation for mechanical biological treatment.

4 FIXING THE FRONT END: BUILDING A MODERN WASTE COLLECTION AND SEPARATION SYSTEM

A successful waste system depends on reliable collection and smart separation to match downstream treatment operations. Multiple waste stakeholders have a role to play in overcoming the funding shortfall and structural challenges.

Building robust waste targets, monitoring systems and governance

As a first step, governments can aim to set ambitious yet attainable national collection and SWM targets. These can take advantage of synergies with other important high priority global and regional agreements. Waste management is for example well embedded within the majority of Sustainable Development Goals, including sustainable consumption and production, safe cities, health for all, clean water and sanitation, climate change and poverty alleviation. Figure 8 shows how the international Sustainable Development Goals breakdown in terms of waste management.

FIGURE 8. WASTE MANAGEMENT'S CONNECTION TO THE SUSTAINABLE DEVELOPMENT GOALS [44]

Graphic supplied with assistance from Zoë Lenkiewicz, WasteAid UK and contributor to Be Waste Wise.

Waste management is also a goal embedded within the sustainability goals of ASEAN's Socio-Cultural Community Blueprint 2025, a key guiding regional document. Specifically, sustainability goal C.4.iii states, "Enhance capacity of relevant stakeholders to implement sound waste management and energy efficiency," and sustainability goal C.4.iv states, "Promote the integration of Sustainable Consumption and Production strategy and best practices into national and regional policies or as part of CSR activities." These are in addition to Blueprint 2025's sustainability goal C.1.iii: "Promote cooperation for the protection, restoration and sustainable use of coastal and marine environment, respond and deal with the risk of pollution and threats to marine ecosystem and coastal environment, in particular in respect of ecologically sensitive areas **[45]**."

Waste management targets can also be integral toward achieving the targets of the recent Paris Agreement attained at COP 21 **[46]** and other green economy indicators, as explicitly stated in the first policy and practice recommendations:

APEC policy and practice recommendation 1 – Set ambitious attainable targets:
Set ambitious yet attainable waste management targets at the economy-wide and municipal levels in consultation with affected stakeholders, consistent with the Sustainable Development Goals (SDGs) and, as appropriate, The Paris Agreement on Climate Change, and encourage regions or provinces to develop detailed action plans to reach agreed targets.

Provincial and regional governments can play an important role in supporting cities to achieve nationally set targets. They can work with cities to develop individual waste management plans that aggregate into regional level plans. They can also facilitate best-practice sharing, technical expertise and even collective waste services across multiple cities.

REGIONAL LEADERSHIP TO REACH WASTE TARGETS IN BELGIUM AND THE PHILIPPINES [47]

In Belgium, each region is responsible for developing regional waste plans with clear goals and targets every four to five years to achieve national targets. Regional authorities work closely with local authorities throughout the entire planning process. They support cities with the development and implementation of waste policy and identify opportunities to group cities to share in collective waste management services like shared landfills and treatment facilities. With this approach, they have achieved some of the highest waste diversion rates in Europe with total material recovery exceeding 70% — close to 50% of waste material is recycled and 22% is composted.

The Philippines also uses a regional approach to reach nationally set waste targets. For example, each city and municipality was mandated to draft a ten-year plan on how it plans to achieve nationally set waste diversion targets of 50% by 2015. These and subsequent plans are then consolidated into ten-year provincial level implementation plans, which are then reviewed and accepted by the National Solid Waste Management Commission.

Targets are only as good as the monitoring and measurement system behind them, and too many cities, regions and countries have insufficient or poor quality data on basic waste statistics like waste generation, collection levels and composition. To support targets, consideration should be given to developing key, carefully standardized waste definitions (e.g., definitions of what is recyclable, organic, etc.) and establishing waste statistics (e.g., waste generation, composition, collection rate, recycling rate). These would ideally be reported from local, regional and national aggregated levels and stored in a transparent database accessible by all stakeholders. An independent agency or firm can provide an auditing and verification function. Strong transparency on waste volumes, flows and costs helps all waste stakeholders plan better and reduces their risk while also giving investors more confidence.

Frontrunner cities that lead nations in their waste management achievements could be identified through a competitive certification process by regional governments and then rewarded and held as role models for other cities to learn from and emulate at regional and national levels. Waste management thus becomes a core theme of "smart cities" and used as a proxy indicator for good urban governance. These ideas are included in APEC policy and practice recommendations 2 and 3:

APEC policy and practice recommendation 2 – Measure and reward progress: Build waste management performance indicators and methodology to track progress against economy-wide and municipal waste targets, maintain an economy-wide waste database, and encourage and acknowledge frontrunner cities for their overall waste and sanitation achievement through competitive award and certification.

APEC policy and practice recommendation 3 – Determine shared terms: Issue APEC guidelines on the development of definitions related to sustainable materials management (SMM) that facilitate trade in new technologies, and investment in recycling, recovery and other related SMM solutions.

APEC Member Economies should continue to work through the APEC Regulatory Cooperation Advancement Mechanism (ARCAM) to help ensure that definitions of SMM-related terms encourage rather than hinder trade and investment. In addition, diagnosis and decision-making by government bodies can be confounded by overlapping ownership of waste management programs and competing agendas among departments. Research has shown that in some cases, more than twenty government agencies and departments are involved in waste management efforts. Recognizing this, the Ecological Waste Management Act (2000) in the Philippines, which frames the country's waste guidelines, established a separate National Solid Waste Commission as a policymaking body and support agency for the implementation of SWM policies. The fourth APEC policy and practice recommendation addresses unclear boundaries of responsibility:

APEC policy and practice recommendation 4 – Streamline decision-making: Concentrate the majority of municipal solid waste responsibilities within a single government entity or independent department or agency, while clearly defining the waste-related roles and responsibilities of remaining institutions **[47]**.

The importance of establishing a sound collection base

Collection is the foundation and starting gate for the entire waste management system and keeping plastics and other waste out of the ocean. A good collection system enables the downstream operations to scale and generate the returns the whole subsystem needs to succeed. In particular, advanced mechanical and chemical recycling operations and many other treatment options depend on reliable collection streams and smart separation. These make leading-edge conversion and reuse systems possible. There is a "leapfrog" opportunity to design the collection system for the technologies and products with an eye to the recycling and treatment technologies of the future, where waste is not given a second or third life. Success requires more than waste consolidation; it also requires a smart separation approach that dovetails with a matching treatment process. Treatment processes like recycling and composting or conversion practices like chemical recycling, gasification, pyrolysis or other forms that can create downstream value require specific separation regimes, often starting with simple "wet" versus "dry" streams **[48]**. Specific waste sorting is only productive when there is a clear market opportunity for recycling and treatment that can be exploited by using a particular waste type.

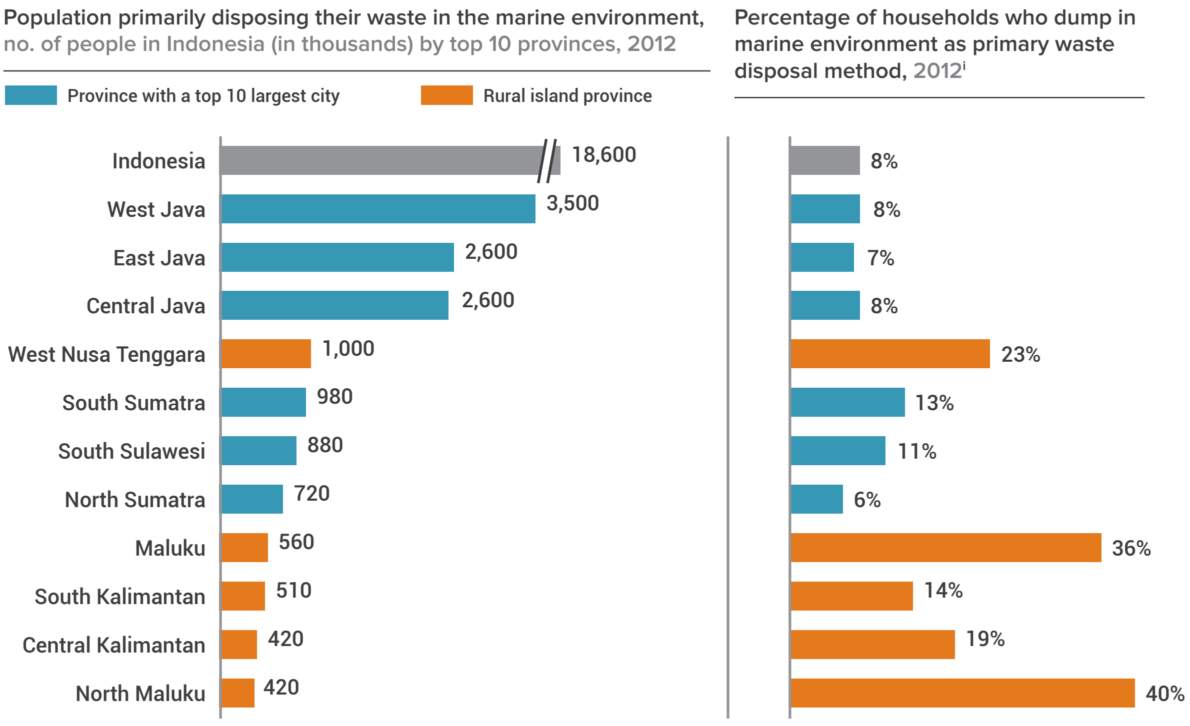
SEPARATION OF WASTE INTO "WET," "DRY" AND "RECYCLABLE" FRACTIONS

Sorting waste materials into different fractions, starting with a simple "wet" (e.g. food waste, yard waste and organic material), "recyclable" (e.g., commodities that can be resold, such as plastics and metals) and "dry" (i.e., everything else) system, significantly increases the value that can be generated from the waste value chain. Waste sorting can happen before collection by households (i.e., source segregation) or after collection using technology and workers through material recovery facilities (MRFs), or a combination of both, depending on local conditions and what's most needed within an integrated waste management system. The more sorting conducted by households, the more value that can be extracted from the material by waste pickers, recyclers and treatment operators; and the less capital and labor required to process the waste to the needed quality. In fact, one of the most significant challenges to generating value from waste is cross-contamination of wet with dry. If a recycling or treatment facility has too much wet waste contaminating in its feedstock, then the value of the commodities or gas it can sell is depressed. Similarly, inorganic material contamination can reduce the effectiveness of an organics processor and the quality of its compost or fertilizer.

Although true source separation can be a tremendous enabler for cleaner, more valuable waste streams, there are a number of factors that must be in place to leverage this value. Implementation of source segregation requires the ability for recyclers and treatment facilities to use the source-separated waste. Proper infrastructure must also be in place (separate bins and waste transport), and effective household source-segregation education must occur in order to change behavior, sometimes over many years. If these conditions are not in place, segregation programs can increase collection costs with limited benefit. In addition, valuable funds spent on educational programs will be wasted and lead to frustration if households see collectors "remixing" trash; later re-education of households will be much harder and more expensive.

Collection is a concern in much of developing Asia; for example, collection coverage is as low as 56% **[49]** in metropolitan areas and 5% in rural areas in Indonesia **[50]**. Although leakage rates are highest in rural island locations without formal collection services, the total volume of leakage is highest in metropolitan areas with larger population numbers, for example, on the islands of Java and Sumatra in Indonesia (Figure 9).

FIGURE 9. INDONESIA MARINE DUMPING BY TOP 10 PROVINCES [51]

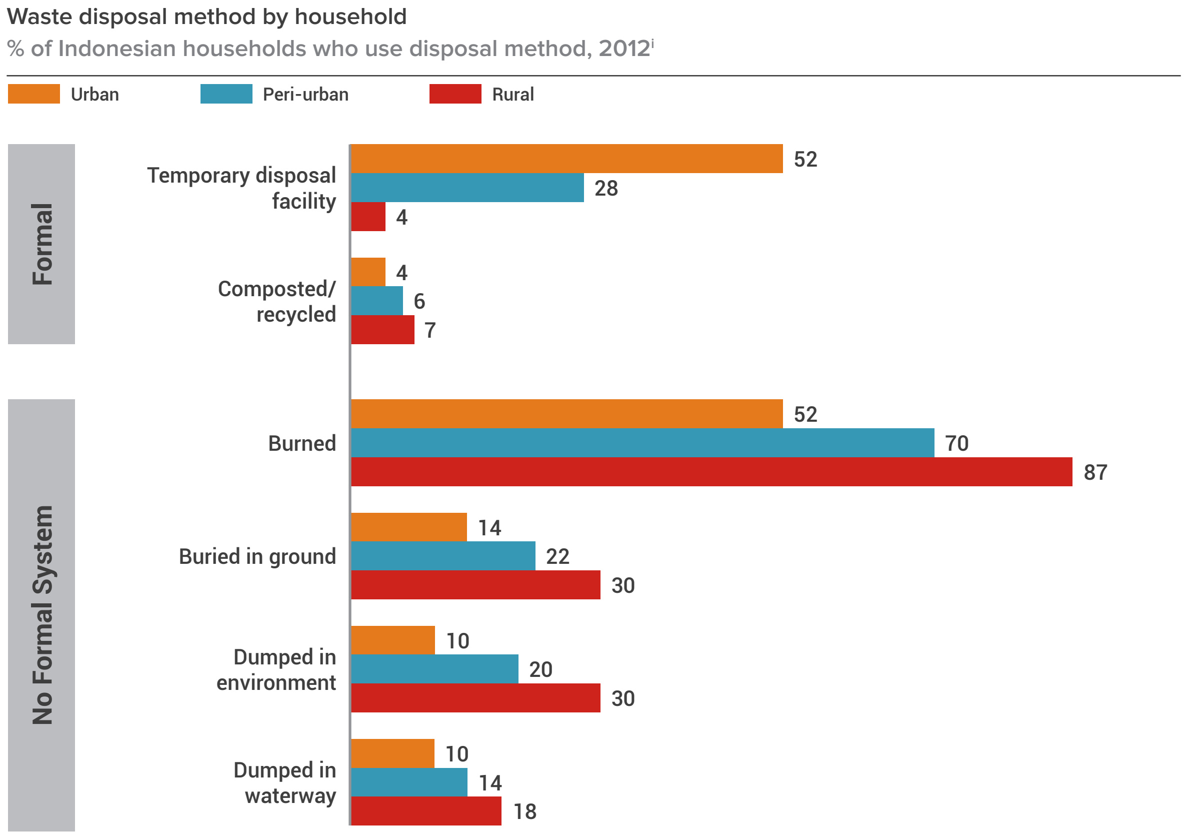


i Only top ten of 34 Indonesian provinces included.

A significant portion of uncollected waste ends up in lakes, rivers and oceans, contributing to plastic pollution. In fact, ***Stemming the Tide*** found that 75% of marine debris came from uncollected waste from the five economies identified as having the greatest waste leakage **[12]**. Although households in the focal countries are applauded for a culture of reuse and lower waste generation levels than comparable households in Organisation for Economic Co-operation and Development (OECD) economies, there are often deeply ingrained dumping and burning habits to deal with uncollected waste, with over 50% of Indonesian urban households and almost 90% of rural households burning waste, for example, shown in Figure 10 **[51]**. The climate impact from burning trash is significant: approximately 40% of global black carbon is emitted from the burning of biomass and waste **[4]**. Black carbon is a potent climate pollutant with a relatively short life span of about 10 days and a global warming potential 3,000 times more potent than that of carbon dioxide over a 20-year period **[52]**.

According to a study by Indonesia's Central Bureau of Statistics on environmental behavior, which surveyed 75,000 Indonesian households across all provinces in 2013, 10-18% of Indonesian households dump their waste directly in waterways and 10-30% dump it in an environment where it can leak into waterways (Figure 9). In fact, 18.5 million people in Indonesia use waterways as their primary trash disposal method, and many millions more use waterways as one of a several methods of disposing trash **[51]**.

FIGURE 10. INDONESIA WASTE DISPOSAL METHOD BY HOUSEHOLD [51]



i *Households asked to list all methods they use to dispose of household waste (answers will therefore not add to 100%).*

Dumping and burning of household waste was a common practice in many OECD countries before reliable waste management was established. In these countries, citizen behavior was changed through formal and informal education as well as public information and social marketing campaigns, often implemented in partnership with local civil society organizations. Changing citizen behavior is an important component of establishing an effective collection and separation program. Investments in these education and social marketing campaigns should be considered as an integral part of implementing waste collection.

Even if waste is collected, leakage into the ocean can occur. Approximately 25% of the plastic that ends up in the ocean from the five economies with the greatest waste leakage is waste that escapes from the collection system. This is primarily caused by inadequately covered waste trucks, illegal dumping practices to avoid landfill tipping fee costs, and improperly sited and secured temporary storage facilities and waste dumps located in flood zones and near waterways **[12]**.

Waste management, like many other quality-of-life enhancements in modern society, including other environmental and public health advancements, suffers from a classic "opt out" risk. This is perhaps most analogous to the classic herd immunity problem, in that full participation of a population is needed to achieve the public health benefit of something such as a vaccination. A single individual deciding to opt out can put the whole community at risk, for example by increasing the risk that a new strain of a preventable disease will spread. Similarly, households opting out of waste collection — thereby resorting to dumping or burning — inevitably externalize this harm and cost to others and the community-at-large.

Plastics producers and consumer brands have focused funding support toward recycling projects, showing stewardship of their branded merchandise in the waste stream. Their higher value plastic products are reliably collected by waste pickers, creating a virtuous cycle for this small fraction of the waste stream. However, collection and disposal do not yet have a similar steward.

Financing waste collection

On average, between $40-70/metric tons of waste is needed to cover basic, safe waste management services of collection and disposal in middle-income economies, depending on the model chosen with costs varying significantly depending on local conditions **[53]**. Today there is a funding deficit in many developing economies. Without building a viable collection (and separation) system, not only will the value that can be extracted from waste be limited, but also there will be no material reduction in marine debris. The goal of funding collection infrastructure is to prevent marine debris while building the guaranteed volume, pricing and quality structure needed to make recycling, composting and treatment more profitable and therefore attractive for investors **[54]**.

If this funding is shared among multiple stakeholders — national and municipal governments, private sector corporations and investors, donors, and DFIs — then the investment can be designed to be more manageable. In Jakarta, for example, total yearly collection costs are $65 million to $110 million **[55]**. A hypothetical funding model could consist of the municipality contributing 50% of the cost, the national government underwriting 10% annual operation cost, DFIs financing the MRFs and the rest funded by a voluntary private sector partnership for 10 years. Assuming this fund is an equal partnership of 10 major companies, this translates into $3 million to $4 million per player per year for the largest city in Indonesia, and much less for smaller cities — an amount well below the benefits of addressing the post-consumer plastic waste crisis piecemeal **[55]**.

Once effective, universal waste management has been in place long enough to change the culture of dumping and burning and to develop a reliance by households on waste services, then other funding mechanisms such as fees or pay-as-you-throw (PAYT) might be introduced to offset some of the collection costs. This consideration is summed up in APEC policy and practice recommendation 5:

APEC policy and practice recommendation 5 – Integrated waste management systems: Increase dedicated financial support from domestic governments and encourage other stakeholders including the domestic and international financial community and other private sector actors to invest in local waste management.

In a results-based financing or pay-for-performance structure, the government, a DFI or a private investor enters into a contract whereby payment of a contract (or release of funds) is made contingent on delivery of certain results or outcomes (e.g., more waste managed, more collection of low-value plastics, etc.). If these results are met, the contract is paid or the money is released. If not, the payment is either withheld or the payment is less. These structures provide incentives for the delivery of certain outcomes, and may even allow governments to outsource the risk of delivery of certain waste management outcomes to DFIs or the private sector. However, the incentive mechanism is strong, and if it is not aligned with the objectives of the project, there is a significant risk of unanticipated outcomes, where the optimization in one area leads to a serious problem in another. The World Bank has used results-based financing on waste management projects in eight countries to date, and while these pilot projects have not yet been evaluated for success, the model shows promise.

5 FIXING THE CENTER: ACCELERATING RECYCLING DEMAND AND WASTE TREATMENT INNOVATION

Defining the approach, aggregation and organization of the waste stream, as described in the previous section, is essential to priming waste treatment and recycling. However, much innovation and initiative is still needed to fit the right approaches and technologies to the right context. This section takes a systematic look at the financing and policy support required to get this done.

