Tri-Market plastics and petrochemical analysis

Research Briefing: Plastic polymer production capacity in South Korea, Japan, and Taiwan

New research by Greenpeace East Asia estimates that the petrochemical industry in South Korea, Japan, and Taiwan has a raw plastic material production capacity of 41.99 million metric tons (Mt) of plastic annually. Producing this much plastic could generate 99.93 Mt of CO_2-Eq emissions.

Executive Summary

1. Based on the analyzed plastic polymer types in this study, the CO_2-Eq emissions from plastic production in South Korea alone match the combined emissions of Japan and Taiwan.
2. South Korea, Japan, and Taiwan collectively have an annual production capacity of 41.99 million metric tons (Mt[1]) of primary plastic polymers. This accounts for the top 7-8 polymers in each market. Regionally this consists of South Korea with 19.92 Mt, Japan with 13.04 Mt, and Taiwan with 9.02 Mt. This level of production capacity has projected emissions equivalent to 99.93 Mt CO_2-Eq.
3. Out of the top 10 companies with the highest plastic production capacity, 7 are headquartered in South Korea. Formosa (Taiwan) and Lotte (South Korea) each account for around 10% of all production capacity in these three markets, with 4.49 Mt and 4.3 Mt of capacity, respectively.

Table 1: Estimated market-level plastic production capacity (in million metric tons) and emissions (in CO2-Eq) for South Korea, Japan, and Taiwan.

	Total	South Korea	Japan	Taiwan
Production Capacity (Mt)	41.99	19.92	13.04	9.02
Projected emissions (Mt CO_2-Eq)	99.93	49.55	27.61	22.77

[1] Mt refers to Mega metric tons, which is equivalent to million metric tons

Table 2: Estimated company-level plastic production capacity (in million metric tons) and emissions (in CO_2-Eq) for the top 10 companies in South Korea, Japan, and Taiwan, ranked by production capacity.

Ranking	Company	Market	Production Capacity[2] (Mt)	Emissions (Mt CO_2-Eq)
1	Formosa	Taiwan	4.49	11.69
2	Lotte	South Korea	4.30	11.12
3	Mitsui Chemicals	Japan	3.49	7.86
4	Hanwha	South Korea	1.73	4.10
5	LG	South Korea	1.35	4.42
6	DL	South Korea	1.34	2.94
7	Hyosung	South Korea	1.30	2.87
8	SK	South Korea	1.23	2.72
9	KPIC	South Korea	1.20	2.67
10	Mitsubishi Group	Japan	1.14	2.58

Background

Plastics, throughout their lifecycle, are globally estimated to be responsible for anywhere between 3.8-4.5% of all global greenhouse gas emissions, with 85% of those emissions coming from the production phase and relatively little from sourcing raw materials, use, and waste management.[1,2] More than half of all plastics ever produced have been produced since 2000,[3] and according to the Intergovernmental Panel on Climate Change (IPCC), at current rates of growth, plastic production will double by 2035.[4] By 2030, global plastic-related CO_2-Eq emissions are forecast to reach 1.34 gigatonnes annually.[5]

Petrochemicals are projected to take up an increasingly larger section of oil demand, with current International Energy Agency (IEA) projections forecasting that of the estimated 10mb/d of oil demand growth by 2030, the chemical sector would account for one-third of this growth, and as much as 50% of demand growth by 2050.[6] Asia Pacific serves a particularly important role in the petrochemical industry, with approximately 40% of CAPEX above $1bn between 2010 and 2020 going to projects in Asia Pacific, with South

[2]The companies' production capacity is limited to the polymer types included in the emissions analysis.

Korea, Japan and Taiwan making up 5%, 3%, and 3% respectively of global petrochemical production capacity.[7]

In recent years, however, the industry has been struggling with issues of overcapacity, with a widening gap between capacity and demand.[8] In 2023 global ethylene production capacity reached 223.82 Mt, yet demand reached only 176.53 Mt.[9] Following on from this, lowered operating rates have resulted in numerous petrochemical companies reporting in August 2024 various mergers, scaling-down of operations, and shuttering of facilities to deal with the global oversupply.[10]

This overcapacity has roots in both short-medium term factors such as high feedstock/energy costs, and increased competition, to long-term factors such as the shift towards low-carbon and recycled materials, new technologies, and shifts in key industries such as automotives.[11]

