A R T I C L E S

THE U.S. PLASTICS PROBLEM: THE ROAD TO CIRCULARITY

by Ruth Jebe

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SUMMARY

Plastics pollution has been an issue in the United States since discovery of the Great Pacific Garbage Patch catapulted it to the forefront of news reporting. Regulatory and academic activity around plastics has had a common feature: it focused almost exclusively on one stage in plastics' linear model and framed the problem as a waste problem. Challenges have come in two forms: the shift from the linear production model of take-make-waste to a sustainability paradigm represented by the concept of circular production, and disruption of the global plastics waste supply chain occasioned by changes in China's waste import policies. These shifts are forcing countries to reassess their approach to plastics. This Article argues for an expanded view of the U.S. plastics problem, one that reframes the problem around sustainability and plastics' full life cycle, rather than a focus on waste alone. It proposes regulatory interventions and ideas for a future research agenda to move the study and regulation of plastics from linear to circular.

In the spring of 2020, at the beginning of the coronavirus pandemic, Connecticut, Massachusetts, and New York all delayed enforcement of their new restrictions on single-use plastic (SUP) carryout bags.[1] The bans were intended to reduce plastics waste, but concerns about the possibility that reusable bags might transmit the coronavirus derailed their implementation.[2] As the pandemic deepened, attention focused on human health, not on environmental impacts of public health issues and not on plastics waste.

Plastics waste had been a topic of interest since the 1997 discovery of the Great Pacific Garbage Patch.[3] Between 1950 and 2015, plastics production increased rapidly, with much of that growth coming in recent years: half of all the plastics produced since 1950 were produced between 2004 and 2017.[4] Plastics demand and production have doubled since 2000,[5] and estimates are that they will double in the next 20 years and perhaps triple by 2050.[6] Plastics produc-

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1. Ariela Lovett, *Governor Lifts Suspension of Plastic Bag Bans, Restrictions on Reusables,* Mass. Mun. Ass'n (July 16, 2020), https://www.mma.org/governor-lifts-suspension-of-plastic-bag-bans-restrictions-on-reusables/ (noting that Massachusetts had suspended SUP bag restrictions beginning in March 2020); Press Release, State of Connecticut Department of Revenue Services, Single-Use Plastic Bag Fee Suspension Set to Expire June 30th (June 26, 2020), https://portal.ct.gov/DRS/Press-Room/Press-Releases/2020/Single-Use-Plastic-Bag-Fee-Suspension-Set-to-Expire-June-30 (notifying retailers of expiration of the March 26, 2020, suspension of bag restrictions).
2. Eliza Fawcett, *The Pandemic Continues, but Connecticut's Single-Use Plastic Bag Fee Will Return Wednesday*, Hartford Courant (June 30, 2020), https://www.courant.com/news/connecticut/hc-news-plastic-bag-tax-returns-20300630-xyixfuxfhzdyzf2ieeqm6bncgq-story-html (reporting that the state's SUP-bag restrictions were suspended in response to concerns raised by retail employees about the potential for reusable bags to spread the coronavirus).
3. The Great Pacific Garbage Patch is a collection of marine debris in the North Pacific Ocean. National Geographic, *Great Pacific Garbage Patch*, https://www.nationalgeographic.org/encyclopedia/great-pacific-garbage-patch/ (last visited Nov. 6, 2021). The patch was discovered by yachtsman Charles Moore. Laura Parker, *The Great Pacific Garbage Patch Isn't What You Think It Is*, Nat'l Geographic (July 3, 2019), https://www.nationalgeographic.org/article/great-pacific-garbage-patch-isnt-what-you-think.
4. Roland Geyer et al., *Production, Use, and Fate of All Plastics Ever Made*, 3 Sci. Advances e1700782 (2017), https://advances.sciencemag.org/content/3/7/e1700782.
5. International Energy Agency (IEA), The Future of Petrochemicals 1 (2018), https://iea.blob.core.windows.net/assets/bee4ef3a-8876-4566-98cf-7a130c013805/The_Future_of_Petrochemicals.pdf.
6. Ellen MacArthur Foundation et al., The New Plastics Economy—Rethinking the Future of Plastics 24 (2016), https://emf.thirdlight.com/link/faarmdpz93ds-5vmvdf/@/preview/1?o; Peter Lacy et al., *Plastic Is a Global Problem. It's Also a Global Opportunity*, World Econ. F. (Jan. 25, 2019), https://www.weforum.org/agenda/2019/01/plastic-might-just-be-the-solution-to-its-own-problem/. 2015 global plastics production, for example, reached 407 million tons and is projected to reach 1,600 million tons per year in 2050. Improving Plastics Management: Trends, Policy

tion now surpasses that of most other human-made materials.[7] With increased production has come increased plastics waste. A recent study concludes that the United States generates more plastics waste than any other nation.[8]

The United States developed an uncomfortable relationship with its ever-increasing amount of plastics waste, one that was dependent on globalized recycling supply chains that led to China. Then, two seismic shocks disrupted this precarious system. First, beginning in 2015, China instituted a number of import requirements that greatly reduced the amount of plastics waste the country would permit inside its borders.[9] These import restrictions sent shock waves throughout global waste supply chains and had devastating effects on U.S. waste management systems.[10]

Second, the COVID-19 pandemic increased consumption of plastics products, especially medical products like personal protective equipment[11] and SUP packaging for consumer items.[12] Overall, it is estimated that consumption of plastics increased between 250% and 300% due to the pandemic.[13] At the same time, recycling of plastics decreased, in part because some localities suspended collection of recyclables.[14] More importantly, demand for recycled content decreased as the pandemic intensified the price war between new plastics and recycled plastics. The economic slowdown punctured demand for oil, cutting the price of new plastics far below that of recycled plastics.[15] With few options for waste recycling, more and more cities and states began disposing of plastics in landfills and incinerators.[16]

The twin disruptions of China's import restrictions and the coronavirus pandemic, and their impact on the U.S. plastics industry, demonstrate the shortcomings of the growth-oriented organizing logic of U.S. business, the foundation of plastic's linear production model. In linear production models, referred to as take-make-waste, raw materials are extracted, processed into finished goods, and become waste after being consumed.[17] The focus of the growth model is to internalize the benefits of resources while externalizing the environmental costs of their exploitation. Unfortunately, this model entails significant resource and value losses[18] and contributes to depletion of natural resources.[19]

As sustainability becomes the organizing logic for 21st century business, there are calls to move away from linear production systems toward circular production and business models.[20] Circular models bridge production and consumption and foster business models that decouple economic growth from environmental loss.[21] Unlike linear production systems, circular systems are closed systems that seek to redirect the flow of materials, keeping them

Responses, and the Role of International Co-Operation and Trade 2 (Organisation for Economic Co-operation and Development (OECD), Environment Policy Paper No. 12, 2018), https://www.oecd.org/environment/waste/policy-highlights-improving-plastics-management.pdf [hereinafter OECD Plastics Management].

7. Geyer et al., *supra* note 4.
8. Kara Lavender Law et al., *The United States' Contribution of Plastic Waste to Land and Ocean*, 6 Sci. Advances eabd0288 (2020), https://advances.sciencemag.org/content/6/44/eabd0288/tab-pdf. The United States also has the highest annual per capita plastic waste generation among top plastic waste-generating countries. *Id*.
9. Saabira Chaudhuri, *Recycling Rethink: What to Do With Trash Now That China Won't Take It*, Wall St. J. (Dec. 19, 2019), https://www.wsj.com/articles/recycling-rethink-what-to-do-with-trash-now-china-wont-take-it-11576776536.
10. Leslie Hook & John Reed, *Why the World's Recycling System Stopped Working*, Fin. Times (Oct. 25, 2018), https://www.ft.com/content/360e2524-d71a-11e8-a854-33d6f82e62f8 (describing the impact of China's import restrictions on global recycling systems); Megan Manning & Stephanie Deskins, *Making It Usable Again: Reviving the Nation's Domestic Recycling Industry*, 50 Golden Gate U. L. Rev. 107, 113-18 (2020) (explaining the interrelationship between China and the U.S. recycling industry).
11. Ana L. Patricio Silva et al., *Rethinking and Optimizing Plastic Waste Management Under COVID-19 Pandemic: Policy Solutions Based on Redesign and Reduction of Single-Use Plastics and Personal Protective Equipment*, 742 Sci. Total Env't art. 140565, at 2 (2020) (noting the sudden surge in demand for plastic products by healthcare workers due to the pandemic). Reuters reported that production of face masks in China was 12 times higher in March 2020 than in February 2020 and that the United States generated a year's worth of medical waste in two months at the height of the pandemic. Joe Brock, *The Plastic Pandemic: COVID-19 Trashed the Recycling Dream*, Reuters (Oct. 5, 2020), https://www.reuters.com/investigates/special-report/health-coronavirus-plastic-recycling/.
12. Tanveer M. Adyel, *Accumulation of Plastic Waste During COVID-19*, 369 Science 1314 (2020) (noting the increased plastic demand created by consumers ordering packaged take-out meals and home-delivered groceries during the pandemic); Ana L. Patricio Silva et al., *Increased Plastic Pollution Due to COVID-19 Pandemic: Challenges and Recommendations*, 405 Chem. Eng'g J. art. 126683, at 4 (2021) (reporting that demand for plastic packaging is expected to increase by 40%).
13. Stephanie Zimmermann, *Plastic Waste Problem "Amplified" by the Pandemic*, Chi. Sun-Times/ABC7 (Nov. 11, 2020), https://chicago.suntimes.com/2020/11/11/21558733/styrofoam-plastic-waste-takeout-delivery-restaurants-coronavirus-pandemic-covid-chicago-recycling.
14. Jacob Duer, *The Plastic Pandemic Is Only Getting Worse During COVID-19*, World Econ. F. (July 1, 2020), https://www.weforum.org/agenda/2020/07/plastic-waste-management-covid19-ppe/ (noting that U.S. curbside recycling pickup had been suspended in many locations); E.A. (Ev) Crunden, *Municipalities Suspend Recycling Due to Coronavirus Impact on Prison Labor, Broader Safety Concerns*, Waste Dive (Mar. 19, 2020), https://www.wastedive.com/news/recycling-mrfs-prison-labor-suspensions-coronavirus-covid-19/574301/ (reporting on several municipalities' suspensions of recycling pickup activities).
15. Brock, *supra* note 11; Adyel, *supra* note 12.
16. Alana Semuels, *Is This the End of Recycling?*, Atlantic (Mar. 5, 2019), https://www.theatlantic.com/technology/archive/2019/03/china-has-stopped-accepting-our-trash/584131/ (reporting that much recyclable plastic was disposed of as municipal solid waste following China's imposition of import restrictions); Silva et al., *supra* note 12, at 5 (contending that much SUP generated during the coronavirus pandemic will be disposed of as solid waste, rather than recycled).
17. Andrea Urbinati et al., *Toward a New Taxonomy of Circular Economy Business Models*, 168 J. Cleaner Prod. 487 (2017); Taylor Brydges, *Closing the Loop on Take, Make, Waste: Investigating Circular Economy Practices in the Swedish Fashion Industry*, 293 J. Cleaner Prod. art. 126245 (2021).
18. Ellen MacArthur Foundation, Towards the Circular Economy 14-18 (2013) (detailing the types of resource and value losses resulting from linear production models). A World Economic Forum (WEF) and MacArthur Foundation study estimates the economic loss of plastics' linear process for plastics packaging alone at between $80 and $120 billion. Ellen MacArthur Foundation et al., *supra* note 6, at 26.
19. Irel De los Rios & Fiona J.S. Charnley, *Skills and Capabilities for a Sustainable and Circular Economy: The Changing Role of Design*, 160 J. Cleaner Prod. 109 (2017).
20. *See, e.g.*, Ira Feldman et al., *The Circular Economy: Regulatory and Commercial Law Implications*, 46 ELR 11009, 11010 (Dec. 2016) (arguing that the "business-as-usual" linear economy is being challenged as the best model for economic growth).
21. Brydges, *supra* note 17, at 2.

in use and generating value for as long as possible.[22] Thus, circularity looks at the full life cycle of a product and the relationship between resource use and waste.[23]

Both the current regulatory regime and the scholarship on plastic suffer from the same error: they ignore circularity and focus almost exclusively on the waste aspect of plastics. For example, federal law in the United States treats our plastic problem as an issue of solid waste management, a myopic view that is exacerbated by delegation of waste management to the state and local levels.[24] Defining the problem as a waste problem means regulation fails to address the environmental impacts embedded in other stages of the production process, and ignores the interconnected nature of production supply chains.[25]

The academic literature on regulating plastics reflects a similarly compartmentalized approach to the industry. Research focuses on specific pieces of the plastics puzzle, with little cohesion and no broader view of strategic issues. Scholars have investigated plastics issues by geographic location, both international[26] and domestic.[27] Other research focuses on the types of plastics items,[28] or the area polluted by plastics, most notably marine environments.[29] Another focus is on waste management and regulatory forms, including scholarship on recycling,[30] extended producer responsibility (EPR),[31] and appropriate regulatory actors.[32] Even literature that purports to examine plastics and the circular economy concept often focuses on only a single portion of the plastics life cycle.[33]

Plastics regulation and scholarship needs a new paradigm that looks at plastics from a sustainability perspective that drives toward true circularity. This Article contributes to that effort by examining plastics' issues through the whole product life cycle, uncovering the limits of a linear production model and laying the analytical groundwork for a comprehensive regulatory regime for plastics. This