GROWING RECYCLING DEMAND

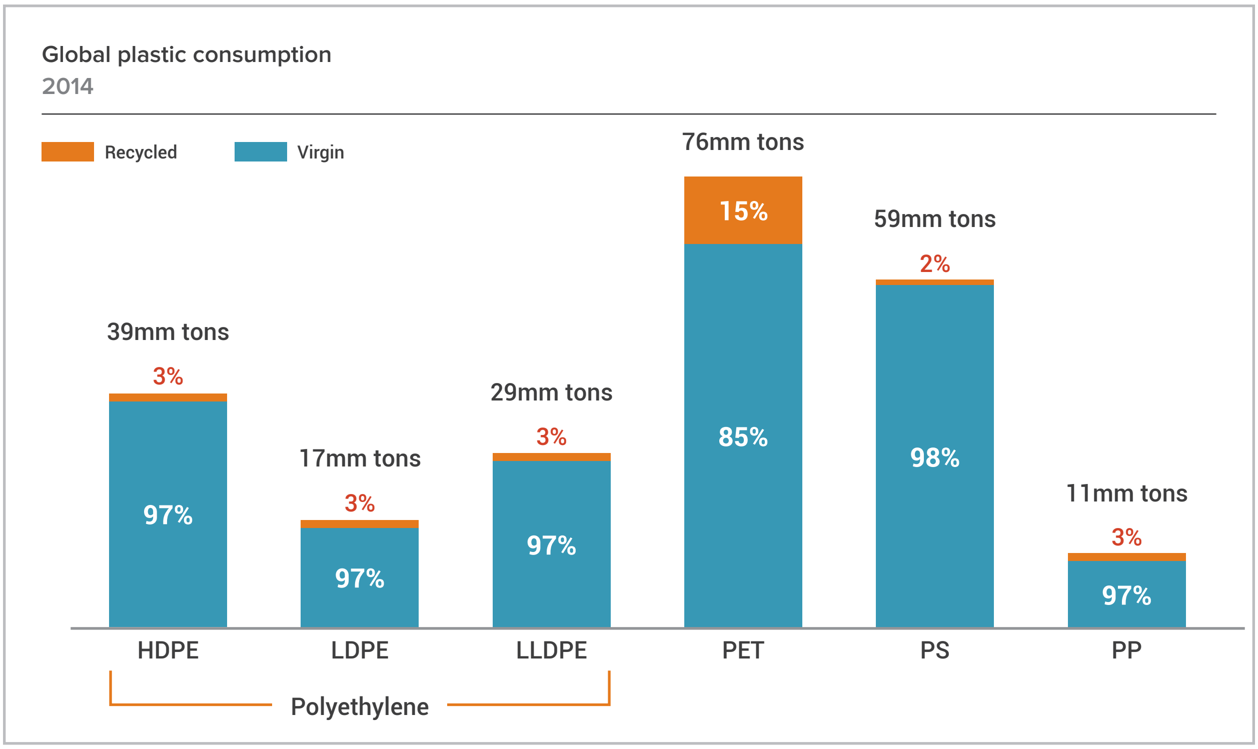
The state of plastics recycling

Most of the economic value of plastic packaging is lost after a short first-use cycle, and new plastic products contain less than 10% of recycled material, most of which is used in PET and HDPE bottles. Although there is significant opportunity for growth, decentralized waste pickers struggle to compete economically against virgin plastic processing facilities.

Although the majority of metal waste is recycled, the same cannot be said for plastics. On average, only 10-20% of plastic waste in the focal geographies is profitably recycled, primarily by waste pickers. This small market of high-value plastics operates profitably with minimal if any funding support in developing (but not developed) economies, though often with narrow margins tied to commodity oil prices. Much of the remaining, low-value, plastic waste (e.g., single-use food service and medical packaging, thin film convenience items, and sophisticated packaging designs that are difficult to disassemble) does not yet have sufficient value in local markets to justify its collection given current virgin material prices and the existing waste management infrastructure in these regions.

But the low value of most plastic waste is not merely a regional issue. Product designers in many industries around the world generally prefer virgin feedstock given its current lower cost and greater versatility compared to recycled feedstock. In some cases, there may be challenges to using recycled plastics for food contact and pharmaceutical packaging. On average, only 8% of the world's plastic products contain recycled feedstock, primarily polyethylene terephthalate (PET) (Figure 11). The Ellen MacArthur Foundation's report, **"The New Plastics Economy,"** found that about 95% of plastic packaging material's value — $80 billion to $120 billion annually — is lost to the global economy after a short first-use cycle **[8]**.

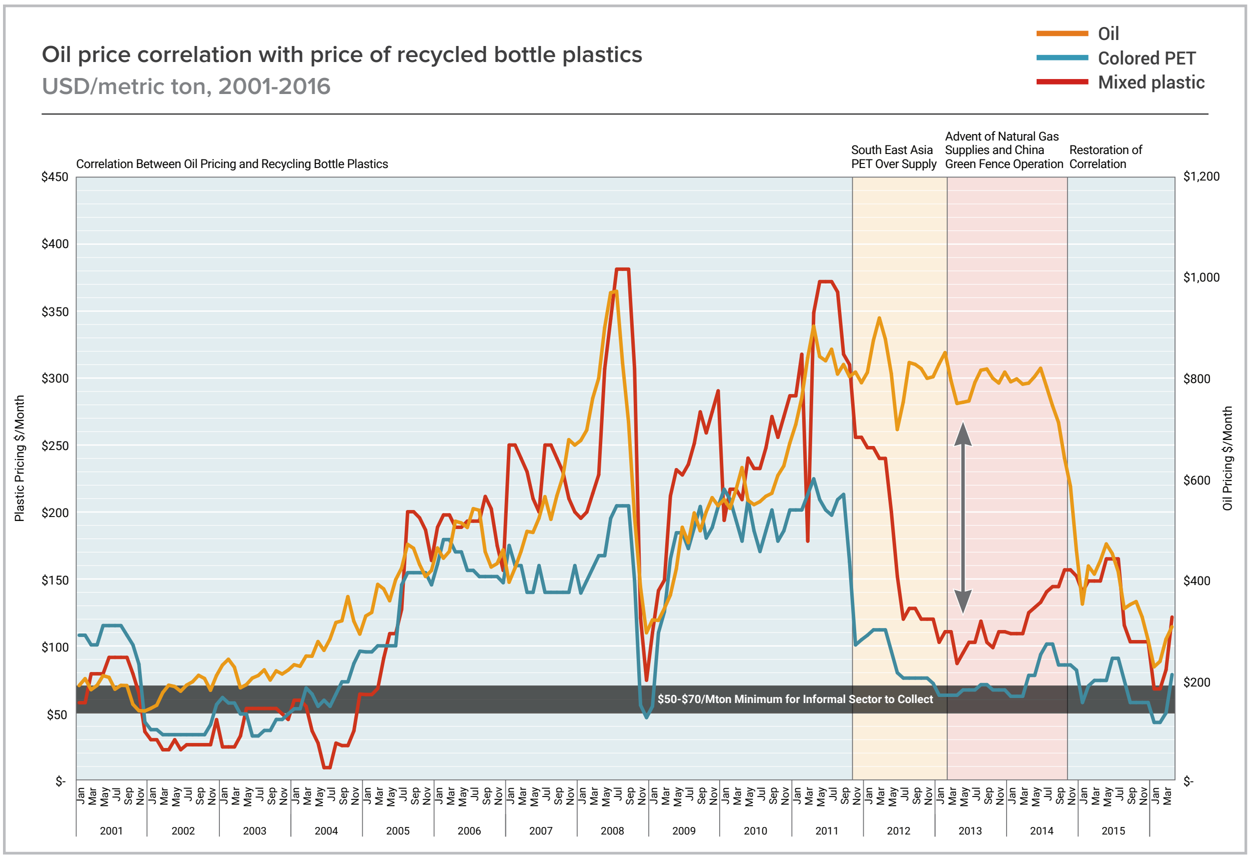
FIGURE 11. RECYCLED CONTENT IN GLOBAL PLASTIC PRODUCTION [24]



Crude oil and natural gas prices govern the price of virgin plastics. Virgin plastics are commonly derived from fossil fuel derivatives from crude oil refining (cracking) or natural gas processing, as well as through the fermenting sugars of different bio-based feedstocks to yield chemical intermediates. It is produced in sophisticated plants in large volumes. Recycled plastics, in contrast, are produced in small, decentralized batches, using low-technology processes. Not surprisingly, recycling plastic waste can cost more than producing virgin plastics at low crude oil prices. In fact, at oil price levels below $40-50/bbl, the private plastic recyclers struggle to compete, and processing innovation stagnates. This is especially challenging given the historically unstable and currently low price of oil. Volatile oil prices are likely to be a major challenge, and solutions must be implemented that remain viable even if oil prices change.

Figure 12 shows 15 years of oil pricing versus key recycling prices. From mid-2003 to mid-2011 the oil and recycling markets were in a healthy equilibrium. Mid-2011 saw the advent of significant recycling market disruptions, including a severe oversupply of PET due to overbuilding PET plant capacity (mid-2011 to late 2012) and the implosion of natural gas prices (early 2013 to late 2014). Also in play were the downstream effects of China's Green Fence program, which decreased the number of contaminated recyclables being imported into China, thereby temporarily interrupting recycling markets. Starting in late 2014, the traditional relationship between recycling and oil prices was restored.

FIGURE 12. OIL PRICE AND RECYCLED PET PRICE CORRELATION [56] [57]



However, most recently, a combination of macroeconomic developments and the oil-shale revolution has created a medium-term ceiling on oil prices at about $65-$85/bbl, and oil markets have responded to recent oversupply with lower prices **[57]**. When prices periodically dipped below $30/bbl, recycling markets were distressed. Oil has since recovered to approximately $50/bbl, but plastics innovators and recycling market entrepreneurs have become acutely aware of and sensitized to the effects of low-priced oil and other recycling market disruptions.

While important, oil is only one factor in determining the value of recycled plastics feedstock. There are other costs in virgin plastics production that might be in over-supply or under-supply from time to time and thus have an impact on recycled plastics pricing. However, if demand for oil is significantly reduced as a consequence of the emergence of alternative energy technologies, markets may see both increased plastics consumption and cheaper oil, which will put more plastics in the waste stream and more pressure on recycling markets **[58]**. If recycling demand can be increased, especially for low-value plastics, greater value will be derived from them, ultimately keeping them out of the natural environment.

Improving supply and demand fundamentals

Ensuring strong recycling and innovation will involve increasing recyclability and recyclable plastics supply through industrial design choices and investing in recycling infrastructure. The growing supply should be matched by increased demand and government and private sector support for recycling markets. This can be done through a combination of market incentives, voluntary private sector commitments and policy levers.

Recycling markets are constrained by volatile oil prices, variable quality waste streams and under-realized demand. Many developed countries have responded by mandating that end-of-life considerations be integrated into product design and value chains, denoted in Europe, for example, by the Green Dot (der Grüner Punkt) **[59]**. Such mandates also provide direct and indirect funding for waste management infrastructure and collection, but they do not yet exist in Southeast Asia for some of the following reasons: lack of information, competing priorities, enforcement challenges and free rider issues. However, there is a strong case for the private sector to act voluntarily and decisively to assure a promising future for recycling markets, **as explored in the sections below**. The entire value chain from chemical and product manufacturers through retailers, waste haulers and recyclers can strengthen supply and demand for recycled products.

Improving supply

Design for increased recyclability in local markets

There is a critical need to increase the proportion of plastic waste that can be economically recycled in local markets. A key component is increasing a product's post-consumer use or recyclability through design choices, keeping in mind the numerous and sometimes conflicting requirements product designers must balance (see The Design Challenge: Systems Approaches box below). Optimizing product package systems is critical to developing robust solutions that minimize overall environmental impact and ensure ocean health. Package designers have already made significant advancements, but further work can be done at two broad levels:

- Designing products for easier recycling (e.g., choices of glue, label design, materials used)
- Supporting innovation in material design via programs like the Ellen MacArthur Foundation's New Plastics Economy to accelerate the pace of movement to circular or second-life systems, which drastically reduce waste, create efficiencies at scale, minimize use of virgin material and can reduce GHG emissions.

THE DESIGN CHALLENGE: SYSTEMS APPROACHES

Although it is clear that progress can be made to improve recyclability, the ultimate goal for designers is to minimize the environmental impact while delivering a desirable, quality product. This requires accounting for the whole picture of environmental impacts incurred over the lifecycle of the product and package in order to avoid shifting environmental burden. For example, rigid packaging is generally easier to recycle, but it typically uses more material in comparison to flexible packaging. This means more resources are used to make rigid packaging, and more fuel is used to transport it. Environmental burden is shifted away from disposal to other stages of the lifecycle. The existence of these trade-offs does not mean improvements cannot be realized; however, it does mean that thorough evaluation is needed when making design choices.

Work in multiple industry and civil society collaborations is ongoing to consider products' conflicting requirements and to innovate solutions that optimize across multiple factors. For example, plastics producers have focused on optimizing polymers for specific performance requirements as well as weight and cost, and consumer goods companies work to optimize product and packaging designs while balancing design decisions across multiple, sometimes competing, priorities. Improving recyclability and other end-of-life considerations for products and packaging needs to feature prominently in these discussions.

As a next step in creating stronger secondary material markets, an industry and government coregulatory framework can be considered. Within this framework, the private sector would develop its own standards and targets in consultation with recyclers, and government would provide legislative backing to ensure a level playing field. This might include recommendations to create national standards, based on international packaging best practices, for actions like the use of recycled content in packaging and, where applicable, re-evaluation of the efficacy of regulations for packaging stability and safety and particular requirements unique to recyclable material that may cause it to be artificially expensive relative to virgin material. In addition, end-of-life plans for product offerings could be negotiated **like those required in British Columbia**, and progress against recycling targets reported publicly.

General principles for packaging design might include:

- Encouraging the use of more readily recyclable materials (e.g. innovative singular material designs and minimal use of multilayer packaging) without shifting environmental impacts to a different life cycle stage.
- Promoting policies that enhance greater disassembly and recyclability, including glue use, barcode size and positioning, and consistent dye use in plastic commodities.
- Defining application-specific recycling opportunities and specifications.
- Considering packaging reduction options like refillable or reusable materials.
- Avoiding trade-offs that shift burdens to other parts of the lifecycle by considering recyclability as a critical part of a package or product delivery system instead of separate from it.

SUSTAINABLE PACKAGING AGREEMENT (SPA) [60]

In 2007, Singapore's National Environment Agency (NEA) launched the Singapore Packaging Agreement (SPA). The SPA is a joint initiative by government, private sector enterprises and CSOs to reduce packaging waste. The agreement is voluntary, so as to provide flexibility for the industry to adopt cost-effective solutions to reduce waste. As of July 2016, 177 signatories had signed the agreement. Through the SPA, the NEA consulted more than 140 representatives from 100 organizations across the manufacturing, food and beverages, and other sectors.

SPA signatories are invited to attend meetings, events and sharing sessions to learn about packaging best practices and find out how other companies have cut business costs by reducing packaging waste. Companies that make notable achievements in reducing packaging waste may also stand to receive one of the annual 3R Packaging Awards, and they have the opportunity to be profiled in the media for their packaging reduction initiatives.

Invest in recycling infrastructure

Product design for recycling will require relatively sophisticated recycling equipment and processing facilities, especially to process many of the low-value materials that are currently making their way into the marine environment. The private sector can help by supporting entrepreneurial recycling ventures build capacity and develop to fulfill their specific manufacturing standard. To do so, businesses may need to export expertise from economies with stronger recycling centers, work with local entrepreneurs and effectively raise the quality levels of recycling feedstock.

DANONE INDONESIA CASE STUDY [61]

Danone, a French-based multinational packaged goods company and one of the leading beverage producers in Indonesia, wanted to use recycled content in its Indonesian packaging in order to manage its plastic waste impact. The company brought European experts to Indonesia to develop a local supplier who could meet Danone's high safety processing standards. The experts supported the building of a processing facility and taught local entrepreneurs how to operate it. In addition, the company started a strong informal market program, training approximately 10,000 waste pickers to the bale quality standard that would be implemented in the factory. As a result, Danone has been instrumental in the development of a food-grade quality recycled plastics processing facility in Indonesia.

Increasing demand

Solving for higher levels of quality recycled feedstock is important, but growing supply needs to be matched with increased demand. If demand for collected recyclables can be grown sufficiently, many of the waste management challenges will resolve themselves organically. Increasing recyclate demand can create a virtuous circle enabling collected waste to deliver greater value across the entire SWM value chain. Beneficiaries will include waste pickers who are incentivized to collect more, recyclers who are then able to invest in more recycling infrastructure, and waste system owners who will gain new access to inputs that have value where there hasn't before. A combination of market incentives, voluntary private sector commitments and policy levers may be needed, at least in the short-term, to support recycling demand. If effective, the economic value of post-consumer plastics could be just high enough in the long run to trigger a shift from the waste chain to the supply chain, ideally enabling the system to become self-sustaining without the need for further external funding support. However, growing demand significantly is difficult given the often lower cost, higher quality and greater versatility of virgin plastics feedstock.

The detailed design of demand incentives is beyond the scope of this paper. Producers will need to be rewarded for using recycled feedstock through recycling credits, tax offsets or other incentives. Meanwhile, incentives can be put in place to source-reduce packaging, to design more plastics for recycling and to encourage the use of recycled content into a wider range of applications. Both supply and demand tools must be used to meet the SDG of ensuring sustainable consumption and production patterns.

A cross private sector and government partnership could define common terms and recommendations, as summarized in APEC policy and practice recommendation 7:

APEC policy and practice recommendation 7 – Reward recycling and innovative, environmentally sound waste treatment: Develop end-of-life incentive policy to stimulate recycling market demand and increase product recyclability; create conditions that encourage investments in waste collection, sorting and environmentally sound waste treatment.

Additional potential considerations include:

- Incorporating voluntary or mandatory recycled content levels in products over time and encouraging industries to promote recycling as a part of their sustainable global supply chain practices.
- Encouraging adjacent market development such as green procurement commitments from government if sound construction and demolition regulation is in place.

- Educating plastics buyers like procurement departments on how to buy recycled plastics locally.
- Publicly tracking product recyclability and recycled content incorporation into products of larger brands and celebrating companies with the strongest records.

Supporting recycling markets

Stable, long-term recycling markets are essential. When companies commit to using recycled content on a multiyear, ongoing basis, it changes the product design equation, improves the economics of waste management, and fuels investment in technology and infrastructure that can take years to recoup. But stabilizing recycling markets will require building scale in the face of low prices, pushing innovation in a time of low supply, and developing new markets in a time of supply constraints. Stabilization is not going to happen by itself. Some help by government, community leaders, waste and educational CSOs, and the private sector will be needed to overcome the multiple dilemmas now faced in private sector recycling. Done right, stable recycling markets can be mutually beneficial for all.

For example, the private sector can offer off-take guarantees that both benefit recyclers and provide fuels or feedstock for private sector plants — multiple examples exist for both. Governments can offer funding support such as recycling credits, especially for low-value plastics. The private sector and government can collaborate on public-private partnerships that create the scale of recycled polymer production required for modern polymer plants. CSOs and community leaders can educate the public on the benefits of recycling and emphasize the importance of strong sorting; they can also make connections to help facilitate and identify opportunities to recycle products into high-value commodities. There are numerous opportunities once the essential step of de-isolating private sector recycling has been taken.

RECYCLING PARTNERSHIP CASE STUDY [62]

The Recycling Partnership (RP) is an industry-funded national nonprofit organization transforming recycling in towns across the United States. RP believes that recycling is fundamental to a healthy environment and economy, so they work closely with communities and companies, continuously innovating to improve recycling systems. Strong recycling programs mean jobs are created, the environment is protected and communities thrive. The RP model deploys human capital and financial resources to help cities significantly improve their recycling performance via public-private partnerships. Working with more than 100 cities over the past few years, RP has leveraged $20 million worth of new infrastructure directly affecting more than 2 million households. Often these cities would like to see change, but they need help overcoming system barriers including financing, staff constraints or missing information regarding best practices. The RP team works with cities to develop a roadmap to accomplish their recycling goals, and it supplements the cities' financial contribution. Their team then project manages the implementation process, provides customized toolkits and economic models, designs an education campaign, and works with local city councils to gain support for the recycling improvements.

