OCTOBER 2023

# Pricing Transparency in the Recycled Plastics Supply Chain in India, Indonesia, Thailand, and Viet Nam

## Research Methodology and References

The Circulate Initiative

# Research Methodology

The following sections provide additional detail on each step of the research methodology.

## 1 Literature review and stakeholder interviews with a focus on the collation of data on costs and prices for each polymer in each country

The data points used for developing the pricing model have mainly been gathered from interviews conducted with 59 collectors, 45 aggregators, and 21 recyclers across the four countries. Critical data points captured are listed in Table 1:

**Table 1:** Critical data points captured for pricing transparency model development

| Cost | Pricing | Waste material flow | Market information |
|---|---|---|---|
| US$ cost per kg of plastic waste collected (overheads, labor) | US$ per kg of plastic waste sold by collectors | Kilograms or tonnes of plastic waste collected for recycling | Avg. kg of plastic waste collected per day by collector |
| US$ cost per kg of plastic waste managed by aggregators (overheads, labor) | US$ per kg of plastic waste bought by aggregators | Kilograms or tonnes of plastic waste recycled in country | Avg. kg of plastic waste managed per day by aggregator |
| US$ cost per kg of plastic waste managed by recyclers (overheads, labor) | US$ per kg of plastic waste sold by aggregators | | Avg. kg of plastic waste managed per day by recycler |
| | US$ per kg of plastic waste bought by recyclers | | Number of collectors operating in country |
| | US$ per kg of recycled plastics sold by recyclers | | Number of aggregators operating in country |
| | US$ per kg of recycled and virgin plastic – national average price points | | Number of recyclers operating in country |

**Note:** Costs and prices were obtained in local currencies and converted to US$ based on fixed exchange rates.

## 2 Review of data quality and its use in the model

The data collected was reviewed for quality and aggregated to provide national average data. This enabled the model to take a normalized view of the polymer supply chains in each country, considering local variances that may otherwise be applicable within wastesheds. Supporting literature was reviewed to help fill gaps or supplement low sample sizes where data was more limited for certain countries or supply chain actors. Table 2 below reviews the availability of data and level of data robustness for each country.

**Table 2:** Data quality collected through interviews

| Country | Overview of collected data | Data ranges of prices | Data robustness | Comments |
|---|---|---|---|---|
| **India** | Limited data points reported during interviews. Data coverage on recycler level is good, with reported cost data for each polymer type generally available. Full supply chain data of prices is only available for PET. | Due to limited data availability, few to no data ranges were available for comparison. | Low level of data robustness. Few data points are available from the interviews, leading to a high degree of uncertainty. PET is the only polymer for which primary data was shared for all stages of the supply chain. | As a result of the limited data available, models developed are functional, but additional data collection would be advised when interpreting the results. |

**Table 2:** Data quality collected through interviews (continued)

| Country | Overview of collected data | Data ranges of prices | Data robustness | Comments |
|---|---|---|---|---|
| **Indonesia** | Good data coverage with data available for each player across the supply chain for PET, LDPE, HDPE, and PP. | Vast data ranges across all polymers and actors in the supply chain. The wide range can be due to different material quality or the opacity of the supply chain, with little to no standardized prices across the country for each polymer. | Good data coverage collected through the in-country interviews, but wide data ranges lead to less robust data averages across the collected data, not representing the nuances of the regions and business models. | The wide data ranges indicate a low level of transparency for PET, LDPE, HDPE, and PP within Indonesia currently. |
| **Thailand** | Good data coverage for PET, HDPE, and PP. Incomplete supply chain data available for LDPE. | Vast data ranges across all polymers and actors in the supply chain. The wide range can be due to different material quality or the opacity of the supply chain, with little to no standardized prices across the country for each polymer. | While wide data ranges exist vertically across the polymer supply chains in Thailand, the horizontal ranges between the different actors are more aligned than in the other countries assessed. | Alignment between the different actors indicates a higher level of transparency between each actor and potentially more robust data. |
| **Viet Nam** | Data is available for the complete supply chain for PET, HDPE, and PP, but no data is available for LDPE at any stage in the supply chain. | The scale of the data ranges differ between polymer types and actors. While PET shows a wide range of data at the collector stage, the data ranges for aggregators and recyclers are smaller. Data availability for HDPE was the opposite, with a wider range on recycler level than on collector and aggregator level. | Good data coverage collected through the in-country interviews, but wide data ranges lead to less robust data averages across the collected data, not representing the nuances of the regions and business models. | Overall, wide data ranges and misalignment of the data ranges from one actor to the next can indicate supply chain opacity and differing polymer quality handled. |

**Note:** Costs and prices were obtained in local currencies and converted to US$ based on fixed exchange rates.

## 2.1 Limitations of data

Given the comparatively smaller sample sizes for the data points collected, the results should be seen as indicative rather than representative of the full supply chain in each country. As a result, limitations of the data include:

- Data ranges are skewed by outliers within survey responses – it can be more difficult to identify outliers in smaller sample sizes.
- Data points are combined for use – due to the smaller sample size, certain data points have been combined. The data points include regional data and data on the different output products (flakes and pellets). This could explain some of the ranges in data.
- Timeliness of data – data was collected from June to August 2022. The survey data represents a point in time and does not capture the full complexity of the dynamic polymer markets within each country.

# 3 Policy shortlisting for analysis, with inputs from stakeholders through roundtable discussions

A policy and regulatory review was undertaken for each country to identify policy interventions for modeling. The review identified the existing policy framework, including policies that are currently in place and those that are already planned for implementation, as well as examples of policies beyond the four countries covered in this study that could support the functioning of an efficient plastics supply chain. The full list of policies reviewed are in Table 3.

The policies were intended to be nationally applicable and provide catalysts for the implementation of direct and practical solutions to improve pricing transparency. Therefore, the interventions did not include evaluation of other measures that could be directly implemented in the ecosystem to support greater transparency at a practical level, such as traceability systems, digital waste tracking, digital marketplaces, or mandatory publishing of prices within the supply chain.

