ISDC 26 – International System Dynamics Conference 2026

Quantifying Future Scenarios Using System Dynamics

Polyolefin Market in 2035

Noriyasu Ninagawa
Mitsui & Co. Global Strategic Studies Institute

Abstract

This study aims to quantitatively explore future scenarios of the polyolefin (PO) market toward 2035 by integrating scenario planning with system dynamics (SD) modeling. While conventional scenario planning often remains qualitative, this research introduces a structured approach to simulate market dynamics under different external conditions.

First, key driving forces were identified through external environment analysis, including sustainability orientation and emerging economy capacity. Based on these uncertainties, four alternative scenarios of the PO market were constructed. Then, an SD model was developed to represent interactions among domestic virgin, foreign virgin, and recycled PO markets, capturing feedback loops such as price formation, capacity utilization, demand shifts, and recycling flows.

Simulation results suggest that market outcomes are highly sensitive to supply expansion in emerging economies and the degree of sustainability-driven demand changes. Increased overseas capacity leads to a decline in domestic prices regardless of sustainability orientation, while sustainability-driven demand alone is insufficient to significantly expand the share of recycled materials in the short term.

By quantifying scenario narratives, this study demonstrates how SD modeling can enhance the robustness of strategic discussions and provide actionable insights for decision-making in the polyolefin industry.

Keywords: scenario planning, driving force, quantification by system dynamics, polyolefin market, recycling, emerging markets

Acknowledgements

The author would like to express sincere gratitude to Professor Yutaka Takahashi, Senshu Univ., for his valuable guidance and insightful advice throughout the development of this study.

Illustrated Scenarios

(1) External Environment Analysis & Driving Forces of Polyolefin Market

Field	Driving Forces	Hypotheses / Direction toward 2035
Political 	●Expansion of International Resource Management and CBAM ●**Capacity Expansion among Emerging Economies** ●Competition over Recycling Policy Standards	●Carbon taxes and waste-related taxation become widespread ●Regional differences in industrial policy become more pronounced ●Localization of technological standards
Economic 	●Supply-demand conditions and price volatility ●Widening price gap between virgin and recycled materials ●Shifts in investment toward petrochemical and recycling sectors	●Margin contraction due to oversupply ●Emergence of new business flows built around integrated recycling
Social 	●**Deepening consumer environmental awareness (education, ESG spending)** ●Stricter plastic-related regulations for companies ●Labor mobility and widening skill gaps	●Consumers and governments choose environmentally conscious materials ●Polyolefin demand gradually shifts toward sustainable uses
Techno-logical 	●Practical adoption of chemical recycling ●Advances in biobased feedstock and cost competitiveness ●Growing traceability through AI/IoT and materials tracking	●LCA-based evaluation becomes mainstream ●Full value-chain CO_2 visibility ●Spread of biobased products
Legal 	●Tighter international waste regulations and recycling requirements ●Product design obligations and circularity-focused regulations (e.g., EU PPWR) ●Expansion of carbon pricing schemes	●Regulatory waves reshape product design and trade flows globally ●Intensified competition for environmental certifications
Environ-mental 	●Acceleration of climate transition and raw material decarbonization ●Marine plastic regulations ●Reduction in water usage and recycling costs	●Growing shift from naphtha crackers to hydrogen crackers and biobased feedstock

(2) 4 Scenarios of Polyolefin Market View in 2035

Scenarios	Worldview
 Scenario A: **"Circular Industry Federation – Establishment of the Clean Alliance"**	EU-led circular-economy policies become global standards, sharply reducing virgin polyolefins through mandatory recycling and carbon traceability. Trading companies shift to circular-resource management, while Europe and Japan lead commercial-scale Car-to-Car recycling under unified regulations.
 Scenario B: **"Fragmented Material Empires – Block-Based Supply Chains"**	Resource and technology controls fragment global standards, with regions diverging between strict environmental policies and cost-focused approaches. Oversupply and geopolitical risks force localized optimization, while high-quality recycled materials remain limited and Car-to-Car recycling progresses unevenly.
 Scenario C: **"Quiet Saturation – Technological Stagnation and Social Fatigue"**	Chemical recycling falls short, slowing decarbonization and leaving recycled materials oversupplied. The industry enters a low-growth phase with cost cuts and consolidation, while strict regulations and technical limits prevent automotive recycling, leading to widespread down-cycling.
 Scenario D: **"Decarbonized Materials Revolution – Technology Redefines Everything"**	Renewables, hydrogen, AI, and chemical recycling mainstream carbon-neutral materials. CO_2-based and bio feedstocks prevail, manufacturing becomes automated and decentralized, and digital traceability supports compliance. Virgin-equivalent recycled PP/TPO is widely adopted in automotive applications.

This scenario is close to ② Sustainability Orientation "High" × Emerging Economy Capacity "Low"

This scenario is close to ③ Sustainability Orientation "Low" × Emerging Economy Capacity "High"

Methodology

- SD model of domestic polyolefin market were illustrated by combining (1) Domestic Virgin, (2) Foreign Virgin, and (3) Domestic Recycled Polyolefin markets.
- The developed model is then populated with the driving forces. In this case, simulations were conducted based on two key driving forces: (1) sustainability orientation and (2) emerging market capacity. Sustainability orientation affects PO demand, while emerging market capacity influences overseas PO demand.