22. Urbinati et al., *supra* note 17, at 487 (arguing that closed production systems generate more value from resources); Brydges, *supra* note 17, at 2 (explaining the connection between circular and closed-loop systems).
23. De los Rios & Charnley, *supra* note 19, at 110 (noting that life-cycle assessment is encouraged in circular design); Ellen MacArthur Foundation, *supra* note 18, at 22-23 (explaining that the circular economy concept involves management of material flows).
24. *See infra* Section II.C.1.
25. Brydges, *supra* note 17, at 2 (noting that the environmental impacts at the take and make stages can outstrip those at the waste stage).
26. Scholars have written about plastics issues in Africa and the European Union (EU). *See* Regis Y. Simo, *Of Sustainable Development in Africa: Addressing the (In)Congruence of Plastic Bag Regulations With International Trade Rules*, 45 Brook. J. Int'l L. 241 (2019); Carole Stuart Comer, *Federalism and Environmental Quality: A Case Study of Packaging Waste Rules in the European Union*, 7 Fordham Env't L.J. 163 (1995). China has been a focus of recent scholarship. *See*, *e.g.*, Colin Parts, *Waste Not Want Not: Chinese Recyclable Waste Restrictions, Their Global Impacts, and Potential U.S. Responses*, 20 Chi. J. Int'l L. 291 (2019) (reviewing the potential for a challenge to China's import restrictions on plastics in the World Trade Organization Dispute Settlement Body); Ying Xia, *China's Environmental Campaign: How China's "War on Pollution" Is Transforming the International Trade in Waste*, 51 N.Y.U. J. Int'l L. & Pol'y 1101 (2019) (positioning China's import restrictions in the context of its environmental programs).
27. Research on the plastics issues in specific U.S. states includes Rebecca Fromer, *Concessions of a Shopaholic: An Analysis of the Movement to Minimize Single-Use Shopping Bags From the Waste Stream and a Proposal for State Implementation in Louisiana*, 23 Tul. Env't L.J. 493 (2010) (exploring plastics waste management issues in Louisiana); Talia Sechley & Michelle Nowlin, *An Innovative, Collaborative Approach to Addressing the Sources of Marine Debris in North Carolina*, 28 Duke Env't L. & Pol'y F. 243 (2018) (discussing Duke Environmental Law and Policy Clinic investigation of the sources of litter in North Carolina's marine environment); David Brewster, *The Lasting Impacts of Mass Consumerism and the Disposable Culture: A Proposition for the Development of Plastic Shopping Bag Bans in Texas Law*, 51 St. Mary's L.J. 271 (2020) (reviewing attempts to ban plastic bags in Texas).
28. Much of this thread of the literature focuses on plastic shopping bags and includes Bridget M. Warner, *Sacking the Culture of Convenience: Regulating Plastic Shopping Bags to Prevent Further Environmental Harm*, 40 U. Mem. L. Rev. 645 (2010); Jennifer Clapp, *Doing Away With Plastic Shopping Bags: International Patterns of Norm Emergence and Policy Implementation*, 18 Env't Pol. 315 (2009); Samantha Weinstein, *Main Ingredient in "Marine Soup": Eliminating Plastic Bag Pollution Through Consumer Disincentive*, 40 Cal. W. Int'l L.J. 291 (2010); Jennie R. Romer & Leslie M. Tamminen, *Plastic Bag Reduction Ordinances: New York City's Proposed Charge on All Carryout Bags as a Model for U.S. Cities*, 27 Tul. Env't L.J. 237 (2014). Scholars have also investigated the impact of plastic straws. *See*, *e.g.*, Marcela R. Mosquera, *Banning Plastic Straws: The Beginning of the War Against Plastics*, 9 Env't & Earth L.J. 5 (2019); Marguerite Moloney, *Flawlessly Strawless?*, 31 Fordham Env't L. Rev. 107 (2020).
29. The literature on plastic pollution in the oceans, called marine debris, is extensive. Notable scholarship includes Stephanie F. Wood, *Move Over Diamonds—Plastics Are Forever: How the Rise of Plastic Pollution in Water Can Be Regulated*, 29 Vill. Env't L.J. 155 (2018); Olga Goldberg, *Biodegradable Plastics: A Stopgap Solution for the Intractable Marine Debris Problem*, 42 Tex. Env't L.J. 307 (2012); Jessica R. Coulter, *A Sea Change to Change the Sea: Stopping the Spread of the Pacific Garbage Patch With Small-Scale Environmental Legislation*, 51 Wm. & Mary L. Rev. 1959 (2010); Xiaoduo Liu, *Protecting Marine Animals: Domestic and International Regulation on Ocean Plastic Dumping*, 8 Chi.-Kent J. Env't & Energy L. 1 (2018); Matthew Schroeder, *Forgotten at Sea—An International Call to Combat Islands of Plastic Waste in the Pacific Ocean*, 16 Sw. J. Int'l L. 265 (2010); Mark Gold et al., *Stemming the Tide of Plastic Marine Litter: A Global Action Agenda*, 27 Tul. Env't L.J. 165 (2014).
30. Examples include Christina Everling, *Chasing Results From the Chasing Arrows: Strategies for the United States to Stop Wasting Time and Resources When It Comes to Recycling*, 52 UIC J. Marshall L. Rev. 147 (2018); Manning & Deskins, *supra* note 10; Anthony R. DePaolo, *Plastics Recycling Legislation: Not Just the Same Old Garbage*, 22 B.C. Env't Aff. L. Rev. 873 (1995).
31. Noah Sachs, *Planning the Funeral at the Birth: Extended Producer Responsibility in the European Union and the United States*, 30 Harv. Env't L. Rev. 51 (2006); Leila Monroe, *Tailoring Product Stewardship and Extended Producer Responsibility to Prevent Marine Plastic Pollution*, 27 Tul. Env't L.J. 219 (2014); Erin Eastwood et al., *Marine Plastic Pollution: How Global Extended Producer Responsibility Can Help*, 50 ELR 10976 (Dec. 2020). Scholars have also explored a companion concept called minimum recycled content requirements. *See*, *e.g.*, Chantal Carriere & Rachael B. Horne, *The Case for a Legislated Market in Minimum Recycled Content for Plastics*, 50 ELR 10042 (Jan. 2020); Catherine M. Myers, *Minimum Recycled Content Requirements for Virginia: One Solution to the Solid Waste Crisis*, 13 Va. Env't L.J. 271 (1994).
32. Danielle Spiegel-Feld & Katrina M. Wyman, *Cities as International Environmental Actors: The Case of Marine Plastics*, 62 Ariz. L. Rev. 487 (2020) (investigating the role of municipalities in creating an international agreement on marine plastic pollution); Ethan D. King, *State Preemption and Single Use Plastics: Is National Intervention Necessary?*, 20 Sustainable Dev. L. & Pol'y 31 (2019) (arguing the U.S. Congress should regulate SUPs in light of state preemption battles).
33. *See*, *e.g.*, Carriere & Horne, *supra* note 31 (focusing on recycling alone to achieve circularity); Amy Mull, *The United States' Lagging Role in Addressing the Global Plastics Crisis Can Be Saved by Subnational Actors*, 46 N.C. J. Int'l L. no. 4 online issue, art. 2, at 1 (2020) (noting the EU's commitment to the circular economy, but discussing U.S. regulation of solid waste); Eastwood et al., *supra* note 31 (referring to the EU's Circular Economy Plan, but examining EPR as a waste management tool); Yeeun Uhm, *Plastic Waste Trade in Southeast Asia After China's Import Ban: Implications of the New Basel Convention Amendment and Recommendations for the Future*, 57 Cal. W. L. Rev. 1, 8 (2020) (focusing on global waste trade to achieve circularity). *But see* Vu Hai Dang et al., *Vietnam's Regulations to Prevent Pollution From Plastic Waste: A Review Based on the Circular Economy Approach*, 33 J. Env't L. 137 (2021) (assessing the circular economy aspects of Vietnam's National Action Plan for Management of Marine Plastic Litter); Brydges, *supra* note 17 (evaluating Swedish fashion industry practices along the take-make-waste paradigm).

broad approach looks at plastics issues at the intersection of law, ecology, and economics.

Part I describes issues and impacts created by the linear focus of current plastics production, connecting issues to life-cycle stages as a way to identify regulatory leverage points. In Part II, the Article unpacks specific challenges embodied in the linear take-make-waste model. Part III then identifies possible regulatory interventions at multiple points of plastic's life cycle. Part III also examines recently introduced federal legislation, the Break Free From Plastic Pollution Act (Break Free Act), which appears to recognize the need for broad regulation of plastics, with provisions on multiple aspects of plastics waste.[34] Part IV concludes with thoughts for a future research agenda oriented toward a circular approach to our plastics problem.

I. Take-Make-Waste: Plastics' Linear Focus

Plastics are a diverse family of materials with specific chemical and physical properties,[35] with different types of plastics used for different purposes.[36] Plastics possess a variety of properties that increase their functionality and versatility. They are durable, easily shaped into different forms, impermeable to liquid, resistant to degradation, and can be produced at low cost.[37] These properties make plastic a workhorse material that is used in a wide variety of sectors, including textiles, consumer goods, construction, and transportation,[38] and for products as diverse as children's toys, Kevlar bulletproof body armor, and packaging.[39]

Unfortunately, both the process of making plastics and the characteristics of the end product create externalities that make plastics environmentally unsound. These externalities are directly attributable to plastics' linear take-make-waste production model. To understand the types and scope of plastics' impacts, we must unpack their life cycle.

A. *Take: Raw Materials and Feedstocks*

Plastics production is inextricably tied to fossil fuels, which provide its main feedstocks, and scholars argue that inexpensive fossil fuels account for the proliferation of cheap plastics products.[40] Ninety percent of plastics produced globally are derived from fossil fuels,[41] and 90% of plastics feedstocks are from virgin fossil fuels.[42] Plastics production accounts for about 6% of global oil and gas consumption.[43] The oil industry earns more than $400 billion per year from producing plastics.[44]

More significantly, petrochemicals are now seen as the largest driver of fossil fuel consumption, outpacing oil demand for fuel production.[45] Petrochemicals are the only oil demand where growth is expected to accelerate in the future,[46] with future oil profits coming increasingly from plastics production.[47] With plastics accounting for two-thirds of oil demand from the petrochemicals sector, plastics production plays a key role in our future use of fossil fuels.[48] Plastics and petrochemicals are estimated to represent half of all fossil fuel demand growth in 2050,[49] and production is expected to consume 20% of total oil by 2050.[50] The importance of plastics production to the oil industry is evident from oil industry investments: the industry plans to spend around $400 billion over the next five years on production plants for virgin plastics, including 176 plants slated for Asian locations.[51]

B. *Make: Raw Material Processing and Product Creation*

The creation of plastics entails both the design and production stages of the material. Packaging is the single largest

34. S. 984, 117th Cong. (2021), known as the Break Free From Plastic Pollution Act [hereinafter the Break Free Act].
35. OECD Plastics Management, *supra* note 6, at 2. Plastics are composed of individual molecules called monomers that are combined in chains to create polymers. Different types of monomers and polymers are combined to create plastic materials with different properties. IEA, *supra* note 5, at 19; Fernando J. Gómez & Simonetta Rima, *Setting the Facts Straight on Plastics*, WEF (Oct. 4, 2019), https://www.weforum.org/agenda/2019/10/plastics-what-are-they-explainer/. The chemical components of plastic and plastics themselves are also referred to as "resins." IEA, *supra* note 5, at 19. This Article will use the term "plastics" to refer to this family of materials.
36. Gómez & Rima, *supra* note 35. For an overview of different types of plastics and their packaging applications, see Ellen MacArthur Foundation et al., *supra* note 6, at 25, fig. 2.
37. Geyer et al., *supra* note 4, at 3; OECD Plastics Management, *supra* note 6, at 2.
38. OECD, Improving Resource Efficiency to Combat Marine Plastic Litter 5 (2019), http://www.oecd.org/g20/summits/osaka/OECD-G20-Paper-Resource-Efficiency-and-Marine-Plastics.pdf [hereinafter OECD Resource Efficiency].
39. IEA, *supra* note 5, at 16.
40. Anastasia M. Telesetsky, *Beyond Existing Legislated Efforts to Control Single-Use Plastics: A Proposal for Ending Fossil-Fuel Subsidies and Standardizing Single-Use Plastic Packaging*, 57 Cal. W. L. Rev. 43, 68-69 (2020).
41. OECD Resource Efficiency, *supra* note 38, at 14; Ellen MacArthur Foundation et al., *supra* note 6, at 27.
42. Ellen MacArthur Foundation et al., *supra* note 6, at 27.
43. *Id. See also* OECD Plastics Management, *supra* note 6, at 4 (estimating fossil fuel consumption by the plastic industry as between 4% and 8%). Most oil companies have petrochemical divisions. *See, e.g.*, ExxonMobil Chemical, *Products*, https://www.exxonmobilchemical.com/en/products (last visited Nov. 6, 2021); Chevron, *Chemicals and Additives*, https://www.chevron.com/operations/chemicals-additives (last visited Nov. 6, 2021); Shell Global, *Chemicals Products Portfolio*, https://www.shell.com/business-customers/chemicals/our-products.html (last visited Nov. 6, 2021).
44. Laura Sullivan, *How Big Oil Misled the Public Into Believing Plastic Would Be Recycled*, Nat'l Pub. Radio (Sept. 11, 2020), https://www.npr.org/2020/09/11/897692090/how-big-oil-misled-the-public-into-believing-plastic-would-be-recycled.
45. IEA, *supra* note 5, at 2; Duane Dickson et al., Deloitte, The Future of Petrochemicals: Growth Surrounded by Uncertainty 1 (2019), https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/the-future-of-petrochemicals.pdf.
46. Hook & Reed, *supra* note 10.
47. Sullivan, *supra* note 44.
48. *Id.*
49. IEA, *supra* note 5, at 2.
50. Ellen MacArthur Foundation et al., *supra* note 6, at 27.
51. Brock, *supra* note 11.

market for plastics,[52] and is almost exclusively designed as single use.[53] For example, Americans use about 100 billion plastic carry-out bags each year,[54] and more than 380 billion plastic bags, sacks, and wraps of all sorts.[55] Plastic bags are typically used for only minutes and then discarded, losing an estimated 95% of the value of their materials[56] and contributing to direct pollution of the environment.

In addition to direct plastics pollution, production of plastics is responsible for significant greenhouse gas emissions, as energy is used to transform petroleum or natural gas into monomers.[57] Incineration of waste plastics also results in direct release of carbon.[58] As plastic use grows, its greenhouse gas footprint will as well: at its current trajectory, plastics will account for 15% of the global annual carbon budget by 2050.[59]

C. Waste: Product After-Use

Plastic's positive attributes—its resistance to degradation and its durability—guarantee waste and create near-permanent contamination of the environment.[60] Dealing with unrecycled plastic waste creates a variety of negative environmental externalities, including direct pollution and emissions from after-use disposal.

Plastic packaging accounts for half of global plastic waste,[61] but globally only 14% of packaging waste is currently collected for recycling.[62] Recent studies indicate that 14% of plastic is disposed of by incineration,[63] which releases carbon directly into the atmosphere.[64] In addition, plastic polymers are often mixed with additives such as stabilizers, pigments, and flame retardants, which can emit toxic substances if incinerated without proper controls.[65]

Even more significant is the direct pollution impact of plastics. Plastic pollution is present in all the world's major ocean basins, with SUP items being the most common plastic in oceans.[66] Plastics reach oceans through multiple pathways, either directly from shipboard[67] or via streams and rivers, as a consequence of the mismanagement of solid waste that is washed into watercourses.[68] Leakage into oceans is on the rise[69]; on the current trajectory, it is estimated that by 2050, the oceans will contain more plastics by weight than they do fish.[70] Because of its small size and low value, plastics packaging is particularly prone to leak out of waste management systems.[71]

Leaked plastics have multiple negative impacts. Marine wildlife is harmed by ingesting plastics or becoming entangled in them, reducing the viability of fisheries.[72] Coastal tourism is negatively affected as waste washes onto beaches.[73] There is also concern over the impacts of chemical accumulation in the food chain, as fish ingest plastics and are then consumed by humans.[74] Plastics packaging waste poses issues on land, as well, where bags blown by the wind can be ingested by livestock and can contaminate crop harvests.[75]

52. OECD Plastics Management, *supra* note 6, at 3; American Chemistry Council, 2020 Resin Situation and Trends 2 (2021), https://www.americanchemistry.com/chemistry-in-america/data-industry-statistics/statistics-on-the-plastic-resins-industry/resources/2020-resin-situation-and-trends. Packaging accounts for 40% of global plastics production. Kristin Hughes, *3 Ways We Are Making an Impact on Plastic Pollution*, WEF (Sept. 25, 2019), https://europeansting.com/2019/09/25/3-ways-we-are-making-an-impact-on-plastic-pollution/.
53. Ellen MacArthur Foundation et al., *supra* note 6, at 26.
54. Center for Biological Diversity, *10 Facts About Single-Use Plastic Bags*, https://www.biologicaldiversity.org/programs/population_and_sustainability/sustainability/plastic_bag_facts.html (last visited Nov. 6, 2021).
55. Marcia Anderson, *Confronting Plastic Pollution One Bag at a Time*, EPA Blog (Nov. 1, 2016), https://blog.epa.gov/2016/11/01/confronting-plastic-pollution-one-bag-at-a-time/. Worldwide, as many as one trillion plastic bags are used each year. *Id*.
56. Ellen MacArthur Foundation et al., *supra* note 6, at 26; IEA, *supra* note 5, at 26. High rates of incineration and landfill disposal of plastics waste also contribute to the loss of value. David Feber et al., McKinsey & Co., The Drive Toward Sustainability in Packaging—Beyond the Quick Wins 3 (2020).
57. Ellen MacArthur Foundation et al., *supra* note 6, at 29.
58. *Id*.
59. *Id*.
60. Geyer et al., *supra* note 4, at 1. *See also* Amy L. Brooks et al., *The Chinese Import Ban and Its Impact on Global Plastic Waste Trade*, 4 Sci. Advances eaat0131 (2018), https://advances.sciencemag.org/content/4/6/eaat0131 (explaining the challenges of recycling different forms of plastic).
61. Gómez & Rima, *supra* note 35.
62. IEA, *supra* note 5, at 17; Ellen MacArthur Foundation et al., *supra* note 6, at 26.
63. Ellen MacArthur Foundation et al., *supra* note 6, at 26; OECD Plastics Management, *supra* note 6, at 4.
64. Ellen MacArthur Foundation et al., *supra* note 6, at 29.
65. *Id*. at 29-30.
66. Sarah Kakadellis & Zoe M. Harris, *Don't Scrap the Waste: The Need for Broader System Boundaries in Bioplastic Food Packaging Life-Cycle Assessment—A Critical Review*, 274 J. Cleaner Prod. art. 122831, at 2 (2020); Joan M. Bondareff et al., *Plastics in the Ocean: The Environmental Plague of Our Time*, 22 Roger Williams U. L. Rev. 360, 361 (2017). Plastics in the oceans and waterways can also take the form of microplastics, tiny fragments of plastics that enter the ocean either as primary microplastics (e.g., microbeads) or secondarily when large plastics break down. *Id*. at 364; Joanna Vince & Britta D. Hardesty, *Plastic Pollution Challenges in Marine and Coastal Environments: From Local to Global Governance*, 25 Restoration Ecology 123, 124 (2017).
67. OECD Resource Efficiency, *supra* note 38, at 9.
68. *Id*. (noting that microplastics, for example, can enter the oceans through municipal wastewater systems). One commentator has also argued that stricter regulation of land waste disposal practices can result in increased use of the ocean as a dumping place for waste. John W. Kindt, *Solid Wastes and Marine Pollution*, 34 Cath. U. L. Rev. 37, 55 (1984).
69. McKinsey Center for Business and Environment & Ocean Conservancy, Stemming the Tide: Land-Based Strategies for a Plastic-Free Ocean 6 (2015), https://www.mckinsey.com/business-functions/sustainability/our-insights/stemming-the-tide-land-based-strategies-for-a-plastic-free-ocean (projecting that plastic leakage into oceans could double by 2025).
70. Ellen MacArthur Foundation et al., *supra* note 6, at 17, 29.
71. *Id*. at 29. *See also* McKinsey Center for Business and Environment & Ocean Conservancy, *supra* note 69, at 7-8 (explaining that 80% of plastic is too low value to recycle and that low-value plastic is more likely to leak).
72. Wood, *supra* note 29, at 164.
73. *Id*. at 163; OECD Plastics Management, *supra* note 6, at 5.
74. Wood, *supra* note 29, at 165. Chemical additives to plastic, such as pigments and flame retardants, can bioaccumulate in animal tissue, further contaminating the food chain. *Id*. at 165-66; Ellen MacArthur Foundation et al., *supra* note 6, at 29.
75. Lara Korte, *Plastic Bags Are Killing Horses and Cows Across the State. What's Texas to Do?*, Tex. Trib. (Aug. 14, 2019), https://www.texastribune.org/2019/08/14/texas-wont-approve-bans-plastic-bags-which-can-be-fatal-livestock/; Morgan O'Hanlon, *With Cotton Harvest Underway, Farmers Fear Grocery Bags, Plastic Contamination*, Victoria Advoc. (Sept. 29, 2020), https://www.victoriaadvocate.com/news/local/with-cotton-harvest-underway-farmers-fear-grocery-bags-plastic-contamination/article_9f8c90b0-c438-11e9-9c61-03c92ae351a7.html.