Regional Key Findings

South Korea

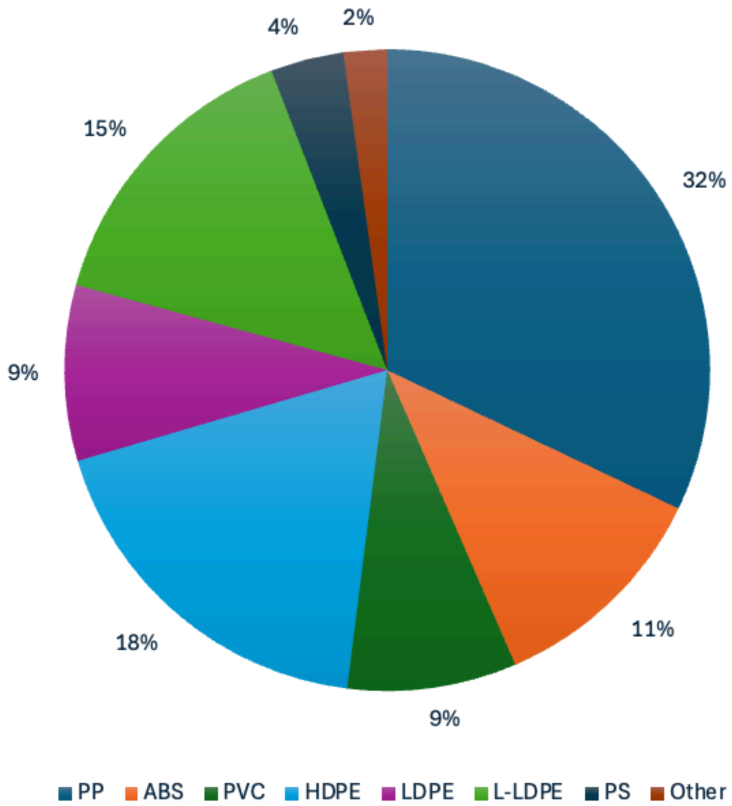
Of the three markets investigated, South Korea holds the biggest petrochemical industry, with an annual plastic production capacity of approximately 20 million tonnes, and the majority of that production capacity is focused around the industrial hubs of Ulsan and Yeosu. Plastic production is led predominantly by the large conglomerates, where Lotte stands out as the largest manufacturer in South Korea, accounting for 22% of the country's domestic production capacity and approximately 10% of the total capacity across the three markets, making it the second largest in the region.

Domestically, the primary plastic polymers produced include polypropylene (PP), acrylonitrile butadiene styrene (ABS), polyvinyl chloride (PVC), high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (L-LDPE), and polystyrene (PS). Together, these seven polymer types account for approximately 97.8% of the country's total plastic production capacity. Based on emissions factors specific to each polymer, the total estimated CO_2-Eq emissions resulting from the production of these plastics reach approximately 49.5 Mt CO_2-Eq. This in turn represents around 7.3% of total domestic emissions for all sectors in 2021.[12] Among the polymer types, polypropylene (PP) has the greatest production capacity (6.4 Mt) and subsequent greatest emissions (14.1 Mt CO_2-Eq). While acrylonitrile butadiene styrene (ABS) has a production capacity of only 2.3 Mt—approximately one-third that of PP—the carbon-intensive nature of its production results in emissions as high as 9.8 Mt CO_2-Eq.

Petrochemicals was identified as a key industry by the South Korean government in June 2023,[13] however, some analysis indicates that the global trend of overcapacity will hit South Korea and result in large-scale shutdowns of capacity in the near future.[14]

Table 3: Estimated plastic production capacity (in metric tons) and emissions (in CO2-Eq) in South Korea, including the top 10 companies ranked by production capacity.

	Production Capacity ('000 metric tons)	Projected Emissions ('000 metric tons CO_2-Eq)
Market Total	19,922	49,555
1. Lotte	4,300	11,117
2. Hanwha	1,732	4,103
3. LG	1,350	4,417
4. DL	1,335	2,938
5. Hyosung	1,300	2,870
6. SK	1,230	2,716
7. KPIC	1,200	2,671
8. Hanwha/Total	1,120	2,473
9. GS	1,080	2,401
10. KKPC	554	2,180



Polymer Type	*Production Capacity (Mt)*
PP	6.39
ABS	2.27
PVC	1.69
HDPE	3.67
LDPE	1.76
L-LDPE	2.96
PS	0.73
Other	0.43
Total	*19.92*