**Table 3:** List of policies researched for country implementation

| Policies researched for implementation | Description |
|---|---|
| **Implementation of Deposit Return Systems to incentivize plastic capture** | **Description**:<br>Implementation involves the addition of fees applied to plastic items when purchased by consumers. This fee can be redeemed on the return of the item to a recognized recycling destination/scheme.<br>**Implication:**<br>The scheme is designed to improve the collection of recyclable material by providing higher volumes, and also to improve the quality of the plastic material through source separation. |
| **Formalization of collection routes through contracted collections** | **Description**:<br>Formalization of collection systems involves the formalization of contracts for waste collection and treatment, which acts as a stimulus for additional investment in structured delivery of services at scale, using more efficient systems and machinery.<br>**Implication:**<br>This increases the volume of material collected via formal routes, effectively reducing labor inputs in collection if the higher volume can be managed via a mechanized system. |
| **Restrictions on the import and export of plastic scrap** | **Description:**<br>Restrictions imposed on the permitted volume of material that can be imported and exported from a country.<br>**Implication:**<br>This supports the local sourcing of material for recycling and the availability of the material, which can increase the prices of locally collected material. |
| **Implementation of Extended Producer Responsibility (EPR) system** | **Description:**<br>Implementation of an additional fee that is paid per unit of plastic packaging placed on the market. This fee can be either:<br>1. Producer obligations paid by producers of goods to cover some of the cost of recycling or disposal of the plastic waste.<br>2. Distributor obligations paid by distributors to cover the cost of collection of plastic waste items placed on the market by these distributors.<br>**Implication:**<br>The core aim of the policy is to provide additional monies to cover the costs of waste management of the plastic waste, paid for by the polluters (producers and consumers). |

**Table 3:** List of policies researched for country implementation (continued)

| Policies researched for implementation | Description |
|---|---|
| **Minimum prices on interim goods, such as plastic scrap**<br><br>**Minimum wages for informal pickers enabled by formalization or price of picked material** | **Description:**<br>Implementation supports the suppliers of plastic scrap by setting market prices for products at the early stages of the supply chain. Alternatively, some form of minimum pricing or credit system could be put in place by the government for plastic waste.<br><br>**Implication:**<br>These systems provide the most direct route to support informal pickers or aggregators selling plastic waste to the recycling supply chain and are also considered as a measure to incentivize the collection of higher-quality segregated material. |
| **Subsidies for energy use for recycling activities** | **Description:**<br>Support recycling industries by subsidizing energy costs or lowering taxes on costs associated with recycling activities. This could include providing incentives for the use of green energy where feasible.<br><br>**Implication:**<br>The key aim of the policy is to support lower operational costs for recycling activities. This could be one of the cost components supported by policies such as EPR. |
| **Landfill/WtE taxes and bans that impact the costs of treatment methods other than recycling** | **Description:**<br>Landfill or WtE taxes or bans are ways in which disposal of waste is disincentivized either through increasing economic costs of disposal or limiting disposal routes with regulatory barriers.<br><br>**Implication:**<br>These policies support recycling industries by increasing the cost of disposal and making alternate disposal solutions more inaccessible. As the cost of disposal rises, recycling is able to achieve greater price competitiveness and more material is diverted towards recycling. |
| **Minimum recycled content targets** | **Description:**<br>Implementation involves the application of minimum recycled content targets on plastic items sold domestically by producers. Producers are regulatorily obligated to source and use recycled content alongside virgin material. This policy can be either a regulated and enforced target or supported by fiscal levers such as a plastics tax.<br><br>**Implication:**<br>This type of policy lever supports suppliers of recycled polymer, creating a demand-pull to support market development as brands are compelled to source recycled content for manufacturing. The regulatory burden of compliance or economic cost of non-compliance (e.g., tax) also create an opportunity cost that supports higher pricing of recycled polymer. |
| **Taxes on the use of virgin polymer within goods** | **Description:**<br>Either independently or in support of minimum recycled content targets, a tax or fee that is applied to producers not using recycled content in their production.<br><br>**Implication:**<br>These fees or taxes should act as a significant opportunity cost for not using recycled content within products sold, and incentivize a shift to consumption of recycled polymer. This shift in behavior should support more sustainable polymer value chains. |
| **Creation of certification standards and product labeling schemes for recycled plastics** | **Description:**<br>Certification systems or product labeling systems provide a consistent framework within which producers can demonstrate and certify the improved environmental credentials of their product. These standards are publicly visible to consumers making purchasing decisions.<br><br>**Implication:**<br>These types of policies provide a clear evidence system that supports consumers in purchasing decisions. This should enable differentiation of products that include recycled content and create demand-pull that supports the recycling value chain. |

**Table 3:** List of policies researched for country implementation (continued)

| Policies researched for implementation | Description |
|---|---|
| **Purchase assistance fee (PAF)** | **Description:**<br>Implementation involves contract pricing support that shares the risk of volatility in polymer prices. Although a contract price is set, contracts are set up to include a formula that supports recyclers if the output market pricing falls. Producers therefore continue to overpay if market prices fall and possibly underpay when prices rise rapidly. In this way, like a profit share mechanism, the risk of price volatility is shared between the recycler and offtake.<br>**Implication:**<br>This type of policy, currently mostly voluntary in nature, creates value by providing longer-term sustainable pricing to recyclers. This enables them to act with more confidence within the market when sourcing material from aggregators and collectors, therefore strengthening the whole supply chain. |

From the various policies described in Table 3 above, in discussion with various stakeholders operating in the recycled plastics ecosystem in India and Southeast Asia, three policies were selected for each country for further examination. The policies were evaluated based on how they could support greater pricing transparency and, if so, how this would influence the supply chains in the form of price points and the supply of recycled polymers. The list of policies selected for each country is provided in Table 4.

**Table 4:** Shortlist of policies selected for intervention analysis by country

| Country | Policy Intervention 1 | Policy Intervention 2 | Policy Intervention 3 |
|---|---|---|---|
| **India** | Extended Producer Responsibility | Minimum Recycled Content Targets | Implementation of a Deposit Return System |
| **Indonesia** | Extended Producer Responsibility | Minimum Recycled Content Targets | Implementation of a Deposit Return System |
| **Thailand** | Extended Producer Responsibility | Taxes on Virgin Polymers | Formalization of the Collection System |
| **Viet Nam** | Extended Producer Responsibility | Taxes on Virgin Polymers | Formalization of the Collection System |

Further rationale for the selection of these interventions and how they will influence pricing transparency is set out below.

