AI in Municipal Curbside Recycling

A Technology Overview and Industry Applications

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Marc Pfeiffer, Associate Director, Bloustein Local Center for Public Policy Research
Bloustein School of Planning and Public Policy
Rutgers University

Introduction

- Current challenges in municipal recycling:
  - High contamination rates (15-25% of collected material)
  - Rising operational costs
  - Inconsistent resident participation
- AI promise: Working smarter, not harder in waste management

Part 1: Key AI Technologies Explained

Machine Learning (ML)

- **Core concept:** Systems that learn from data without explicit programming
- **Types:**
  - Supervised learning (classification tasks)
  - Unsupervised learning (pattern recognition)
  - Reinforcement learning (optimization through feedback)
- **Key strength:** Can handle complex variables and continuous improvement

Computer Vision

- **Core concept:** AI systems that interpret visual information
- **Technologies:** Image recognition, object detection, segmentation
- **Key strength:** Can process visual data far faster than humans with increasing accuracy
- **Application process:** Recognizes images → searches across databases and video → provides input to control systems

Generative AI & Chatbots

- **Core concept:** AI systems that create new content and engage in human-like conversations
- **Components:**
  - Large language models
  - Content generation engines
  - Natural language processing
- **Key strength:** Understanding context, providing personalized responses, and generating relevant information on demand

Digital Twins

- **Core concept:** Virtual replicas of physical assets (e.g., layers of a GIS map) sitting in a computer's memory
- **Components:**
  - Real-time data feeds
  - Simulation capabilities
  - Predictive modeling
- **Key strength:** Enables testing scenarios without disrupting operations

Internet of Things (IoT) & Robotics

- **Core concept:** Connected devices that generate and respond to data
- **Components:** Sensors, communication infrastructure, control systems
- **Key strength:** Creates real-time operational visibility and automated responses
- **Robotics integration:** Physical automation systems guided by AI for performing repetitive or hazardous tasks

Part 2: AI Applications in Municipal Recycling

Collection Optimization

- **Dynamic routing:** ML algorithms that adjust collection routes based on fill levels, traffic, and seasonal patterns
- **Smart bins:** IoT-enabled containers that monitor contamination and fullness
- **Real-world impact:** 15-30% reduction in collection costs in early adopting cities

Material Recovery Facility (MRF) Intelligence

- **Advanced optical sorting:** Computer vision systems identifying materials with 95%+ accuracy
- **Robotic picking:** AI-guided robots removing contaminants or recovering high-value materials
- **Digital twin facilities:** Virtual MRFs that model and optimize operations before physical implementation

Resident Engagement

- **Recycling chatbots:** AI assistants answering "what goes where" questions instantly
- **Personalized feedback:** ML-driven communications about household recycling habits
- **Mobile applications:** Image recognition tools to scan items and provide disposal instructions

Data-Driven Decision Making

- **Predictive analytics:** Forecasting material volumes, commodity values, and system needs
- **Contamination mapping:** ML systems identifying neighborhood-level recycling behaviors
- **Performance dashboards:** Real-time visualization of key metrics for operators and policymakers

The End