INTEGRATION OF THE INFORMAL AND FORMAL RECYCLING SECTORS

The waste picker sector is an important player in the waste systems of the focal region. Waste pickers experience the greatest return for their efforts by removing high-value items from the waste stream, and they perform a vital role in keeping these plastics away from rivers and beaches. The effectiveness of this sector in recovering high-value materials, however, means that the majority of waste value is not captured within the formal system, effectively externalizing the cost of treating the low-value waste remaining. The value of high-value recyclables thus extracted from the waste stream can exceed the value of what remains **[30]**.

To capture more of this value, waste pickers should be given the opportunity, although not the requirement, to act in an entrepreneurial way with the formal waste sector. Emphasis should be on inclusion — improving the safety, health, efficiency and wages of the waste pickers, while working to integrate the value of their collection into a more holistic waste management system. The performance of waste pickers could be greatly improved with capability building, access to capital and basic tools, a reliable and source-segregated waste stream, and cooperation from municipalities. Any proposed integrated waste system strategy should be designed with meaningful consultation with waste pickers and the nonprofit institutions that support them to ensure their interests are protected and the project implementation is holistic.

The waste picker sector

The waste picker sector refers to an entire ecosystem of waste pickers, itinerant metal collectors, aggregators, junk shop operators, processors and recyclers who work outside the formal waste management system. Left to its own economic devices, this sector is focused almost entirely on finding, separating and processing high-value waste from the overall waste stream. Typically, 15-20% of the total waste volume is removed from the waste stream by waste pickers in developing economies.

The sector is deeply entrepreneurial and decentralized. The waste pickers often recruit from the ranks of migrants and urban poor. They deliver to a range of material or junk shops that operate in different capacities, with some working only as aggregators and supplying specific materials to recycling companies. Figure 13 shows the pyramid-like structure of the waste picker sector.

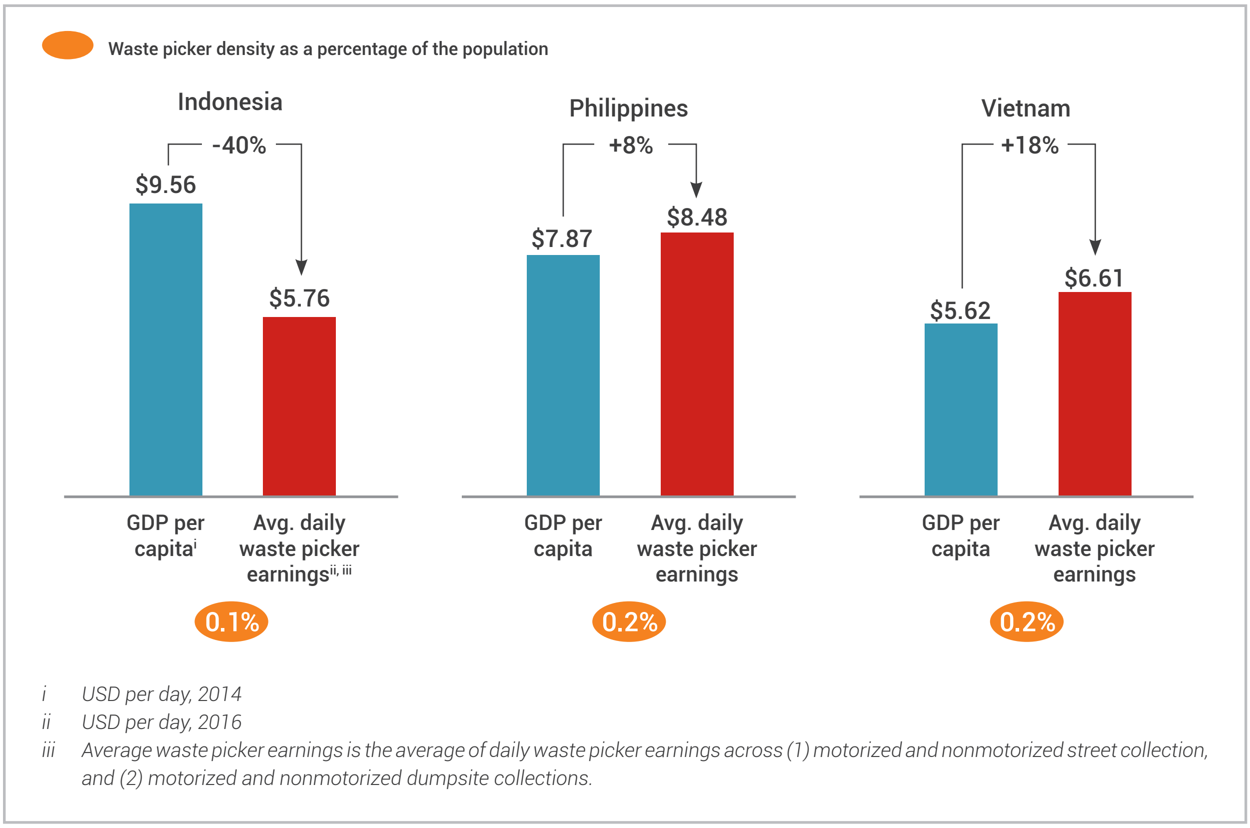
FIGURE 13. WASTE PICKER SECTOR RECYCLING HIERARCHY

Waste pickers are deeply entrepreneurial and skilled at harvesting high-value goods from the waste stream to make a basic living. Working with an absolute minimum of infrastructure, they are at least twice as effective as the formal sector at gathering high-value plastics (although they operate at higher collection cost per metric ton than the mechanized formal sector). Their livelihoods depend on their ability to identify items that local junk dealers will buy **[63]**, and their entrepreneurial nature drives them to be thorough, highly selective and always in search of the most efficient sources of high-value waste.

Waste picker jobs are often dangerous and dirty. Undercapitalized waste dumps and primitive recycling centers, often entirely unregulated, make for generally unsafe and unhealthy working conditions. However, there is no shortage of labor supply: according to the World Bank, 1% of the urban population in emerging economies worldwide is engaged in waste-related activities **[5]**.

It is possible to make a basic living as a waste picker. Figure 14 shows the profession's earning potential to be within 50-80% of average GDP per capita or even higher **[64]**.

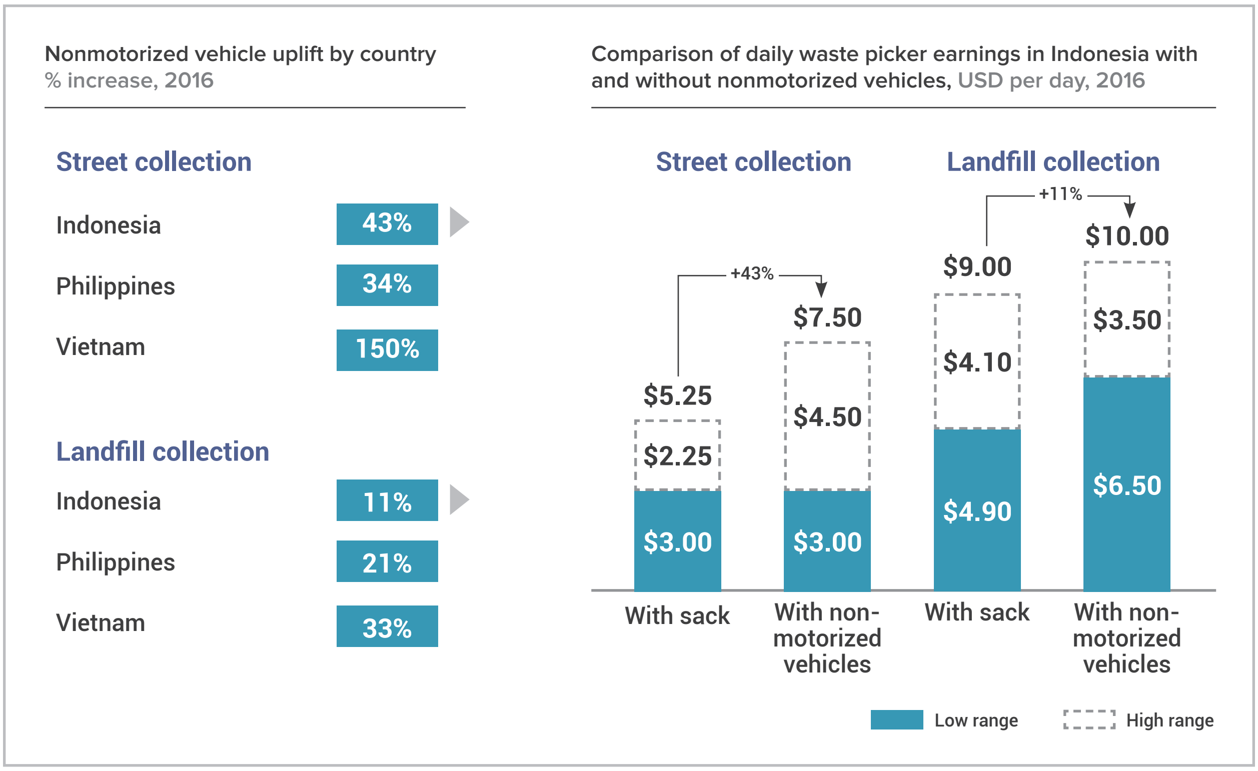
FIGURE 14. COMPARISON OF WASTE PICKER EARNINGS TO GDP PER CAPITA AND RESULTING WASTE PICKER DENSITY [64]



Despite their efficiency, waste pickers are typically faced with livelihood challenges. They suffer from severe lack of infrastructure, marketing and technological disadvantages, and poor working conditions. The waste picker sector is also resistant to structural change; there is a strong preference for the freedoms associated with its highly entrepreneurial structure. Attempts to displace it or formalize it have often been met with large protests, and court judgments have come down in support of waste pickers' rights **[65]**. The dynamics of this system challenge the SDG of ensuring healthy lives and ending poverty; however, there are opportunities to work more closely with the people in a fully integrated waste management system. In the Philippines, for example, waste pickers have been successfully integrated into some formal systems.

The performance of waste pickers has great potential for improvement. The cost of poor working conditions can be sharply reduced, improved work flow engineering can offer huge benefits, and the provision of basic tools such as nonmotorized carts can greatly increase earnings. Few waste pickers have sufficient capital to afford basic tools outright, and a small amount of capital can make a large impact. Figure 15 shows how simple tools can improve earnings, suggesting that increased availability of microfinancing could enable significant improvement.

FIGURE 15. WASTE PICKER EARNING IMPROVEMENT [64]



The systematic improvement of waste picker earnings and working conditions is key to any attempt at improving waste collection and improving the livelihoods for these workers. Strategies to do so include the following:

- **Low interest, risk-adjusted loans or working capital.** Access to capital is a major issue for the entire sector. Waste pickers need basic tools. Aggregators need cash to float purchases before all accounts receivable are paid. Recyclers need balers and shredders. Preferably, provision of these requirements can be structured as trade finance or a working capital loan from recyclable buyers, rather than much more expensive third-party microfinancing.
- **Increase source segregation.** Waste pickers are only as good as the quality of the waste stream. Even very basic source segregation (e.g., wet versus dry waste) greatly enhances the working conditions and productivity of the waste pickers.
- **Recognition and cooperation from municipalities.** Municipalities can support waste pickers with a registration system that allows them with to receive health and occupational benefits, and guarantees them access to municipal waste streams.

Integration of the waste picker and formal waste sectors

The waste picker sector collects many of the high-value goods in the waste stream, consisting primarily of metals. Based on extensive interviews and discussions with members of the waste picker community, a set of gradual measures is recommended to integrate the formal and the waste picker sectors over time. The goal is to improve incomes and working conditions while ensuring that valuable recyclables help fund a collection system that can process a wider variety of materials.

In the long-term, the separation of the formal and informal sectors can prevent critically needed reform of the overall, integrated waste management system. But working together in an integrated model, these the two sectors can achieve more for material recovery, ocean health and community health than either can achieve separately.

However, an immediate, wholesale transition is neither recommended nor feasible. A set of gradual measures is recommended to make the slow transition for waste pickers to the formal labor force. The shift, which will significantly improve workers' health, safety and economic stability, directly supports the SDG to promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all. Examples in Chile and Brazil have shown that integration is possible if it is smartly linked with operational and infrastructure support (e.g., vehicles and MRFs), preferably under fair pay conditions **[66]**. By moving waste pickers closer to valuable waste streams, such as those found at MRFs, their income and workplace conditions improve, and the high-value recyclables stay within the formal system.

This slow transition from informal to formal labor force and concomitant introduction of protections could begin with a few easy steps through national or municipal policies, ideally through a participatory and consultative process that includes waste pickers and CSOs. With formal recognition, waste picker contributions can be tracked and recognized, and legal protections (such as guaranteed access to waste from municipal governments or haulers) can be ensured. The market also gains greater transparency, bringing with it greater opportunities for efficiency as well as a reduction of unregulated activities. Standards can be issued for operational health and safety, and waste picker cooperatives and other organized labor groups can be formally recognized.

Opportunities at the front and middle of the waste value chain (collection, MRFs and treatment) can be prioritized over waste picking at dumpsites at the back of the value chain. Outsourcing collection work to waste picker cooperatives can be a highly cost-effective option to municipalities. Latin America is a frontrunner in the inclusion of entrepreneurial waste collectors. The Buenos Aires municipal corporation partnered with a 2500-member waste picker cooperative called the Movement of Excluded Workers in 2005. The municipality provided workers with vehicles to transport waste, a monthly stipend of $209 each (in addition to what they earned from selling scrap), as well as health insurance and subsidized childcare **[67]**. Organized groups of waste pickers can also be provided with jobs at MRFs (like Payatas MRF), or in private waste treatment companies, and civil society organizations such as waste picker cooperatives can play an invaluable role in helping to transition the waste management sector to a model that protects and enhances waste pickers' rights.

There is growing enthusiasm about waste picker inclusion, often as part of integrated solid waste management (SWM). The World Bank and the Inter-American Development Bank, for example, have both funded projects to support waste picker integration into formal sector recycling. Advocacy organizations such as WIEGO have called for an intensification of such efforts through access to credit and technology, as well as through partnerships to collect recyclables in underserved communities. These measures have given many waste pickers higher standards of living, economic security and a sense of inclusion in society. To truly address the needs of waste pickers, waste management modernization must be coupled with broader social policies, which civil society can help define, develop, advocate for and advance.

APEC policy and practice recommendation 8 outlines the key points from this section:

APEC policy and practice recommendation 8 – Incentivize entrepreneurial waste pickers: Encourage the waste picker sector to assume new service roles in waste collection, recycling, composting, and treatment through facilitation by NGOs and municipalities to improve health and safety while improving economic livelihoods.

ACCELERATING WASTE TREATMENT INNOVATION

In the long-term, enabling innovative technologies will be a fundamental part of achieving a sustainable waste management system. Setting strong environmental standards, conducting rigorous monitoring and enforcement, and determining best-fit local treatment solutions will be key to making waste management safe, resilient and sustainable.

As waste is highly heterogeneous and variable from place to place, there will not be a one-size-fits-all solution to waste treatment — new technologies have to be technically, commercially and environmentally viable, as well as flexible and highly modular. The ultimate objective would be for a community's waste to act as a resource for its unique economy and to become a sustainable source of economic livelihood for many citizens. In addition, chosen waste solutions should be environmentally and socially responsible, emphasize principles of circularity, and be adaptable to changing waste conditions and technologies to minimize lock-in. Technologies should meet the following criteria:

- Benefit both environment and people
- Be environmentally and socially responsible
- Be adaptable to changing waste conditions and technologies (i.e., minimize lock-in)
- Emphasize principles of circularity (waste reduction, recycling, waste repurpose, etc.)
- Be politically viable and locally appropriate, working within existing structures whenever possible and respectful and supportive of national and local laws
- Address areas of high ocean plastic waste leakage

The relative GHG emissions of any waste management solutions should be a priority consideration. Any of the treatment methods **discussed in the sections below** has lower GHG emissions than uncontrolled dumping and burning of waste, which is the status quo in many regions. However, none of the treatment methods discussed are as effective at reducing GHG emissions as reducing the amount of waste generated in the first place, whether through pure avoidance or through increasing recycling and reuse. As economies work toward meeting GHG reduction targets, many are successfully adopting a broader, systemic view of material use that accounts for a range of lifecycle considerations such as resource utilization, energy efficiency, waste avoidance and minimization, and the role that packaging plays in preventing food spoilage.

Multiple potentially promising treatment pathways are emerging that are technically viable today for treating portions of the waste stream **[68]**, including low-value plastics. But these potential technical pathways, which are explored in detail below, are not yet commercially viable given external factors such as the price of oil or the cost of capital due to the perceived risk profile of waste management and the relative infancy of the technologies. Adoption of waste technologies in the target countries represents a unique opportunity to advance or leapfrog developed market timelines to improve waste management but does come with important social and environment considerations. The conditions are conducive for innovation: there are relatively few existing infrastructural assets at risk of getting stranded; labor is available, knowledgeable and economical; markets are flexible and relatively undefined and unstructured; and strong growth is creating massive demand for energy, plastics and building infrastructure. If the highly effective waste picker sector has the opportunity to participate in new waste management constructs, it can also represent an advantage for less developed regions above more developed regions, which lack the entrepreneurial labor pool to stimulate recyclable recovery at scale. All of these factors create ripe conditions for advancing these tailored solutions for waste.

However, most developing countries do not have the monitoring or transparency regulations in place to ensure strong environmental standards and enforcement. Strict definition of, adherence to and monitoring of environmental and social safeguards is necessary to ensure that solutions to the waste problem do not create other problems. Governments need to set regulations (especially if thermal treatment technologies are being considered) in place prior to investing in new technologies. Specific requirements for air, water and soils are essential, as are monitoring and transparency conditions for traditional mechanical recycling as well as new treatment options. Furthermore, companies investing in and implementing these technologies will need to monitor facility environmental performance closely in a manner that is publicly transparent, with independent external validation. Economies may also want to consider community engagement strategies for building greater transparency, accountability and ultimately trust with the local communities. APEC policy and practice recommendation 9 speaks to these considerations:

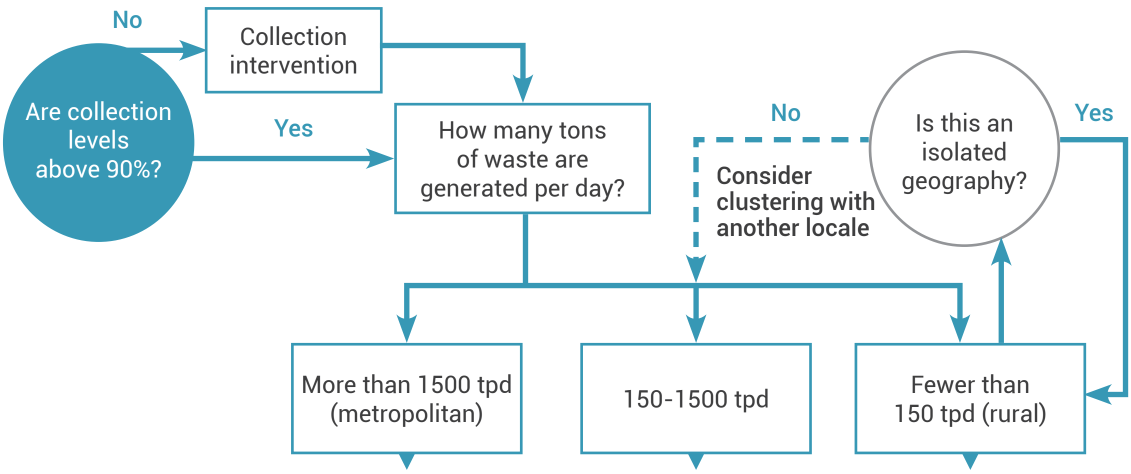
APEC policy and practice recommendation 9 – Enforce strong environmental standards to guide innovation: Set strong environmental standards with reliable and transparent monitoring; consider community engagement strategies for transparency and accountability.

Determining best-fit local treatment solutions

A common mistake when considering the extraction of value from waste is to look for the perfect technology that already exists. The very nature of waste — heterogeneous, variable regionally and seasonally — make a one-size-fits-all solution impractical. There is no ready-to-use technology that can work in every circumstance. However, while the technical approaches differ from city to city, there are some underlying best practices that can guide the design.

Figure 16 shows a simple decision tree to consider when evaluating a local waste situation. Detailed knowledge of the waste stream is key. Its volume, composition, recyclable content and so on are strongly predictive of the type of material recovery facility and conversion technology to be considered. Comparing the disposal rate and the likely generation rate will inform whether a collection intervention is warranted.