**Table 5:** How policies impact pricing transparency

| Intervention | Impact on pricing transparency |
|---|---|
| **Extended Producer Responsibility** | • The calculation of producer fees is based on the actual costs of collection, aggregation, sorting, and recycling of plastics. This will require greater transparency around the processing costs and will lead to much greater interest in vertical integration. If these costs are known, then the types of costs and where they can be reduced with integration will become clear. It will also shed light on the scale of margins made by each actor in the value chain. Minimizing the points at which margin is shared between multiple actors helps keep costs low for those further down the supply chain, while also giving them greater security of feedstock.<br>• Within business models for operations, a known proportion of costs should be covered by EPR. The allocation of EPR fees will provide a certain level of transparency to the revenue model of operators within the supply chain.<br>Fees can be modulated to reflect the costs associated with difficult-to-recycle material streams and support the transition towards increased recycling and greater recyclability of products placed on the market. |

**Table 5:** How policies impact pricing transparency (continued)

| Intervention | Impact on pricing transparency |
|---|---|
| **Implementation of a Deposit Return System** | • Setting a deposit return can be used to set a minimum guaranteed value for the material when collected or returned by providing a "reward" for returning the plastic items to an aggregator.<br>• Depending on the implementation pathway, this also provides an element of transparency in terms of the cost associated with the purchase of scrap plastic, which will be the value of the material plus the set token rate when redeemed by collectors. This token rate will either be a pass-through cost to a compliance scheme or it could be a fixed cost covered within the supply chain.<br>• Supply chains for managing single polymers are also more transparent than mixed polymers as there is a much more tangible link between single polymer streams' input and recycled polymer output applications at the end of the supply chain. |
| **Minimum Recycled Content Targets** | • The establishment of minimum recycled content targets within the supply chain creates a quantified demand for recycled polymers.<br>• Any fines for non-compliance with minimum recycled content targets become a very tangible and quantifiable opportunity cost of not using recycled content. This opportunity cost acts as a clear indicator of the pricing premium that can be expected on the purchase of recycled content; i.e., manufacturers are willing to pay up to a certain premium in order to avoid the opportunity cost of missing their recycled content targets. In this regard, the minimum recycled content target supports the differentiation of recycled polymers from virgin polymers as one is a "green product" and has a different cost structure.<br>Trade in recycled polymers is also more developed in international markets as a result of interventions and the implementation of minimum recycled content targets in certain markets. Manufacturers will need to consider the cost of accessing material from this market. International markets will therefore provide an indication of the trade value of recycled polymer, stimulating investment domestically to ensure supply for feedstock from these markets to one where minimum recycled content mandates are applicable by law. |
| **Formalization of the Collection System** | • Collection costs for polymers will be better understood as they will be accounted for within the contracted terms and values of the material.<br>• Contracting of polymer collection often also includes some element of profit share on material values. Typically, a collection contract for recyclables on behalf of municipalities will have two components:<br>  • A contractual component relating to the collection methodology and costs associated with this. This element is a fixed fee and will only increase in line with inflation within the contracting period.<br>  • A contractual component relating to the sale price of the material collected. A base basket price will be assumed but costs or profits caused by variance from this are shared between the collector and the municipality. This is therefore a variable component of the contract addressed monthly on sale of materials.<br>• With the formalization of collection routes, not only are the costs of collection better understood, but the offtake value of plastics is also included (normally linked to some sort of material price index) so that the increased revenue derived from the increasing value of polymers collected can be shared with the municipality from which the waste is being collected.<br>In addition to adding transparency, the formalization of collections may also improve the security of polymer prices for collectors (informal or other) as part of the collection costs are fixed, reducing exposure to fluctuations in material prices. |

**Table 5:** How policies impact pricing transparency (continued)

| Intervention | Impact on pricing transparency |
|---|---|
| **Taxes on Virgin Polymers** | • The establishment of a tax on virgin material within the supply chain creates the most direct and transparent price indicator for manufacturers and producers.<br>• The tax level becomes a very tangible and quantified fixed cost of using virgin polymer. This additional cost inflates the price of virgin material, and manufacturers have to pay more for every tonne of virgin polymer they use in their products.<br>• This inflated price therefore becomes the opportunity cost of not using recycled polymer within the manufacturing process. This differentiates recycled polymer as a "green product" and a means to avoid taxation.<br>• As a price point for recycled material, it means manufacturers are able to pay **up to** the cost of virgin polymer **plus** the cost of the tax. At any point below this, recycled content is more viable. Therefore, by raising the price of virgin material, the market rate for recycled content can increase to reflect the additional cost of collection and recycling associated with the production of recycled content. |

# 4 Development of the economic model

Following the selection of the interventions, the economic model was developed for each country.

Economic principles were applied in what is assumed to be a linear supply chain, with material taking a straight path from production to consumption, and finally to disposal. In this supply chain:

- Collectors use their own labor to collect plastics. They add value in the separation of plastic scrap from other waste streams.
- Collectors sell the plastics to aggregators.
- Aggregators buy plastics from collectors, treat the plastic, adding value via aggregation and further separation (inputs of capital and labor), and sell the plastics to the recyclers.
- Recyclers buy plastics from the aggregators and add value through recycling processes (inputs of capital and labor), producing recycled plastic products (i.e., flakes or pellets). The products are sold onwards to the buyer at a price that corresponds with the maximum global average market price for virgin plastic.

Based on these assumptions and supply chain flow, the model can analyze a range of policy interventions, and also translate the policy interventions into a set of tangible impacts on the supply chain actors. The model output then shows economically rational responses to the economic incentive and corresponding amounts of collected plastics, as well as their market prices for the different actors.

Once calibrated, the models were then programmed with assumed impacts, which were different for each policy. The assumptions are linked to the implementation of each policy, based on examples from other countries outside of the study, industry knowledge, and the current situation in each country. The estimated impact of each policy can be adjusted to see how it affects the volumes of plastics recycled and value distribution within the supply chain. The rationale for modeling each policy measure is explained in detail within Technical Appendix 1.