Bioplastics[76] are often touted as an antidote to key issues with traditional plastics. However, bioplastics come with their own environmental, technical, and market issues, reducing their potential benefits. Production of bioplastics uses less energy and emits fewer greenhouse gases than production of traditional plastics.[77] But because bioplastics are plant-based, their production creates pollutants in the form of fertilizers, herbicides, and pesticides released into the environment.[78] One study of several biobased plastics found that several used genetically modified organisms for feedstock manufacture, while others used toxic chemicals in the production process or generated these as byproducts.[79]

II. The Limits of Take-Make-Waste

The linear take-make-waste paradigm has no built-in tendency to conserve resources or recycle; it treats the environment as a waste reservoir,[80] rather than as connected to production needs. Thus, the take-make-waste system, based on consumption, creates loss along the whole value chain.[81] Analysis of plastics' linear production process surfaces four categories of challenges, marking out key limits to the take-make-waste paradigm.

A. Design Challenges: Value Chain Impacts of Design Choices

The design stage of a product determines 80% of its environmental impact.[82] Thus, addressing our plastics dilemma begins with identification of major design issues. Plastics' overarching design flaw is that designers create them with no thought to the material's life cycle.[83] Manufacturers design products to maximize performance, not for end of life.[84] However, the characteristics that are designed into products influence the whole value chain,[85] meaning that we cannot ignore the value chain impacts of design decisions.

Key aspects of plastics design show how decisions in the upstream value chain ensure negative results downstream. Plastics' dependence on fossil fuels is a case in point: while the use of oil as a feedstock creates plastics' indestructibility, it also guarantees that plastics will not biodegrade, but will remain as waste once they are no longer in use. Similarly, designs requiring myriad formulations of plastics, multiple color additives, and various adhesives make it difficult to bring recycling to scale because different forms of plastics must be recycled separately. Multiple categories of plastics fragment recycling past the point of economic viability. Last, many plastics, especially those used for packaging, are specifically designed as single use.[86] When coupled with plastics' lack of degradability, the result is that most plastics cannot be recycled.[87]

Some argue that designing plastics to be nonbiodegradable and for single use is not a flaw, seeing waste as a value stream.[88] This view predisposes the production system away from designing for source reduction and toward the creation of waste. But the traditional reuse and recycling of plastics forces the material into more lives than it was intended for, with resulting lost value. Thus, viewing waste as a valuable input only works if the material is *designed* for reuse.

In their seminal work on product design, William McDonough and Michael Braungart set out a paradigm to maximize materials' potential value and move to circularity.[89] McDonough and Braungart pioneered the concept of designing materials for reuse in either biological or technical systems,[90] a design model known as cradle-to-cradle.[91] Only by reconceptualizing and redesigning waste

76. "Bioplastics" is a term used to identify two forms of plastics (i.e., plastics whose raw materials are biological materials and plastics that biodegrade). Maja Rujnic-Sokele & Ana Pilipovic, *Challenges and Opportunities of Biodegradable Plastics: A Mini Review*, 35 Waste Mgmt. & Rsch. 132, 133 (2017). Plastics made from organic materials are called "biobased" plastics and are made from sugars derived from plants or by organisms acting on organic materials. Policies for Bioplastics in the Context of a Bioeconomy 14 (OECD, Science, Technology, and Industry Policy Paper No. 10, 2013) [hereinafter OECD Bioplastics]. Not all biobased plastics biodegrade and not all biodegradable plastics are biobased. Rujnic-Sokele & Pilipovic, *supra* at 133.
77. OECD Bioplastics, *supra* note 76, at 24; Fausto Gironi & Vincenzo Piemonte, *Bioplastics and Petroleum-Based Plastics: Strengths and Weaknesses*, 33 Energy Sources Part A 1949, 1952-53 (2011).
78. Gironi & Piemonte, *supra* note 77, at 1958.
79. Clara Rosalía Álvarez-Chávez et al., *Sustainability of Bio-Based Plastics: General Comparative Analysis and Recommendations for Improvement*, 23 J. Cleaner Prod. 47 (2012).
80. Urbinati et al., *supra* note 17, at 488.
81. Ellen MacArthur Foundation, *supra* note 18, at 14.
82. Emma Watkins et al., Policy Approaches to Incentivise Sustainable Plastic Design 26 (OECD, Environment Working Paper No. 149, 2019) [hereinafter OECD Policy Approaches].
83. Tabitha Whiting, *Why Plastic Is a Design Failure*, Modus (June 1, 2019), https://modus.medium.com/why-plastic-is-a-design-failure-b8f04faa662e. A design flaw is defined as a product-related product property that impairs product quality or does not meet customer expectations. Bruno Gries & Lucienne Blessing, Design Flaws: Flaws by Design?, Presentation at International Design Conference—Design 2006 (May 15-18, 2006), *in* Human Behaviour in Design Workshop, at 1452, https://www.designsociety.org/publication/19158/DESIGN+FLAWS%3A+FLAWS+BY+DESIGN%3F.
84. OECD Resource Efficiency, *supra* note 38, at 12.
85. De los Rios & Charnley, *supra* note 19, at 109.
86. Ellen MacArthur Foundation et al., *supra* note 6, at 26 (noting that plastic packaging is almost exclusively single use, especially business-to-consumer packaging); OECD Resource Efficiency, *supra* note 38, at 6 (explaining that the majority of plastic waste is from short-lived applications).
87. Whiting, *supra* note 83 (pointing out that of the 300 million tons of plastic produced per year, 91% cannot be recycled); OECD Policy Approaches, *supra* note 82, at 14 (noting that some plastic is designed in such a way that it is inevitably unrecyclable).
88. *See*, *e.g.*, Hook & Reed, *supra* note 10, at 15 (describing scrap as a "valuable input").
89. William McDonough & Michael Braungart, Cradle to Cradle: Remaking the Way We Make Things (2002) [hereinafter Cradle to Cradle]. *See also* William McDonough & Michael Braungart, *The NEXT Industrial Revolution*, Atlantic (Oct. 1998), https://www.theatlantic.com/magazine/archive/1998/10/the-next-industrial-revolution/304695/ [hereinafter *NEXT Industrial Revolution*].
90. Biological materials should be designed to be biodegradable and to be consumed by microorganisms in the soil. These materials provide nutrients for the organic cycle. Technical materials should be designed to feed back into the technical cycle, providing materials in closed-loop industrial cycles in ways that retain their value and avoid downcycling. *NEXT Industrial Revolution*, *supra* note 89.
91. Cradle to Cradle, *supra* note 89. For example, compostable packaging is a biological nutrient because its byproduct—compost—feeds the soil where it is used. Ellen MacArthur Foundation et al., *supra* note 6, at 69-70.

as nutrients will we begin to move plastics production toward circularity.

B. Waste Management Challenges: Technical Limits, Environmental Impacts

Roland Geyer's pivotal study of all plastics ever produced revealed plastics' troubling end of life, calculating that between 1950 and 2015, 12% of plastics waste had been incinerated, 60% discarded, and only 9% recycled.[92] U.S. plastics waste recycling rates are somewhat lower than the global rate of 14%, hovering at 9% since 2012.[93] Plastics that are recycled are generally downcycled, transformed into lower value applications that are not again recyclable after use.[94]

The challenge of managing waste—where waste is moved from the point of use to recycled material—has several key complications. Most waste in the United States is household waste in the form of single-use packaging.[95] Waste generation is dispersed across millions of households, and recycling requires that raw plastics waste be collected and bulked at the municipal level, before being transported to processing facilities.[96] At processing facilities, the diverse types of plastics and technical limits of recycling can prevent recyclers from producing the pure, uncontaminated waste stream required by buyers in the secondary market. Examination of the major forms of recycling illuminates these issues.

1. Mechanical Recycling

Mechanical recycling is the traditional picture of recycling, where waste is sorted, crushed or shredded, pelletized, and then melted and remade into new products.[97] Mechanical recycling aims to preserve the chemical structure of the polymers,[98] with new products composed of the same type of plastics as the old products. Mechanical recycling has environmental benefits in that it is less energy-intensive than other recycling methods,[99] and has lower negative impacts on climate overall.[100]

Unfortunately, technical and economic issues undercut these environmental benefits. The mechanical recycling process relies on pure waste streams that include only clean plastics of the same type. Waste streams of mixed plastics or plastics with high levels of additives or contaminants hamper recycling.[101] The recycling process itself also degrades the quality of the resulting plastic[102] and the life-span of the polymers; plastics can be mechanically recycled only a limited number of times and always to lower-quality products in a process called downcycling.[103] In addition, mechanical recycling processes have limited ability to produce uncontaminated material streams.[104] Contaminated waste streams put pressure on downstream market actors who bear the costs of further treatment or disposal of the waste.[105]

The end of life of bioplastics is also more complicated than many imagine. Rather than being able to simply throw bioplastics into the environment and have them biodegrade, recycling of bioplastics requires careful management.[106] Different bioplastics require different conditions for them to biodegrade, and many bioplastics do not biodegrade completely.[107] Composting is the most common method of recycling bioplastics, but bioplastics require high-temperature industrial composting to break down the plastics.[108] Because the recycling process is different for bioplastics and traditional plastics, bioplastics must be treated as a separate recycling stream from traditional plastics.[109] This further increases the cost of the overall recycling process for all plastics materials.

92. Geyer et al., *supra* note 4, at 2-3.
93. *Id*. at 3. Recycling rates appear to have increased in the 1990s, but declined afterward because of variations in curbside recycling programs. Everling, *supra* note 30, at 156.
94. Ellen MacArthur Foundation et al., *supra* note 6, at 26; Carriere & Horne, *supra* note 31, at 10047 (referring to this phenomenon as cascaded recycling).
95. OECD, Improving Markets for Recycled Plastics: Trends, Prospects, and Policy Responses 57 (2018) [hereinafter OECD Recycled Plastics]; Tanja Narancic et al., *Biodegradable Plastic Blends Create New Possibilities for End-of-Life Management of Plastics but They Are Not a Panacea for Plastic Pollution*, 52 Env't Sci. & Tech. 10441 (2018).
96. OECD Recycled Plastics, *supra* note 95, at 57-60. Plastics processing facilities are usually called "materials recovery facilities," or MRFs. David Hosanky, *Materials Recovery Facility*, Britannica, https://www.britannica.com/technology/materials-recovery-facility (last visited Dec. 9, 2021).
97. Andrew N. Rollinson & Jumoke Oladejo, Chemical Recycling: Status, Sustainability, and Environmental Impacts 13 (2020). For a detailed description of the steps in the mechanical recycling process, see Kim Ragaert et al., *Mechanical and Chemical Recycling of Solid Plastic Waste*, 69 Waste Mgmt. 24, 29-32 (2017).
98. Rollinson & Oladejo, *supra* note 97, at 13.
99. *Id*.
100. Raoul Meys et al., *Towards a Circular Economy for Plastic Packaging Wastes—The Environmental Potential of Chemical Recycling*, 162 Res. Conservation & Recycling art. 105010, at 8 (2020).
101. Alexander H. Tullo, *Plastic Has a Problem: Is Chemical Recycling the Solution?*, Chem. & Eng'g News (Oct. 6, 2019), https://cen.acs.org/environment/recycling/Plastic-problem-chemical-recycling-solution/97/i39; Ragaert et al., *supra* note 97, at 34. Contaminated recycling is material included in recycling collection that is not accepted in their program and material that has unacceptable amounts of residue on it. Scott Mouw, Recycling Partnership, 2020 State of Curbside Recycling Report 21 (2020), https://recyclingpartnership.org/wp-content/uploads/dlm_uploads/2020/02/2020-State-of-Curbside-Recycling.pdf.
102. Ragaert et al., *supra* note 97, at 32-33 (describing recycling-related degradation of plastics).
103. Rollinson & Oladejo, *supra* note 97, at 13. Transfer of contaminants from the original plastic to the recycled plastic during the recycling process also reduces the quality of the resulting plastic. *Id*.
104. OECD Recycled Plastics, *supra* note 95, at 64. Primary recyclers may try to speed up the sorting process by using capital-intensive sorting equipment that is often less accurate than hand sorting. *Id*.
105. *Id*. at 62.
106. Gironi & Piemonte, *supra* note 77, at 1951 (explaining that conditions must be strictly controlled to make bioplastics composting effective).
107. OECD Bioplastics, *supra* note 76, at 13-14, 27 (noting that the biodegradability of different bioplastics cannot be presumed and that partial degradation can result in microplastics pollution). Plastics that are biodegradable can be broken down by microorganisms. OECD Recycled Plastics, *supra* note 95, at 35.
108. Renee Cho, *The Truth About Bioplastics*, Colum. Climate Sch. (Dec. 13, 2017), https://news.climate.columbia.edu/2017/12/13/the-truth-about-bioplastics.
109. OECD Bioplastics, *supra* note 76, at 22.

2. Chemical Recycling

A newer form of recycling, chemical recycling, is increasingly promoted as answering the shortcomings of mechanical recycling. Chemical recycling is a set of technologies that subject plastics waste to heat, pressure, or chemical treatment to break down the plastics polymers to create new molecules.[110] The end product of the process is then used to make new plastics, not just new products.[111] Because chemical recycling results in new plastics, it avoids the performance losses of mechanical recycling and avoids the use of virgin feedstock.[112]

Andrew Rollinson's meta-analysis of research on chemical recycling identifies the technical limits and environmental and health impacts of this recycling method. Chemical recycling is noted for its high energy use,[113] making it less climate-friendly than mechanical recycling, and the end product is often low quality.[114] Further, chemical recycling cannot be used with mixed plastics waste streams or at scale.[115] Rollinson notes that environmental impacts include emissions in the form of smoke and other toxins,[116] as well as contaminants that remain in the resulting new plastics and leach into them.[117] The Rollinson meta-analysis and Organisation for Economic Co-operation and Development (OECD) study on recycled plastics conclude that most chemical recycling technologies are still at the research stage, with no demonstration of their commercial viability.[118]

C. Regulatory Challenges: Drawbacks of the U.S. Plastics Regulatory Scheme

An early commentator on solid waste law noted that U.S. regulatory efforts had been largely directed at controlling specific pollutants and activities, resulting in a disjointed process of waste management with multiple statutes that affect solid waste, even though focused on other areas.[119] Some legislative attempts have been made to detangle federal solid waste regulation, but the practice of delegating waste management to states has resulted in ineffectual regulation of plastics.