FIGURE 16. FRAMEWORK TO GUIDE LOCAL TREATMENT CHOICES [32]



Economy needs	Outputs from waste treatment		
Localized			
Agriculture	▸ Fertilizer (AD, compost)	▸ Fertilizer (AD, compost)	▸ Fertilizer (AD, compost)
Construction/roads	▸ Building Materials (repurpose) ▸ Ash (gas.)	▸ Building Materials (repurpose) ▸ Ash (gas.)	▸ Building Materials (repurpose) ▸ Carbon black (pyr.)
Refrigerated goods	▸ Biogas (AD) ▸ Heat (stacked gas.)	▸ Biogas (AD) ▸ Heat (gas.)	▸ Biogas (AD)
Textile	▸ Fibers (rec.)	▸ Fibers (rec.)	▸ Fibers (rec.)
Transportation/fuel			▸ Fuel (pyr.) ▸ Biogas (AD)
Generic			
Plastics	▸ Monomer (chem. rec.)	▸ Monomer (chem. rec.)	▸ Monomer (chem. rec.)
Transportation/fuel	▸ Electricity (stacked gas.)	▸ Electricity (gas.)	

Because scale matters greatly in waste management (which has high capital expenditures and low margins), cities generating fewer than 150 metric tons per day often find it advisable to partner with another nearby locality should it be logistically viable, for example, if there are good connecting roadways, shared utilities and previously existing partnerships. Provincial governments may help with coordination of waste management activities across cities.

The local economy should also be taken into consideration. For example, if textiles are a large local industry, developing infrastructure to leverage post-consumer plastics to make fibers usable in clothing or carpet may be advantageous. (But note that science increasingly shows that textile-derived microfiber pollution in freshwater and marine environments is occurring in large magnitudes, so consideration must be given to the fate of plastics in their secondary form as well.) Agricultural communities would benefit from source-separated derived compost and fertilizer as well as biogas for produce refrigeration.

There are numerous conversion outputs from waste, but making the right output for the economy under consideration will be critical for long-term economic viability of the waste management construct.

Understanding treatment technology options

There are multiple treatment options to turn low-value waste into higher value output such as building materials, electricity, fuel and even monomer to make virgin-like plastic feedstock. Each option differs in its economic and technical viability and environmental considerations.

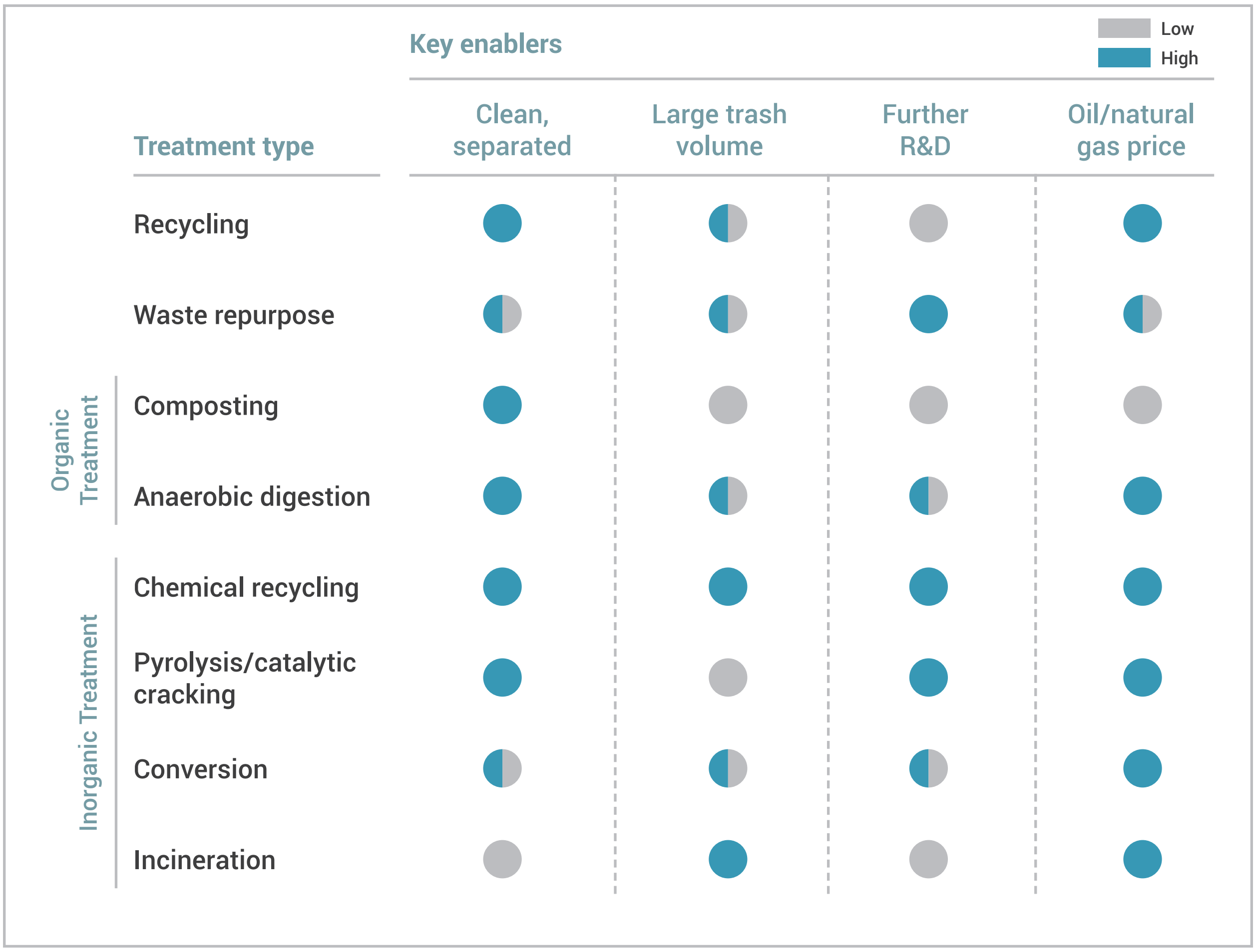
The volume and composition of the waste stream guides the right technology choice in any given local environment. Technology development will be greatly enhanced if the right waste stream "manipulation" technologies are put in place. These include segregation technologies such as hydraulic presses (for segregating organic waste in a mixed stream), eddy current separators, density sorters and blowers, and bio-drying, as well as cleaning technologies such as cyclones, sink tanks and autoclaving.

An additional caveat to the technology discussion below: tipping fees are not included. While these can do much to finance parts of the waste system, they are difficult to enforce consistently. In some cases, tipping fees can negatively affect collection as cash-strapped cities dump waste into waterways to avoid paying the fee.

In this discussion, it is assumed that high-value waste items have already been collected by the recycling community. Treatment technology is thus assumed to focus on the remaining, lower value waste. Ultimately, any treatment technology development decisions should also consider other environmental and social factors, including community support or opposition, impact on GHG emissions, potential pollution and community health impacts as well as the national legal, regulatory and enforcement contexts in which the technology would be deployed.

All treatment facilities benefit from a guaranteed, stable off-take customer and pricing support to compete against often lesser expensive virgin alternatives. Four additional enablers are key to the business case for treatment investment: clean, separated feedstock; large trash volumes; further investment in R&D; and the oil and natural gas prices, as outlined in Figure 17.

FIGURE 17. PRIMARY ENABLERS TO TREATMENT INVESTMENT [32]



Waste repurpose technologies

Waste repurposing

Treatment Waste repurpose

Output Fibers, fabrics, building materials

Description Numerous processes that take plastic waste as input material and convert it into other products such as power impression molding, in which pulverized plastics are used as a filler between plastic sheets to create blocks and planks.

Rapid urbanization in developing regions is straining the waste management system. However, some cities have used the opportunity to repurpose waste toward urban infrastructure and into their local economy. For example, the Ministry of Environment and Forests of the Government of India has introduced the Plastic Waste Management Rules, 2016, which require the promotion of plastic waste usage for road construction **[70]**. While more research needs to be done before widespread implementation, current legislation mandates new roads to be built with up to 15% post-consumer plastics **[71]**. In the construction industry, power impression molding incorporates pulverized plastics as filler between plastic sheets to create blocks and planks. Companies like IntegriCo, Axion International, Trex, Tie Tek and Bedford are using low value plastic waste to build a range of products from structural building products to railroad ties and marine piers.

In all cases, however, the key driver of economic viability, as it is with most mechanical, traditional recycling, is the price differential of these materials versus virgin material. Furthermore, demand also plays a critical role when assessing the economic viability of these options. And government price support, or tax advantages, for products containing plastic waste as a key component of their composition can also bolster economic viability.

INTEGRICO COMPOSITES CASE STUDY

IntegriCo Composites is a US-based manufacturing company that creates railroad ties out of low-value plastics that are usually destined for landfill. These railroad ties use over 370 metric tons of 100% post-consumer plastics per track mile. Each tie has a life expectancy of over 50 years, lasting up to 3-5 times longer than conventional wood ties. Ties also have a higher resiliency than wood ties in varying environmental conditions, particularly wet and humid climates. As such, there has been high demand from the rail industry.

Biological treatments

Anaerobic digestion (AD)

Treatment Anaerobic digestion

Output Biogas consisting primarily of methane and carbon dioxide

Description The biological conversion of organic materials (typically food and green waste) in the absence of oxygen via microorganisms.

There are many forms of anaerobic digestion; this discussion will focus on AD as a technology class. In an MSW context, anaerobic digestion is best used on the segregated biodegradable wastes such as food and green wastes. Because these types of wastes are entering from an MSW stream, there is a strong likelihood of contamination with other fractions of the stream such as pieces of plastics, rocks, glass, metals or other materials. This is true even of a source-segregated stream as complete segregation is typically unfeasible. Even in small amounts, these contaminants can hinder controlled biodegradation and cause maintenance issues in the vessels. For this reason, enabling technologies such as cyclones, sifters and sink tanks are advisable to clean the stream prior to introducing it to an AD construct. The output of AD is biogas comprised primarily of methane, the main constituent of natural gas. This gas can be used in any typical methane construct such as conversion to electricity via engines or fuel for motorized transportation vehicles.

Other outputs include fertilizer, which can be processed further to create compost for agricultural use. In the focal countries, however, the market for this type of fertilizer is lacking, thereby making disposal of the digestate a cost rather than revenue. This absence of market is due both to the mistrust of digestate as a clean fertilizer and to the low cost of chemical fertilizers (which are at times subsidized). For this reason, AD can be made more viable by developing price advantages for the resultant fertilizer or compost against existing chemical fertilizer options and by creating public awareness as to the cleanliness of the AD-generated fertilizer. This can be done by leveraging and maintaining European fertilizer quality standards.

Composting

Treatment Compost

Output Compost

Description Decomposition of organic material (typically food and green waste) as a result of the action of aerobic bacteria, fungi and other organisms.

Waste composition in the focal countries skews heavily toward organic waste (upwards of 60% in some cases). If organic waste were profitable, it could help fund the overall collection system and reduce contamination, thus increasing the value for the rest of the waste stream. However, composting currently has very little value in the markets in focal countries, but it does represent a market growth opportunity over the next decade. There are numerous reasons for compost's current low value, including the heavy metal and toxin contaminations of mixed waste composting, the fact that existing subsidies keep alternative fertilizer prices artificially low, and the fact that composting is subject to more stringent, more expensive control requirements than alternatives such as fertilizers. However, the United States and Europe have been able to make waste-derived compost profitable, generally by using source-separated (rather than mixed) waste streams and quality standards certification and a tipping fee.

Thermal treatments

Chemical recycling

Treatment Chemical recycling

Output Hydrocarbon-rich gases that can be condensed to liquid diesel, naphtha and heavier fuel oils

Description Mixed plastic waste is hydrolyzed to monomeric form and passed through a purification and re-polymerization process before converting to virgin-like plastic specifications.

Chemical recycling is also known as de-polymerization. Plastics are comprised of chemical chains called polymers. In the case of chemical recycling, a catalyst and heat are used to break the polymer chains apart and create monomers or intermediates. These monomers can then be "reassembled" into new polymers to create new plastic material that in many cases is equivalent to virgin plastics.

While relatively early in the development process, the potential to "close the loop" on currently low-value plastics represents an exciting possibility, especially if an industrial scale off-take customer for these monomers is identified. However, the key challenge for this process to be viable is securing enough low-value, nonrecyclable plastics as feedstock. A single world-scale PE plant would require 20 chemical recycling plants, which would in turn need waste from 1 million to 2 million people. Once the first large-scale (50 metric tons/day or more) plant is established and proves its performance, potential purchasers of the output (which would be input for making plastics) would be far more willing to sign supply agreements that will then facilitate financing allowing more plants to be built. The key technical challenge is dealing with an ever-changing input stream and various contaminants. As with all with recycling, the economics are dependent on the price comparison to virgin material.

Pyrolysis/catalytic cracking

Treatment Pyrolysis/catalytic cracking

Output Hydrocarbon-rich gases that can be condensed to liquid diesel, naphtha and heavier fuel oils

Description The thermal decomposition of waste materials at high temperatures (200-800+ C, technology dependent) without the addition of air or oxygen resulting in solid and/or liquid residues as well as a gaseous mixture

Of all the thermal conversion treatments evaluated, efficient pyrolysis is the one most dependent on the presence of a more homogeneous feedstock. In an MSW context, the most viable output can be achieved via separation of a highly calorific portion such as plastics and conversion into liquid fuels such as diesel. In addition, the proven scale (no more than 10 metric tons/batch) of this technology is a limiting factor when using this technology in an MSW context **[72]**. For these reasons, pyrolysis to liquid fuel technology is best used in isolated areas with smaller amounts of waste and where the transportation of liquid fuels allows local production to be price competitive with imported fuel. Further, because pyrolysis can be used to convert a number of types of homogenous feedstocks, designing the units to accommodate other useful feedstocks can result in other useful off-takes.

Municipal-scale gasification

Treatment Gasification

Output Syngas, heat, ash

Description The thermal decomposition and partial oxidation of waste materials at high temperatures (400-800+C, technology dependent) using a limited amount of air or oxygen, resulting in solid residues and a gaseous mixture

Though several variants of gasification are available, this discussion will focus on the generic best uses of gasification as a technology class. Examples of technically established systems include Japan's Mitsubishi MSW Gasification and Ash Melting System and its Sorain Cecchini Tecno JFE gasification system, Norway's Energos Gasification Plant, and the United States' ICM Advanced Gasification Technology Municipal-scale gasification can be most viable when using a highly calorific and controlled moisture (20-35%) feedstock **[72]**. This can be accomplished by using stream manipulation technologies such as hydraulic presses or rotating drums that segregate the biodegradable fraction from the nonbiodegradable fraction. The segregated biodegradable/ high moisture fraction is best used in technologies such as anaerobic digestion. Dryers using the heat sink from gasifiers are also often used to control the moisture of the calorific feedstock, allowing for more efficient energy recovery post-gasification. The absence or limited amount of oxygen also allows for a cleaner emissions profile than mass-burn technology does, resulting in the need for less sophisticated, less expensive air emissions control equipment (which presently comprises approximately 10% of total equipment costs of gasification) **[72]**.

Historically, one of the biggest downsides of gasification using a feedstock derived from MSW has been the presence of tars in the resulting syngas. These tars tend to cause maintenance issues with power conversion mechanisms such as internal combustion engines. However, this phenomenon can be mitigated by using less sophisticated power generation equipment such as heat recovery steam generators (HRSG) in combination with either gas turbines or increased gasification temperatures. Note, however, that both options result in less energy output, which will need to be balanced against other variables such as maintenance costs.

In addition, given the capital costs associated with this type of technology, the amount of feedstock is an important consideration. Generally, operations that process fewer than 150 metric tons/ day are difficult to make economically viable. However, encouraging developments are underway for smaller, less capital-intensive gasification units. While gasification units can be modular, the capital expenditure for the purchase of multiple units in operations that handle over 1500 metric tons/day becomes a limiting factor, depending on the fraction of biodegradable material **[72]**.

Incineration/mass-burn combustion

Treatment	Incineration
Output	Electricity, ash
Description	thermal decomposition and rapid oxidation of waste materials at high temperatures (230-800+C, technology dependent) with the addition of air or oxygen as sub-stoichiometric to excess levels, resulting in solid residues and a gaseous mixture.

Mass-burn waste-to-energy combustion is generally a commercially viable technology only when using tipping fees and energy feed-in tariff subsidies. Currently there are more than 765 operating waste-to-energy plants combusting municipal solid waste worldwide, with the majority in Western Europe, followed by China and the United States. Annual capacity of waste-to-energy combustion is about 83 million metric tons **[73]**. Incineration has a long and controversial past given issues with air emissions and pollution. Because combustion occurs in the presence of oxygen and water, the flue gas can contain dioxins and furans, and it can create other harmful emissions such as nitrous oxides and sulfur oxides that require removal using expensive advanced air pollution control equipment (which can comprise as much as 15% of the total equipment costs) **[72]**. When this equipment is in place and operated under optimal conditions, air pollution can be reduced considerably. However, in less stringent environmental regulatory and enforcement contexts, the economic incentive to operate under suboptimal conditions and without appropriate controls is strong, leading to potentially significant risk for pollution and serious community health impacts.

Because of incineration's capital-intensive nature, it is most economical when large amounts of waste have been aggregated. Depending on the amount of water and biodegradable fraction present, a general rule of thumb is that the minimum level of waste required would be 600-1000 metric tons/day to be economically viable **[74]**. Historically, the main appeal of incineration is that it can tolerate a mixed stream, requiring minimal preparation. The disadvantage is that, because it is taking a mixed stream, the energy conversion is less predictable and efficient compared to other types of thermal treatment. In addition, emission levels need to be monitored closely.

Incinerators can lock up large volumes of waste for decades. In the presence of potential alternative technologies with more environmentally benign, and more profitable, operating models, their use should be carefully evaluated. Wherever possible, innovation should not be set back by the premature installation of capital-intensive established technologies.

INCINERATION IS NOT COMMERCIALLY VIABLE WITHOUT FEED-IN TARIFF AND TIPPING FEE SUBSIDIES

Incineration currently operates at a net cost requiring subsidies in the form of both tipping fees and electricity feed-in tariffs, which make up 65% on average and 25% of current revenue respectively **[75]**. In addition, incineration tipping-fee levels are often considerably higher than equivalent tipping fees for standard landfill disposal and alternative treatment options like anaerobic digestion. Without these subsidies, many incineration plants close.

The table below provides an overview of the level of tipping fees calculated for various projects in Indonesia.

Examples of tipping fees for different treatment options in focus countries [76]

Type of treatment	Country/city	Tipping fee
Incineration plant	Average Indonesia (estimate)	between 24.60 and 28.70 USD/metric ton
Landfill disposal	Jakarta	8.60 USD/metric ton
	Surabaya	9.40 USD/metric ton
	Average Indonesia	Below 8.20 USD/metric ton
Anaerobic digestion and landfill gas projects	Average Indonesia (estimate)	15.00 USD/metric ton or slightly less

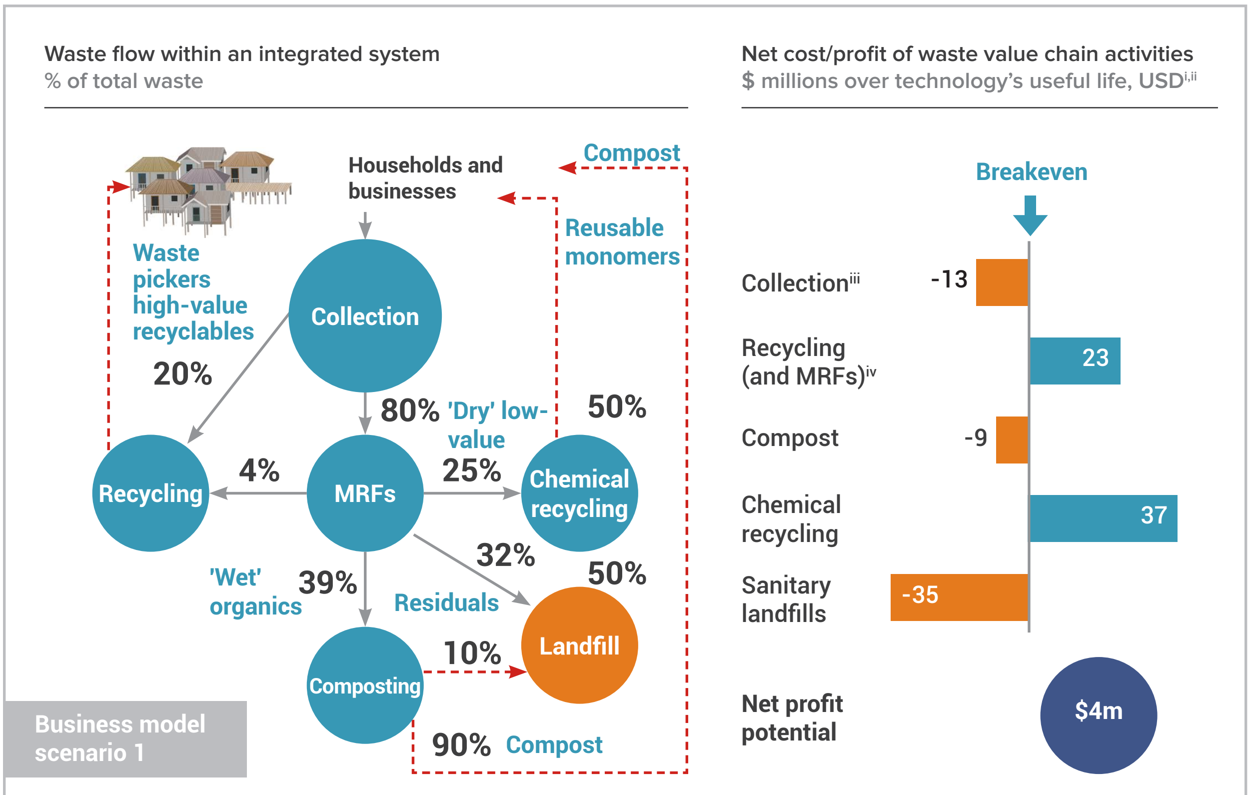
Finally, tools like the **Waste to Energy Rapid Assessment Tool** developed by the Collaborative Working Group, a global community of leading solid waste management (SWM) professionals and institutions, can help local governments evaluate and navigate potential treatment options. Using a series of checklists, it can also help decision-makers without significant technical expertise gage the credibility of firms pitching thermal technology solutions **[77]**.

