How Can the United States Achieve the Same Efficiency in Recycling as Denmark?

A Comparative Policy and Governance Analysis

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Overview

Denmark and the United States both rank among the wealthiest nations in the world, yet their recycling systems produce dramatically different outcomes. Denmark operates a tightly coordinated national system combining producer responsibility laws, economic incentives, public trust, and integrated infrastructure. The United States operates something closer to thousands of separate systems, fragmented across states and municipalities, with inconsistent rules, uneven infrastructure, and limited federal coordination.

This paper compares the two countries across five dimensions (policy frameworks, economic instruments, technological infrastructure, public engagement, and governance coordination) and identifies the structural changes the U.S. would need to make to approach Danish-level recycling performance.

The Policy Gap: Direction Without Coherence

Legislative Frameworks

Denmark's recycling system is embedded in a national legislative framework that integrates waste policy with climate, circular economy, and sustainability goals. The Danish Waste Management Plan establishes clear diversion targets, waste hierarchy principles, and uniform standards for municipalities, while EU directives set minimum performance requirements that Denmark typically exceeds (Christensen et al. 2021). Extended producer responsibility (EPR) is legally mandated across multiple product categories, with producers required to finance and physically manage the end-of-life phase of their products through Producer Responsibility Organizations. This means accountability is baked into the supply chain, not left to municipalities or consumers.

The United States has no equivalent national framework. The EPA's National Recycling Strategy offers guidelines, but they are non-binding and inconsistently adopted. Regulatory authority sits primarily at the state or local level, producing wide variation in what gets collected, how it is sorted, and what counts as recycled. Some states, for instance California and Oregon, have implemented meaningful EPR programs and bottle deposit laws. Most states however, have not. The result is a patchwork in which a household in one county operates under entirely different recycling rules than a household twenty miles away, and in which national

manufacturers face a thicket of conflicting requirements rather than a coherent system they can design products around (Tan et al. 2021).

The National Sword Lesson

The fragility of the U.S. approach was on full display when China's National Sword policy went into effect in 2018, banning imports of low-quality recyclables and imposing strict contamination limits. Because the U.S. system had relied heavily on exporting mixed, poorly sorted recyclable material to China, the policy triggered immediate disruptions: municipalities cancelled curbside programs, material recovery facilities (MRFs) were overwhelmed with material they could not move, and plastic landfilling increased by more than 23% (Vedantam, Suresh, and Ajmal 2022). Denmark, operating a domestically integrated system with high-quality sorted material, was far less exposed to this shock. The contrast illustrates how structural dependence on export markets and poor material quality (both being products of fragmented governance and weak enforcement standards) undermine U.S. recycling resilience.

Economic Instruments: What Gets Rewarded Gets Done

Deposit-Refund Systems

Denmark's "pant" system – a mandatory deposit-refund program covering glass, plastic, and aluminum beverage containers – achieves return rates consistently above 90%, with 1.7 billion containers returned in 2020 alone (Malindžakova et al. 2022). The system works because it creates a direct, visible financial incentive for consumers at the point of purchase and at the point of return. Containers are eligible for refund at thousands of reverse vending machines in retail locations, meaning convenience and economic motivation are aligned. European DRS programs broadly demonstrate that return rates in the 83-98% range are reliably achievable when deposit amounts are meaningful and infrastructure is accessible (Gorgun, Adsal, and Misir 2021).

The U.S. has deposit programs in only about ten states, with varying deposit values and inconsistent infrastructure. Research on California's “CRV” program, which is the most well-developed U.S. example, found that the deposit successfully drives participation, particularly among lower-income households who represent 69% of CRV redeemers, and that program design details (location of redemption centers, hours of operation) matter as much as the deposit amount itself (Berck et al. 2021). This points to a critical design lesson: a bottle bill is only as effective as the network of return points supporting it. States that have not adopted deposit programs continue to lose recoverable material to landfills at high rates, with no economic signal to change behavior.

Pay-As-You-Throw and Waste Taxes

Denmark pairs the deposit system with pay-as-you-throw (PAYT) pricing, under which waste disposal fees vary based on how much waste is generated. This creates an ongoing financial incentive to reduce waste and sort recyclables correctly. Research across European contexts has found that PAYT systems reliably increase recycling rates, with Dutch municipalities seeing gains of 5-10% (Gradus, Homsy, and Liao 2019). Environmental taxes on

incineration and landfill disposal further raise the relative cost of not recycling, making the overall incentive environment coherent.