Graph 1: Polymer types by estimated production capacity in South Korea

Japan

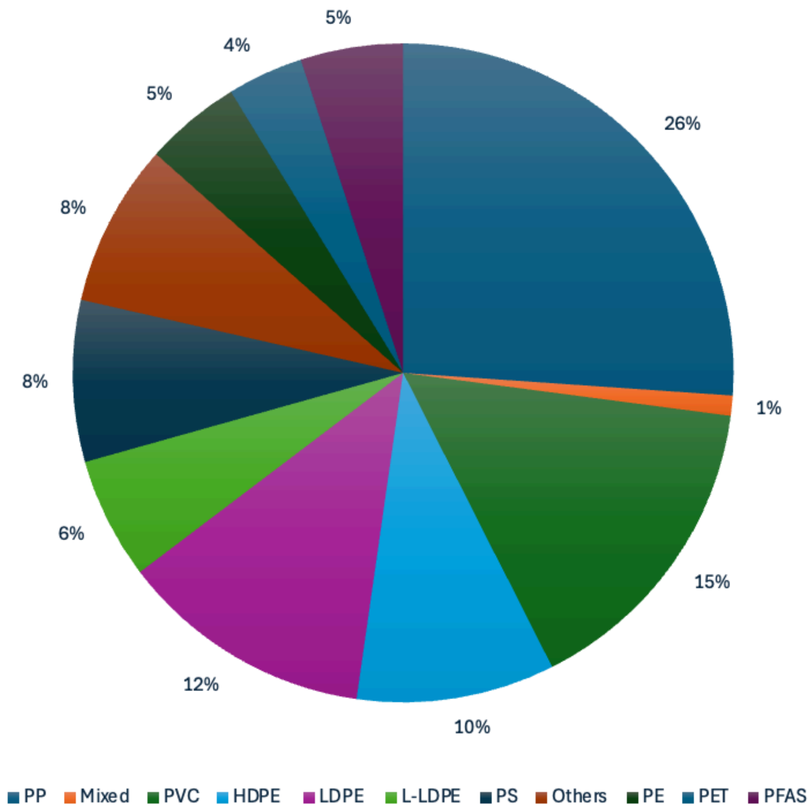
In Japan, the domestic petrochemical industry hosts an annual production capacity of approximately 13 Mt, spread relatively evenly across a number of production hubs, with approximately 50% of domestic capacity located in Chiba, Ibaraki, Mie, and Kanagawa prefectures. Mitsui Chemicals holds the largest domestic production capacity of any petrochemical company in Japan at 3.49 Mt, ranking as the third largest company by capacity volume in the three markets.

Domestically, the primary plastic polymers produced include PP, PVC, LDPE, HDPE, PS, L-LDPE, PFAS, PE, and PET. Together, these nine polymers account for approximately 92% of the country's total plastic production capacity. As no corresponding emission factor exists for PFAS in the Ecoinvent database, it was excluded from the analysis. Therefore, eight polymers—representing 87% of the total production capacity—were analyzed. Together, they result in an estimated 27.6 Mt of CO_2-Eq emissions. Of these polymer types, PP holds a production capacity of 3.4 MT, accounting for the highest emissions, generating approximately 7.5 Mt of CO_2-Eq.

As of 2023, documents released by the Ministry of Economics, Trade, and Industry have indicated that the government's approach to the decarbonization of the petrochemical sector will center largely on increasing resource recycling, with a focus on maintaining production capacity.[15]

Table 4: Estimated plastic production capacity (in metric tons) and emissions (in CO2-Eq) in Japan, including the top 10 companies ranked by production capacity.

	Production Capacity ('000 metric tons)	Projected Emissions ('000 metric tonsCO_2-Eq)
Market Total	13,043	27,607
1. Mitsui Chemicals	3,487	7,855
2. Mitsubishi Group	1,140	2,583
3. Tosoh	878	2,113
4. Asahi Kasei	722	2,257
5. Sumitomo	662	1,493
6. Mitsubishi/JNC	595	1,314
7. Shin-Etsu	550	1,340
8. Kaneka Corp	430	1,048
9. Tokuyama	430	1,002
10. Resonac	408	900



Polymer Type	Production Capacity (Mt)
PP	3.40
Mixed[3]	0.13
PVC	2.02
HDPE	1.27
LDPE	1.62
L-LDPE	0.78
PS	1.03
Others	1.04
PE	0.62
PET	0.48
PFAS	0.65
Total	*13.04*

Graph 2: Polymer types by estimated production capacity in Japan[4]

Taiwan

Although the Taiwanese market is the smallest of the three analyzed with less than half of South Korea's production capacity, Formosa stands out as having the largest estimated capacity of any company assessed, holding around 11% of tri-market capacity, and just under 50% of all Taiwanese capacity.