An integrated waste management system — pulling the pieces together

To illustrate the potential for an integrated approach across the full waste value chain — collection, separation, recycling and treatment —three examples are presented, in Figures 18, 19 and 20, of possible pathways that might lead to the overall goal of self-sustaining systems. These are intended for illustrative purposes only; they are not specific recommendations. While both scenarios show profitability over the useful life of the technology, the scenarios do not necessarily represent investment-grade economics.

Figure 18 illustrates one of many possible scenarios for making waste management more profitable. It assumes that waste pickers extract the highest value waste (20%) before it is available for formal collection and processing; that households separate dry and wet waste; and that presorted waste enters an MRF where the few remaining high-value recyclables are picked off for mechanical recycling (4%), as well as all low-value plastics (polyethylene and polypropylene used in flexible films, bags, hygiene items, etc.) as feedstock for chemical recycling (25%). The low-value plastics are sent through a pyrolysis unit that breaks them down into monomers that can be reformed into virgin-like plastics. Meanwhile, roughly 40% of the stream representing the presorted wet items (comprised largely of food and landscape waste) is sent to municipal composting. The reject material from composting and the chemical recycling plant as well as the remaining waste from the MRF — primarily consisting of rubber, leather, inerts like stone and porcelain, nonusable plastics such as polystyrene, wood, nonrecyclable paper, and other unclassified waste — is sent to a sanitary landfill.

FIGURE 18. INTEGRATED RECYCLING, COMPOSTING AND CHEMICAL RECYCLING WASTE SYSTEM [30]



i Model case example with all revenue, operating costs (including maintenance), and capital costs normalized over 313 metric tons waste generation per day and over equipment's useful life.
ii Assumes oil price of $45/bbl.
iii Recycling profit includes MRF costs.
iv Collection costs exclude disposal tipping fees, which have been reallocated to disposal costs.

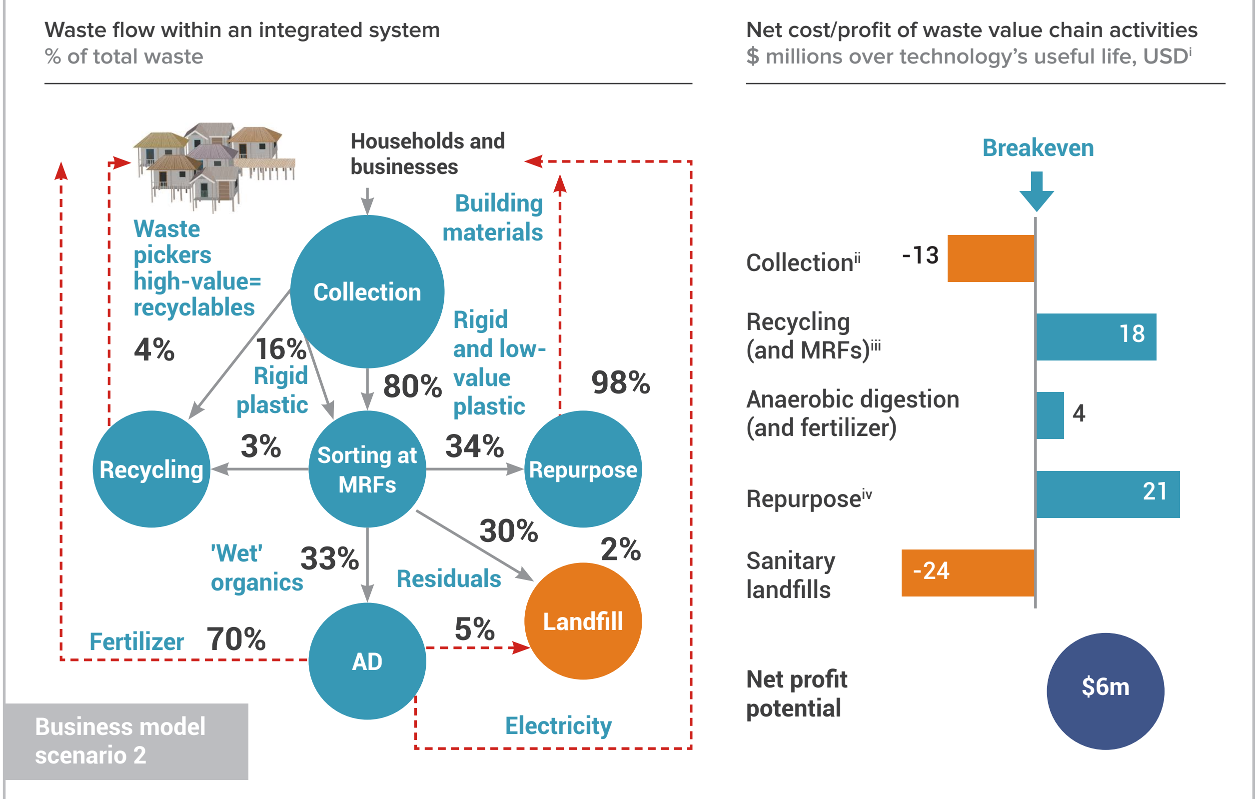
In this scenario, the value extracted from the waste over the useful life of the technology (20-25 years, depending on the technology), would deliver approximately $4 million profit. The primary drivers of profitability are the chemical and mechanical recycling; composting, landfilling and collection represent net negatives on the overall system. System profitability is also tied to the price of oil unless pricing guarantees can be extracted for the recycling outputs (both recyclate material and monomers for chemical recycling). This scenario assumes an oil price of $45/bbl. For perspective, the profitability of this scenario drops to zero at $20/bbl, while profitability increases to $30 million at $55/bbl.

To make this scenario economically viable, approximately 50 metric tons per day of the type of plastics mentioned above are needed for one monomer plant. This amount of plastic can be generated with approximately 200 metric tons of trash per day, which requires a population of 333,000 people, each producing 0.6 kg of trash per day. If feasible, cities of smaller population may consider partnering with other locations to achieve the required level of input.

Further, to enhance the economic viability of this scenario, vertical integration (singular siting) of all processing operations from MRF through conversion would eliminate duplicative costs and multiple transfer points for the waste. Additional value and savings can be sought by developing a viable compost market, currently a net cost due to general lack of existing markets, or by using waste residuals for energy generation or for waste repurpose outputs like building supplies.

Figure 19 illustrates a scenario in which low-value plastic and mixed rigid plastics are repurposed into plastic lumber. Low-value plastic (in combination with higher value, mixed rigid plastic) can be reconverted to a variety of high grade building materials such as construction lumber, flooring, and furniture. This scenario envisions railroad ties as the final product.

FIGURE 19. INTEGRATED RECYCLING, PLASTIC REPUROSE AND ANAEROBIC DIGESTION WASTE SYSTEM [30]



i Model case example with all revenue, operating costs (including maintenance), and capital costs normalized over 313 metric tons waste generation per day and over equipment's useful life.
ii Collection costs exclude disposal tipping fees, which have been reallocated to disposal costs.
iii Recycling profit includes MRF costs.
iv Assumes oil price of $45/bbl.

As in business model scenario 1, this scenario assumes waste pickers extract the highest value waste (20%) before it is available for collection and processing. However, in this case, a large percentage of the scavenged stream, consisting of mixed rigid plastic (MRP) such as bottle crates, pallets, toys, etc., is purchased by the MRF to give the repurposed building materials the desired density and strength. MRP is then combined with low-value (grade 3-7) plastics. The low-value plastic and MRP (34% of the MRF stream) is blended at a specified ratio and shredded/granulated before entering a compounder that heats the plastic just enough to make it malleable for repurposing. A binding agent is added to the plastic mix in the compounder and the resulting mixture is pressed into a mold to achieve the desired shape/size for the building material under consideration.

Meanwhile, roughly 33% of the stream representing the presorted wet items (comprised largely of food and landscape waste) is sent to anaerobic digestion and converted to energy and organic fertilizer.

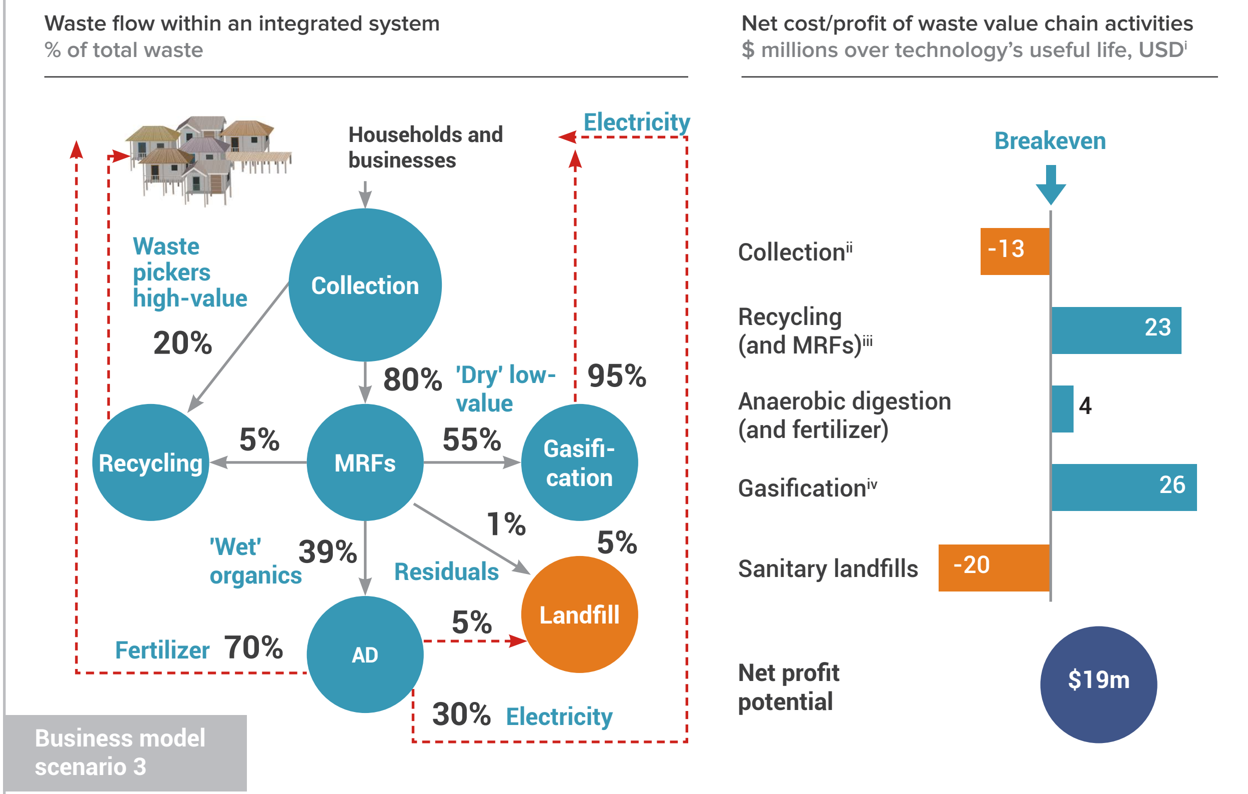
The reject materials from the AD unit, the repurpose plant and the remaining waste from the MRF — primarily consisting of rubber, leather, inerts like stone and porcelain, hygiene items, nonrecyclable paper, and other unclassified waste — is sent to a sanitary landfill.

In this scenario, the value extracted from the waste over the useful life of the technology (20-25 years, depending on the technology), would deliver approximately $6 million profit. The primary drivers of profitability are the building material sale from the repurpose unit and the energy derived from anaerobic digestion. In the current market environment, organic fertilizer is break even at best while collection and landfill represent net negatives. The current expected off-take price reflected in this scenario is $31 per 151 kg of railroad ties. A $1 change in the off-take price of railroad ties means an increase or decrease of $4 million in profitability.

To enhance the economic viability of this scenario, vertical integration (singular siting) of all processing operations from MRF through conversion would eliminate duplicative costs and multiple transfer points for the waste. In addition, to enable the conversion of all low-value plastic usually requires more MRP than a municipality can generate, thus requiring the purchase of MRP from alternate sources to supplement the MRP in the existing municipal stream. Manufacturing waste is typically an ideal source of MRP. Thus, coordinated partnerships with local industry to provide industrial MRP waste can create not only a steady source of feedstock, but also increase profitability for manufacturers. However, MRP is currently in demand for other applications including mechanical recycling. Competition for this material could potentially increase the price of the feedstock to the point that it could negatively impact financial viability. Furthermore, for the railroad tie output, the primary competition in the target economies for railroad ties is concrete ties, and the pricing of those ties dictates the market price a repurposed tie can command. Given this and the prevalence of a strong concrete industry, premium pricing (and better profitability) may be achievable when producing output products that could more readily compete with the lumber industry (such as framing construction, decking, docks, etc.).

Figure 20 shows another integrated scenario. As before, most of the valuable waste is removed directly from households. However, this scenario assumes that wet/dry separation occurs at the MRF using a mechanical separator that can segregate the wet from dry fraction. The dry fraction, representing roughly 55% of the stream and comprised largely of mixed plastics, textiles, rubber, and hygiene items is then sent to a gasification unit, where an anaerobic thermal process is used to break it into a clean gas that can be used in a boiler to generate electricity. Meanwhile, the wet fraction, representing 39% of the stream and comprised largely of food and green waste, is sent to an anaerobic digester. The anaerobic digester forces the biodegradation of the material and results in methane, which can be used in an internal combustion engine to create electricity. In addition, post-gas capture, the resulting material (digestate) from the anaerobic digester, can be used as an organic fertilizer, assuming proper cleaning of the wet stream entering the digester. The remaining waste from the MRF and the reject material from the AD and gasification units is sent to sanitary landfill. However, given the utilization of the vast majority of the stream, the fraction sent to sanitary landfill is quite small.

FIGURE 20. INTEGRATED RECYCLING, ANAEROBIC DIGESTION AND GASIFICATION WASTE SYSTEM [30]

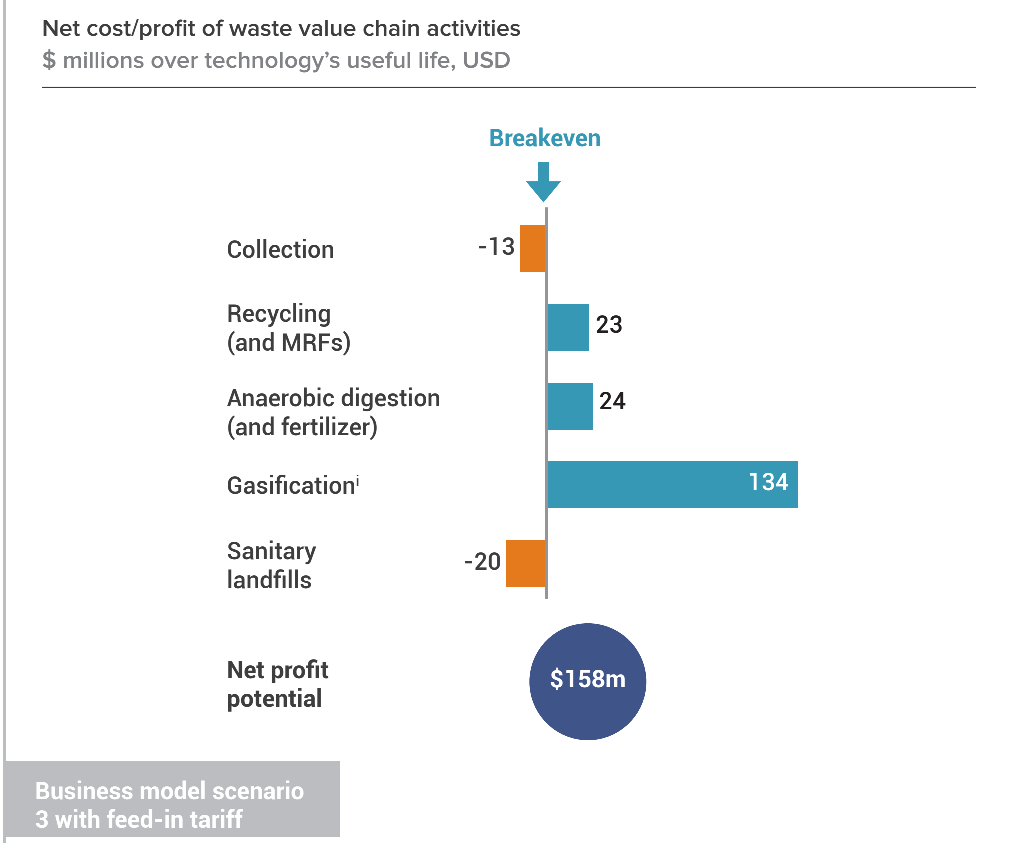


i Model case example with all revenue, operating costs (including maintenance), and capital costs normalized over 313 metric tons waste generation per day and over equipment's useful life.
ii Collection costs exclude disposal tipping fees, which have been re-allocated to disposal costs.
iii Recycling profit includes MRF costs.
iv Assumes an electricity price of $.08/kWh.

In this scenario, the value extracted from the waste over the useful life of the technology would deliver approximately $19 million. The primary driver of profitability is energy production from the gasification and AD units followed by recycling. As in scenario 1, landfilling and collection represent a drain on the profitability. However, in this scenario, landfill cost is far less because more of the waste stream is converted. Note that fertilizer also represents at best a break-even proposition given the lack of available market. Increases and decreases in profitability will be driven primarily by the electricity price. In this scenario, an electricity price of $.08/kWh was assumed. Dropping the electricity price by one cent per kWh (to $0.07), would extract $16 million of profitability out of the system. Alternatively, an increase in a single cent to the electricity price (to $.09/kWh) would add an additional $18 million of profitability. As before, vertical integration (singular siting) of all processing operations from MRF through conversion enables better profitability by optimizing the cost side of the equation.

Figure 21 shows the impact on profitability of scenario 3 with a feed-in tariff (FIT) in place, a guarantee for a higher level of electricity pricing.

FIGURE 21. INTEGRATED RECYCLING, ANAEROBIC DIGESTION AND GASIFICATION WASTE SYSTEM [30]



i Same scenario as model 2, except assumes a guaranteed electricity price of $.15/kWh.

In this scenario, a feed-in tariff of $0.15/kWh, in line with existing FITs in focal countries, improves the profitability of both the gasification and anaerobic digestion units. The lifetime profitability increases from $19 million to $147 million. Even though the nonsubsidized version produced $19 million in profit over the lifetime of the facilities. With an electricity price support, such investments are more attractive to investors.