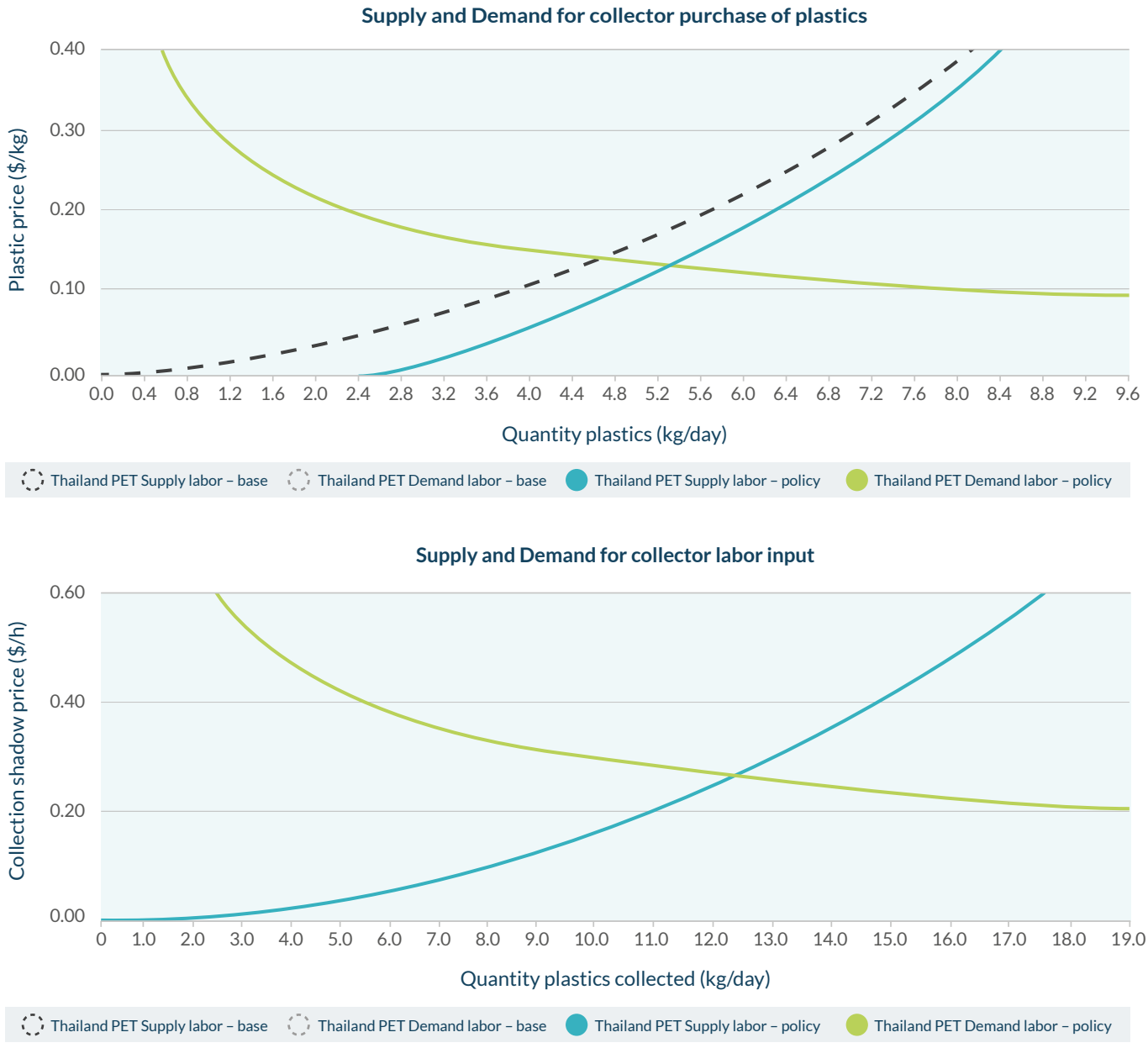
# Technical Appendix 1 –
# Modeling Rationale for Policy Impacts

The modeling assumptions for each of the policy scenarios are set out in the sections below. These underpin the modeling results provided within the report.

## Extended Producer Responsibility

EPR impacts the expected additional income that will be provided to parties within the supply chain paid for by producers and consumers. In the modeling, this has the impact of lowering the overhead costs for all actors in the supply chain, assumed to be paid for by the policy measure.

**Figure 1:** Potential effect of Extended Producer Responsibility on collector supply and demand for purchased plastics

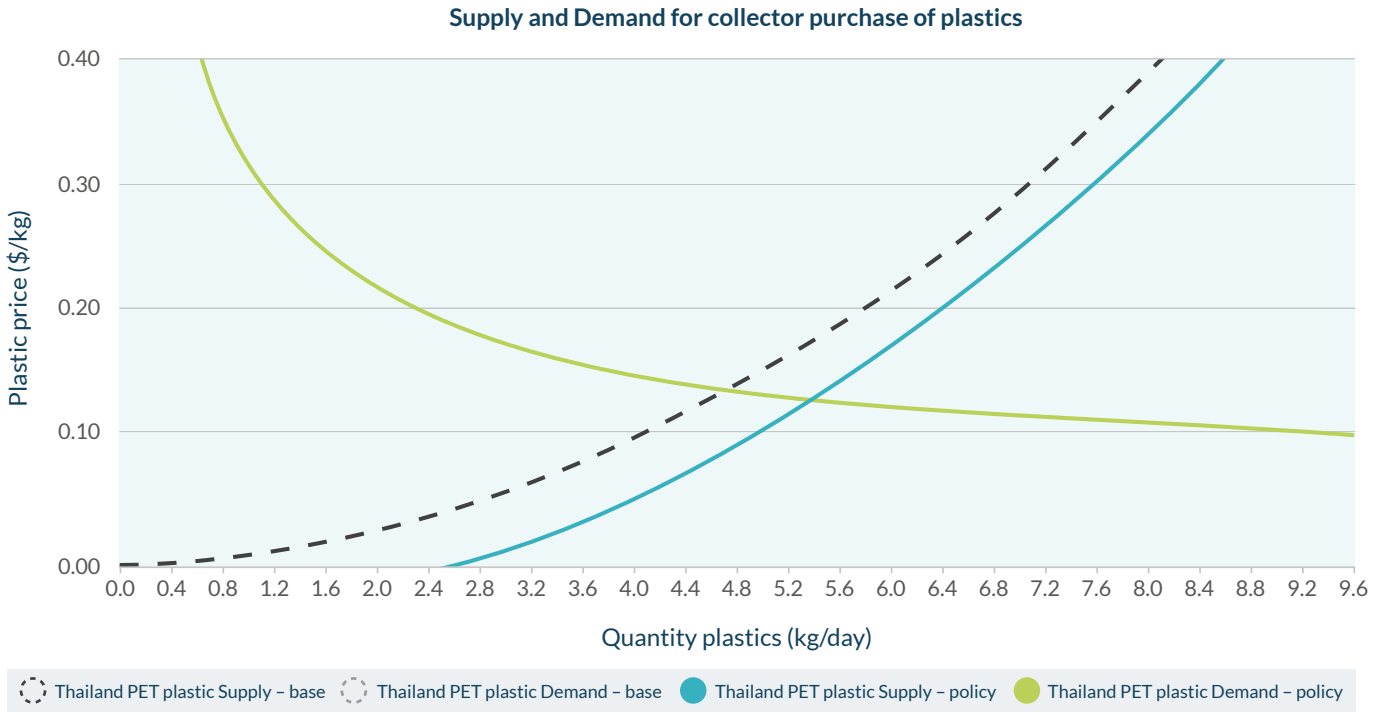



*The example modeled above is for recycled PET sales in Thailand.* In the graphs, the impact of the policy is represented by the parallel rightward shift of the plastic supply curve, indicating greater production from collectors within the supply chain. There is no shift in the labor supply curve, indicating that there is no increase in labor cost and therefore there is an increase in effectiveness of the plastics supply chain with more plastic being collected without additional cost/resources required. This improvement in effectiveness is assumed to be impacted by the EPR funding resulting from the policy measure.