Formosa however is the exception to the rule, with analysis by the US International Trade Commission pointing out that 98% of Taiwanese plastic and rubber companies are small-medium enterprises.[16]

Overall Taiwan has just over 9 Mt of production capacity, which could result in 22.77 Mt of CO_2-Eq emissions, of which Formosa alone is responsible for 11.7 Mt of CO_2-Eq emissions. The main polymer types are polyvinyl chloride (PVC) and ABS representing 21% and 19% of the market respectively, yet ABS's high carbon intensity makes it the single-largest

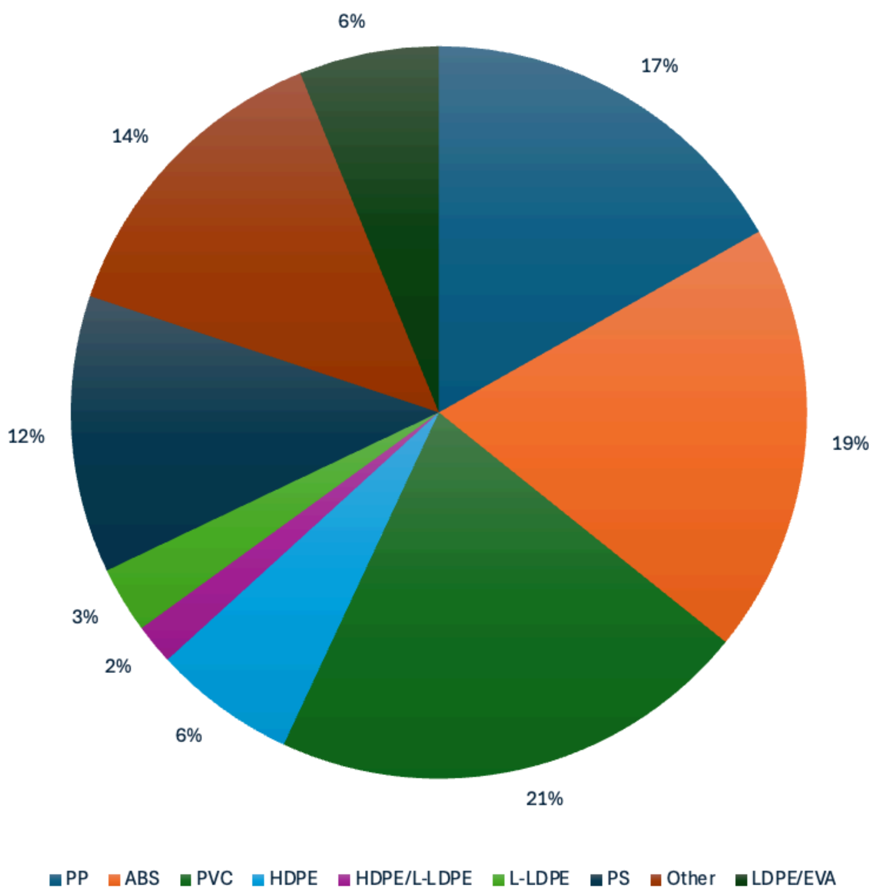
[3] For several facilities, there was insufficient data on which polymers were produced. These facilities are represented here as "Mixed" and consist of: ABS/PE/PP/PS (0.5%), PE/PP (0.2%), PE/PP/PS (0.2%), PE/PET/PP (0.1%)

[4] Although included here in production capacity, as the emissions factor for PFAS was not available in the Ecoinvent database, it was not included in emissions calculations.

source of emissions. This capacity accounts for just under 8% of Taiwan's total emissions and more than 15% of industrial emissions in 2022.[17]

Table 5: Estimated plastic production capacity (in metric tons) and emissions (in CO2-Eq) in Taiwan, including the top 10 companies ranked by production capacity.