Enabling this construct would require minimum collected waste of approximately 150 metric tons per day, with even larger population centers more likely to achieve economic viability. This would translate to a population of 250,000 (0.6 kg trash per person per day) and a waste stream that is no more than 40-50% food and green waste in the focal countries to enable adequate energy production from the gasification unit, which is the primary driver of the economics. Streams of higher food and green waste content can be considered for populations of 350,000 or more. As with the above scenario, the economic viability can be enhanced considerably by developing local off-take markets for the fertilizer output, turning a net negative into a positive. Given the requirement of large land space for various components of treatment facilities, municipalities can enhance the economic viability of this scenario by donating city land for construction, thereby eliminating land costs.

These hypothetical examples illustrate that only by focusing on improving the performance of the waste management system as a whole, starting with establishing a strong collection foundation, can the waste-spend deficit be reduced to a point at which no further funding is required (i.e., where the system breaks even), and can both development finance and private investor funds be attracted. The examples also illustrate that multiple configurations are possible to break even.

6 WASTE FUNDING ARCHITECTURES

Private sector stakeholders, donors, and other private investors need strong, transparent assurance that money given will be used efficiently and effectively, and governments must take care to tackle the issues of full disclosure of important investment information, engaging the most relevant actors and preventing free ridership. Funding models can be used to inject funds at critical points in the waste supply chain to stimulate desired market behaviors and waste management results.

While strong arguments can be made for a joint funding arrangement, the challenge comes in identifying the mechanism for funding this cost in a way that is fair, transparent and without undue burden on any one party; that creates a positive incentive to collect as much waste as possible; and that ideally generates backward pressure up the chain to minimize the cost and maximize recovery while reducing the deficit over time. In addition, if a substantial portion of the funds were from sources external to local governments themselves, it could powerfully change their underlying incentive structure from collecting as little waste as possible to collecting far more.

If the private sector, donors and other private investors are to cooperatively support cities with a shared funding model for basic waste services, they will need strong assurance that money given will be used appropriately. All funds must be demonstrated to be fairly and equitably sourced, effectively and efficiently placed, and transparently governed. In addition, it is important to ensure that the funds raised are not higher than needed to reach specified goals. Funders also need to know that their contribution into waste collection and separation is effective — that is, that it primes the entire waste collection system for investment.

Fair and equitable sourcing of private sector funds requires tackling the twin issues of materiality and free ridership. Materiality demands that all stakeholder contributions fairly represent their relative involvement in the issue. The free rider problem can be avoided by requiring all players to contribute. Materiality and free ridership are reasonable concerns, and they need to be addressed carefully. They are also impossible to get perfectly right. Many partnership funding efforts have "failed slowly" as some players insisted on perfect algorithms, while the others took a wait-and-see approach.

There are ways to start simply. Materiality becomes much easier to manage when membership is perceived as an opportunity rather than an obligation. Privileges can include, among other benefits, participation in fund deployment decision-making, tax relief, regulatory certainty, transfer of environmental liability, attractive public-private partnership opportunities and access to inputs and resources. Similarly, the magnitude of funding from each contributor may not need a complex algorithm; initially at least, a voluntary scheme could be considered that gives major plastics producers and consumer brands the chance to become part of the waste management solution at favorable and potentially exclusive terms.

ENVIRONMENTAL LIABILITY

Some economies and private sector players are considering product end-of-life environmental responsibility. By supporting municipal waste management services, the private sector essentially pays for environmental insurance, effectively transferring the environmental liability of properly disposing product waste to an independent body with government oversight. For a fee, independent bodies then handle product disposal and take on any further risk. Such arrangements can be seen in South Africa, Canada, Denmark, Holland and the UK, where mandatory environmental disposal charges are required for tires.

As the concept of partnership funding proves itself over time, there may be a desire to broaden the participation and address the problem of free ridership. At that stage, the established members of the funding partnership may consider tightening the standards for materiality and participation. Contributions can also be calculated in a way that creates incentives for greater recycling. For example, collecting money from product manufacturers based on level of virgin plastic materials or by ease of product recyclability incentivizes product design changes away from 'lower value' plastic items that cannot be economically recycled in local markets and concurrently grows recycling demand.

PRODUCT STEWARDSHIP IN BRITISH COLUMBIA

One approach to private sector-led product stewardship is the Extended Producer Responsibility Program in British Columbia, which shifts the responsibility for end-of-life management of recyclable products and packaging from taxpayers and governments to producers and consumers. The initial mandate involved a deposit-refund system for beer containers, but over time, additional products were targeted for recovery **[78]**.

Producers wishing to distribute products in British Columbia must operate under an end-of-life management plan approved by the Ministry of Environment **[79]**. Many opt to contract with stewardship agencies to help develop and manage these development plans. These agencies are nonprofit organizations that are funded by the producers of a particular product group, such as batteries, packaging or electronics, and are charged with managing the waste supply chain from collection to post-collection processing and marketing **[80]**. Producers have to pay only for their management agency to operate, not per metric ton of material produced **[79]**. If a producer's product is not recyclable with current technology, the producer must also pay a separate research and development fee to help resolve technical and market barriers for the product.

There are different benefits and challenges with both voluntary and regulatory approaches to engaging the private sector in funding partnerships. Approaches need to be designed to be appropriate for the local context and with clear performance, operational and materiality criteria in mind. Determining which entities are physically responsible for managing the systems is an important step to ensure existing, locally appropriate recycling schemes are not undermined.

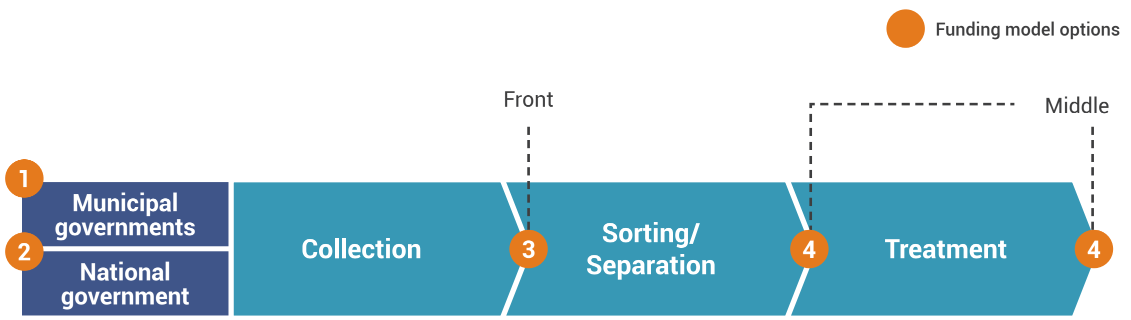
An independent funding and disbursement agency could provide needed transparency and fiscal assurance to nongovernmental stakeholders considering supporting waste management. This agency could use pay-for-performance incentives, regardless of which model is used to disperse those funds (explored in Figure 22 and subsequent sections). The operation of this intermediary institution should be jointly convened and financed by all players in the waste value chain, including the private sector, federal government, cities and DFIs for grant funding, and could be housed in an established institution. In a simplified design, the intermediary could manage the collection, payment and auditing of funds and report performance of waste indicators. It would act as a monitor on both sides of the investment, checking to see that the funders' (voluntary) pledges have been fulfilled and whether the projects have performed well.

Additionally, the scope of the intermediary agency could be expanded to provide technical assistance in setting up best-in-class collection models **(See Recycling Partnership case study)**, and it could serve as a mentor or advisor to support the incorporation of waste pickers into the integrated model. The intermediary could also help with the coordination of national and local policies. National standards for incentives (like recycling credits or feed-in tariffs), including waste classification, environmental performance and monitoring, are critical for enabling investments but can be challenging to synchronize with local policy. Finally, the intermediary could serve as a fiscal agent, either with cities or independently in public-private partnerships with municipal and private sector funders, though governments may also decide to use the intermediary as a broker to set up these partnerships. These institutional design issues need further exploration, as discussed in the final section of this report **The Path Ahead.** This is explicitly included in the sixth policy and practice recommendation for APEC:

APEC policy and practice recommendation 6 – Enable innovative, transparent funding approaches: Where appropriate, enable the establishment of innovative, transparent funding approaches. These might include independent, blended pooled funding entities, and pay for performance delivery models.

There are multiple points in the waste supply chain where funds can be applied based on locally specific characteristics and goals (Figure 22). Funds can be provided at the front end of the waste system, directly enabling cities or even national governments to strengthen and build collection systems. Alternatively, funds can be injected in the form of a price guarantee for plastic waste at a price high enough to stimulate an entrepreneurial race to deliver the waste. Finally, funds can be used to provide off-take guarantee pricing for the end product of the waste treatment process (e.g., synfuel, monomers), creating pull-through demand to the front of the chain. This can help output derived from waste treatment to compete with virgin alternatives, which are sometimes subsidized (e.g., fertilizer, fossil fuels). The appropriate model will be dictated by the particular local circumstance, and multiple models may be used simultaneously depending on context.

FIGURE 22. FOUR POTENTIAL FUNDING MODELS [33]



Municipal pay-for-performance

Support local municipalities with waste management funding using pay-for-performance incentives and with technical expertise (e.g., land-use planning, PPP contracts, treatment selection).

Nationalized system

Nationalize waste management, taking back responsibility for waste management from municipalities, and contracting with large private suppliers (e.g., Veolia, WMX) to provide waste services regionally or country wide.

Pay-for-trash

Pay for delivered bags of mixed and separated trash, thereby driving entrepreneurial collection enterprises and directly incentivizing greater collection levels.

Output price support

Offer competitive off-take pricing for output goods developed from MSW (e.g., electricity feed-in tariffs, recycling credits or subsidies) to stimulate investment in processing technology.

Front-end funding models

Model 1: Municipal pay-for-performance model

Municipal governments choose collection and disposal solutions that work best for local conditions, and funding is given on the condition of keeping up with MSW best-practice guidelines and maintaining transparency. Municipalities are given financial and technical support for key waste management challenges.

+ Pros

- Municipalities are given both financial and technical support while still retaining decision-making control to choose waste solutions that best fit their needs.
- Facilitates monitoring and generation of waste management data using consistent methodologies that can be used for national planning, corruption prevention, etc.
- Enforces national waste regulations through positive incentives and works toward waste carbon dioxide targets.
- Generates efficiencies as models pay for performance outcomes rather than processes.
- Could potentially provide sufficient long-term contracts and opportunities for tripartite agreements among private providers, municipalities, and IMF and governments.

- Cons

- The success of pay-for-performance models depends on the reliability of metrics and the right targets, which may not be in place.
- May be harder to scale and implement across a country like Indonesia with 34 provinces and hundreds of cities; although it could be more manageable if led by regions.

Model 2: Nationalized system

This model suggests nationalizing and then privatizing waste management. The national government would relieve local municipalities of waste responsibilities and then contract them out to private waste collection services.

+ Pros

- Easier to raise waste funding as an economy versus numerous individual cities.
- Often cities don't have the technical skillset to manage local waste.
- Waste is not currently profitable, so cities hold onto control less.
- Municipal contracts are routinely ignored, particularly when administrations change, although this is an issue of contract enforcement law.
- Easier to aggregate feedstock for national applications like chemical recycling.

- Cons

- Can be politically challenging.
- Takes power away from local governments, who may have region-specific knowledge.
- Locks in potentially unfavorable terms for seven to eight years or more.
- Creates a new bureaucracy that could be prone to governance challenges.

SINGAPORE CASE STUDY [81]

The National Environmental Agency (NEA) plans, develops and manages Singapore's waste management system. NEA appoints waste collectors to manage domestic MSW in each of Singapore's seven geographic sectors. Public waste companies interested in bidding are required to meet established criteria and submit bids to provide collection services. MSW in Singapore is largely recycling, an offshore sanitary landfill and energy recovery (four plants with tipping fees of $77-$81/metric ton). Awarded contracts typically last for seven to eight years.

Central funding model

Model 3: Pay-for-trash

In this model, households, waste pickers or entrepreneurial material collectors are paid for bags of mixed and separated waste delivered to collection stations, thereby stimulating entrepreneurial collection enterprises. This model has the most direct link between incentive and outcome — all trash is given a direct value.

+ Pros

- Savings on capital costs (e.g., trucks, temporary storage facilities) because households and waste pickers internalize the cost of collection in their business models as they bring waste to the processor.
- New employment opportunities for local entrepreneurs and income seekers.
- Circumvents potential municipal corruption.
- Encourages public awareness of the value of waste.
- Enables effective waste aggregation.
- Can pull waste from entrepreneurial waste collection (e.g., waste pickers sell waste to central collection facility rather than a local junk shop).

- Cons

- Tagging and scanning technology would be prohibitively expensive, face private sector resistance and complicate recycling.

A game changer for this model, although not necessary to prove success, would be embedding plastic packaging with tags that could then be scanned dynamically to determine bag contents, level of sorting and underlying value of waste in each bag. Compensation for waste collected could also be paid electronically in what would be a no-cash system. Before making payments for sorted trash, it is essential to establish that there is an endpoint at which that waste type can be used.

HASIRU DALA CASE STUDY [82]

Bruhat Bengaluru Mahanagara Palike (responsible for civic and infrastructural assets in the greater Bangalore metropolitan area) establishes dry waste collection centers, where dry waste gets sorted, graded and sent off for recycling. Hasiru Dala, an organization dedicated to improving the health and livelihoods of waste pickers, manages 33 of the 198 dry waste collection centers in operation. They sign collection agreements with individual waste pickers and dealers and have diverted 8,610 metric tons of low- and high-value dry waste and 3,713 metric tons of organic waste from landfills.

Back-end funding model

Model 4: Output price support

In this model, competitive off-take pricing is given for output goods developed from MSW (e.g., electricity feed-in tariffs, recycling credits) to incentivize investment in processing technology and pull-through collection levels. Providing off-take guarantees for recycling, monomers or energy would also minimize risk for investors.

+ Pros

- Easiest model to implement, involving only price controls at the end of the waste value chain.
- Costs for interventions like feed-in tariffs can be passed directly onto consumers.
- Stimulates investment by increasing recycling and treatment returns.

- Cons

- May not be strong enough to pull collection of waste through the system.
- Historically, when price support disappears, many businesses fail.

7 THE PATH AHEAD

This report identifies the key factors that inhibit investment in and the development of effective waste management systems in developing Asia and proposes several possible solutions that work toward the ambitious goal of sustainably reducing plastic waste leakage into the ocean annually by 50% by 2025. Key themes included why developing Asia has not prioritized and invested more in waste management and what it would take to incentivize and de-risk such investment in the short- to medium-term. Key factors identified that inhibit investment in and development of waste management systems include:

- Municipalities find implementation of national waste management policies challenging. Moreover, enforcement is minimal.
- Currently the value of the plastic waste stream available as feedstock to recycling and treatment is low and does not offset collection and sorting costs; the cumulative value of all waste generated does not offset all costs.
- Operating funds are thus required for waste management, but national and local governments may not prioritize waste management as much as other competing priorities in their budgets.
- When external waste management support is provided, it is often in the form of capital or infrastructure investments in sanitary landfills and waste to energy systems. Currently these are capital intensive, require significant ongoing operation expenditures, lock in cities for 30 or more years and may forestall innovation in emerging treatment technology to process low-value plastics.
- Households typically find ways to dispose of waste themselves, primarily through dumping or burning in the absence of waste services or where there is a specific charge.

To combat these endemic problems, there is a need to develop solutions at both the opportunistic and the systemic level.

Opportunistic solutions

The data shows that reducing the volume of plastic waste flowing into the ocean is imperative. There are a number of solutions that are highly cost effective and can be clearly demonstrated as being in the public and private interest. These include:

- **Beach and waterway cleanups.** Over 30 years, the International Coastal Cleanup™ has involved 11 million volunteers from 153 countries who retrieved 95,000 tons of trash from beaches and waterways. A significant portion of this retrieved litter is plastic waste. Many other groups conduct similar cleanups on a regular basis throughout the world. While this is indeed a small fraction of the overall plastic waste in the ocean, cleanups can be very effective at the local level, and they build strong issue recognition within local community. There is great potential in expanding these efforts, with more frequent cleanups, "adopt-a-beach programs" and more formal involvement at varying levels of government.
- **Waterway infrastructure.** The use of traps for plastic near shores and in rivers has proven effective in areas ranging from the Anacostia River in Washington, D.C., to Bali, Indonesia. These trap systems are maintenance intensive and can be can be overwhelmed by surges of trash, but properly done, they can provide effective local relief until more systemic infrastructure solutions are found.
- **Local monitoring and blocking of leakage points.** In each city, there are a number of relatively simple behavioral interventions that can keep plastic out of waterways. These include designating rain-heavy days to be free of outdoor trash deposition, reduction of single-use plastic packaging and neighborhood collection schemes. These initiatives can be sponsored and organized in key metropolitan areas by consumer packaged goods companies, plastic producers, hospitality and tourism industries and other businesses using their considerable marketing and analytical capacity.

Systemic solutions

For sustainable improvement, the root causes of the waste management breakdown need to be addressed. Because waste management is not yet an infrastructure priority in many developing economies, and traditional systems are not economically self-sustaining, a dramatic improvement of the economic viability of waste management infrastructure is needed to reduce the need for subsidies on a long-term basis and to attract public and private investment. To successfully implement these solutions, partnerships with other groups that derive value from improving waste management, such as government agencies and private enterprises interested in improving public health, fishing and tourism should be considered, where appropriate. These solutions include:

- **Whole waste stream collection and separation infrastructure.** Collection is the foundation of any waste management system. All waste management solutions require the efficient collection and separation of waste. As with other priority infrastructure projects in developing economies, the goal should be to build collection and separation systems that are designed to accommodate the treatment and recycling technologies of the future, not of the past. The future generation of technologies has the potential of turning low-value plastic waste into high-value products and energy, but they all have specific feedstock requirements that in turn necessitate carefully designed and calibrated waste separation schemes. If today's collection and separation systems are built to serve only landfills and waste-to-energy facilities, a huge opportunity is lost.

  Again, as with other innovative infrastructure solutions, these collection and separation systems will require subsidies, at least initially. Subsidy levels can be reduced over time by employing new, heavily data-driven efficiencies and new separation approaches and as new treatment and recycling technologies generate greater value from waste feedstock. In short, collection and separation should be regarded by governments and investors not as a dead end, but as setting the stage for technological innovation on the treatment and recycling side. Plastic producers, consumer brands, cities and international development finance institutions can collaborate on developing and financing these systems, at least for an initial period long enough to provide attractive feedstock security for a new generation of treatment and recycling technologies.

- **Traditional waste management: sanitary landfills, reuse, repurpose, and small-scale waste-to-energy**. There are a number of situations in which traditional waste management systems are the preferred solution. For example, in rural areas with relatively low waste density, the safe storage of residual plastic waste is often an integral component of even the best designed "zero-waste" programs. In smaller towns, there is often an opportunity to combine an upgrade of landfills with relatively small-scale pilots of promising new technology. Lastly, the list of potential reuse technologies (e.g. plastic to railroad ties or local building materials) is steadily growing and may have very attractive local applications.

- **Vertically integrated waste management systems using emerging technologies to process low-value plastics.** Ultimately, this may be a transformative solution for big cities: well-integrated waste management systems designed to reduce costs and serve high-technology treatment options that are sufficiently profitable to pay for most, if not all, of the waste management system. These technologies will include a mix of reuse, chemical recycling, and advanced anaerobic waste-to-energy systems. Many of these technologies are in development and have yet to be commercialized. The challenge today is to create an environment that significantly accelerates the pace of commercialization. This includes the "on spec" development of appropriate collection and separation systems (see above); the financing of pilot innovation in suitable environments (in areas with robust monitoring and enforcement controls); and the systematic reduction of structural risks such as contract security, political succession, commodity definitions, and waste-stream ownership, among others.

Creating value from waste is a complex challenge, but one that could be met in a relatively short time frame through a partnership involving, in each economy, a set of municipalities, national government agencies, DFIs, local CSOs and their community partners, and private sector players to design a concrete, institutionally and financially well-supported strategy for moving ahead. Each of these actors has a strong interest in solving the post-consumer waste crisis in developing Asia. Through cooperative financing, sharing of analytical and marketing resources, research and development joint ventures, and joint advocacy for the right policies, it is possible to meet the environmental goal of significantly reducing the leaking of plastic waste to the ocean.