## Implementation of a Deposit Return System (DRS)

Implementation of DRS will result in an expected reduction of operational costs (lower transport costs and reduced processing, resulting from more segregated material collection). It also increases output prices through better quality material (and "guaranteed" food-grade rPET) and lower sorting/contamination costs. This approach is being proposed in the EU and is operational in the US, where required deposits are estimated to incentivize up to 80% returns/recycling of containers. This results in much greater segregation and a reduction in sorting costs. Where deposits are not redeemed, systems still artificially lower operating costs as unredeemed deposits will be fed back into the system to support the recovery and recycling costs.

**Figure 2:** A potential effect of a DRS on collector supply and demand for purchased plastics and labor is represented as a parallel shift of the plastic and labor supply curves



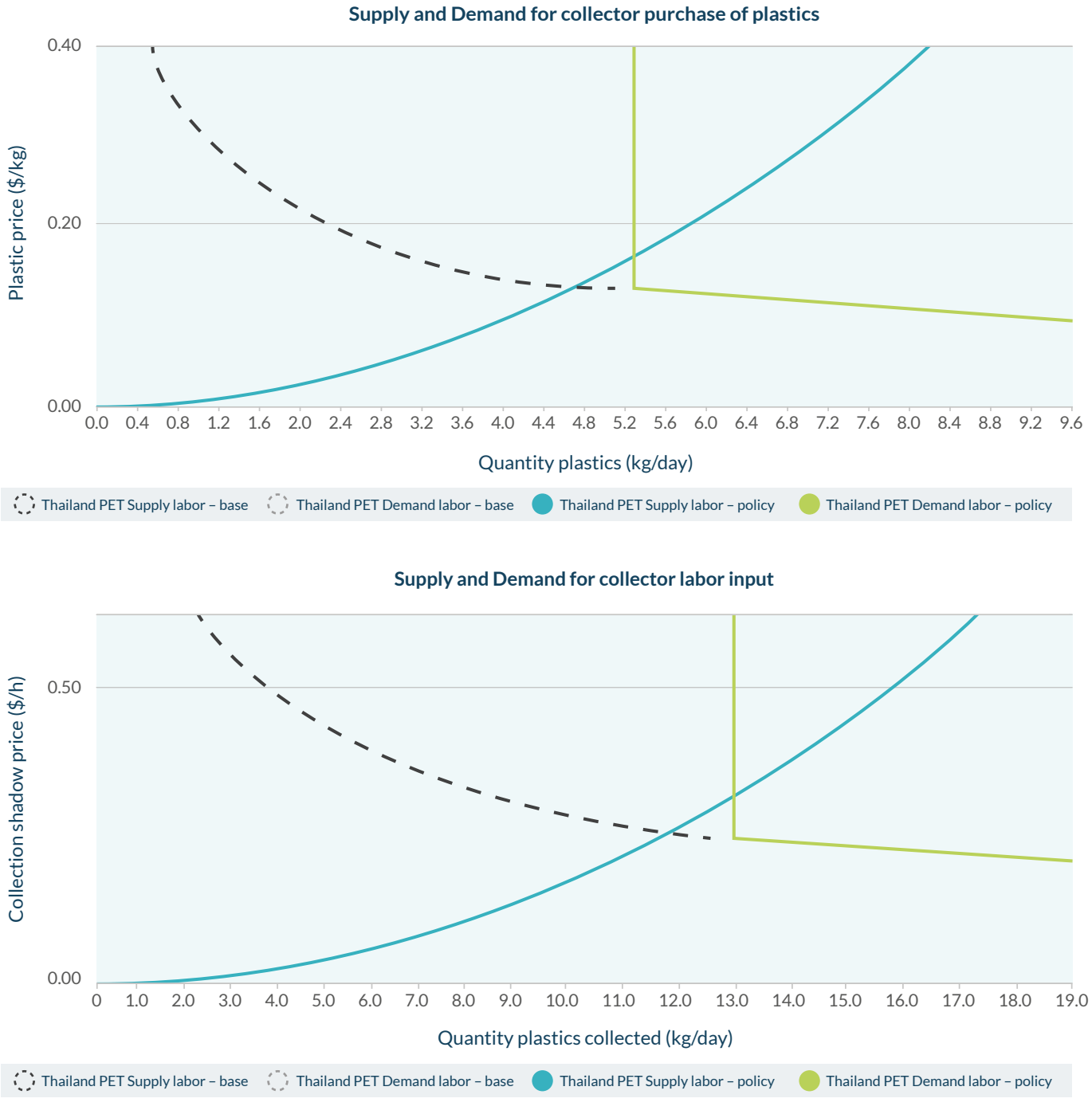


In the graphs, the impact of the policy is represented by the rightward parallel shift of both the plastic supply curve and labor supply curve. This enables the market to increase supply while either maintaining price points or lowering them through increased efficiency due to the DRS impacts.

## Minimum Recycled Content Targets

Minimum recycled content targets are expected to boost output price security by providing a demand signal to the market to improve recycling performance and output. This will be supported by greater revenues passed back down the supply chain as prices are assumed to rebalance as gains from trade are shared across the supply chain. For modeling purposes, this is assumed to affect the demand for recycled plastic with infinite willingness to pay (i.e., buyers will pay any price for recycled content to meet the minimum recycled content thresholds) for recycled content up to the minimum quantity requirement set by the policy.

**Figure 3:** A potential effect of a policy imposing minimum recycled content mandates on collector supply and demand for purchased plastics and labor