1. Federal Regulation of Plastics Waste

The United States first specifically addressed issues around solid waste disposal in the Solid Waste Disposal Act (SWDA).[120] The SWDA empowered the Secretary of Health, Education, and Welfare to conduct and encourage research activities to solve solid waste disposal problems.[121] However, the focus of the SWDA was on hazardous waste, leaving regulation of nonhazardous solid waste primarily to state and local governments, with the federal government taking an advisory role.[122]

By 1976, solid waste management had become a subject of national concern, and the SWDA was amended by the Resource Conservation and Recovery Act (RCRA), now the principal federal law governing the disposal of solid waste and hazardous waste.[123] RCRA was intended as a comprehensive scheme,[124] and, on its face, RCRA appears to regulate disposal, storage, and treatment of both nonhazardous and hazardous solid waste.[125] However, the statute exempts household waste from coverage, with the result that much municipal solid waste is not regulated by RCRA.[126] This continued the pattern of the federal government leaving regulation of solid waste in the hands of states and municipalities.[127]

2. State and Municipal Regulation of Plastics Waste

Legislative activity at the state level addressing plastics waste has been relatively concentrated, with about half of all states accounting for most of the work on the issue. Data from the National Conference of State Legislatures (NCSL) shows minimal action to regulate plastics waste until 2018.[128] The increase in state activity after China's

110. Rollinson & Oladejo, *supra* note 97, at 4, 13; Neena George & Thomas Kurian, *Recent Developments in the Chemical Recycling of Postconsumer Poly(ethylene terephthalate)*, 53 Indus. Eng'g Chemistry Rsch. 14185, 14186-94 (2014) (discussing processes for chemical recycling of polyethylene terephthalate (PET) bottles).
111. Rollinson & Oladejo, *supra* note 97, at 4.
112. Meys et al., *supra* note 100, at 2; George & Kurian, *supra* note 110, at 14195.
113. Rollinson & Oladejo, *supra* note 97, at 28. Chemical recycling uses energy to create the external heat or pressure used to break down the plastic waste, and uses additional energy in the process that makes new plastics from the recycled feedstock. Andrew N. Rollinson, GAIA, Chemical Recycling: Distraction, Not Solution 5 (2020). *But see* George & Kurian, *supra* note 110, at 14195 (meta-analysis of studies of chemical recycling of PET finding energy savings in some forms).
114. Rollinson & Oladejo, *supra* note 97, at 17-20.
115. *Id.* at 17; OECD Recycled Plastics, *supra* note 95, at 68 (explaining that chemical recycling technologies require consistent feedstocks, which are not always available).
116. Rollinson & Oladejo, *supra* note 97, at 24.
117. *Id.* at 25-28.
118. *Id.* at 18, 20 (noting that researchers doubt the viability of chemical recycling as a response to plastic waste issues inside the next decade); OECD Recycled Plastics, *supra* note 95, at 69 (concluding that chemical recycling technologies have not entered the mainstream and are considered "fairly marginal"). The Raoul Meys study determined that current chemical recycling technology produces environmental benefits over mechanical recycling in only specific limited scenarios. Meys et al., *supra* note 100, at 9-10.
119. Kindt, *supra* note 68, at 53-54. John Kindt notes as examples of this phenomenon the Clean Air Act Amendments of 1977, the Rivers and Harbors Appropriations Act of 1899, and the Safe Drinking Water Act of 1974.
120. 42 U.S.C. §§6901-6992; Everling, *supra* note 30, at 152.
121. Kindt, *supra* note 68, at 60.
122. *Id.*
123. 42 U.S.C. §§6901-6992k, ELR Stat. RCRA §§1001-11011.; Xia, *supra* note 26, at 1122 (describing RCRA as the primary legislation regulating hazardous waste).
124. Kindt, *supra* note 68, at 61; Steven G. Davison, *EPA's Definition of "Solid Waste" Under Subtitle C of the Resource Conservation and Recovery Act: Is EPA Adequately Protecting Human Health and the Environment While Promoting Recycling?*, 30 J. Land Res. & Env't L. 1, 8-9 (2010) (describing RCRA as a "multi-faced approach toward problems associated with 3-4 billion tons of discarded materials generated each year").
125. Davison, *supra* note 124, at 8-9.
126. Sachs, *supra* note 31, at 58; Everling, *supra* note 30, at 159-60 (noting that there is only minimal federal regulation of nonhazardous solid waste).
127. Everling, *supra* note 30, at 159-60.
128. For example, in 2015, 22 states entertained 56 bills to regulate plastics; only two bills were enacted. NCSL, *Environment and Natural Resources State Bill*

import bans is marked, with more than five times the number of bills on all plastics waste considered in 2019 over 2015, and two-and-a-half times more activity on single-use plastic bags (SUPBs).[129] Despite the increase in legislative activity, few bills regulating plastics waste were enacted into law. For example, only eight states currently have bans on SUPBs.[130] Enforcement is through civil actions and resulting fines, which are often minimal.[131]

Lack of significant action at the state level prompted some municipalities to enact citywide bans on some plastics, most commonly SUPBs.[132] However, increased local-level action sparked preemption battles between cities and states.[133] Some states rely on existing state legislation to invalidate local plastics bans, but others go a step further and pass laws creating bans on local plastic bag bans.[134] For example, 17 states currently have preemption statutes in place, restricting regulation of plastic bags to the state level.[135] To counter the preemption bills, several state legislatures created anti-preemption laws giving local governments the authority to pass or reinstate bans or fees on plastic bags.[136]

Preemption battles demonstrate the politicization of regulating plastics. The plastics industry has lobbied aggressively against any regulation of the bags, and exerts considerable power at the state level.[137] In the face of industry lobbying at higher levels of government, environmental groups' tactics focus on local government, where they are better able to influence law making.[138] The preemption statutes thus undercut the ability of nonprofit organizations to gain the local victories that can eventually turn into statewide legislation.[139]

The federal strategy of delegating waste management to the state level has resulted in fragmented and anemic regulation. State-level efforts to regulate plastics waste have largely stalled. Only a few states have placed any serious restrictions on plastics use to date. The power of chemical and plastics industry lobbying, coupled with the rise of state preemption of the local regulation of plastics, undercut future regulatory efforts. This standstill highlights the regulatory challenges of managing plastics in the United States.

D. Market Challenges: The Uncomfortable Economics of Recycling

Both mechanical and chemical recycling face serious market flaws, resulting in a market with limited resilience. First, cost structures at all stages of plastics' post-consumer life disincentivize recycling. Low waste disposal costs mean that much household waste simply is not separated out for recycling.[140] Geographic dispersion of waste makes it expensive for recyclers to aggregate waste streams.[141] Operating costs are high, especially costs associated with the multistage sorting processes necessary to achieve pure waste streams.[142] Recycling of plastics also suffers from

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Tracking Database, https://www.ncsl.org/research/environment-and-natural-resources/environment-and-natural-resources-state-bill-tracking-database.aspx (last updated Nov. 17, 2021). In 2018, 34 states considered 127 bills and enacted seven. *Id*. The major forms of plastics waste addressed by legislation are single-use items, including plastic bags, straws, and stirrers.

129. *Id*.

130. The states with bans are California (Cal. Pub. Res. Code §§42280-42287 (2016)), Connecticut (An Act Concerning the State Budget for the Biennium Ending June Thirtieth, 2021, and Making Appropriations Therefore, and Implementing Provisions of the Budget, H.B. 7424, Pub. Act No. 19-117 (2019)), Delaware (Del. Code Ann. tit. 7, §6099A (2019)), Maine (Me. Rev. Stat. Ann. tit. 38, §1611 (2019)), New York (N.Y. C.P.L.R. §§27-2801 to 27-2809 (2019)), Oregon (Or. Rev. Stat. §§459A.755-.759 (2019)), and Vermont (Vt. Stat. Ann. tit. 10, §§6691-6700 (2019)). Hawaii does not have a state law regarding SUPBs. However, most of Hawaii's counties have passed ordinances imposing restrictions, resulting in an essentially statewide ban of SUPBs. NCSL, *State Plastic Bag Legislation*, https://www.ncsl.org/research/environment-and-natural-resources/plastic-bag-legislation.aspx (last visited Dec. 2, 2021).

131. For example, violation of Vermont's law gives rise to a warning for a first offense, a $25 fine for a second offense, and a $100 fine for a third offense. Vt. Stat. Ann. tit. 10, §6697 (2019). Oregon fines are a maximum of $250. H.B. 2509, 81st Leg. Assemb., Reg. Sess. §4 (Or. 2019). Delaware's statute is more aggressive, with fines starting at $500 for a first offense and increasing to $2,000 per day for a third offense. Del. Code Ann. tit. 7, §6099A(h) (2018). Enforcement power is generally held by the state's department of environmental protection. *See, e.g.*, *id*. §6099A(h)(1) (granting power to determine fines for violations of the ban to the Department of Natural Resources and Environmental Control).

132. In 2018, *Forbes* published a list of more than 350 U.S. cities with plastic bag bans. Trevor Nace, *Here's a List of Every City in the U.S. to Ban Plastic Bags, Will Your City Be Next?*, Forbes (Sept. 20, 2018), https://www.forbes.com/sites/trevornace/2018/09/20/heres-a-list-of-every-city-in-the-us-to-ban-plastic-bags-will-your-city-be-next/?sh=782d2d873243.

133. One notable battle occurred when Laredo, Texas, passed an ordinance banning SUPBs within the city limits. Anti-bag ban interest groups challenged the local ban as preempted by Texas state law on solid waste and convinced the Texas Supreme Court to invalidate the law as beyond the municipality's authority to regulate. Julia Wallace, *Texas Supreme Court Rules That Laredo's Plastic Bag Ban Is Unlawful*, Laredo Morning Times (June 22, 2018), https://www.lmtonline.com/news/article/LMT-Bag-ban-ruling-13022859.php; Emma Platoff, *Texas Supreme Court Strikes Down Laredo's Plastic Bag Ban, Likely Ending Others*, Texas Trib. (June 22, 2018), https://www.texastribune.org/2018/06/22/texas-supreme-court-rules-bag-bans/.

134. Sarah Gibbens, *See the Complicated Landscape of Plastic Bans in the U.S.*, Nat'l Geographic (Aug. 15, 2019), https://www.nationalgeographic.com/environment/2019/08/map-shows-the-complicated-landscape-of-plastic-bans/.

135. NCSL, *State Plastic Bag Legislation*, *supra* note 130. The states are Arizona, Colorado, Florida, Idaho, Indiana, Iowa, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, Tennessee, Texas, and Wisconsin.

136. Angela Howe, *What's the Score on Plastic Pollution Laws and Preemption of Local Ordinances?*, Surfrider Found. (May 28, 2019), https://www.surfrider.org/coastal-blog/entry/whats-the-score-on-plastic-pollution-laws-and-preemption-of-local-ordinance.

137. Samantha Maldonado et al., *Plastic Bags Have Lobbyists. They're Winning.*, Politico (Jan. 20, 2020), https://www.politico.com/news/2020/01/20/plastic-bags-have-lobbyists-winning-100587.

138. *Id*.

139. This snowballing is what happened in California, where multiple cities and municipalities passed local plastic bag regulation, setting the foundation for the statewide ban. Ryan Mahoney & Scott Seaward, *Proposition 67: Ban on Single-Use Plastic Bags*, 2016 Cal. Initiative Rev. art. 18, at 3-7 (2016), https://scholarlycommons.pacific.edu/california-initiative-review/vol2016/iss1/18/ (explaining how local ordinances in California cities acted as the catalyst and framework for a statewide law).

140. OECD Resource Efficiency, *supra* note 38, at 15; Mouw, *supra* note 101, at 54 (noting that cheap landfill disposal is detrimental to recycling initiatives).

141. OECD Resource Efficiency, *supra* note 38, at 14.

142. Ragaert et al., *supra* note 97, at 29-32 (outlining the mechanical recycling sorting process and noting that manual sorting is expensive); Rollinson & Oladejo, *supra* note 97, at 20 (noting the high operating costs of chemical recycling); Sullivan, *supra* note 44 (explaining that the multiplicity of types of plastics raises costs associated with sorting).

high raw material costs,[143] and the need for significant capital investment.[144]

A second market issue is that recycling requires significant scale to overcome high operating cost barriers, scale that to date has not been achieved.[145] Disconnected collection structures and practices that vary from state to state, and sometimes city to city, make it difficult to move collection and sorting to scale. Low landfill tipping fees disincentivize building recycling infrastructure, while the low price of oil makes it cheaper to produce virgin plastics than to work from recycled feedstocks.[146]

Last, the case for recycling depends on there being effective markets for recycled content.[147] Recyclable material only has value when a processor sells it into a secondary market.[148] However, existing secondary markets have been characterized as "dysfunctional" and not competitive,[149] with the high price and low quality of much recycled plastics limiting its market applications.[150] Recyclers are generally only interested in specific high-value plastics[151] resulting in limited markets for other recycled plastics streams.[152]

These limited markets lead to price fluctuations that make constructing a profitable business model challenging.[153] Further, there is no differentiated market for recycled plastics. Recycled plastics are considered imperfect substitutes for virgin plastics, resulting in a single market for all plastics materials where recycled plastics compete with virgin plastics.[154] Low oil prices and high recycling costs mean that virgin material generally outcompetes recycled material.[155]

Market factors also undercut the viability of bioplastics as the answer to our plastics problem. Bioplastics suffer from the same secondary market problem as do traditional plastics: composting bioplastics only makes economic sense if there is a market for the resulting compost. Despite projected growth over the next five years,[156] bioplastics constitute less than 1% of total plastics production.[157] The OECD has noted that nonbiodegradable plastics make up more than 75% of bioplastics production and that biodegradable bioplastics are not expected to increase their share of the market.[158]

In the United States, cost issues associated with recycling, combined with the fragmented U.S. solid waste regulatory scheme and higher labor and environmental compliance costs, undermined the economic viability of recycling.[159] Thus, the U.S. domestic recycling industry languished, leaving the country without adequate infrastructure to address its own recycling needs.[160] Recyclers looked to foreign markets to outsource post-collection recycling processes, allowing the United States to avoid the implications of increased plastics use. Shifting the burden of plastics end-of-life issues onto foreign recyclers created a global plastics waste supply chain.