	Production Capacity ('000 metric tons)	Projected Emissions ('000 metric tons CO_2-Eq)
Market Total	9,024	22,771
1. Formosa	4,492	11,692
2. Chimei	1,066	4,547
3. USI Group	1,045	2,916
4. LCY	400	883
5. GPPC	180	728
6. OPC	120	292
7. Kao Fu	100	351
8. Eng Chuan	60	211
9. Great Eastern	15	65
Other	309	1084



Polymer Type	*Production Capacity (Mt)*
PP	1.51
ABS	1.72
PVC	1.91
HDPE	0.57
HDPE/L-LDPE	0.16
L-LDPE	0.26
PS	1.11
Other	1.24
LDPE/EVA	0.56
Total	*9.02*

Graph 3: Polymer types by estimated production capacity in Taiwan

Methodology

Research for this project was conducted in two stages, firstly the compilation of a production capacity database, and secondly the calculation of projected emissions. Researchers first compiled a database of plastic production in the target markets of South Korea, Japan, and Taiwan, using a combination of corporate disclosures, industrial information (all data, reports, and information from industrial sources), and academic/government studies of the petrochemical industry. This database was supplemented by high-quality secondary data for Taiwan, specifically the Annual Report 2024 of the Petrochemical Industry of Taiwan,[18] for South Korea, specifically Petrochemical Minibook 2024 of the South Korea Petrochemical Industry Association.[19]

Emissions were then calculated by multiplying production capacity (metric tons of plastic polymer pellets per year) by life-cycle assessment (LCA) CO_2-Eq emissions data from production, including upstream emissions and emissions from production activity.

Production emissions at full capacity = Production capacity (weight) × LCA emissions for CO_2-Eq (per weight produced)
(LCA data for climate change is expressed in CO_2-Eq)

This work incorporated the following assumptions:

- **Capacity:** We assume all plants operate at full capacity, positioning the results as the emissions from the total production capacity of the subregion, rather than actual emissions.
- **Plastic Production:** We assess emissions solely from pellet production, as most plastic products are derived from pellets. We lack comprehensive data on the proportions of end-use plastic products, so processes occurring after the pellet stage are excluded.
- **Plastic Types:** We calculated emissions for the top eight polymer types (in case of South Korea top seven) for each area and company based on their production capacities (e.g., PP, PVC, LDPE, HDPE). If the emission factor for any of the top seven/eight polymers was unavailable in the Ecoinvent database[5], that polymer was excluded from the ranking. For polymer capacity data that were not disaggregated, such as those classified as LDPE/LLDPE, we averaged the emission factors of the two types and utilized this average in our calculations. ABS and PS have relatively different emission factors, however these two only account for around 0.9% of total calculated emissions, with other emission values being relatively similar.
- **Source Materials:** The Ecoinvent dataset setting assumes that source material for pellet production is 100% virgin plastic.
- **Emissions Type:** Although there are many other environmental impacts associated with plastic, for the purpose of this study we considered only CO_2-Eq emissions, using only the "climate change" emissions category within the LCA framework.
- **Emissions Data:** We used Ecoinvent 3.8, a subscription-based LCA database recognized as a standard in the field. Version 3.8 was published in 2021, and as such changes to emission factors may have occurred. Since specific data for East Asia was not available, we also employ Rest-of-the-World (RoW) settings, representing the world average excluding all local geographies for which a process exists in the database.
- **Cut-off:** We calculated emissions data for the polymer types with the highest production capacities in each region, which together account for 97.8% in South Korea, 92% in Japan, and 86.3% in Taiwan respectively of total production capacity. The polymer types with the highest production capacity vary among these regions.

[5] See Appendix I

	South Korea	Japan	Taiwan
Polymer types with the highest production capacity	PP ABS PVC HDPE LDPE L-LDPE PS	PP PVC LDPE HDPE PS L-LDPE PE PET	PP ABS PVC HDPE HDPE/L-LDPE L-LDPE LDPE/EVA PS

Limitations

The production capacity database is limited to data sources in the English language and by the level of corporate disclosure, which may constrain its adequacy for analyzing "market emissions." Furthermore, the database contains numerous unknowns (N/As) that could represent a substantial portion of the production capacity and, consequently, the associated emissions. In addition, the published date of the data among various companies differ.

Also, although the Ecoinvent database is widely utilized, it may occasionally rely on outdated data. Additionally, assumptions such as the use of 100% virgin plastic and the application of the Rest-of-the-World (RoW) dataset, stemming from the absence of country-specific databases, may affect the accuracy of the calculations.

Greenpeace recommendations & analysis

As the global trend of overcapacity in petrochemicals continues, this research indicates that the production capacity and greenhouse gas emissions potential of the South Korea, Japan, and Taiwan markets is not economically or environmentally sustainable in the long-term.