APPENDICES

APPENDIX 1: POLICY AND PRACTICE RECOMMENDATIONS ENDORSED BY APEC MEMBER ECONOMIES

Asia-Pacific Economic Cooperation (APEC) aims to support sustainable economic growth and prosperity in the Asia-Pacific region. APEC is driven to build a dynamic and harmonious Asia-Pacific community by championing free and open trade and investment, promoting and accelerating regional economic integration, encouraging economic and technical cooperation, enhancing human security, and facilitating a favorable and sustainable business environment. Its 21 Member Economies are home to around 2.8 billion people and represented approximately 57% of world GDP and 49% of world trade in 2014.

In 2014, the APEC Virtual Working Group on Marine Debris was jointly established by the Chemical Dialogue and the Oceans Fisheries working groups. This project promotes innovative solutions to the issue of marine debris with a particular focus on innovations in land-based solid waste management **[83].** It is also of interest to APEC Senior Officials and APEC Senior Finance Officials.

This work supports APEC's work on "addressing marine debris through pilot projects to design and implement economically sustainable waste management infrastructure **[84]**," which proposes to demonstrate the feasibility of a range of interventions to address marine debris in APEC cities. The project also supports the current APEC Regulatory Cooperation Advancement Mechanism (ARCAM) initiative to facilitate trade and investment in sustainable materials management solutions **[85]**. Ocean-related issues for economic growth, including the reduction of marine debris, have been identified as a top priority for APEC economies in 2016.

The results of this analysis helped in formulating the policy and practice recommendations that have been endorsed by APEC Member Economies to overcome barriers to the financing of waste management projects in the APEC region. These policy and practice recommendations provide guidance for establishing the political, economic, legal and regulatory conditions that will prioritize and incentivize investment by countries, multilateral development banks, venture capital firms and others in the private sector in waste management and thus mitigate the associated human health, economic and ecological effects caused by poor waste management infrastructure.

These policy and practice recommendations were first discussed at the APEC High Level Meeting on Overcoming Barriers to Financing Waste Management Systems to Prevent Marine Litter held on September 28-29, 2016 in Tokyo, and they were later endorsed by the Oceans and Fisheries Working Group, the Chemical Dialogue Working Group and the Committee on Trade and Investment. They were then explicitly endorsed by the Annual Minster's Meeting (AMM) Joint Statement, and the importance of the topic and need for work on waste management by Member Economies was stated at the highest level in APEC through the **Leaders' Declaration** issued in November 2016.

- ***APEC policy and practice recommendation 1 – Set ambitious attainable targets:*** Set ambitious yet attainable waste management targets at the economy-wide and municipal levels in consultation with affected stakeholders, consistent with the Sustainable Development Goals (SDGs) and, as appropriate, The Paris Agreement on Climate Change, and encourage regions or provinces to develop detailed action plans to reach agreed targets.

- ***APEC policy and practice recommendation 2 – Measure and reward progress:*** Build waste management performance indicators and methodology to track progress against economy-wide and municipal waste targets, maintain an economy-wide waste database, and encourage and acknowledge frontrunner cities for their overall waste and sanitation achievement through competitive award and certification.

- ***APEC policy and practice recommendation 3 – Determine shared terms:*** Issue APEC guidelines on the development of definitions related to sustainable materials management (SMM) that facilitate trade in new technologies, and investment in recycling, recovery and other related SMM solutions.

- ***APEC policy and practice recommendation 4 – Streamline decision-making:*** Concentrate the majority of municipal solid waste responsibilities within a single government entity or independent department or agency, while clearly defining the waste-related roles and responsibilities of remaining institutions **[47]**.

- ***APEC policy and practice recommendation 5 – Increase funding and improve outcomes by financing all phases of integrated waste management systems:*** Increase dedicated financial support from domestic governments and encourage other stakeholders including the domestic and international financial community and other private sector actors to invest in local waste management.

- ***APEC policy and practice recommendation 6 – Enable innovative, transparent funding approaches:*** Where appropriate, enable the establishment of innovative, transparent funding approaches. These might include independent, blended pooled funding entities, and pay for performance delivery models.

- ***APEC policy and practice recommendation 7 – Reward recycling and innovative, environmentally sound waste treatment:*** Develop end-of-life incentive policy to stimulate recycling market demand and increase product recyclability; create conditions that encourage investments in waste collection, sorting and environmentally sound waste treatment.

- ***APEC policy and practice recommendation 8 – Incentivize entrepreneurial waste pickers:*** Encourage the waste picker sector to assume new service roles in waste collection, recycling, composting, and treatment through facilitation by NGOs and municipalities to improve health and safety while improving economic livelihoods.

- ***APEC policy and practice recommendation 9 – Enforce strong environmental standards to guide innovation:*** Set strong environmental standards with reliable and transparent monitoring; consider community engagement strategies for transparency and accountability.

APPENDIX 2: ANALYSIS OF THE WASTE MANAGEMENT LANDSCAPE

Table 3 shows the basic waste and waste management statistics for Indonesia, Vietnam and the Philippines. Though there are important differences in, for example, collection rates, the overall story is quite similar: rapid growth of waste volume confronting a lack of collection and recycling infrastructure with most trash deposited into unsanitary dumpsites and landfills **[86]**.

TABLE 3. SUMMARY OF WASTE MANAGEMENT IN INDONESIA, THE PHILIPPINES AND VIETNAM

	Indonesia	Philippines	Vietnam
Waste value chain statistics			
Population	256 million (2015 est.) [87]	101 million (2015 est.) [87]	94 million (2015 est.) [87]
GNI per capita based on 2015 purchasing power parity (PPP), in USD	$3,440 [88]	$3,540 [88]	$1,980 [88]
Total municipal solid waste generation	38.5 million metric tons (2008) (major islands only) [49]	14.4 million metric tons (2014) [89]	12.8 million metric tons (2013) [90]
Waste generation rate per capita per day	0.45 kg (2008) (major islands only) [49]	0.69 kg (metro Manila) (2010) [89] 0.34 kg (all local government units in the country, excluding Manila)(2010) [89]	1 kg (urban population only) (2010) [91]
Percentage of waste composition	MSW composition [49] Organics – 65% Plastics –11% Paper – 13% Fabric – 1% Glass – 1% Metal – 1% Other – 8%	MSW composition [89] Biodegradable waste –52.31% Paper and cardboard – 8.7% Plastics – 10.55% Metals – 4.22% Glass – 2.34% Textile, leather and rubber – 1.97%; Residual waste –17.98% Special waste – 1.93%	MSW composition [90] Food wastes – 41.9% Plastics – 15.6% Paper – 1.9% Metal – 6% Glass – 7.2% Other – 27.4%
Waste collection rate (urban/rural)	56% [51] / 5% [50]	90% / 80% [69]	76% / 40% [90]
Life expectancy (years)	67 (male) / 71 (female) [92]	65 (male) / 72 (female) [93]	71 (male) / 81 (female) [94]
Corruption Perception Index score	35 [95]	35 [95]	31 [95]

National policy frameworks for waste management have been developed in each of the focal countries: Indonesia, the Philippines and Vietnam. While waste governance and policy has many strengths, there are also a number of challenges (such as budgetary and technical limitations) national and local governments face in implementing the frameworks on the ground. Table 4 outlines the waste management landscape for each economy.

TABLE 4. WASTE MANAGEMENT LANDSCAPE OVERVIEW

	Indonesia	Philippines	Vietnam
Institutional arrangements for waste management			
The main national institution(s) involved in waste management planning	• Ministry of Environment and Forestry • Ministry of Public Works • Ministry of Energy and Mineral Resources	• National Solid Waste Management Commission (NSWMC)* • Department of Environment and Natural Resources (DENR)	Ministry of Natural Resources and Environment (MONRE)
Other subsidiary national line ministries involved in waste management	• Coordinating Ministry for Maritime Affairs • Ministry of Finance • Ministry of Home Affairs	• Department of Interior and Local Government (DILG) • Department of Public Works and Highways (DPWH) • Department of Trade and Industry (DTI) • Department of Science and Technology (DOST) • Department of Health (DOH) • Department of Agriculture (DA) • League of Barangay, Cities, Municipalities and Provinces** • Metropolitan Manila Development Authority (MMDA) • Philippine Information Agency (PIA) • Technical Education and Skills Development Academy (TESDA)	• Ministry of Construction (MOC) • Ministry of Industry and Trade (MOIT) • Ministry of Planning and Ministry of Agricultural and Rural Development (MARD) • Ministry of Health (MOH) • Ministry of Planning and Investment (MPI) • Ministry of Transportation (MOT • Ministry of Finance (MOF)
The main provincial- , regional- or federal-level institutions involved in WM	Provincial Environment Agency	Provincial Solid Waste Management Department	Provincial People's Committee (PCCs) /Municipal People's Committee (PC)
The main municipal-level institutions mandated for WM	City/municipality Cleansing Agency	Environmental Protection and Waste Management Department	• Department of Natural Resources and Environment (DONRE) • Department of Construction (DOC)

**NSWMC and DENR are separate agencies. NSWMC is under the Office of the President*
***The Leagues are not government agencies*

	Indonesia	Philippines	Vietnam
Waste management policy landscape			
Waste management policy/ national waste management law	Waste Management Law No. 18/2008	Ecological Solid Waste Management Act of 2000 (R.A. 9003)	▸ Law on Environmental Protection [No. 55/2014/QH13) – Revised in 2014]: the first law text relevant to all environmental protection issues including waste management ▸ Decree on Solid Waste Management [Decree No 59/2007/ND-CP dated April 9, 2007]
Other important waste management legislations, regulations, strategies and guidelines	▸ Government Regulation No. 81/2012: Management of Household Waste and Waste Similar to Household Waste ▸ Ministerial Decree 33/2010: Guideline of Municipal Solid Waste Management ▸ Ministerial Decree 13/2012. Under Ministry of Environment and Forestry stipulates encouragement of enforcing Waste Bank Program	▸ Toxic substances and Haz. And Nuclear Waste Act of 1990, Clean Air Act of 1999 ▸ PD No. 856, Code of Sanitation and PD 1152, Philippine Environmental Code required cities and municipalities to provide efficient collection, transportation and disposal of wastes ▸ Renewable Energy Act of 2008 (RA9225) ▸ Resolution Adopting the National Framework Plan of the urban poor waste picker sector in Solid Waste Management	▸ Decision No. 2149/QD- TTg of the Prime Minister issued on 2009 - National Strategy on Integrated Solid Waste Management until 2025 ▸ Waste and scrap management Decree [Decree 38/2015/ND-CP dated 22 April 2015] – effective from 15 June 2015 ▸ Circular No.: 32/2015/TT-BCT Regulations on project development and electricity purchase contract applying for generator projects using solid waste ▸ Decree No. 67/2011/NĐ-CP [plastic bag tax] ▸ Decree 121/2008/TT-BTC dated 12/12/2008 [guides the preferential policies and financial support for establishment of solid waste treatment (eligibility incentives and support for financial incentives and financial support for the solid waste disposal facilities) ▸ The Prime Minister's Decision No. 71/2010/QD-TTg dated November 09, 2010 on promulgating the Regulation on pilot investment in the public-private partnership form indicates waste treatment plants as one of the nine sectors for pilot investment in the public-private partnership form

Indonesia

Indonesia has utilized regulatory tools to encourage higher clarity and transparency to waste management, and to encourage public-private partnerships in product responsibility. Until now, however, most municipalities have struggled to enforce these policies due largely to gaps in funding and technical support. In general, the main focus is still to collect, transport and dispose of MSW rather than other activities such as recycling or treatment of waste. Although some municipalities are doing well, particularly when waste is made a political priority and funding made available, a comprehensive waste management system and clear institutional arrangements at all levels are not yet in place. In practice, collection levels in Indonesia remain low at 56% in urban areas **[49]** and 5% in rural areas **[50]**.

There are more than 20 various government ministries that are associated with waste management, including the Ministry of Environment and Forests and the Ministry of Public Works. Although the ministries offer sectoral interlinkages among departments, they suffer overlaps in their rights and responsibilities, creating ownership and diffused responsibility issues.

Some best-practice examples of private sector initiatives in waste management have emerged in Indonesia. Payatas MRF, for example, provides jobs for organized groups of waste pickers.

TABLE 5. WASTE MANAGEMENT POLICY LANDSCAPE IN INDONESIA

Strengths	Challenges	APEC Policy and Practice Recommendations
• The Waste Management Law is expansive with a wide range of provisions. • The Ministry of the Environment (MOEF) has a 20% waste reduction target. • Multiple agencies are involved in waste management. For example, MOEF is in charge in policymaking, and the Minister of Public Works (MPW) heads infrastructure planning and development. • Indonesia provides feed-in tariffs for energy produced by municipal solid waste and landfill gas. Subsidies are quoted in USD, reducing foreign exchange concerns for investors.	• Provisions in the Waste Management Law provide less detailed guidance for local governments' implementation of the law as well as unclear funding allocation. • Limited technical guidance, and roles and responsibilities of the multiple agencies involved include unclear integration of private sector waste management efforts. • Overlapping roles and responsibilities among government departments. • Lack of evidence-based research for waste management needs, target setting (e.g., 20% waste reduction) and planning. • Minimal waste data. • Citizen participation in waste handling and funding of waste management infrastructure contributes to widely practiced dumping.	• APEC PPR 1: Set ambitious yet attainable waste management targets at the economy-wide and municipal levels in consultation with affected stakeholders, consistent with the Sustainable Development Goals (SDGs) and, as appropriate, The Paris Agreement on Climate Change, and encourage regions or provinces to develop detailed action plans to reach agreed targets. • APEC PPR 2: Build waste management performance indicators and methodology to track progress against economy-wide and municipal waste targets, maintain an economy-wide waste database, and encourage and acknowledge frontrunner cities for their overall waste and sanitation achievement through competitive award and certification. • APEC PPR 4: Concentrate the majority of municipal solid waste responsibilities within a single government entity or independent department or agency, while clearly defining the waste-related roles and responsibilities of remaining institutions. • APEC PPR 5: Increase dedicated financial support from domestic governments and encourage other stakeholders including the domestic and international financial community and other private sector actors to invest in local waste management. • APEC PPR 6: Where appropriate, enable the establishment of innovative, transparent funding approaches. These might include independent, blended pooled funding entities, and pay for performance delivery models. • APEC PPR 7: Develop end-of-life incentive policy to stimulate recycling market demand and increase product recyclability; create conditions that encourage investments in waste collection, sorting and environmentally sound waste treatment. • APEC PPR 8: Encourage the waste picker sector to assume new service roles in waste collection, recycling, composting, and treatment through facilitation by NGOs and municipalities to improve health and safety while improving economic livelihoods. • APEC PPR 9: Set strong environmental standards with reliable and transparent monitoring; consider community engagement strategies for transparency and accountability.

The Philippines

The Ecological Waste Management Act (2000) in the Philippines outlines institutional arrangements, roles and responsibilities, incentives, unlawful activities, reduction targets, collection mandates and sanctions of SWM. It also provides detailed guidance on waste collection and transportation, recycling and disposal, as well as appropriate funding sources **[96]**. The Act mandates the establishment of a separate National Solid Waste Commission as a policymaking body and support agency for the implementation of SWM policies. The Ecology Center, which serves as the technical support for waste management, was also established under the Act. The Act is further supported by the Code of Sanitation (PD 856) **[97]** and the Philippine Environmental Code (PD 1152) **[98]**, requiring cities and municipalities to enforce sanitation requirements for hospitals, markets, ports, airports, vessels, aircraft, food establishments, buildings and other establishments with clear guidance to provide efficient collection, transportation and disposal of waste.

Although the picture of waste collection is not the same across all municipalities and localities, in general, the Philippines has a high collection rate in both urban areas (90%) and rural areas (80%) **[69]**. This is attributed to the provision of a clear legal framework and technical and funding support for collection, as well as the engagement of many stakeholders (although this is lacking for disposal). This has included the integration of the waste picker sector in the formal waste management system through the 2009 National Framework for the Informal Sector in Solid Waste Management (NSWMC). The NSWMC further works to provide skills development, livelihood security, employment and social services. The Philippines also has a national-level Informal Waste Sector Network (PIWSNet), which supports waste pickers through trainings focused on information exchange, knowledge management and network building.

TABLE 6. WASTE MANAGEMENT POLICY LANDSCAPE IN THE PHILIPPINES

Strengths	Challenges	APEC Policy and Practice Recommendations
▸ Comprehensive Ecological Solid Waste Management Act 2000 (RA9003) provides clear and detailed provisions and guidance on how waste should be managed by local governments and stakeholders involved at all levels. ▸ Funding mechanisms are provided for by the Ecological Act. ▸ Integration of the informal sector to the waste sector structure increases waste collection and recycling capacity as well as contributing to poverty reduction and increased quality of life. ▸ The Philippines provides feed-in tariffs for energy produced by landfill gas.	▸ No comprehensive monitoring and evaluation system for waste management at all levels. ▸ Most of the personnel engaged in SWM at the local level have ill-defined roles, or have limited knowledge or appreciation of the existing SWM framework. ▸ Limited external funding and technical support assistance for local governments and municipalities supporting systems for waste separation, recycling and composting technologies. ▸ National Solid Waste Management Fund under the RA9003 not funded by the national government under the Office of the President. ▸ Lack of citizen participation in waste segregation at source for proper recycling/treatment/ disposal of waste. ▸ Continuity of Solid Waste Programs of Local Government Units with the 3 year political transition of local officials.	▸ APEC PPR 1: Set ambitious yet attainable waste management targets at the economy-wide and municipal levels in consultation with affected stakeholders, consistent with the Sustainable Development Goals (SDGs) and, as appropriate, The Paris Agreement on Climate Change, and encourage regions or provinces to develop detailed action plans to reach agreed targets. ▸ APEC PPR 2: Build waste management performance indicators and methodology to track progress against economy-wide and municipal waste targets, maintain an economy-wide waste database, and encourage and acknowledge front-runner cities for their overall waste and sanitation achievement through competitive award and certification. ▸ APEC PPR 5: Increase dedicated financial support from domestic governments and encourage other stakeholders including the domestic and international financial community and other private sector actors to invest in local waste management. ▸ APEC PPR 6: Where appropriate, enable the establishment of innovative, transparent funding approaches. These might include independent, blended pooled funding entities, and pay for performance delivery models. ▸ APEC PPR 7: Develop end-of-life incentive policy to stimulate recycling market demand and increase product recyclability; create conditions that encourage investments in waste collection, sorting and environmentally sound waste treatment.

Vietnam

Vietnam has long recognized the need to address solid waste management (SWM) as evidenced by the 1977 Prime Ministerial Instruction 199/TTg, "Urgent methods in the work of solid waste management in urban areas and industrial zones **[99]**." Since then, Vietnam has created legal frameworks, institutions and systems at different levels of governance to address SWM issues. In Vietnam, national-level institutions mainly look after SWM policy formulation, while decentralized provincial and local institutions organize waste management on the ground. "Sustainable solid waste management" is one of the seven priority programs of the "National Strategy for Environmental Protection until 2010, and Vision Toward 2020 **[100]**."

"The National Strategy of Integrated Solid Waste Management up to 2025, and Vision Toward 2050 [Decision No. 2149/QD-TTg of the Prime Minister]" is the most recent government action toward waste management **[101]**. Issued in 2008, these National Strategies clearly define the targets, tasks and solutions for 2025. They also define the roles and responsibilities of ministries, sectors and localities in separation of waste at the source, and in applying reducing, reusing and recycling (3R) mechanisms.

TABLE 7. WASTE MANAGEMENT POLICY LANDSCAPE IN VIETNAM

Strengths	Challenges	APEC Policy and Practice Recommendations
▸ Waste management is one of seven priority programs of the National Strategy for Environmental Protection. ▸ The National Strategy on Integrated Solid Waste Management sets ambitious targets and provides for charging sanitary fees from waste generators. ▸ Vietnam encourages private sector and foreign investment, and Vietnam's amended constitution 1992 recognizes the role of the private sector in the economy. ▸ Provision of financial support for environmental protection activities (including 3R activities) through the Vietnam Environment Protection Fund (VEPF).	▸ Despite an exemplary early mover initiative for integrated waste management, a lack of action plans and adequate funding to meet the ambitious targets. ▸ Mechanisms for revenue collection are insufficient and far from full-cost recovery. ▸ Opportunity to attract more private investments and increase the national budget allocation toward waste management. ▸ Need for greater transparency and control of private sector monopolies. ▸ Overlapping roles and responsibilities among agencies involved in waste management.	▸ APEC PPR 1: Set ambitious yet attainable waste management targets at the economy-wide and municipal levels in consultation with affected stakeholders, consistent with the Sustainable Development Goals (SDGs) and, as appropriate, The Paris Agreement on Climate Change, and encourage regions or provinces to develop detailed action plans to reach agreed targets. ▸ APEC PPR 2: Build waste management performance indicators and methodology to track progress against economy-wide and municipal waste targets, maintain an economy-wide waste database, and encourage and acknowledge front-runner cities for their overall waste and sanitation achievement through competitive award and certification. ▸ APEC PPR 4: Concentrate the majority of municipal solid waste responsibilities within a single government entity or independent department or agency, while clearly defining the waste-related roles and responsibilities of remaining institutions. ▸ APEC PPR 5: Increase dedicated financial support from domestic governments and encourage other stakeholders including the domestic and international financial community and other private sector actors to invest in local waste management. ▸ APEC PPR 6: Where appropriate, enable the establishment of innovative, transparent funding approaches. These might include independent, blended pooled funding entities, and pay for performance delivery models. ▸ APEC PPR 8: Encourage the waste picker sector to assume new service roles in waste collection, recycling, composting, and treatment through facilitation by NGOs and municipalities to improve health and safety while improving economic livelihoods. ▸ APEC PPR 9: Set strong environmental standards with reliable and transparent monitoring; consider community engagement strategies for transparency and accountability.