E. The Global Plastics Waste Supply Chain

China has played an outsized role in global plastics waste and recycling. For example, since 1992, 45% of global plastics waste has been exported to China.[161] But a series of policy changes instituted in China between 2013 and 2017 are disrupting markets for recyclable plastics and upending the $200 billion global plastics recycling industry.[162]

China's programs of economic development answered the market challenges presented by plastics recycling in developed countries and drove its rise as a global recycling powerhouse. The country's industrial and manufacturing

143. George & Kurian, *supra* note 110, at 14186 (noting that chemical recycling of PET is more expensive than virgin PET due to cost and scale issues); Sullivan, *supra* note 44 (observing that virgin plastic is cheaper to make due to materials costs for recycling).
144. OECD Recycled Plastics, *supra* note 95, at 94 (outlining the high capital cost structure of recycling). Cost issues persist even in the face of technological advancements in sorting and processing equipment. Sullivan, *supra* note 44.
145. Ragaert et al., *supra* note 97, at 43 (explaining that chemical recycling is only economically viable in large volumes and that large-scale recycling has not been attempted); OECD Recycled Plastics, *supra* note 95, at 88 (noting that economies of scale are important for plastics recycling).
146. Tullo, *supra* note 101; Rollinson, *supra* note 113, at 6 (arguing that chemical recycling's high costs make it uncompetitive with virgin plastics); John Hocevar, Greenpeace, Circular Claims Fall Flat: Comprehensive U.S. Survey of Plastics Recyclability 7 (2020) (noting that manufacturers prefer to buy virgin plastic because of its lower cost compared to recycled material).
147. Ragaert et al., *supra* note 97, at 28.
148. Mouw, *supra* note 101, at 6.
149. OECD Resource Efficiency, *supra* note 38, at 7, 13.
150. Narancic et al., *supra* note 95, at 10442.
151. Tullo, *supra* note 101 (explaining that recycling facilities are primarily interested in plastics numbers 1 and 2 for recycling and that most other plastics go to landfills); Maricica Stoica et al., *The Financial Impact of Replacing Plastic Packaging by Biodegradable Biopolymers—A Smart Solution for the Food Industry*, 277 J. Cleaner Prod. art. 124013, at 2 (2020); Hocevar, *supra* note 146, at 7-8 (revealing that the United States has viable markets only for numbers 1 and 2 plastics). A Recycling Partnership study estimated material prices for number 1 plastic PET bottles at $188.60 per ton and number 2 plastic high-density polyethylene (HDPE) bottles at $1,008.00 per ton. By contrast, numbers 3-7 plastic packaging was valued at $5.00 per ton. Mouw, *supra* note 101, at 6.
152. Ragaert et al., *supra* note 97, at 28; Kakadellis & Harris, *supra* note 66, at 4.
153. Ragaert et al., *supra* note 97, at 28; Sullivan, *supra* note 44 (arguing that recyclers' capital investment depends on customer commitment for recycled materials, which are often lacking).
154. OECD Recycled Plastics, *supra* note 95, at 86.
155. *Id.* at 84; Stoica et al., *supra* note 151, at 12 (arguing that recycling of conventional plastics is often not economical); Hocevar, *supra* note 146, at 7.
156. European Bioplastics, Bioplastics Market Data 2019, at 2 (2020) (projecting that global bioplastics production capacity will increase from 2.1 million tons in 2019 to 2.43 million tons in 2024). As of 2018, there were 21 types of bioplastic in the marketplace or under development. OECD Recycled Plastics, *supra* note 95, at 33.
157. Axel Barrett, *Bioplastic Production Growth Pale Compare to Fossil Plastic Production Growth*, Bioplastics News (Dec. 6, 2019), https://bioplasticsnews.com/2019/12/06/bioplastic-production-growth-fossil-plastic-production-growth/ (noting that more than 300 million tons of virgin plastics are produced every year, with 2.1 million tons of bioplastics produced in 2019).
158. OECD Recycled Plastics, *supra* note 95, at 36.
159. Laura Parker, *China's Ban on Trash Imports Shifts Waste Crisis to Southeast Asia*, Nat'l Geographic (Nov. 16, 2018), https://www.nationalgeographic.com/environment/2018/11/china-ban-plastic-trash-imports-shifts-waste-crisis-southeast-asia-malaysia/.
160. Parts, *supra* note 26, at 294 (arguing that the United States has insufficient recycling infrastructure); Christopher Joyce, *U.S. Recycling Industry Is Struggling to Figure Out a Future Without China*, Nat'l Pub. Radio (Aug. 20, 2019), https://www.npr.org/2019/08/20/750864036/u-s-recycling-industry-is-struggling-to-figure-out-a-future-without-china (explaining the connection between outsourcing of recycling and lack of domestic industry).
161. Dickson et al., *supra* note 45, at 8.
162. Parker, *supra* note 159.

growth in the 1990s and 2000s created demand for raw materials,[163] which coincided with the growth of interest in recycling in developed countries. In addition to being a market for the outputs of recycling, China's lower operational and regulatory cost structure made it an attractive alternative for the pollution- and labor-intensive recycling of plastics.[164] The United States also saw the opportunity to use its trade imbalance with China to its advantage: cargo ships that brought goods to the United States were happy to return to China with loads of recyclable material, rather than return empty, and shipping companies offered discounted pricing to transport recyclables.[165]

These factors combined to incentivize developed countries like the United States to outsource their recycling to China, rather than build domestic recycling capability. By 2016, half of all plastics scrap for recycling was traded internationally[166] with China importing more than half of that plastics waste,[167] most of it from the United States and European countries. The globalized recycling pattern persisted until changes in China's policies created the present upheaval in global plastics recycling.

During the early 2010s, China's government became increasingly concerned about the environmental impacts of its position as primary global waste importer and questioned the merits of trading for recyclables. While the mountains of accumulating waste at one time represented the economic opportunity of raw materials, they now loomed large as environmental contaminants.[168] Beginning in 2013, China instituted several key programs focused on restricting imports of contaminated recyclables,[169] including lodging technical barriers to trade (TBT) notifications with the World Trade Organization (WTO).[170]

Scholars disagree as to whether China's TBT restrictions would withstand challenge before the WTO Dispute Settlement Body,[171] but the practical implications of the TBT restrictions are clear. With U.S. plastics recyclables unable to meet the new Chinese standards,[172] the TBT notifications present significant issues for American recycling collectors who would have to upgrade equipment and hire additional workers to meet the more stringent standards.[173] Unable to do so, the Chinese policies amount to a ban on imports of waste.

The new restrictions completely change the face of global plastics recycling: China bought 60% of plastics waste exported by the Group of Seven (G-7) countries in the first half of 2017, but less than 10% of that waste in the first half of 2018.[174] Having lost China as a market for its recyclables, developed countries began shipping recyclables to new markets, creating a cascade of waste through key Southeast Asian countries. Malaysia, Thailand, and Vietnam were particularly hard hit with recyclables redirected from China.[175] Diverting waste to these countries was, at best, a stopgap approach, since none of them had the capacity to absorb the sheer amount of waste normally destined for China,[176] and they had no desire to become the "landfill of the world."[177] Restrictions on imports of plastics waste soon followed.[178]

The loss of first China and then alternative markets for waste de-globalized waste and highlighted the uncomfortable economics of household recycling. Import restrictions created a glut in global plastics recyclables markets and reduced prices for those materials.[179] With prices collaps-

163. Xia, *supra* note 26, at 1110; Hook & Reed, *supra* note 10.
164. Parts, *supra* note 26, at 294.
165. Xia, *supra* note 26, at 1110-11 (highlighting the trade imbalance as facilitating waste shipments to China); Erica E. Phillips, *U.S. Recycling Companies Face Upheaval From China Scrap Ban*, Wall St. J. (Aug. 2, 2018), https://www.wsj.com/articles/u-s-recycling-companies-face-upheaval-from-china-scrap-ban-1533231057 (noting discounted prices offered by ocean carriers to recycling collectors).
166. Parker, *supra* note 159.
167. Parts, *supra* note 26, at 303 (noting that China imported 57% of global plastic waste imports in 2014).
168. *Id.* at 298 (noting China's concerns about waste contamination); Xia, *supra* note 26, at 1133-37 (explaining the environmental impact of China's economic growth and anti-pollution protests).
169. The programs included Green Fence in 2015, National Sword in 2017, and Blue Sky in 2018. All focused on reducing the amount of contaminated recyclable material imported into China. *See*, *e.g.*, Will Flower, *What Operation Green Fence Has Meant for Recycling*, Waste360 (Feb. 11, 2016), https://www.waste360.com/business/what-operation-green-fence-has-meant-recycling; Press Release, State Council, People's Republic of China, Action Plan to Phase Out Waste Imports (July 27, 2017), http://english.www.gov.cn/policies/latest_releases/2017/07/27/content_281475756814340.htm; Dan Sandoval & Brian Taylor, *China Continues Scrap Scrutiny in 2018*, Recycling Today (Mar. 9, 2018), https://www.recyclingtoday.com/article/china-scrap-imports-blue-skies-2018/ (discussing focus of Blue Sky program); Parts, *supra* note 26, at 297.

Contamination of recycling occurs when materials that cannot be recycled are put into the recycling system or when recyclable materials are prepared the wrong way (e.g., food left in containers or recyclables put into plastic bags). Cody Marshall & Karen Bandhauer, *The Heavy Tool of Contamination*, Recycling Today (Apr. 19, 2017), https://www.recyclingtoday.com/article/the-heavy-toll-of-contamination/. Contamination also happens through what is called "aspirational" recycling, where people include items for recycling that they hope are recyclable, even when they are not. Livia Albeck-Ripka, *Your Recycling Gets Recycled, Right? Maybe, or Maybe Not*, N.Y. Times (May 29, 2018), https://www.nytimes.com/2018/05/29/climate/recycling-landfills-plastic-papers.html. The Green Fence restrictions on contamination rates led Chinese customs officials to reject many shipments of recyclable materials from the United States. Parts, *supra* note 26, at 297-98 (noting the rejection of 61,700 metric tons of recyclable imports in the first months after Green Fence was implemented).
170. The new restrictions reduced accepted rates of contamination in imports of recyclables to no more than 0.5%. Announcement No. 6, Ministry of Ecology and Environment, People's Republic of China, Announcement on Adjustment to the Catalogue for the Administration of Import Solid Waste (Apr. 19, 2018) (English translation by the Institute of Scrap Recycling Industries available for reference at https://perma.cc/6K9K-66AZ); Parts, *supra* note 26, at 301.
171. Xia argues that prior environmental exception cases brought before the WTO would support China's actions. Xia, *supra* note 26, at 1158-59. Colin Parts, on the other hand, concludes that China's TBT restrictions likely violate the WTO's national treatment principle and are not consistent with WTO treaty obligations. Parts, *supra* note 26, at 309-17.
172. Contamination rates for U.S. plastics sometimes approached 25%. Nicole Javorsky, *How American Recycling Is Changing After China's National Sword*, Bloomberg CityLab (Apr. 1, 2019), https://www.citylab.com/environment/2019/04/recycling-waste-management-us-china-national-sword-change/584665/; Everling, *supra* note 30, at 175.
173. Phillips, *supra* note 165.
174. Hook & Reed, *supra* note 10.
175. *Id.* (noting that, in 2018, Malaysia became the largest importer of waste, that Vietnam's waste imports doubled, and that Thailand's waste imports increased by 1,370%).
176. Xia, *supra* note 26, at 1167.
177. *Id.*
178. Malaysia, for example, stopped issuing import licenses and Thailand placed bans on plastic imports. Xia, *supra* note 26, at 1167; Parts, *supra* note 26, at 304.
179. Phillips, *supra* note 165.

ing, costs to municipal recycling programs increased, as recycling collectors imposed higher processing fees to make up for revenue shortfalls.[180] These increased costs undercut the economic viability of many local recycling programs' material collected, as recyclables were either incinerated or discarded in landfills.[181]

The collapse of the global plastics waste supply chain is a clear symptom of the unsustainability of our approach to plastics. The design, regulatory, economic, and waste management challenges discussed here identify the fault lines in that system. Any path forward must look broadly at plastics issues to address these myriad challenges.

III. Regulatory Design for Plastics' Life Cycle

The new realities of plastics in the present complex, disrupted system, coupled with the growing expectation that countries deal with their own waste issues, require a fresh regulatory approach to plastics. The new focus should be on building a sustainable plastics industry, without the externalities inherent in the take-make-waste paradigm. Regulating for circularity requires a comprehensive governance scheme with interventions at key leverage points throughout plastics' life cycle. This section is a first attempt at identifying major components of such a regulatory program, including review of relevant provisions from the Break Free Act.

A. Altering "Take"

Tackling the plastics problem must start at the raw materials level. Operational, functional, and market forces combine to maintain plastics' path-dependence on fossil fuels as their primary feedstocks. Changing the current paradigm requires regulation that levels the playing field for alternative materials as feedstocks, and promotes development of bioplastics and other alternative materials by addressing the obstacles to the new path.

The existing plastics paradigm benefits from the simple fact that traditional plastics provide products that meet consumer needs. Bioplastics compete in a market that already has plastics products with multiple functionalities.[182] Unfortunately, many existing bioplastics technologies fail to meet customer needs because they lack key functional characteristics such as flexibility and strength.[183] Shifting consumer behavior to bioplastics requires changing the packaging supply side through the twin tools of source reduction measures and development of new bioplastics materials.

As the name implies, source reduction regulation attempts to decouple packaging from fossil fuels by reducing the amount of traditional plastics in use through prohibitions on certain types of plastics. Plastics bans try to change the culture of convenience, as exemplified by the single-use design paradigm and to resuscitate the use of reusable materials. State bans on SUPBs, straws, and stirrers are an example of source reduction regulation that federal law should adopt. A key objective of the Break Free Act, for example, is to "turn off the plastics tap,"[184] to reduce the amount of new traditional plastics produced by prohibiting stores from providing SUPBs to customers.[185]

Bans on traditional plastics items remove the safety net of the existing fossil fuel-dependent plastics paradigm, creating a gap in the market and accelerating the need for alternative materials. Thus, source reduction regulation must be coupled with development of substitute materials to decouple plastics from fossil fuels.[186] While advances in industrial biotechnology have decreased costs associated with bioplastics production,[187] the market size for bioplastics is still limited by costs that make bioplastics more expensive than traditional plastics.[188]

A primary cost for this nascent industry is research and development (R&D).[189] Government funding of R&D to address the functionality issues is a necessary part of a future regulatory scheme.[190] The entrepreneurial sphere in bioplastics is flourishing with experimentation with recyclable paper bottles[191] and edible seaweed-based packaging.[192] Some private capital is beginning to flow into bioplastics startups.[193] Several established agriculture and

180. *Id.*; Hook & Reed, *supra* note 10; Parts, *supra* note 26, at 304-05.
181. Hook & Reed, *supra* note 10; Javorsky, *supra* note 172.
182. Alastair Iles & Abigail N. Martin, *Expanding Bioplastics Production: Sustainable Business Innovation in the Chemical Industry*, 45 J. Cleaner Prod. 38, 41 (2013).
183. Narancic et al., *supra* note 95, at 10442; Kakadellis & Harris, *supra* note 66, at 10 (noting that bioplastics often fail to deliver properties necessary for certain types of packaging).
184. News Release, U.S. Public Interest Research Group, New Bill Calls for U.S. to Move Beyond Plastic (Feb. 11, 2020), https://uspirg.org/news/usp/new-bill-calls-us-move-beyond-plastic (reporting on the original version of the bill introduced in 2020).
185. S. 984, §12201(b). A SUPB is defined as a bag that is made of plastic and provided by a store to a customer at the point of sale to use to carry away purchases. *Id.* §12201(a)(1). Excluded from the definition are SUPBs for bulk food or small hardware items; wrap for meat, seafood, or plants; packages of plastic bags; newspaper bags; and laundry/dry cleaning bags. *Id.* §12201(a)(2). Enforcement is through the U.S. Environmental Protection Agency (EPA). *Id.* §12201(c).
186. Ellen MacArthur Foundation et al., *supra* note 6, at 92-96 (describing a variety of nonpetroleum-based materials in development).
187. Iles & Martin, *supra* note 182, at 38.
188. Renata Dobrucka, *Bioplastic Packaging Materials in Circular Economy*, 15 LogForum 129, 132 (2019); Stoica et al., *supra* note 151, at 2 (noting that bioplastics' high cost limits its competitiveness).
189. Iles & Martin, *supra* note 182, at 41.
190. OECD Policy Approaches, *supra* note 82, at 35 (explaining that public funding can support research that identifies knowledge gaps and technology needs for the industry).
191. Maxine Perella, *In the Spirit of Sustainability: Absolut Set to Unveil Fully Recyclable Paper Bottles*, Sustainable Brands (Sept. 28, 2020), https://sustainablebrands.com/read/chemistry-materials-packaging/in-the-spirit-of-sustainability-absolut-set-to-unveil-fully-recyclable-paper-bottles; Rachel Arthur, *Absolut Trials Paper Bottle Prototype*, Beverage Daily (Sept. 8, 2020), https://www.beveragedaily.com/Article/2020/09/08/Absolut-trials-paper-bottle-prototype.
192. Fin Slater, *An Inside Look at Notpla's Edible Seaweed-Based Packaging*, Packaging Eur. (July 14, 2020), https://packagingeurope.com/an-inside-look-at-notplas-edible-seaweed-based-packaging/; Adele Peters, *This Edible Blob Filled With Water Means You Don't Need a Plastic Bottle*, Fast Co. (Feb. 18, 2020), https://www.fastcompany.com/90464501/this-edible-blob-filled-with-water-means-you-dont-need-a-plastic-bottle.
193. Most notably, Danimer Scientific, a pioneer in developing biodegradable materials, was acquired by Live Oak Acquisition Corp. in December

chemical companies are also working on commercializing bioplastics innovations.[194]

However, given the magnitude of plastics use and the plastics waste crisis, government support would provide a more stable base for the needed R&D. The Save Our Seas 2.0 Act (SOS 2.0), a bill introduced in January 2020,[195] includes a possible model for government-sponsored innovation in its Genius Prize, a technology competition carrying a cash prize.[196] The project categories identified in SOS 2.0 focus overwhelmingly on treating or managing waste,[197] but the basic idea of promoting technological innovation through the competition is sound. Future legislation could build on project categories that focus on source reduction efforts[198] and increase the amount of the prize to generate greater interest.[199] Legislation could combine the competitive aspect of the Genius Prize with aspects of the U.S. Department of Energy's Agile BioFoundry consortium, which provides grant money and collaboration opportunities with the United States' National Laboratories[200] to accelerate commercialization of innovative technologies.[201]

Our current plastics framework also benefits from direct government support through federal subsidies to the fossil fuel industry.[202] Conservative estimates place U.S. fossil fuel subsidies in 2017 at about $2 billion.[203] These subsidies distort cost structures and pricing, contributing to the artificially low price of traditional plastics. Reducing or eliminating fossil fuel subsidies would correct at least some of the pricing issues currently favoring traditional plastics. Despite calls to revise the structure of U.S. subsidies,[204] fossil fuel industry lobbies are strong enough to keep current programs in place,[205] making it unlikely that oil industry subsidy dollars will be reduced or reallocated.