PAYT programs cover fewer than one in ten U.S. households (Gradus, Homsy, and Liao 2019). Flat-rate or tax-funded waste collection is the norm in most American communities, but it provides no price signal to reduce waste or sort carefully. Without this, the economics of recycling fall entirely on MRF operators and commodity markets, which are volatile and frequently work against diversion and recycling due to the complexity of these activities versus sourcing virgin materials.

Infrastructure: Sorting Quality Determines Outcomes

Denmark has invested systematically in advanced sorting infrastructure, including automated MRFs with optical sorters, sensor-based classification, and AI-assisted separation. These are paired with centralized data systems that track material flows, contamination rates, and facility performance in real time. Co-located composting, incineration, and recycling facilities in many Danish regions allow resource optimization across the waste stream. This infrastructure supports high material purity, which is what makes Danish recyclables attractive to processors and European secondary material markets.

U.S. infrastructure is more uneven. Well-funded cities have invested in modern MRFs and organics processing; many communities (particularly rural and lower-income areas) rely on aging equipment or lack facilities altogether. The absence of a centralized data infrastructure means that even basic performance metrics, such as what share of curbside-collected recyclables are actually processed versus landfilled, are often unavailable at the national level. This data gap impedes both evidence-based policymaking and public trust in the system.

One proposed structural remedy for U.S. market fragility is the development of exchange-traded futures contracts for post-consumer materials (PCMs), which would introduce price transparency, reduce volatility, and give large buyers and sellers a mechanism for managing risk. These are functions that organized commodity markets perform for agricultural and energy products (Howell, Moore, and Folkinshteyn 2022). A futures market for PCMs would not replace infrastructure investment, but it could reduce the market volatility that currently makes investment decisions for MRF operators unnecessarily risky.

Public Engagement: Trust, Clarity, and Civic Culture

Danish recycling performance is not merely a product of policy and infrastructure, but instead reflects a civic culture in which waste sorting is understood as a shared responsibility. Environmental education begins in primary schools and is reinforced by consistent public messaging and visible infrastructure (Christensen et al. 2021). Standardized bins, clear instructions, and digital tools reduce confusion and make correct sorting the path of least resistance. Citizens generally trust that the materials they sort are actually recycled, which sustains participation.

In the U.S., inconsistent messaging across jurisdictions contributes to widespread confusion about what can be recycled and how. Public trust has been further eroded by

documented cases in which curbside-collected recyclables were sent to landfill; this problem that became more visible after National Sword disrupted markets (Vedantam et al. 2022). Research on EU recycling systems has found that institutional trust is a significant predictor of recycling performance at the national level. When residents trust that the institutions managing their waste are doing so competently and transparently, participation increases (Pronti and Zoboli 2024). Building that trust in the U.S. context requires not just better messaging but a demonstrably more reliable system.

Governance: Who Is Responsible for What

Denmark's system demonstrates that effective recycling does not require centralized administration of day-to-day operations, but rather that it requires centralized standard-setting combined with well-resourced local execution. National legislation establishes targets and uniform rules; municipalities, often working through joint waste companies and regional bodies, implement them with the capacity and mandate to do so effectively. A two-way data infrastructure connects local performance to national oversight, enabling adaptive governance.

The U.S. system inverts this: local governments bear primary responsibility but often lack resources, technical capacity, and consistent state or federal support. Without national mandates, there is no unified data reporting, no shared benchmarks, and limited mechanism for collective learning across jurisdictions (Tan et al. 2021). EPR frameworks in Europe, including Finland's well-documented reverse logistics system covering batteries, paper, packaging, vehicles, and electronics, show that shifting financial and operational responsibility from municipalities to producers through binding laws and clear compliance infrastructure dramatically improves both consistency and performance (Mayanti and Helo 2023).

Key Findings

The gap between U.S. and Danish recycling performance is primarily structural. That is to say, Denmark has not achieved high recycling rates because Danish citizens are unusually motivated, it has achieved them because the policy and institutional environment makes recycling the rational, convenient, and financially rewarded choice at every level of the system. What is interesting is that the U.S. has the individual pieces in many instances, such as deposit laws in some states, PAYT programs in some municipalities, and EPR laws for some products, but it lacks the coherence that makes them add up. Specifically:

- Fragmented governance produces fragmented outcomes. Without national standards and binding EPR obligations, recycling performance in the U.S. is determined largely by local political will and budget availability, producing large disparities across communities and no reliable floor.
- Financial incentives must be designed, not assumed. Denmark's pant system and PAYT pricing create coherent economic signals throughout the system. The U.S. relies primarily on mandates and voluntary behavior, which are less reliable drivers of participation and quality.