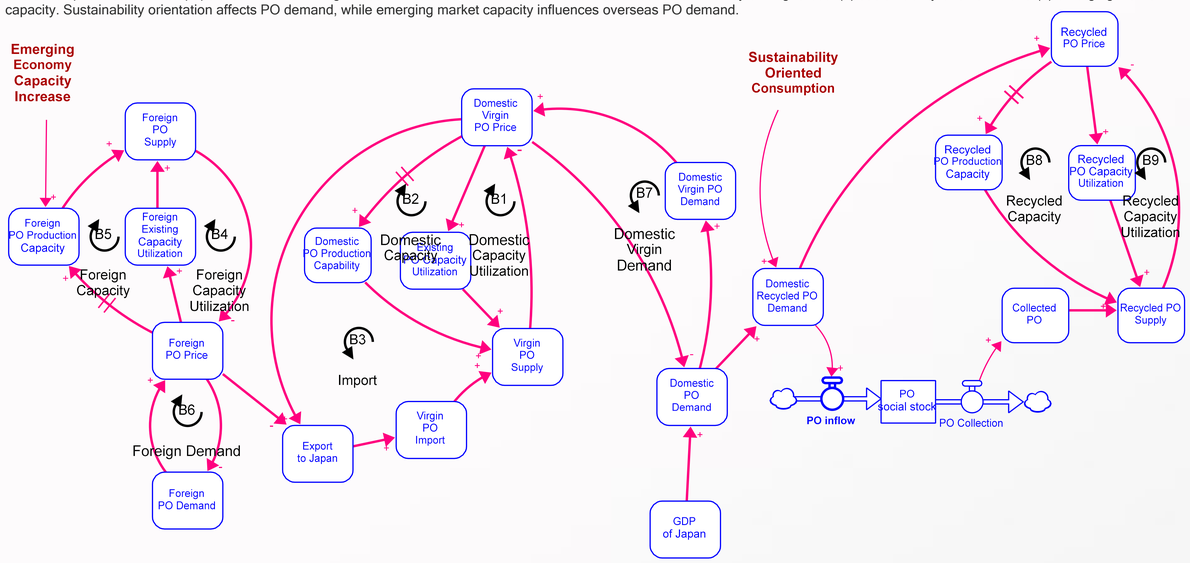

Fig.1 Overview of the simulation model

Results

(1) Simulation Results

- When emerging market capacity does not increase and sustainability orientation is not strong, prices tend to rise.
- When emerging market capacity does not increase but sustainability orientation is strong, prices still show an upward trend; however, the magnitude of the increase is moderated. This is because demand for polyolefin shifts toward recycled materials, preventing tight supply-demand conditions for virgin materials.
- On the other hand, if emerging market capacity continues to expand, prices decline regardless of the degree of sustainability orientation. At a certain point, the price decline accelerates. This occurs because overseas prices fall below domestic prices at that stage, prompting foreign producers to increase exports to Japan. As a result, prices may drop to as low as one-twentieth of their original level, causing severe damage to the domestic polyolefin market.
- In every case, recycled material accounts for only a small share of the total.
- Once overseas prices fall below domestic prices, imports from abroad surge and domestic capacity is almost entirely driven out.

(2) Expected Practical Effects

- Internal and external communication
  - ➢ Simulation results can be used to explain future market outlooks within the company and to external customers.
  - ➢ Inflection points in price and supply trends provide useful inputs for discussion and decision-making.
- Support for concrete decision-making
  - ➢ Results can serve as reference information for decisions on capacity utilization, facility shutdown, and supply structure restructuring.
  - ➢ For stakeholders who use capacity utilization as a threshold for continuing operations, the model provides practical decision-making criteria.

(3) Conclusion

- By integrating scenario planning with SD, we achieved a quantitative representation of scenarios.
- Based on these results, the effects on practitioners engaged in real-world business are discussed.

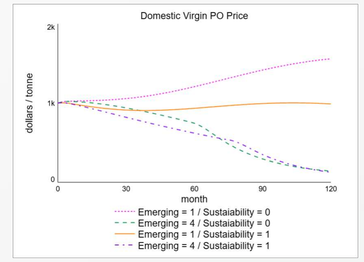

Fig.2 Simulated trajectory of domestic virgin polyolefin prices

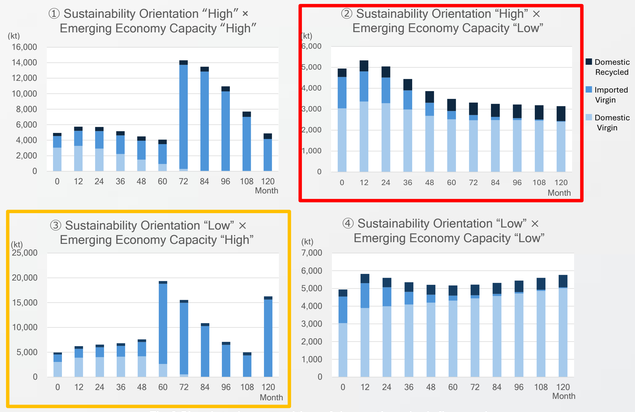

Fig.3 Simulated composition of domestic polyolefin supply