A second avenue to level the playing field would be federal subsidies for agriculture and other raw materials used as feedstocks for bioplastics. To the extent that subsidies can lower the costs of production or defray the cost of R&D, federal subsidies would provide the financial support needed to launch a viable bioplastics industry. These subsidies would need to be carefully structured to avoid unintended consequences of competition between crops for food and crops for bioplastics and the potential for an industry to become dependent on government support.[206]

2020. Press Release, Danimer Scientific & Live Oak Acquisition Corp., Danimer Scientific, a Next Generation Bioplastics Company, to Become a Public Company (Oct. 5, 2020), https://www.businesswire.com/news/home/20201005005265/en/Danimer-Scientific-a-Next-Generation-Bioplastics-Company-to-Become-a-Public-Company; Richard Ivey, *Danimer Scientific Completes Business Combination With Live Oak Acquisition Corp.*, Danimer Sci. (Dec. 29, 2020), https://danimerscientific.com/2020/12/29/danimer-scientific-completes-business-combination-with-live-oak-acquisition-corp/. Beverage maker Bacardi collaborated with Danimer Scientific to develop a 100% biodegradable bottle, which Bacardi plans to have on the shelf in 2023. *That's the Spirit! Bacardi's Biodegradable Bottle Latest Boon to Beverage Packaging*, Sustainable Brands (Oct. 22, 2020), https://sustainablebrands.com/read/chemistry-materials-packaging/that-s-the-spirit-bacardi-s-biodegradable-bottle-latest-boon-to-beverage-packaging. London-based bioplastics company Teysha Technologies has also raised private investment money through the Angel Investment Network, the world's largest online angel investing platform. Alara Basul, *London-Based Teysha Technologies Raises £1.2m*, UK Tech News (Nov. 15, 2019), https://www.uktech.news/news/london-based-teysha-technologies-raises-1-2m-20191115.

194. *See*, *e.g.*, Press Release, NatureWorks, Cargill, Teijin Form Joint Venture for NatureWorks (Oct. 1, 2007); Press Release, Cargill, Cargill Strengthens Its Bio-Industrial Offerings With Acquisition of BioBased Technologies' Polyols Product Lines (May 16, 2017), https://www.prnewswire.com/news-releases/cargill-strengthens-its-bio-industrial-offerings-with-acquisition-of-biobased-technologies-polyols-product-lines-300458210.html; Press Release, Dow Corporate, Dow and UPM Partner to Produce Plastics Made With Renewable Feedstock (Sept. 24, 2019), https://corporate.dow.com/en-us/news/press-releases/dow-and-upm-partner-to-produce-plastics-made-with-renewable-feedstock.html.

195. S. 1982, 116th Cong. (2020), known as the Save Our Seas 2.0 Act, or SOS 2.0, https://www.congress.gov/bill/116th-congress/senate-bill/1982/text.

196. The bill provides that a prize be awarded biennially in an amount not less than $100,000. *Id.* §§123(b)(1)(J), 301-308.

197. For example, project categories include improving debris detection and cleanup and increasing solid waste collection. *Id.* §122(a)(2).

198. Save Our Seas 2.0 Genius Prize categories include designs to reduce overall packaging needs. *Id.* §122(a)(2)(E). This category could be retained and enhanced with categories that focus on development of substitute feedstock materials such as bioplastics.

199. Some critics of Save Our Seas 2.0 argue that the amount of the prize is inadequate to serve its purpose. Katie Pyzyk & E.A. (Ev) Crunden, *Senate Passes "Save Our Seas 2.0" Bill Focused on Plastic Waste*, Waste Dive (Jan. 13, 2020), https://www.wastedive.com/news/save-our-seas-act-plastics-congress/564108/.

200. Agile BioFoundry, *About Us*, https://agilebiofoundry.org/about/ (last visited Nov. 6, 2021). In 2020, the Agile BioFoundry consortium awarded grants totaling more than $5 million to eight public and private organizations. *Agile BioFoundry Selects New Projects to Accelerate Biomanufacturing*, Berkeley Lab Biosciences (July 13, 2020), https://biosciences.lbl.gov/2020/07/13/agile-biofoundry-selects-new-projects-to-accelerate-biomanufacturing/.

201. Agile BioFoundry, *History & Foundation*, https://agilebiofoundry.org/history-foundation/ (last visited Nov. 6, 2021).

202. Federal oil and gas subsidies take the form of several tax advantages, including direct subsidies such as deductions for drilling costs and reserves depletion and indirect subsidies such as foreign tax credits and last-in first-out accounting. Environmental and Energy Study Institute (EESI), Fact Sheet: Fossil Fuel Subsidies: A Closer Look at Tax Breaks and Societal Costs 2-3 (2019), https://www.eesi.org/files/FactSheet_Fossil_Fuel_Subsidies_0719.pdf. The fossil fuel industry also benefits from significant federal support for R&D. *Id.* at 4-5.

203. EESI, *supra* note 202, at 1; Oil Change International, *Fossil Fuel Subsidies Overview*, http://priceofoil.org/fossil-fuel-subsidies/ (last visited Nov. 6, 2021). This figure does not include the portion of the U.S. defense budget that is allocated to protecting oil interests in foreign countries or the cost of externalities from the use of fossil fuels. Oil Change International, *supra*. A study by the International Monetary Fund calculated the total cost of U.S. subsidies to fossil fuel industries in 2015 at $649 billion. David Coady et al., Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates 5 (International Monetary Fund, IMF Working Paper No. WP/19/89, 2019).

204. Lawmakers have introduced several bills to alter U.S. subsidies, including the Off Fossil Fuels for a Better Future Act and the Clean Energy for America Act. EESI, *supra* note 202, at 4. Environmental and energy advocacy groups also argue for a reduction in subsidies. Oil Change International, *supra* note 203.

205. James Ellsmoor, *United States Spend Ten Times More on Fossil Fuel Subsidies Than Education*, Forbes (June 15, 2019), https://www.forbes.com/sites/jamesellsmoor/2019/06/15/united-states-spend-ten-times-more-on-fossil-fuel-subsidies-than-education/.

206. The United States has already experienced a version of this dynamic in the mid-2000s with the tension between corn production and ethanol production. Government subsidies, tax credits, and fuel mandates incentivized the development of the ethanol industry. Wallace E. Tyner, *The US Ethanol and Biofuels Boom: Its Origins, Current Status, and Future Prospects*, 58 BioScience 646, 647 (2008). As a result of the government support and rapid expansion of the ethanol industry, corn producers reallocated corn acreage for food to corn for ethanol. C. Ford Runge & Benjamin Senauer, *How Biofuels Could Starve the Poor*, N.Y. Times (May 7, 2007), https://archive.

However, such a program would contribute significantly to mitigating cost and pricing issues that bioplastics face in the marketplace.

B. Shifting "Make"

Review of key plastics production issues reveals several opportunities for regulatory intervention to mitigate negative environmental impacts.

As a baseline, government can use environmental law's traditional focus on pollution prevention to move plastics toward cleaner production, including further reductions in greenhouse gas emissions, energy use, and effluent discharge. Production facilities in the United States are subject to the federal air and water pollution legislation, but more exacting measures could be used to leapfrog the environmental performance of new facilities. For example, the Break Free Act proposes revisions of federal environmental laws as they apply to plastics,[207] including a requirement that plastics production facilities use only zero-emission energy sources.[208] The bill imposes a "temporary pause" on U.S. Environmental Protection Agency (EPA) permitting of new plastics production facilities pending those revisions.[209]

To move beyond pollution prevention toward a circular approach, regulation must recognize the importance of design as affecting the complexity and economics of after-use processes. The current design paradigm, with its focus on SUPs, simply transfers design failures to consumers.[210] Moreover, simple dematerialization of products is not necessarily the answer to waste issues, because it can reduce after-use value to the point where recycling is not economically viable.[211]

Aligning design with circularity requires a multimodal approach. First, government can incentivize use of bioplastics in product design to avoid creation of nonbiological nutrients. It does this by addressing the market barriers that favor production models for traditional plastics with incentives that counter those barriers. Bioplastics are a new entrant challenging and attempting to disrupt an incumbent industry in a mature market. Traditional plastics production benefits from sunk infrastructure costs and stable supply chains that developed over decades.[212] Bioplastics have none of those advantages, with the result that bioplastics are rarely cost-competitive with traditional plastics.[213]

As bioplastics startups are finding, it is challenging to build out the necessary upstream supply chains or to gain access to capital for facilities where the market for bioplastics products is uncertain.[214] Government support focused on commercialization and steering innovation investment toward new materials could help. This could come in the form of low-interest loans or tax credits for construction of production facilities. A second option is to establish business incubators to facilitate connections between bioplastics innovators and potential investors.

For the remaining traditional plastics market, the opportunity is to reduce fragmentation of the after-use market at the product design stage. Design for the environment,[215] where a product is designed with end of life in mind, suggests several coordinated initiatives to improve after-use potential. A necessary first step is to move away from the single-use paradigm as the default for plastics product design, especially packaging design. Government can mandate use of design-for-the-environment principles for plastics producers to disincentivize designing for single use. For example, the Break Free Act requires EPA to pass rules requiring that producers design products with an eye to minimizing their environmental impacts across the whole value chain.[216]

Government can partner with the private sector to support development of design guidance. The Association of Plastic Recyclers provides a design guide for recyclability that purports to identify design criteria at the industry level, rather than by tying design specifications to specific

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nytimes.com/www.nytimes.com/cfr/world/20070501faessay_v86n3_runge_senauer.html?pagewanted=print; *An Earful on Ethanol: Rising Food Prices, Inefficient Production, and Other Problems*, Knowledge@Wharton (May 28, 2008), https://knowledge.wharton.upenn.edu/article/an-earful-on-ethanol-rising-food-prices-inefficient-production-and-other-problems/. Increased demand for corn caused corn prices to increase modestly in the United States. Bruce A. Babcock & Jacinto F. Fabiosa, The Impact of Ethanol and Ethanol Subsidies on Corn Prices: Revisiting History 5, 9 (Iowa State University Center for Agricultural and Rural Development, CARD Policy Brief No. 11-PB 5, 2011); Congressional Budget Office, U.S. Congress, The Impact of Ethanol Use on Food Prices and Greenhouse-Gas Emissions 6-7 (2009).

However, globally, the shrinking of corn supplies for food had more dire results, especially in developing countries that were sensitive to even moderate price increases. Some countries experienced food shortages. Runge & Senauer, *supra*; Knowledge@Wharton, *supra*. Later commentators investigating the impact of diversion of food crops for biofuels echoed the concerns about food security. *See, e.g.*, J. Popp et al., *The Effect of Bioenergy Expansion: Food, Energy, and Environment*, 32 Renewable & Sustainable Energy Revs. 559, 562 (2014). Other commentators have criticized the government support programs for ethanol as creating an industry dependent on government funding and the political climate. Robert Rapier, *The Problem With the Ethanol Industry*, Forbes (Aug. 11, 2019), https://www.forbes.com/sites/rrapier/2019/08/11/this-is-what-is-wrong-with-the-ethanol-industry/.

207. The Break Free Act calls for revisions to both source performance standards and emission standards under the Clean Air Act. S. 984, §4(d)(2)(A). Other provisions require EPA to issue a rule that certain plastics production facilities are stationary sources under the Clean Air Act and to set emission standards for those production facilities requiring no detectable emissions of hazardous air pollutants. *Id.* §4(d)(2)(B). It also calls for new EPA rules under the Clean Water Act regulating effluents and runoff from plastics production. The new rules must ensure that best-available-technology limitations apply to plastics production and must set new source performance standards regarding effluents. *Id.* §4(e)(1)(A)(i)-(iii), (B).

208. *Id.* §4(d)(2)(A).

209. The temporary pause focuses on permits issued by the Secretary of the Army under the Clean Air Act and/or the Federal Water Pollution Control Act for new production facilities, but also requires EPA to object to permits issued by a state agency on its delegated authority under the two federal laws. *Id.* §4(b)(1)(C).

210. Whiting, *supra* note 83.

211. Ellen MacArthur Foundation et al., *supra* note 6, at 88.

212. Iles & Martin, *supra* note 182, at 41.

213. *Id.*

214. *Id.*

215. Design for the environment is a product design approach where producers consider environmental impacts along with traditional business considerations of cost and performance. U.S. EPA, Design for the Environment Projects (2002), https://www.epa.gov/sites/production/files/2013-12/documents/dfe_fact_sheet_2002-08.pdf.

216. S. 984, §12303. Design aspects can include redesigning products to reduce the quantity of materials used, designing to extend the life-span of products, and designing to incorporate more recyclables into products. *Id.* §12303(b).

municipal collection programs.[217] Regulation can further support after-use markets by imposing minimum recycled content standards, requiring plastics manufacturers to incorporate specified levels of recycled materials into product design.[218] Several states have recycled content mandates in place,[219] and recyclers generally favor the laws as important in bolstering secondary markets for recyclable materials.[220] The Break Free Act leverages this approach by requiring EPA to set standards for minimum percentages of post-consumer recycled content for plastics products.[221]

Convergence of materials and formats through global design standards is critical for fostering viable after-use markets. Individual design choices yield a complex array of materials and additives, labeling, and marking schemes, a complexity that deters after-use because many plastics materials are used only in small amounts, undercutting the economics of recycling.[222] Further, industry-sponsored marking schemes can mislead consumers into attempting to recycle materials that do not have after-use value. The "chasing arrows" insignia, prevalent in the United States, suggests to most consumers that the plastic container can be recycled. However, the mark, known technically as the resin identification code, only indicates basic information on the material content of the plastics and was never intended to facilitate recycling.[223]

These discontinuities underscore the need to coordinate design standards across the whole plastics value chain, which often crosses national borders. A recent study proposes establishing a Global Plastics Protocol that would create packaging design standards with an eye to reducing the number and type of materials and additives used in plastics manufacture.[224] The protocol would also establish labeling and materials marking standards that are aligned with after-use sorting and separation systems.[225]

Designing specifically for recycling will not automatically eliminate all waste management issues. Thus, there will still be the need for a waste management system and to think about waste management at the system level. The U.S. experience demonstrates that our existing system is unworkable, its very fragmentation demonstrating the need for significant federal government intervention.

C. Managing "Waste"

The United States' dismal recycling rates reflect the traditional waste management philosophy of local control and aggregating waste from households for disposal. The foundation of a new waste management system should be the creation of viable after-use markets that change the end-of-life scenario for plastics. Government can shift the incentives toward recycling by addressing structural issues that favor disposal over recycling. It can restructure to reduce fragmentation in materials and recycling industries, creating a coherent domestic scheme with the scale needed to avoid dependence on foreign recyclers. Government should pursue the connected goals of capturing more material and capturing more value from material.

1. Capturing More Physical Material

Capturing more physical material requires significant improvement in collection systems and recovery infrastructure. The drive to increase recycling rates focuses on increasing convenience of collection processes for consumers. A study of curbside recycling in the United States uncovered several common practices contributing to low recycling rates.