APPENDIX 3: WASTE VALUE CHAIN MODELS

These models were developed using the best available data including interviews with experienced waste industry and technology experts, and equipment and technology developers. They also draw on demonstrated operations and best practices, where available. However, because the models are intended to be forward-looking to examine what could be achieved with systems and technology at varying levels of development and implementation, the data should be considered limited and may not reflect actual results over multiple years since historical data is not yet known. The models presented are not intended to be used for designing specific approaches or informing specific proposals, but instead may be useful in demonstrating the relative magnitude and direction that changing different components of the waste handling system might achieve, including overall economics. Naturally, any specific project analysis must be based on site-specific data, with careful consideration given to the unique operating characteristics of that project, as well as environmental, social, economic and political priorities and objectives.

The high-level numbers generated by the models should be used to better understand the potential value proposition that each value chain step offers, without explicitly determining the profitability of any one intervention. Coupled with the ability to apply various funding strategies, the models allow public- and private-sector stakeholders to consider several possible waste handling system variations that may assist in targeting new policies that make waste management infrastructure investment more attractive.

Integrated waste value chain model assumptions and sources (August, 2016)

Waste composition

Waste composition varies greatly among municipalities, but to give an indicative example, the table below shows waste composition data gathered during the wet season in Angeles City, Philippines. The largest component of the waste stream, food and green waste, comprised 38.9% of the total amount. Hygiene items and nonrecyclable plastic were the second largest source with 34.15% of the waste stream, while recyclable plastic made up only 1.41% of the total. "Recyclable" and "nonrecyclable plastic are differentiated purely in commercial terms (that which there is a recyclables market for versus that which is too low-value to have a market). These data were gathered at transfer stations within the city, so they reflect a waste stream that has already been stripped of many high-value recyclables (like PET and metals) at the household level.

Food/green	38.90%	Glass	1.42%
Paper	14.03%	Leather	1.08%
Textiles	3.97%	Rattan/wood	1.32%
Hygiene items and nonrecyclable plastic	34.15%	Unclassified waste	1.79%
Rubber tires	0.09%	Inert	0.70%
Recyclable plastics	1.41%	Hazardous waste	0.19%
Metals	0.94%	**Total**	**100.00%**

Source: Waste Characterization Study, Angeles City, Philippines (data reflect wet season), July 2014.

Energy generation (in USD)

Electricity price per kWh	$0.08	Source: Meralco (Philippines) Electric Generation Cost, June 2016.
Feed-in tariff price per kWh	$0.15	Source: Indonesian Ministry of Energy and Mineral Resource Decree number 44/2015; Philippines Biomass FIT, Department of DOE.
Diesel price per liter	$0.60	Source: http://www.globalpetrolprices.com/Philippines/diesel_prices/; as of June 20, 2016 in the Philippines.

Integrated dirty MRF

The dirty MRF in an integrated system refers to a 250 metric tons per day (TPD), transfer station that accepts completely mixed waste with no presorting done beforehand. Its total cost of $5 million is for a highly manual simplistic MRF but includes equipment (sorting conveyors, platforms, shredding and belt conveyors), E/M installation, three pay loaders and two dump trucks. Costs, which are considered duplicative if all facilities are co-located (such as site development, leachate control, fire protection, telecommunication system and civil works), combine to $2,150,000. No costs for the actual building were assessed as this is part of a joined facility. The figures assume that waste at the dirty MRF is picked for high-value recyclables and that the remainder is sent on for further processing. The majority of the opex costs come from running equipment used to segregate the organic from residual fractions. Labor costs are benchmarked to national averages. Land costs come from Laguna Philippines property values.

Capex	**MRF SYSTEM TOTAL**	$4,020,000 – 6,030,000	Source: Vendor quotes; Laguna Philippines property values per recent site search. Benchmark is 50,000,000 for 5 hectares.
Opex	Opex cost year 1 =	$623,200 – 925,900	Source: Angeles City hauling costs; Labor Survey, Philippines; 10% contingency, utilities.
	Useful life	20-25 years	

Clean MRF

The Clean MRF refers to a 250-TPD transfer station that accepts presorted dry waste. Its total cost of approximately $1.5 million includes equipment (sorting conveyors, tables, balers and weighing scales), the building itself, and a dump truck. Costs, which are considered duplicative if all facilities are co-located (such as fire protection, telecommunication system and civil works), combine to $175,000. The figures assume that waste at the clean MRF is picked for high-value recyclables and that the remainder is sent on for further processing. The majority of the opex costs come from additional collection costs. Labor costs ($88,500) are benchmarked to the national minimum wage. Land costs ($108,000) come from Laguna Philippines property values.

Capex	**MRF SYSTEM TOTAL**	$1,208,000 – 1,812,000	Source: http://adb.org/sites/default/files/pub/2013/materials-recovery-facility-tool-kit.pdf; assumes Philippine pesos (PHP) 18,000 per sq. meter for building; Laguna Philippines property values per recent site search. Benchmark is 50,000,000 for 5 hectares.
Opex	Opex cost year 1 =	$372,200 – 540,600	Source: Angeles City hauling costs; minimum wage Philippines; assumes sorters are paid minimum wage; 10% contingency, utilities.
	Useful life	20-25 years	

Anaerobic digestion

There are multiple types of anaerobic digesters (AD) shown in this model, depending on whether the output desired is compost or fertilizer and energy. Prices shown are for a unit that can receive up to 200 metric tons of substrate per day (TPD) but the output is based on 85 TPD of food and green waste entering the unit. Opex costs include AD maintenance and engine maintenance. The opex cost is primarily driven by engine maintenance and was achieved by vendor quote as a percent of total project cost. Labor prices are benchmarked via labor survey in the Philippines.

Capex	**MRF SYSTEM TOTAL**	$8,514,000 – 12,771,000	Source: Vendor quotes for a SE Asian construct (most equipment sourced in SE Asia); Laguna Philippines property values per recent site search. Benchmark is 50,000,000 for 5 hectares.
Opex	Opex cost year 1 =	$409,600 – 614,400	Source: Labor Survey, Philippines; vendor quotes — SE Asia.
Output	Fertilizer generated	55-80 TPD	Source: Vendor quotes, technical modeling.
	Fertilizer price per ton	$1	Sources are limited for Asia; assumes a breakeven price (at best) given lack of market.
	Net MW output	1.4-2 MW	Source: Technical modeling
	Compost generated	60-90 TPD	Source: Technical modeling; only if compost is the desired output vs. fertilizer + energy, but not both; Opex/Capex reflects energy plus fertilizer.
	Compost price per ton	$5-7	Sources are limited for Asia; assumes a breakeven price (at best) given lack of market.
	Useful life	20 years	

Gasification

This gasification system assumes 132 TPD of calorific feedstock (mostly nonrecyclable plastic, hygiene items, nonrecyclable paper, rubber, etc.) that has been segregated from the food and green waste stream. The capex of the gasifier represents a total system size of 150 TPD. Power generation is based on steam turbine conversion and accounts for the expected parasitic load of the equipment. The opex cost was derived via vendor quote based on electrical output capacity and percent of project cost. Labor prices are benchmarked via labor survey in the Philippines and expected staffing requirements.

Capex	**GASIFIER SYSTEM TOTAL**	$20,816,000 – 31,224,000	Source: Vendor quotes for a SE Asian construct (nonproprietary equipment sourced in SE Asia); Laguna Philippines property values per recent site search. Benchmark is 50,000,000 for 5 hectares.
Opex	Opex cost year 1 =	$800,000 – 1,200,000	Source: Labor Survey, Philippines; vendor quotes.
Output	Electricity	6.8-10 MW	Source: Technical modeling, vendor quotes.
	Useful life	20 years	

Pyrolysis

The pyrolysis facility considered has four units of an 8-ton per shift batch system each capable of running two 8-hour shifts per day and runs nonrecyclable plastics that have been hand sorted from the stream. Waste pickers are paid for the feedstock according to a price point obtained from waste picker surveys for this job or material. The system costs $5 million to build, consisting of $3.5 million to $4 million for the shredder, tanks, cooling towers, separation equipment and other infrastructure; $500,000 for other equipment on site; and $550,000 for site preparation and civil works. These numbers are informed by vendor interviews. Opex comes in the form of labor, feedstock purchases, equipment maintenance and catalyst per facility.

Capex	**PYROLYSIS SYSTEM TOTAL**	$16,873,000 – 25,384,000	Source: Vendor quotes; represents the cost for four 8-ton per shift units running two shifts/day; Laguna Philippines property values per recent site search. Benchmark is 50,000,000 for 5 hectares.
Opex	Opex cost year 1	$1,460,000 – 2,100,000	Source: Labor Survey, Philippines; Plastics for Change Waste Picker Survey; vendor quotes.
Output	Diesel output	37,000-55,000 liters	Source: Vendor quote and 60% machine efficiency.
	Useful life	20 years	

Landfill

The total project cost for a 100 TPD landfill is Philippine pesos (PHP) 110 million with an initial capex requirement of PHP 40 million for Phase 1. The cost includes the construction of the disposal cell, gas collection, leachate management, run-off control, double liner system, monitoring wells and other support facilities. The costs does not include procurement of collection trucks and the establishments of MRFs and composting facilities (which were identified as project auxiliaries). These numbers are extrapolated from a World Bank-supported Philippines landfill.

Capex	**Total capex =**	$6,560,000 – 9840,000	Source: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2014/04/11/000371432_20140411155413/Rendered/PDF/E13550V20Ozami0mental0Review0Report.pdf; Number scaled to accommodate 250 TPD from 100 TPD; Source: 10 hectares required is; Laguna Philippines property values per recent site search. Benchmark is 50,000,000 for 5 hectares.
Opex	Opex cost year 1	$350,000 - 490,000	Source: http://www.mdlf.org.ps/Files/solid-waste-gaza/Final_FS_31Jan2012.pdf; Sofia landfill example, pp. 125-126; Labor Survey, Philippines.
Output	Landfill gas capex	$1,200,000-1,800,000	Source: http://www.eesi.org/papers/view/fact-sheet-landfill-methane
	LFG energy output	.6-.9 MW	1 million short tons of landfill produce about .78 MW of electricity (at 250 TPD)
	Useful life	20 years	

Chemical recycling

Because chemical recycling is in its infancy, less refined numbers are available for evaluation. Based on estimates from vendors developing this technology, the total capex of a 50 TPD unit would be in the range of $20 million. The waste feedstock under evaluation in this model would provide 62 tons of input per day, which extrapolated the capex to roughly $25 million. This system would be a continuous pyrolysis system that would be fed exclusively with polyethylenes, polypropylene and hygiene items. Because of the unrefined feedstock, unit efficiency is assumed to be 50%. Opex is assumed to be similar to pyrolysis with the exception of the cost required to procure the feedstock via hand sorting. Procurement of the feedstock would be the highest opex contributor. At the 50% efficiency level, this would produce roughly 30 TPD of naphtha, the desired monomer input (Source: Plastics industry).

Capex	**Pyrolysis system, 50 TPD**	$20,360,000 -30,540,000	Source: Laguna Philippines property values per recent site search; vendor interviews. Benchmark is 50,000,000 for 5 hectares.
Opex	Total opex	$1,500,000 – 2,160,000	Source: Assumed same as pyrolysis; Plastics for Change Waste Picker Survey; Assumed same percentage of capex as pyrolysis.
Output	Naphtha	30 TPD	Source: http://www.eesi.org/papers/view/fact-sheet-landfill-methane
	Useful life	20 years	

Plastic Repurpose

Mixed plastic waste can be repurposed into a variety of building materials. Using this technology, mixed plastic waste can be melted and repurposed into higher value plastic lumber. For this model, the output material derived was railroad ties, but other forms of plastic lumber are also possible. The facility under consideration for this model would require 101 metric tons of input per day and produce 670 certified grade railroad ties per day. The plastic inputs required for this facility consist of mixed rigid plastics (MRP) such as pallets, bottle crates, toys, etc., as well as nonrecyclable (grade 3-7) plastic and a small percentage of metalized foil sachets. To enable the use of all the low-value plastic for this scenario would require the purchase of the previously scavenged MRP as well as approximately10 additional TPD of MRP from alternate sources. Vendors currently running this technology estimate the total capex of this system would be in the range of $17,000,000. System losses for this type of technology are quite low as off-quality product can be re-fed to the machinery and reformed. Thus, losses typically run at around 2%. The system consists of shredders, granulators, compounders, molds and conveyance and quality control systems. As with chemical recycling, feedstock procurement is the greatest contributor to opex and is even higher given the inclusion of MRP. This model assumes purchase of both low-value and MRP from the informal sector.

Capex	**Repurpose – 100 MT system**	$14,000,000 -18,000,000	Sources: Laguna Philippines property values per recent site search. Vendor Interviews Benchmark is 50,000,000 for 5 hectares
Opex	Total opex	$2,800,000 -3,500,000	Source: Plastics for Change Waste Picker Survey, Vendor interviews
Opt-Out	Railroad ties	670 ties	
	Useful life	20 years	

GLOSSARY

Anaerobic digestion (AD) – Process of converting organic waste to biogas in the absence of oxygen.

APEC — The Asia-Pacific Economic Cooperation, a group that aims to support sustainable economic growth and prosperity in the Asia-Pacific region.

APEC PPR — APEC's nine policy and practice recommendations, or guidelines for establishing the political, economic, and legal and regulatory conditions that prioritize and encourage investment in waste management.

ASEAN – Association of Southeast Asian Nations, a regional intergovernmental organization (IGO) that promotes cooperation and economic integration among its members.

Asia – Largest (44.5 million km_2) and most populous (4.4 billion people) continent in the world. Regions of Asia include West Asia (which is part of the Middle East), the Caucasus (sometimes also considered as part of the Middle East), Central Asia, East Asia, South Asia, and Southeast Asia (Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam).

Asia Pacific – Region of the world near the Western Pacific Ocean. It includes much of East Asia, South Asia, Southeast Asia and Oceania.

Biodegradable – Capable of breaking down into its chemical constituents in the natural environment.

Capex – Capital expenditure.

Circular systems – Intentionally designed industrial systems in which output from one system becomes input for that system or another industrial system, thereby minimizing the creation and disposal of waste and minimizing the need for raw material extraction.

Civil Society Organization (CSO) — A nonprofit, voluntary citizens' group organized on a local, national or international level (similar to a nongovernmental organization).

COP 21 – The twenty-first annual meeting of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC).

Development finance institute (DFI) – Financial institutions (microfinance, community development, revolving loan funds) that play a crucial role in providing credit in the form of higher risk loans, equity positions and risk-guarantee instruments to investments in developing countries.

Dump or dump site – Open waste pile, which may be a formal or informal end repository of waste.

Feed-in tariff (FIT) – An off-take buyer guarantee to pay a higher than market price for electricity generated.

Gasification – The thermal decomposition and partial oxidation of waste materials at temperatures generally above 400°C using a limited amount of air or oxygen, resulting in solid residues and a gaseous mixture.

Hauler – Waste transporter operating truck(s) that haul waste from point of collection to MRF, from MRF to dump site, or both. Services are typically contracted by local governments but often managed directly by public authorities.

HDPE – High-density polyethylene, a type of polymer/plastic.

High-value plastics – Plastic waste materials commonly collected by waste pickers for selling into local recycling markets (e.g., PET and rigid HDPE).

IGO – Intergovernmental organization, a standing organization often but not exclusively created by an international treaty and is comprised primarily but not exclusively of sovereign states and other intergovernmental organizations

Incineration – thermal decomposition and rapid oxidation of waste material at temperatures generally above 230°C with the addition of air or oxygen at sub-stoichiometric to excess levels, resulting in solid residues and a gaseous mixture.

Landfilling – Disposal of waste in a waste pile that is usually underground and may be sanitary (i.e., measures have been taken to prevent leachate) or unsanitary (no prevention measures have been taken).

LDPE – Low-density polyethylene, a type of plastic.

Low-value plastics – Plastic waste materials that do not have value in local recycling markets (e.g., grocery bags, thin films, composite plastics and residual polypropylene). Polystyrene, PVC and polypropylene are considered "medium value," with approximately 25% being recycled locally.

Mandatory recycled content – Minimum requirement for use of recycled content in products.

Material design – Redesign of products to meet specifications intended to make the products either more attractive for material- or energy-extraction markets or less likely to leak into the ocean.

Material recovery facility (MRF) – Facility used for separating different materials from the waste stream.

MBT — A type of waste processing and sorting facility that uses mechanical and biological treatments (MBT) such as composting or anaerobic digestion.

Mixed waste – Unseparated or unsorted waste.

Municipal solid waste (MSW) – Waste generated by households and sometimes including streams of commercial and industrial waste.

Opex – Operating expense.

Pay-as-you-throw (PAYT) – A pricing model in which users are charged by the local authority based on how much waste they create for collection.

Peri-urban – Relating to an area immediately surrounding a city or town.

PET – Polyethylene terephthalate, a type of polymer/plastic.

Plastic-waste leakage – Movement of plastic from land-based sources into the ocean.

Polymer – Chemical combination of smaller particles.

Presorting – Separation of different components of waste at the household level.

Product ban – Legislative action with supporting implementation to forbid the use of certain types of products (e.g., plastic bags).

Public-private partnership (PPP) – partnerships between government agencies and private sector companies, which can be used to finance and operate projects.

Pyrolysis – The thermal decomposition of waste materials at temperatures beginning around 200°C without the addition of air or oxygen, resulting in solid and/or liquid residues as well as a gaseous mixture.

RDE – a rapidly developing economy.

Solid Waste Management (SWM) – The control of generation, storage, collection, transport or transfer, processing, and disposal of solid waste to address health, conservation, aesthetics, economics and other environmental considerations.

Technical assistance (TA) – Funding typically cosponsored with costs shared by a DFI and a reputable third party such as an investing firm, a private sector partner or a government partner.

Thin film – Mixed plastic film, typically constructed of some variation of polyethylene.

Throughput – Feedstock or material designated for a particular process.

TPA – Metric tons per annum.

WASH – A common acronym to short hand the correlated issues of water, sanitation and hygiene.

Waste – Any discarded material such as household or municipal garbage, trash or refuse, food wastes, or yard wastes that no longer has value in its present form but may or may not be recyclable or otherwise able to be repurposed.

Waste aggregation – Collection of waste, which may occur at multiple points (such as waste trucks, MRFs or dump sites).

Waste exchange program – A system set up to allow for the exchange of specific articles of waste with recycling value for monetary equivalents (e.g., food vouchers or supermarket tokens).

Waste to energy (WTE) – The process of creating energy (electricity or heat) from waste treatment technologies such as incineration and gasification.

Waterway – Large marine body, such as an ocean, river or tributary.

Zero waste – The elimination of waste throughout the life cycle of a product.

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[98] "Philippine environmental code," Presidential Decree No. 1152, 1977.

[99] "Directive no. 199/TTg dated April 3, 1997 of the Prime Minister on urgent measures to manage the hard wastes in the urban and industrial districts," Socialist Republic of Vietnam, 1997.

[100] "National strategy for environmental protection until 2010 as vision toward 2020," Socialist Republic of Vietnam, Ministry of Natural Resources and Environment, 2013.

[101] "National strategy on integrated management of solid waste to 2025, vision to 2050," Socialist Republic of Vietnam, Ministry of Natural Resources and Environment, 2013.

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