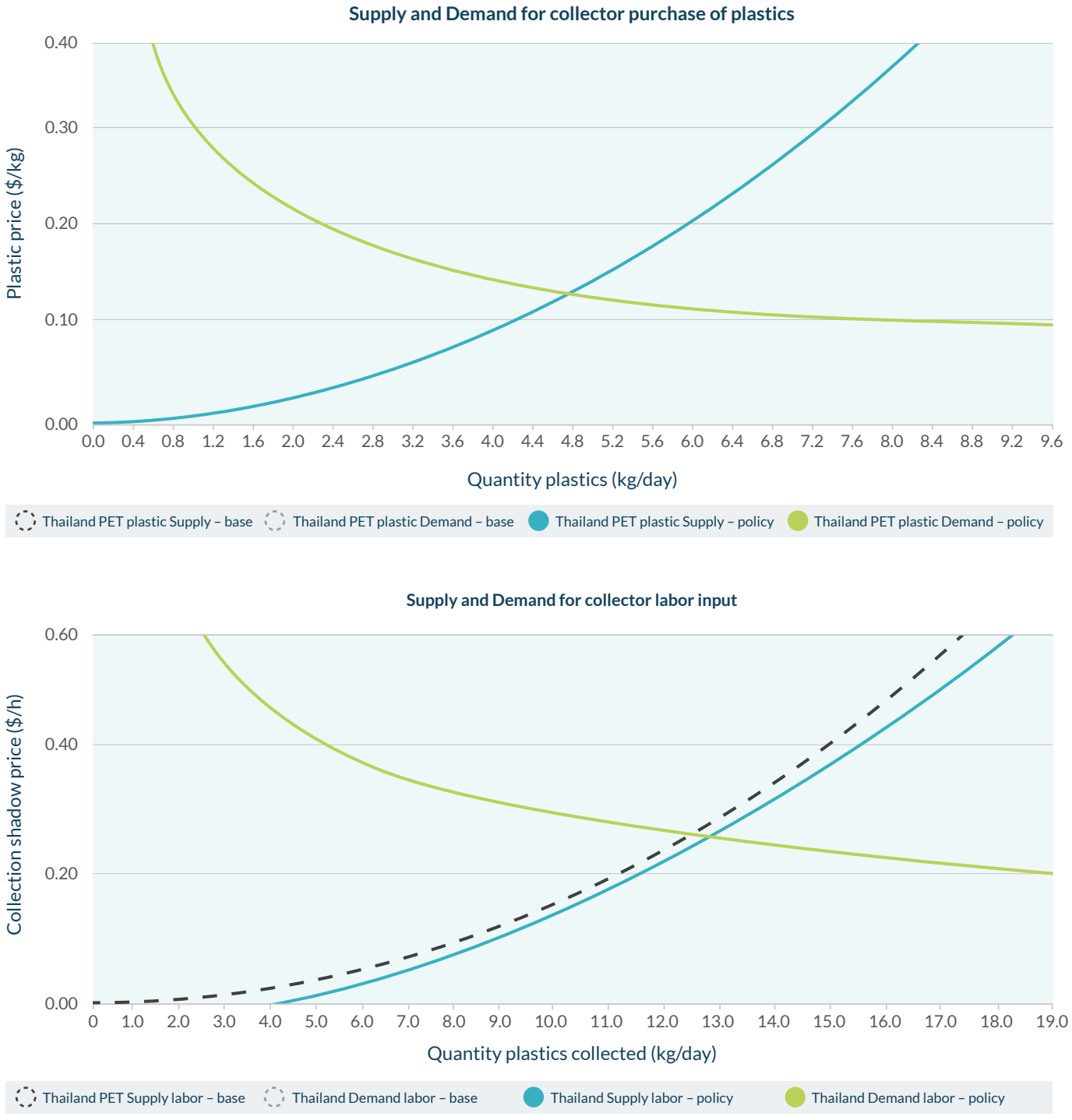



In the graphs, the impact of the policy is represented as a shift of the plastic and labor demand curves to the point at which the required recycled content is being collected and processed within the supply chain. The demand curves can then be seen to represent L-shaped curves (where demand curves are artificially vertical at minimum quantity required by the market) as the market is assumed to demand the required recycled plastic corresponding to the threshold defined by the policy as a minimum. The new market output is then defined by the new intersection between demand and supply, a shift to both greater plastic collection and labor input supported by a rise in prices.

## Formalization of the Collection System

Formalization of the collection system will result in an expected reduction of operational costs (lower transport costs and reduced processing resulting from more segregated material collection). It also increases output prices through increased scale at collection and aggregation, and greater bargaining power by collectors and aggregators. For modeling purposes, it is assumed to increase the efficiency of collectors' labor input and lower the cost per kg of material collected and provided as feedstock for the recycling supply chain. This may result from more structured collection systems, greater material segregation at source or a greater use of fleet (mechanized collection vehicles)/machinery.

**Figure 4:** A potential effect of a formalization of the collection system on collectors' supply and demand for labor is represented as a parallel shift of the labor supply curves