For example, a significant portion of U.S. households are located in recycling deserts, with no access to curbside recycling.[226] The study further found that switching curbside recycling systems from opt-in systems to opt-out systems would improve material capture rates.[227] Technology is also changing the recycling landscape with innovative collection systems like reverse vending. In a reverse vending system, collection machines are placed in public locations. Consumers return permitted plastics and claim deposit refunds through the reverse vending machine.[228]

At a macro level, there is a need to standardize and simplify collection protocols across jurisdictions. U.S. recycling is dominated by collection schemes established at the municipal or state level, with the inevitable conflicts and gaps that defeat attempts to create scale. Federal legislation has been proposed that would channel federal funding to improve recycling logistics, but does so in a way that continues the disjointed and inefficient system currently

217. Association of Plastic Recyclers, *APR Design® Guide*, https://plasticsrecycling.org/apr-design-guide (last visited Nov. 6, 2021).
218. RecycleNation, *Minimum Recycled Content Laws*, https://recyclenation.com/green-glossary/minimum-recycled-content-laws/ (last visited Nov. 6, 2021).
219. Notably, California state law requires plastic trash bag manufacturers to certify the amount of post-consumer plastic content in their products. Cal. Code Regs. tit. 14, §17979 (1995). A Washington state bill requires 40% recycled content in paper and reusable plastic bags. S.B. 5323, 66th Leg., 2019-2020 Reg. Sess. (Wash. 2020).
220. Katie Pyzyk & Rina Li, *Recyclers Request Government Mandates for Recycled Plastic Content in Bags*, Waste Dive (July 3, 2019), https://www.wastedive.com/news/recyclers-request-government-mandates-for-recycled-plastic-content-in-bags/554363/.
221. S. 984, §12302. The draft Act sets out minimum percentages that increase in five-year increments, from 2025 to 2040.
222. Ellen MacArthur Foundation et al., *supra* note 6, at 48 (explaining that small waste streams of plastics materials cannot be sorted at competitive costs).
223. Brad Kelechava, *Resin Identification Codes (RICs), as Specified by ASTM D7611*, Am. Nat'l Standards Inst. (Feb. 21, 2019), https://blog.ansi.org/2019/02/resin-identification-codes-rics-astm-d7611/; Carriere & Horne, *supra* note 31, at 10046-47.
224. *See* Ellen MacArthur Foundation et al., *supra* note 6, at 50-51.
225. *Id.* at 39-40, 50-55. A recent study of curbside recycling in the United States similarly called for standardization and alignment of design standards and commodity specifications. Mouw, *supra* note 101, at 54.
226. Mouw, *supra* note 101, at 51 (noting that 21% of U.S. households have access to drop-off recycling only).
227. *Id.* at 17, 51.
228. Jan Dell & Marcus Eriksen, *How to Close the Loop on a Quarter-Trillion Plastic Bottles a Year*, GreenBiz (Nov. 8, 2018), https://www.greenbiz.com/article/how-close-loop-quarter-trillion-plastic-bottles-year. There is also innovative research being done to marry the reverse vending concept to standard recycling bins. Razali Tomari et al., *Development of Reverse Vending Machine (RVM) Framework for Implementation to a Standard Recycle Bin*, 105 Procedia Computer Sci. 75 (2017).

in place.[229] Industry supporters of the bill see its emphasis on government support for infrastructure improvements as a "necessity" since aging infrastructure hinders recycling efforts,[230] glossing over the key issue of externalization of the costs of recycling. The Break Free Act does a better job of recognizing the current challenges of our fragmented U.S. recycling system and calls on EPA to issue guidance to standardize recycling collection nationwide[231]; however, standardized collection does not address all externalities associated with plastics waste.

The federal government in the United States needs to revisit its traditional view that waste management is a government responsibility issue, and take a leadership role in considering EPR as an approach to addressing plastics waste. EPR is a public policy approach where a producer's responsibility for impacts is extended to the post-consumer stage of a product's life cycle,[232] assigning long-term environmental responsibility to producers.[233] EPR systems use a variety of policy instruments, including product take-backs, recycling rate targets, advanced recycling fees, and tradable recycling credits[234]; the goals of the system affect the choice of tools employed.[235] While voluntary EPR schemes do exist,[236] most commentators recognize the need for government involvement for EPR to work.[237]

EPR is an application of the polluter-pays principle that regulates division of waste management responsibility using economic tools.[238] In the polluter-pays framework, externalities, such as the financial and environmental costs of disposal, point to the existence of incomplete market systems.[239] EPR attempts to correct those market failures by reallocating responsibility to product producers, who must then internalize costs.[240]

In an EPR system, the producer is deemed to be the polluter (rather than the consumer) because producers are the least-cost avoiders with control over product and production decisions and market offerings.[241] Requiring producers to internalize the environmental costs of their products shifts the burden of waste management off the shoulders of government.[242] In theory, internalization of costs should incentivize producers to incorporate environmental impacts into product design with an eye to reducing environmental impacts and costs.[243] Some scholars view EPR as a method to promote circularity in supply chains.[244]

Scholars of EPR are guarded in recommending the approach, uncovering several types of issues to be considered in configuring an EPR system. Generally, EPR systems have succeeded in increasing recycling rates and reducing the use of virgin materials but struggle to achieve the desired design improvements. The challenges in implementing EPR are not technical issues; rather, they are issues surrounding EPR's interaction with economic actors and include incentive, structural, and coordination issues. Incentive issues are easy to identify: EPR comes with high transaction costs and the costs of the system may outweigh the benefits, making it difficult to provide the proper incentives to producers to comply with all of their obligations.[245] Commentators argue that high transaction costs of EPR are a barrier to the desired product design improvements unless there are specific design-related goals in the system.[246]

Second, EPR systems must confront structural issues that can encourage producers to free-ride on the system. EPR systems covering large markets or heterogenous systems, such as the European Union's country-by-country EPR, lead to fragmentation and the opportunity to shirk responsibilities[247]; scholars point to Canada's national EPR

229. H.R. 5115, 116th Cong. (2019). Known as the RECOVER Act, the bill proposes financial assistance to state and local governments to improve collection and processing by establishing recycling infrastructure programs. *Id.* §3(b). However, the focus is on state and local governments, with no provisions that encourage regional or national coordination of efforts.

230. E.A. (Ev) Crunden, *Industry-Backed RECOVER Act Calls for $500M in Recycling Infrastructure Grants*, Waste Dive (Nov. 20, 2019), https://www.wastedive.com/news/RECOVER-act-plastics-glass-industry-backing-recycling-waste-legislation/567541/. The Plastics Industry Association, for example, lauded the legislation's potential to address infrastructure issues, noting that recycling priorities in the United States required greater focus on issues with material recovery facilities. Plastics Industry Association, *Recycling Infrastructure Priorities*, https://www.plasticsindustry.org/advocacy/infrastructure/recycling-infrastructure-priorities (last visited Nov. 6, 2021).

231. S. 984, §12301.

232. OECD, Extended Producer Responsibility: Updated Guidance for Efficient Waste Management 18-19 (2016) [hereinafter OECD Updated Guidance].

233. Sachs, *supra* note 31, at 52.

234. OECD, Extended Producer Responsibility: A Guidance Manual for Governments 40-45 (2001) [hereinafter OECD EPR Guidance Manual].

235. Margaret Walls, Extended Producer Responsibility and Product Design 5 (Resources for the Future, Discussion Paper No. 06-08, 2006).

236. OECD EPR Guidance Manual, *supra* note 234, at 33 (summarizing types of voluntary EPR policy tools); Nicole Kibert, *Extended Producer Responsibility: A Tool for Achieving Sustainable Development*, 19 J. Land Use & Env't L. 503, 517-20 (2004) (describing the industry-driven EPR program in the U.S. carpet industry).

237. Kibert, *supra* note 236, at 521 (arguing that industry is not motivated enough to create EPR without government); Sachs, *supra* note 31, at 80 (claiming that EPR as practiced involves substantial regulatory mandates).

238. OECD Updated Guidance, *supra* note 232, at 21; Kleoniki Pouikli, *Concretising the Role of Extended Producer Responsibility in European Union Waste Law and Policy Through the Lens of the Circular Economy*, 2020 ERA F. 491, 494 (2020). The polluter-pays principle originated in the Rio Declaration, the sustainability framework crafted at the 1992 United Nations Conference on Environment and Development. Kibert, *supra* note 236, at 505.

239. Hans Wiesmeth & Dennis Häckl, *How to Successfully Implement Extended Producer Responsibility: Considerations From an Economic Point of View*, 29 Waste Mgmt. & Rsch. 891, 897 (2011).

240. Pouikli, *supra* note 238, at 494.

241. Monroe, *supra* note 31, at 220 (arguing that producers are the least-cost avoiders for plastic waste because they dictate the market for packaging); Pouikli, *supra* note 238, at 494-95 (explaining that producers are the party to most effectively provide a remedy to plastic waste issues); Sachs, *supra* note 31, at 66 (claiming that principles of industrial ecology point to the producer as the polluter, rather than the consumer).

242. OECD Updated Guidance, *supra* note 232, at 18-19; Sachs, *supra* note 31, at 53.

243. OECD Updated Guidance, *supra* note 232, at 17-18.

244. Louis Dawson, *Our Waste, Our Resources: A Strategy for England: Switching to a Circular Economy Through the Use of Extended Producer Responsibility*, 21 Env't L. Rev. 210 (2019).

245. Sachs, *supra* note 31, at 54, 66-67.

246. Monroe, *supra* note 31, at 230-32 (explaining that producers sometimes pay for disposal or recycling of products rather than engage in an intensive product redesign process); Sachs, *supra* note 31, at 75 (arguing that EPR systems must achieve true cost internalization to incentivize design improvements).

247. OECD EPR Guidance Manual, *supra* note 234, at 85 (noting the potential for freeriding in large EPR systems); Pouikli, *supra* note 238, at 501 (explaining the impact of political borders on fragmenting an EPR system).

system as a better model.[248] EPR regulations must define "producer" broadly enough and with the intention to capture all producers, and must shift all responsibility for end-of-life management to producers to be effective.[249]

Scholars also identify possible problems with EPR systems that impose collective responsibilities at an industry level, as opposed to individual responsibilities at a firm level. In a collective EPR system, producers establish a separate entity called a producer responsibility organization (PRO) to manage the physical collection and recycling of products.[250] However, it is not clear that collective EPR systems provide the incentives for design innovation to the extent that individual systems do.[251] Moreover, collective PRO systems may result in anticompetitive behaviors, such as price gouging by the PRO.[252] On the other hand, firm-level responsibility for materials collection and recycling increases costs to the producers.[253] EPR regulations must take into account these and other trade offs between individual and collective producer responsibility.

Finally, successful EPR depends on the existence and functioning of secondary markets for recyclable materials. Recyclables coming through the EPR system must be of sufficient value to be recycled cost effectively in the secondary market or the scheme will collapse.[254] Further, if the domestic secondary market is not viable, recyclers may export collected materials to other countries, undercutting the environmental benefits of EPR.[255]

The research and critiques of EPR identify design choices for a successful EPR system. Generally, regulators need to tailor EPR programs to the specific legal, economic, and social context.[256] Because EPR is a goal-oriented approach to product impact, the policy tools used must align with the policy goals. Tools that increase recycling rates may not support product design changes.

Economists studying EPR have identified the tools most economically efficient to achieve various EPR goals. A key study by Margaret Walls concluded that a product tax used in conjunction with a return subsidy was the economically optimal tool.[257] The tax, in the form of a deposit paid at point of sale, acts as an environmental handling charge and the subsidy, in the form of a deposit refund, creates the incentive to return the product. Container deposit programs, often called bottle bills, are an obvious example of this type of system.

Although not without critics, bottle bills have long been touted as effective at increasing recycling rates,[258] and the Break Free Act includes a national container deposit program that applies to beverage containers.[259] The combination tax and subsidy exemplified by such a system can incentivize increased recycling rates, and thus reduce the use of virgin materials.[260] Its impact on product design is potentially more limited. For example, if the fee to the PRO to recycle the bottles is based on weight, the producer has the incentive to dematerialize its product, but may not be inclined to undertake more extensive product redesign. For design changes other than light-weighting, Walls recognizes only a possible indirect impact through the signal sent upstream by the fee to make the product more recyclable.[261]

Despite the successes of the tax and subsidy model, especially as applied to beverage containers, it is not feasible for many types of plastics packaging, leading to experimentation with other EPR tools. The most commonly used alternative to the deposit/refund model is mandated product take-backs. Take-back schemes hold the product producer directly responsible for the product life cycle by transferring some or all of the economic and operational responsibility from government to the producer.[262] Take-back legislation can require the producer to pay the costs of collection and recycling, to physically collect and recycle the product, and/or to appropriately label the product to promote recycling.[263]

Take-back programs often take the form of a suite of policy tools, each designed to provide incentives toward different policy goals and all designed to work synergistically. For example, the Break Free Act's core provisions are a plastics take-back program shifting physical, economic, and informational responsibilities to producers. The Act makes producers responsible for collection and recycling

248. Pouikli, *supra* note 238, at 501.
249. King County Department of Natural Resources and Parks, Extended Producer Responsibility Policy Framework and Implementation Model: Residential Recycling of Packaging and Paper Products in Washington State 14 (2020) (arguing that all producers should be obligated to contribute financially, not just producers who generate recyclable materials); Dawson, *supra* note 244, at 215-16 (explaining that full responsibility for end-of-life management is needed to incentivize product redesign).
250. Walls, *supra* note 235, at 6; Pouikli, *supra* note 238, at 498-99.
251. Wiesmeth & Häckl, *supra* note 239, at 894-95; Walls, *supra* note 235, at 6.
252. Walls, *supra* note 235, at 7.
253. *Id.*
254. Dawson, *supra* note 244, at 217.
255. Yasuhiko Hotta et al., *Policy Considerations for Establishing an Environmentally Sound Regional Material Flow in East Asia*, 17 J. Env't & Dev. 26, 44 (2008).
256. Monroe, *supra* note 31, at 225.
257. Walls, *supra* note 235, at 11-12. For *contra*, see Ravi Subramanian et al., *Product Design and Supply Chain Coordination Under Extended Producer Responsibility*, 18 Prod. & Operations Mgmt. 259, 261 (2009), arguing that optimal EPR tools depend on supply chain structure.
258. Bottle Bill Resource Guide, *Bottle Bills Promote Recycling and Reduce Waste*, http://www.bottlebill.org/index.php/benefits-of-bottle-bills/bottle-bills-promote-recycling-and-reduce-waste (last visited Nov. 6, 2021); Colin Staub, *Legislation Pushing National Bottle Bill Hits Congress*, Plastics Recycling Update (Feb. 12, 2020), https://resource-recycling.com/plastics/2020/02/12/legislation-pushing-national-bottle-bill-hits-congress/. For criticism of bottle bills, see generally Clayton Coleman, *Bottle Bills and Curbside Collection: An Overview of Recycling Policy Approaches*, Env't & Energy Study Inst. (Sept. 21, 2018), https://www.eesi.org/articles/view/bottle-bills-and-curbside-collection-an-overview-of-recycling-policy-approa; Arlene Karidis, *Do Bottle Bills Boost Recycling?*, Waste360 (May 24, 2018), https://www.waste360.com/legislation-regulation/do-bottle-bills-boost-recycling.
259. S. 984, §12104. Under the proposed provisions, a distributor charges a deposit to a retailer on delivery of full containers and then pays that deposit to the retailer on receipt of empty containers. Similarly, the retailer charges and pays the consumer the same amount of deposit. *Id.* §12104(a)(1).
260. Walls, *supra* note 235, at 13 tbl.1.
261. *Id.*
262. OECD EPR Guidance Manual, *supra* note 234, at 40-41; Sachs, *supra* note 31, at 62.
263. OECD EPR Guidance Manual, *supra* note 234, at 53-54.

of plastics with escalating recycling performance targets[264] and standardized labeling,[265] to increase actual recycling rates. To incentivize incorporation of post-consumer materials into product design, the Act imposes minimum recycled content standards[266] and includes design-for-the-environment requirements.[267]

Product take-back is an attractive EPR option to shift responsibility from government to producers, especially where the program is a comprehensive system moving financial and operational responsibility to the producer. Economic assessment of take-back programs reveals specific considerations to make such a system economically efficient and to produce product design changes. EPR regulations can require product design for the environment, but the structure of the take-back system determines the incentives to producers. Take-back legislation generally permits or requires producers to discharge their EPR responsibilities through a PRO, with incentives dependent on the PRO financing and fee structure.[268]

For example, PRO fees function like a tax, but if they are based on the weight of product collected for recycling, they incentivize only product dematerialization.[269] To promote more thorough product redesign, EPR take-back programs can use eco-modulated fees, where producers pay higher fees to the PRO for products that hinder recycling than for products that do not.[270] The Break Free Act appears to allow for eco-modulated fees, permitting PROs to set higher fees for hard-to-recycle products and lower fees for products that are easier to recycle.[271]

Operational issues also affect incentives. A collective take-back system must address potential freeriding. Walls notes that returned materials need to be identified to specific producers, with costs traced back to those producers, to incentivize product design changes.[272] However, that process can greatly increase the transaction costs of the take-back program. Recycling performance targets will generally increase recycling rates up to the required minimum; improved recycling past the amount required is unlikely.[273]

EPR tools like bottle bills and take-back systems can be effective ways to increase recycling rates and reduce waste leakage. Where regulators wish to pursue other goals, such as product redesign, they must weigh the trade offs carefully to craft an appropriate incentive structure. Overall, the use of EPR signals an important philosophical change in society's view of waste management, forcing producers to face the impacts of the full product life cycle. The EPR provisions of the Break Free Act, while a good starting point, need to be subjected to rigorous economic analysis to assess their effectiveness in addressing plastics waste.