Global pressure is mounting to reduce greenhouse gas emissions in line with the 1.5°C degree goal outlined in the Paris Agreement, and reducing emissions from the petrochemical sector is a crucial part of this along with the energy transition. The IPCC identified the petrochemical industry as one with >99% reliance on fossil fuels for feedstock, making it a challenge for reaching net zero emissions.[20] This stance has subsequently been supported by research which has argued that caps on plastic production can help smooth out structural market imbalances while new technologies can decrease the demand for virgin plastics.[21] At the same time, the chemical and petrochemical sector has more than doubled their percentage share of global industrial emissions since 1970.[22]

On average, global ethylene production capacity has exceeded demand by approximately 20 million metric tons since 2010. Our research has found that growth in the East Asian petrochemical industry has resulted in plastic production capacity with potential emissions of 99.93 Mt CO_2-Eq.

Although it is beyond the scope of this paper to analyse the factors behind this growth, ultimately this background paints a picture of an industry with capacity that cannot be fully used, amidst a growing need to reduce the emissions inherent to its production processes. To ensure Paris alignment, a reduction in the capacity and emissions of these companies is crucial, however, the current state of the industry shows that this is unlikely without a strong regulatory framework.

To that end, a strong global plastics treaty is needed to ensure that the petrochemical industry and plastic production remain firmly aligned with the goal of 1.5°C of global warming.

Based on this, ahead of the fifth session of the Intergovernmental Negotiating Committee (INC-5), Greenpeace East Asia recommends the following measures for policymakers and delegates:

1. Set legally binding targets for a reduction in domestic petrochemical production, with the goal of contributing towards a global reduction of the production of primary plastic polymers by at least 75% by 2040 compared to 2019 levels.[23]
2. Require petrochemical producers to create a roadmap for a just transition to achieve carbon neutrality by 2050.
3. Sign the Bridge to Busan Declaration as proposed by Member States in alignment with United Nations Environment Assembly (UNEA) Resolution 5/14 to develop an international legally binding instrument on plastic pollution.

Endnotes

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Appendix I: Ecoinvent database

Types of plastic	Impact to Climate Change	Reference product	Data Generator	Citation
PP	2.2080e+0 kg CO2-Eq	polypropylene production, granulate	Fröhlich, T.	Fröhlich, T.,polypropylene production, granulate, Rest-of-World (RoW), apos, ecoinvent database version 3.8
ABS	4.3156e+0 kg CO2-Eq	acrylonitrile-butadiene-styrene copolymer production	Hischier, R.	Hischier, R.,acrylonitrile-butadiene-styrene copolymer production, Rest-of-World (RoW), apos, ecoinvent database version 3.8
PVC	2.4368e+0 kg CO2-Eq	polyvinylchloride production, bulk polymerisation	Hischier, R.	Hischier, R.,polyvinylchloride production, bulk polymerisation, Rest-of-World (RoW), apos, ecoinvent database version 3.8
HDPE	2.2404e+0 kg CO2-Eq	polyethylene production, high density, granulate	Fröhlich, T.	Fröhlich, T.,polyethylene production, high density, granulate, Rest-of-World (RoW), apos, ecoinvent database version 3.8
LDPE	2.4278e+0 kg CO2-Eq	polyethylene, low density, granulate	Fröhlich, T.	Fröhlich, T.,polyethylene production, low density, granulate, Rest-of-World (RoW), apos, ecoinvent database version 3.8
L-LDPE	2.1726e+0 kg CO2-Eq	polyethylene, linear low density, granulate	Fröhlich, T.	Fröhlich, T.,polyethylene production, linear low density, granulate, Rest-of-World (RoW), apos, ecoinvent database version 3.8
PE	2.2803 kg CO2-Eq	This emission factor is an average of the emission factors for HDPE, LDPE, and LLDPE, since the Ecoinvent database does not provide a specific average emission factor for polyethylene (PE).		
PS	3.5097e+0 kg CO2-Eq	polystyrene, general purpose	Hischier, R.	Hischier, R.,polystyrene production, general purpose, Rest-of-World (RoW), apos, ecoinvent database version 3.8
EVA	2.2718e+0 kg CO2-Eq	ethylene vinyl acetate copolymer	Hischier, R.	Hischier, R.,ethylene vinyl acetate copolymer production, Rest-of-World (RoW), apos, ecoinvent database version 3.8
PET	2.7501e+0 kg CO2-Eq	polyethylene terephthalate	Fröhlich, T.	Fröhlich, T.,polyethylene terephthalate production, granulate, bottle grade, Rest-of-World (RoW), apos,ecoinvent database version 3.8