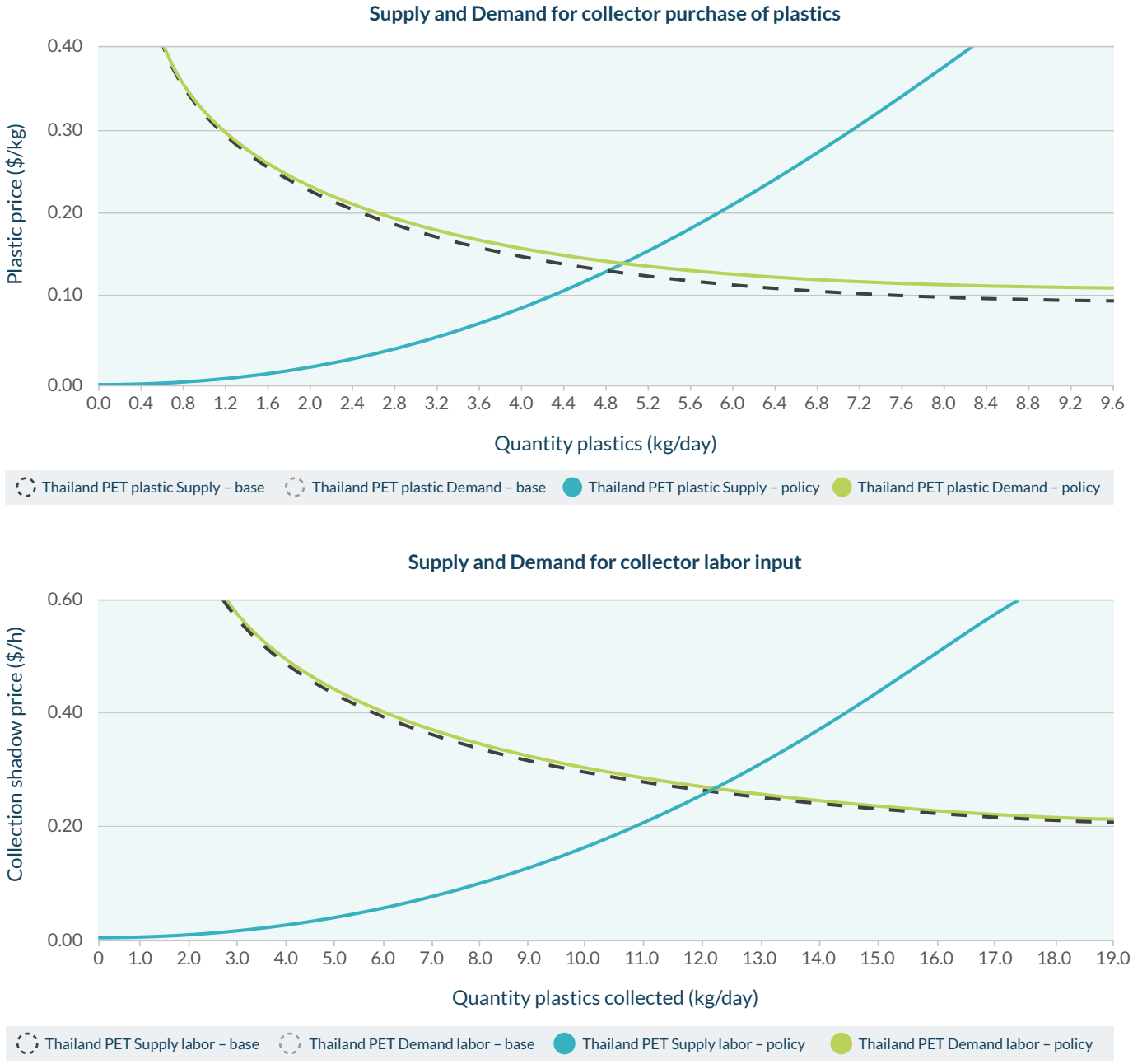



In the graphs, the impact of the policy is represented by the rightward parallel shift of the labor supply curve, illustrating an increase in labor efficiency resulting from more formalized collection systems. This lowers the cost of collection per kg of plastic waste. This enables the market to either maintain price points and increase profits or lower prices and provide increased plastic collection and recycling volumes.

## Taxes on Virgin Polymers

Taxes on virgin polymer products are expected to support output prices for recycled content production from the recycling supply chain. As an example, if a plastic bottle uses 1kg of virgin polymer costing $1 and is taxed 10%, this raises its base cost to $1.10 for the same level of output. This creates a $0.1 opportunity cost that could be negated by shifting to recycled content. The extent to which this happens will depend on relative price points of the two substitute materials. This type of approach is currently being applied in the EU alongside minimum recycled content targets. This acts as a demand signal to markets with additional material collected and additional revenues split across supply chain actors. For modeling purposes, it is assumed to affect the final consumer's willingness to pay for recycled plastics. In this regard, a tax on virgin polymer makes recycled content more economically attractive, indicating to the market that this could be a growth market. This trickles down to the collectors and influences the plastic demand curves for both labor and the plastic purchased from non-market collectors (informal waste workers). In this regard, as prices rise and demand increases for recycled content, this filters down to greater willingness to collect plastic material from the market.

**Figure 5:** A potential effect of taxes on the use of virgin polymer on the supply of plastic waste and demand for purchased plastics and labor




In the graphs, the impact of the policy is represented as an upward parallel shift of the plastic and labor demand curves. This increases the price points for plastic and acts as an indicator to the market, allowing additional investment or entry of higher-cost actors. The new intersection of demand and supply shifts up and to the right, with higher prices resulting in increased recycling output. Impacts of this policy may be limited by an imbalance of market power within which recyclers retain a large proportion of the price increase and do not pass it back to the supply chain.

# Appendix A:
# Research Methodology Step 4: Design and build of an economic model to represent the behavior of actors within the polymer supply chains

## 4.1 Economic modeling and review of the supply chain for a consistent, simplified approach

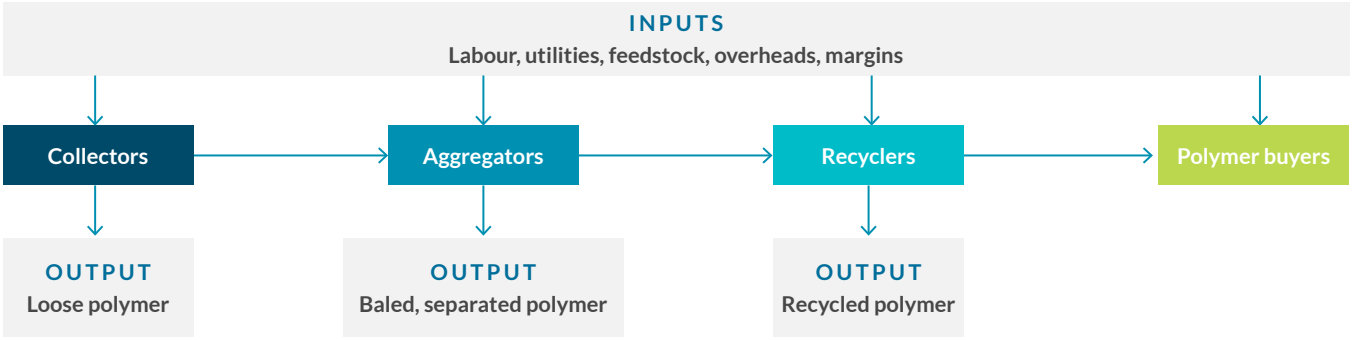
Following the selection of the interventions, the economic model was developed for each country.

The supply chains were simplified to their core actors and their activities so that the economic model developed would accurately and adequately reflect the core activities and parties involved. This supply chain format was utilized consistently across the polymer supply chains and countries as shown in Figure 6 below.

- **Collectors –** first step of the supply chain; those who physically collect the various plastic waste materials. This can include both formal and informal collectors of varying scales.
- **Aggregators –** second step of the supply chain; those who aggregate smaller amounts of recycled materials for onward sale and processing, or are involved in the onward transport of plastics. They may deal with many smaller collectors aggregating small volumes of plastic. Activities may include sorting.
- **Recyclers –** final step of the supply chain; the physical recyclers turning plastic waste into recycled polymers sold in the market.
- **Manufacturers/brands/polymer buyers –** although not part of the supply chain, buyers are included in the model as the offtakers of recycled polymers.

The Recycled Plastics Policy and Pricing Tool, which consolidates the various economic models, allows users to estimate the impact of various policy interventions on the output volumes, market share and prices of recycled plastic polymers. The tool also informs the potential impact of policy interventions on the profits of the value chain participants.

**Figure 6:** Supply chain overview




## 4.2 Economic principles that underpin and guide the model

As data captured during the project was limited (both in coverage and detail provided by respondents), the economic modeling had to be set up following an expected set of behaviors between actors within the supply chain. In the case of this study, the economic modeling strives to show economically rational responses to policy interventions aimed at increasing the recycling of plastics. This means actors within the supply chain are expected to behave in rational ways, and consider options and decisions within logical structures of thought to achieve simple goals, such as maximizing profit, as opposed to involving emotional, moral, or potentially strategic thinking that may distort the market.

The model uses the input data collected and complements this input with standard economic theory for how actors in the recycled plastics market will react to incentives activated through policy interventions. The model then translates these anticipated responses into impacts on key market metrics, such as the amounts of recycled plastics collected and the corresponding price levels.

To calculate these impacts, the model functions require a base set of data inputs for each polymer and geographic supply chain. The following are the key model inputs:

- Supply chain analysis of recycled plastics, including clarification of the actors relevant to the market (collectors, aggregators, recyclers, buyers).
- Interview data clarifying the volume of recycled plastics collected and treated, purchase and sale prices, and operational costs. Data is specified by actor, polymer, and country.
- Literature data on average plastic flows on a national level, which was used to scale interview data from stakeholders into national averages and determine an estimated number of collectors, aggregators, and recyclers.
- A set of policy interventions that are designed to have an impact on key model variables, such as operational efficiency, cost, and price data.