- Infrastructure investment follows policy certainty. Danish processors, municipalities, and producers invest in advanced sorting and recovery infrastructure because they operate in a stable, predictable policy environment. U.S. market volatility discourages investment and perpetuates reliance on export markets for low-quality material, which may suddenly go offline (as the National Sword episode demonstrated).
- Public trust is a system output, not an input. Consistent rules, visible infrastructure, and reliable processing outcomes build the civic trust that sustains high participation. Inconsistency and opacity erode it.

Recommendations

- Establish a national (or even statewide) recycling strategy with binding targets and minimum performance standards, providing the foundation that currently does not exist.
- Expand EPR legislation nationally, including operational accountability mechanisms such as Producer Responsibility Organizations, rather than content-only mandates. Finland and other Nordic models offer useful implementation templates (Mayanti and Helo 2023).
- Create a national deposit-return framework for beverage containers, with attention to redemption center accessibility. Research on the California CRV program makes clear that location, hours, and wait times drive participation as much as deposit amounts do (Berck et al. 2021).
- Scale PAYT programs with federal support, including technical assistance and equity provisions for lower-income communities where unit-based pricing creates disproportionate burdens (Gradus, Homsy, and Liao 2019).
- Invest in national data infrastructure and standardized reporting so that recycling performance can be tracked, compared, and improved at the system level. This a prerequisite for evidence-based policymaking, and some states have attempted to do something like this already.
- Explore market-stabilization mechanisms for post-consumer materials, including exchange-traded futures contracts, to reduce the price volatility that discourages domestic processing investment (Howell, Moore, and Folkinshteyn 2022).

References

Berck, Peter, Marshall Blundell, Gabriel Englander, Samantha Gold, Shelley He, Janet Horsager, Scott Kaplan, Molly Sears, Andrew Stevens, Carly Trachtman, Rebecca Taylor, and Sofia B. Villas-Boas. 2021. "Recycling Policies, Behavior and Convenience: Survey Evidence from the CalRecycle Program." *Applied Economic Perspectives and Policy* 43(2): 641-658. https://doi.org/10.1002/aepp.13117

Christensen, D., Hjul-Nielsen, J., Moalem, R.M., Johansen, B. (2021). "Circular Economy in Denmark: Bornholm's Vision to Achieve 100 Percent Reuse and Recycling." In: Ghosh, S.K., Ghosh, S.K. (eds) *Circular Economy: Recent Trends in Global Perspective*. Springer, Singapore. https://doi.org/10.1007/978-981-16-0913-8_13

Gorgun, Erdem, Kardelen Adsal, and Aybike Misir. 2021. "Deposit Refund System for Beverage Containers as a Best Practice Example for Recycling Maximization." *Environmental Research and Technology* 4(3): 199-205. https://doi.org/10.35208/ert.862611

Gradus, Raymond, George C. Homsy, and Lu Liao. 2019. "Which US Municipalities Adopt Pay-As-You-Throw and Curbside Recycling?" *Resources, Conservation and Recycling* 143: 178-183. https://doi.org/10.1016/j.resconrec.2018.12.012

Howell, Jordan P., Jordan Moore, and Daniel Folkinshteyn. 2022. "The Potential for Exchange-Traded Futures on Recycled Materials to Improve Recycling Efficiency." *Investment Management and Financial Innovations* 19(3): 93-104.

Malindžakova, Marcela, Jana Stofkova, and Milan Majernık. 2022. "Economic-Environmental Performance of Reverse Logistics of Disposable Beverage Packaging." *Sustainability* 14(13): 7544. https://doi.org/10.3390/su14137544

Mayanti, Bening, and Petri Helo. 2023. "Circular Economy through Waste Reverse Logistics under Extended Producer Responsibility in Finland." *Waste Management and Research* 42(1): 59-73. https://doi.org/10.1177/0734242x231168801

Pronti, Andrea, and Roberto Zoboli. 2024. "Institutional Quality, Trust in Institutions, and Waste Recycling Performance in the EU27." *Sustainability* 16(2): 892. https://doi.org/10.3390/su16020892

Tan, Juan, Mathias V. Wehde, Frederik Brønd, Per Kalvig. 2021. "Traded metal scrap, traded alloying elements: A case study of Denmark and implications for circular economy." *Resources, Conservation and Recycling* 168. https://doi.org/10.1016/j.resconrec.2020.105242.

Vedantam, Aditya, Nallan C. Suresh, and Khadija Ajmal. 2022. "Impact of China's National Sword Policy on the U.S. Landfill and Plastics Recycling Industry." *Sustainability* 14(4): 2456. https://doi.org/10.3390/su14042456

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