2. Capturing More Value From Materials

Physically capturing more material is just the starting point to facilitating plastics after-use. Capturing value from the collected material requires robust secondary markets for recyclable materials, markets that are lacking in the United States. Several policy tools can provide support for secondary markets. First, enable better supply-demand matching for recyclable plastics with transparent standards for materials composition and labeling.[274] An initiative like the Global Plastic Protocol could aid in simplifying sorting and cleaning of after-use plastics, thereby reducing costs and fostering economic viability.

Government can also establish and support materials matchmaking mechanisms, to help connect supply and demand partners. For example, the U.S. Business Council for Sustainable Development, a nonprofit organization, hosts a materials marketplace, an online platform that allows manufacturers and recycling companies to source and buy recycled materials.[275] The marketplace has limited scope, operating in only a few U.S. states and Ontario, Canada, and has diverted only 5,300 tons of waste since its inception in 1992.[276] Government support could speed the deployment and expansion of marketplaces for secondary materials, especially when combined with establishment of global design protocols.[277]

3. Closing the Loop Globally

Effective waste management strategy must consider the global impacts of waste generation. Import restrictions on waste have de-globalized waste management to some extent, but the temptation to outsource our waste problem still exists. Falling back into our previous pattern may be only a matter of finding a country willing to take U.S. waste, unless U.S. policy considers and incorporates a broader view.

The movement of waste has been a topic of international concern since the 1980s, when exports of hazardous waste from the global North to the global South gave rise to the Basel Convention on the Control of Transboundary

264. S. 984, §§12103-12104, 12105(f).
265. *Id*. §12304. The goal of the standardized labeling requirement is to make it easier for consumers to correctly recycle and compost appropriate products.
266. Minimum recycled content standards generally identify percentages of post-consumer content that must be included in new products. The Break Free Act provision contemplates increasing percentages of recycled content over the five years after the Act goes into effect. *Id*. §12302.
267. *Id*. §12303.
268. Walls, *supra* note 235, at 12.
269. *Id*. at 12, 29.
270. King County Department of Natural Resources and Parks, *supra* note 249, at 15.
271. S. 984, §12102(b)(3)(B)(iv), (v). Subsection (iv) identifies several types of materials that increase the cost of recycling and states that the PRO "shall" consider those higher costs when setting the producer's fee. Similarly, subsection (v) identifies materials that are less expensive to recycle.
272. Walls, *supra* note 235, at 29.
273. *Id*. at 12.
274. Ellen MacArthur Foundation et al., *supra* note 6, at 50-51.
275. U.S. Business Council for Sustainable Development, *About the Materials Marketplace*, http://usbcsd.org/materials/ (last visited Nov. 6, 2021).
276. *Id*.
277. The World Business Council for Sustainable Development (WBCSD) has identified challenges facing materials marketplaces, several of which would benefit from government action. WBCSD MarketplaceHub, *Challenges*, http://marketplacehub.org/challenges/ (last visited Nov. 6, 2021).

Movements of Hazardous Wastes and Their Disposal.[278] Although the Convention was intended to apply to traditional hazardous waste categories, it was amended in 2019 to include more categories of plastics waste,[279] ostensibly making it more challenging to export such waste.[280]

Several factors undercut the Convention's potential to effectively regulate global plastics waste. First, the United States is not a Party to the Basel Convention[281]; any impact the Convention has on U.S. practices will be indirect from U.S. interactions with countries who are Convention Parties.[282] Second, the Convention's regulatory approach, which relies on the mechanism of prior informed consent from importing countries to regulate waste trade, resulted in loopholes and weaknesses that waste-exporting countries exploited.[283] These weaknesses led to proposed amendment to the Convention that would ban movement of hazardous waste between developed and developing countries.[284] Resistance from industrialized nations has prevented the amendment, called the Basel Ban, from receiving the necessary ratifications to go into effect.[285]

Tension between developed and developing countries over waste trade highlights the fundamental disagreement over the philosophical underpinnings of the Basel Convention, a tension that is reflected in scholars' assessment of the Convention. Trade in waste has been examined through both economic and environmental lenses. The economic logic for trade in waste is related to the costs of waste management in developed countries with strict environmental regulation and the economic advantage of exporting waste to countries with lower compliance costs.[286]

The Basel Convention was adopted in the late 1980s in an era of the global campaign for free trade and was resisted by General Agreement on Tariffs and Trade countries, who saw the Convention as a restriction on trade and not economically advantageous.[287] Thus, the ultimate philosophy of the Convention was not to stop trade in hazardous waste, but to supply rules for the movement of waste from developed to developing countries.[288] Starting from the assumption of the economic lens that trade in waste is economically desirable, these scholars look to the Convention rules and their effectiveness in serving that end, finding the Convention to balance the interests of developed and developing countries.[289]

Other scholars contend that trade in waste is fundamentally an issue of environmental justice, rather than economics. Environmental justice is defined as the "fair treatment and meaningful involvement" of all people regardless of race or income with respect to environmental regulation,[290] and seeks to ensure that environmental burdens do not land disproportionately on low-income communities or communities of color.[291] At the global level, environmental injustice is often referred to as toxic colonialism[292] or toxic imperialism,[293] denoting the phenomenon of developed countries using developing countries as disposal sites for waste.

These commentators see the Basel Convention's response to the globalization of waste exchange as normalizing trade in waste at the expense of eliminating waste.[294] They argue that the economic lens changed the framing of waste, transforming it into a raw material commodity to be regulated, rather than an environmental hazard to be reduced.[295] This metamorphosis made environmental protection merely a collateral effect of international environmental agreements

278. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, Mar. 22, 1989, 1637 U.N.T.S. 57 [hereinafter Basel Convention]. For the history and origins of the Basel Convention, see Ishtiaque Ahmed, *The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal: A Legal Misfit in Global Ship Recycling Jurisprudence*, 29 Wash. Int'l L.J. 411, 413-15 (2020); Laura A. Pratt, *Decreasing Dirty Dumping? A Reevaluation of Toxic Waste Colonialism and the Global Management of Transboundary Hazardous Waste*, 35 Wm. & Mary Env't L. & Pol'y Rev. 581, 592-95 (2011). The Convention regulates trade in hazardous waste through a system of prior informed consent for importing countries, notification of waste content by exporting countries, and tracking requirements. *Id*. at 597; Kenneth I. Ajibo, *Transboundary Hazardous Wastes and Environmental Justice: Implications for Economically Developing Countries*, 18 Env't L. Rev. 267, 275 (2016).

279. Basel Convention, *supra* note 278, Annex II, 1673 U.N.T.S. at 151.

280. Carriere & Horne, *supra* note 31, at 10045.

281. Teeming Yang & C. Scott Fulton, *The Case for U.S. Ratification of the Basel Convention on Hazardous Wastes*, 25 N.Y.U. Env't L.J. 52, 64-66 (2017) (detailing U.S. ratification efforts and their failure). U.S. trade in plastic waste proceeds under the terms of the *Decision Concerning the Control of Transfrontier Movements of Wastes Destined for Recovery Operations*, OECD Council, OECD Doc. C(92)39/FINAL (1992), and through several bilateral agreements. *Id*.

282. For example, the Basel Convention contains a provision prohibiting Convention Parties from trading in waste with non-Parties. Basel Convention, *supra* note 278, art. 4, para. 5. However, Article 11 allows non-Parties to enter into separate agreements for the import and export of wastes with Parties. *Id*. art. 11, para. 1.

283. Pratt, *supra* note 278, at 605-10 (cataloguing loopholes in Convention provisions); Lisa Widawsky, *In My Backyard: How Enabling Hazardous Waste Trade to Developing Nations Can Improve the Basel Convention's Ability to Achieve Environmental Justice*, 38 Env't L. 577, 603-10 (2008) (identifying key weaknesses of the Basel Convention).

284. Yang & Fulton, *supra* note 281, at 68-71 (arguing that the proposed ban resulted from concern that the prior informed consent system did not prevent dumping of waste in developing countries); Jing Jin, *E-Waste & the Regulatory Commons: A Proposal for the Decentralization of International Environmental Regulation*, 39 Brook. J. Int'l L. 1251, 1261 (2014) (explaining that developing countries sought amendment of the Convention to overcome its weaknesses).

285. Widawsky, *supra* note 283, at 613; Pratt, *supra* note 278, at 601.

286. Ajibo, *supra* note 278, at 272. This argument traces its origins to a now-infamous memo issued by then-chief economist for the World Bank Lawrence Summers, setting out reasons why the World Bank should encourage the migration of polluting industries from the global North to the global South. Carmen G. Gonzalez, *Beyond Eco-Imperialism: An Environmental Justice Critique of Free Trade*, 78 Denver U. L. Rev. 981, 989-90 (2001).

287. Ahmed, *supra* note 278, at 416-17; Ajibo, *supra* note 278, at 275.

288. Jin, *supra* note 284, at 1259.

289. Widawsky, *supra* note 283, at 612; Ajibo, *supra* note 278, at 280-81.

290. U.S. EPA, *Environmental Justice*, https://www.epa.gov/environmentaljustice (last updated Oct. 29, 2021).

291. Jeanne Marie Zokovitch Paben, *Green Power & Environmental Justice: Does Green Discriminate?*, 46 Tex. Tech L. Rev. 1067, 1071 (2014); Ann M. Eisenberg, *Beyond Science and Hysteria: Reality and Perceptions of Environmental Justice Concerns Surrounding Marcellus and Utica Shale Gas Development*, 77 U. Pitt. L. Rev. 183, 191 (2015). For the origin of the environmental justice movement, see David Monsma, *Equal Rights, Governance, and the Environment: Integrating Environmental Justice Principles in Corporate Social Responsibility*, 33 Ecology L.Q. 443, 450-52 (2006).

292. Gonzalez, *supra* note 286, at 986; Pratt, *supra* note 278, at 586-87.

293. Andrea Giampetro-Meyer, *Captain Planet Takes on Hazard Transfer: Combining the Forces of Market, Legal, and Ethical Decisionmaking to Reduce Toxic Exports*, 27 UCLA J. Env't L. & Pol'y 71, 88-89 (2009).

294. Olivier Barsalou & Michael H. Picard, *International Environmental Law in an Era of Globalized Waste*, 17 Chinese J. Int'l L. 887, 898 (2018).

295. *Id*. at 888; Giampetro-Meyer, *supra* note 293, at 76.

like the Basel Convention.[296] Prof. Giampetro-Meyer notes that the language of the economic lens makes the transfer of waste and its impacts sound morally neutral; it becomes a trade, like any other trade.[297] Portraying waste as a commodity blurs important distinctions,[298] and functions as an excuse for developed countries to ignore the consequences of their consumption patterns and waste generation.[299]

Environmental justice issues resurfaced in the wake of China's and other Southeast Asian countries' plastics waste import restrictions. While the United States is not a Party to the Basel Convention, disruption of global waste disposal patterns provides the United States the opportunity to adjust its direction away from an exclusively economic lens. It can adopt an environmental justice point of view, take responsibility for its own waste generation, and regulate to live within its disposal capabilities. Government can start the movement toward justice by limiting plastics waste exports, especially to countries without the infrastructure to handle the waste in an environmentally sound manner.

The Break Free Act appears to recognize the need for export controls, and includes a provision banning exports of plastics waste to non-OECD countries without the country's prior consent.[300] This provision mirrors the much-criticized informed consent approach used in the Basel Convention, and may fall prey to the same abuse as has the Convention. Other provisions in the Break Free Act address trade in waste, prohibiting exports of plastics to purchasers who turn them into SUPs and mandating creation of a tracking system to monitor plastics from sale to disposal.[301]

IV. Conclusion

A focus on growth built our take-make-waste approach to plastics, giving rise to the problems we are now experiencing with the material. Truly addressing our plastics problem requires wholesale revision and reframing of the problem.

The starting point is to reject the current linear model—for production, regulation, and scholarship—and to move to circular models. Circularity calls for consideration of multiple points in the system, rather than a single point. To date, we have framed the plastics problem as a waste problem, focusing all attention on one aspect of the situation. But plastics waste is not the problem; plastics waste is a symptom of defects in the larger plastics system. Waste is caused by factors upstream, including choice of raw materials, design selections, and market distortions. The true problem is that we do not consider the full life cycle when designing and producing plastics. Myopically construing the problem as a waste problem contributes to the current linear system's inevitable externalities, including plastics waste.

Effectively addressing our plastics problem requires a transition to circular models, a transition that will not be easy. Both government and academia have roles to play in this process. Expanded regulatory schemes are needed to direct and support systemic change. Experience to date demonstrates that market forces alone will not drive the necessary change, if for no other reason than existing market structures favor the current state of affairs.

Government sets market conditions through regulation, and can use its authority to change policies that distort markets and to incentivize innovation away from the status quo. Despite its extensive provisions, the Break Free Act still frames the plastics problem as a waste problem. As introduced, the bill's focus is too narrow, but debate around the legislation can provide a platform to spark discussion of a regulatory architecture for plastics' full life cycle.

Scholars working in this area can also make important contributions to the transition, but only by widening the analytical aperture to look holistically at plastics. We must craft a research agenda that recognizes the interconnectedness of issues across multiple stages of plastics' life cycle and that considers regulation from a more entrepreneurial perspective.[302] Components of such a research agenda could include:

- Study of specific legal tools needed to create the economic conditions to develop alternative feedstocks for plastics;
- Thoughts on optimal institutional structure to develop and house the much-needed global plastics design protocol;
- Investigation of legal context and business models to integrate circular practices across the whole plastics value chain; and
- Examination of co-operative governance models to move the United States' current fragmented plastics regime from its local focus to a system with a national focus.

The task of transforming plastics' linear system to circularity is daunting. But the experiences of the past years make clear such a transition is imperative. Only by eschewing the oversimplifications of linear thinking and embracing the sustainability inherent in circularity can we work our way out of our plastics problem.

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296. Giampetro-Meyer, *supra* note 293, at 76 (describing the reframing of waste); Barsalou & Picard, *supra* note 294, at 897 (contending that the objective of environmental treaties is the efficient management of externalities, rather than protection of the environment).
297. Giampetro-Meyer, *supra* note 293, at 74-75.
298. Barsalou & Picard, *supra* note 294, at 898-99 (arguing that the Basel Convention legalized the movement of waste at the expense of the reduction or elimination of waste).
299. Yang & Fulton, *supra* note 281, at 59 (explaining that economic pressures in developed countries increased the incentive to avoid proper waste management); Gonzalez, *supra* note 286, at 994 (arguing that the waste trade reduced incentives for developed countries to minimize waste generation).
300. S. 984, §12307.
301. *Id.* §4(g).
302. Prof. Colleen Baker's notion of regulatory legal strategy could inform a new regulatory paradigm for plastics. *See* Colleen M. Baker, *Entrepreneurial Regulatory Legal Strategy: The Case of Cannabis*, 57 Am. Bus. L.J. 913, 944 (2020).