To translate this raw data into a market model, a set of economic principles were defined, which dictate how actors behave within the marketplace. The economic theory applied in the context of the model is that actors within the supply chain are economically rational and that the "market is under perfect competition" with one major exception – that individual agents can affect the market price via utilizing their market power to be price-setters. Conceptually, the "market under perfect competition" assumes economically rational buyers and sellers, which implies that all buying actors in the market maximize utility, given that:

- They can rank and compare options in the marketplace.
- They have stable preferences.
- Their preferences are internally consistent.
- There is a rule of marginal returns (more is better than less, but to a declining extent).
- Commodities and services are substitutable.

All selling actors adhere to the same rules, but instead of maximizing utility they strive to maximize profit and their production is not subject to economies of scale. Furthermore, the "market under perfect competition" is characterized as follows:

- All products on the market are identical.
- No transaction costs between buyers and sellers.
- Both buyers and sellers in the market have perfect information about the commodities.
- No price discrimination; all actors pay the market-clearing price. (The market-clearing price is that which enables the market to clear and the quantity supplied equals the quantity demanded.)
- No individual agent in the market can affect the market price.

In a market under perfect competition, prices and quantities sold correspond to the quantities for which the consumers' marginal willingness to pay is equal to producers' marginal willingness to accept.

When analyzing the information from the supply chain analysis, it is clear that the assumption that no agent can affect the market price is not applicable for the modeling of recycled plastics supply chains in Southeast Asia and India. This was apparent from the variety in pricing information received and the ability of some actors to set prices. The model developed therefore takes a more lenient approach to this marketplace assumption and replaces it with the assumption that there are known differences in market bargaining power, which influence behaviors. This bargaining power assumption is calculated as a function of how many actors exist at each stage of the supply chain and the difference between buying and selling prices of each agent gathered from the interviews (i.e., the share of total gains from trade retained by each actor within the supply chain).

### 4.3 Model development and calibration

Following the available data and economic principles that underpin the model, the model was scoped, built, and calibrated for each country and polymer supply chain. Four separate models were developed, representative of one of each of the geographies included in the study.

The model framework was established to separate key parts of the input data, calculations, and output metrics for users. This allows users to focus on the parts of the model where they can review and edit key assumptions or focus on the data visualization output.

# References


1. The Circulate Initiative. (2023). *Mapping Local Plastic Recycling Supply Chains: Insights from Selected Cities in India, Indonesia, Thailand, and Viet Nam* [online]. Available from: https://www.thecirculateinitiative.org/mapping-local-plastic-recycling-supply-chains-in-india-indonesia-thailand-Viet Nam

2. The Energy and Resources Institute (TERI). (2018). *Circular Economy for Plastics in India: A Roadmap* [online]. Available from: https://www.teriin.org/sites/default/files/2021-12/Circular-Economy-Plastics-India-Roadmap.pdf

3. Shanker, R. et al. (2022). *Plastic waste recycling: existing Indian scenario and future opportunities* [online]. Available from: https://pubmed.ncbi.nlm.nih.gov/35401771/

4. ICIS data. (2022).

5. The Circulate Initiative. (2023). *Mapping Local Plastic Recycling Supply Chains: Insights from Selected Cities in India* [online]. Available from: https://www.thecirculateinitiative.org/_files/ugd/77554d_3015af411a8c4e5c98473757e86f1d28.pdf?index=true

6. ICIS data. (2022).

7. The Circulate Initiative. (2023). *Mapping Local Plastic Recycling Supply Chains: Insights from Selected Cities in Indonesia* [online]. Available from: https://www.thecirculateinitiative.org/_files/ugd/77554d_0ed00073d7ba461190398bb0e3d3f6c1.pdf?index=true

8. Temesi Recycling. (2022). *Waste Banks* [online]. Available from: http://temesirecycling.com/waste-banks/

9. Greeners.co. (2019). *Waste Bank in West Jakarta Hit Billions Rupiah of Profit* [online]. Available from: https://www.greeners.co/english/waste-bank-in-west-jakarta-hit-billions-rupiah-of-profit/

10. Information provided by in-country research partner Rebel/Waste4Change (2022).

11. Al Jazeera Centre for Public Liberties and Human Rights. (2022). *Indonesia plastic waste* [online]. Available from: https://liberties.aljazeera.com/en/indonesia-plastic-waste/

12. Bring Back Recycle. (2021). Recycling Drop Off. http://www.bringbackrecycle.com/recycle

13. Data provided by SEI based on information extracted from OIE – Directory (2019).

14. ICIS data. (2022).

15. The Circulate Initiative. (2023). *Mapping Local Plastic Recycling Supply Chains: Insights from Selected Cities in Viet Nam.* Available from: https://www.thecirculateinitiative.org/_files/ugd/77554d_ad28e8ae2a17401c9a6367737ec473a5.pdf

16. Reloop Platform. (2022). *Global Deposit Book 2022: An Overview of Deposit Return Systems for Single-Use Beverage Containers* [online]. Available from: https://www.reloopplatform.org/wp-content/uploads/2022/11/RELOOP_Global_Deposit_Book_11I2022_P1.pdf

17. Cass Talbott, T., Chandran, P., Allen, C., Narayan, L. and Boampong, O. (2022). *Extended Producer Responsibility (EPR) and Waste Pickers* [online]. Available from: https://www.wiego.org/sites/default/files/publications/file/technical-brief-no-15.pdf

18. Ocean Conservancy. (2022). *Recommendations for Recycled Content: Requirements for Plastic Goods and Packaging* [online]. Available from: https://oceanconservancy.org/wp-content/uploads/2022/02/RRS_OceanConReport_Feb2022_Final.pdf

19. United Nations Human Settlements Programme. (2022). *Leaving no one behind – How a global instrument to end plastic pollution can enable a just transition for the people informally collecting and recovering waste* [online]. Available from: https://unhabitat.org/sites/default/files/2022/11/un-habitat_niva_report_leaving_no_one_behind_1.pdf

20. Aparcana, S. (2017). *Approaches to formalization of the informal waste sector into municipal solid waste management systems in low- and middle-income countries: Review of barriers and success factors* [online]. Available from: https://doi.org/10.1016/j.wasman.2016.12.028

21. Wongpanit. (n.d.). Wongpanit home page [online]. Available from: https://wongpanit.com/

22. SWaCH Cooperative. (2023). SWaCH home page [online]. Available from: https://swachcoop.com/

The Circulate Initiative