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# A comparison of obstacles in emerging and developed nation dry waste recovery

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**Abstract**

In recent years recycling rates have begun plateauing below their full potential in developed nations. This paper presents a review of literature summarizing the major obstacles on municipal recyclables recovery and infers there is a link to the plateauing behaviour of recycling levels. It also aims to compare these major influences between emerging and developed countries, with the goal of highlighting the regions most in need of improvement. The major influences are categorized under six headings; government policy, technology and human resources, local recycling market, household education, government finances and household economics, Municipal Solid Waste (MSW) administration and personnel education. There is also a comparison between emerging and developed nations recycling system effectiveness. The conclusions of this paper will inform more effective policies in emerging and developed nations.

*Keywords:* recycling; review; emerging; developed

## 1. Introduction

Recycling is a key component of current waste reduction and plays an important role in preventing the waste of useful materials and the reduction of landfill. In Organisation for Economic Co-operation and Development (OECD) countries the recycling of materials initially saw rapid growth but more recently has begun to plateau. In Australia recycling rates have plateaued at about 30% of general municipal waste with some highly recyclable products, such as newsprint achieving recycling rates of 60-70% [1]. Sustainable manufacturing has previously been defined as 'the creation of manufactured products that use processes that minimise negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound' [2]. A 6R methodology has been emphasized in relation to Sustainable Manufacturing; reduce, reuse, recover, redesign, remanufacture, recycle [2]. This paper will focus upon the link between recycling and Sustainable Manufacturing.

The material recycling system is a complex system involving a diverse range of stakeholders and influencing factors. These factors range from the technical or economic, such as the value of materials, to social factors such as social norms and accepted behaviours. In this paper we use a literature review to identify key obstacles that can drive the current plateau in municipal kerbside recycling systems and carry out a comparison with the recycling barriers seen in developing countries. There is some ambiguity to the definition of emerging and developed economy status. In this paper we use the income criterion, Gross National Income (GNI) per capita, and the 2014 UN World Economic Situation and Prospects report as the main measures for development [2]. Australia is classed as a high income nation; Brazil, China, Peru and Romania as upper-middle-income; and the remaining countries being lower-middle-income and low income (see Table 1 for income brackets) [3].

Table 1. World Bank GNI income categories [3]

| Income categories (US $ per annum) | |
| --- | --- |
| Low Income | $1045 or less |
| Lower Middle Income | $1046 - $4125 |
| Upper Middle Income | $4126 - $12735 |
| High Income | $12736 or more |

Section two presents the data from past literature on obstacles of recycling levels and contrasts between emerging and developed nations. The major obstacles have been categorised under six headings; government policy, technology and human resources, local recycling market, household education, government finances and household economics, Municipal Solid Waste (MSW) administration and personnel education. Section three offers some measures that may be used to measure the effectiveness of recycling systems in developed and emerging economies, and presents some of the contrasts seen.

## 2. A comparison of recycling obstacles in developing and developed nations

### 2.1. Government Policy

There is evidence that in emerging countries it is the lack or instability of government policy that effects recycling levels [4]. It is interesting to observe the evolution of waste related government policies in developed nations. Early environmental policies were relatively broad, mandating air and water pollution limits and contained limited overlap with waste disposal services [5]. As landfills neared capacity and social consensus formed behind waste mitigation, material recovery policies were often introduced [6]. Examples include formal kerbside collection systems, the setting of state recycling targets, and the mandating of data collection and annual waste reporting [6]. More recently landfill disincentives and Extended Producer Responsibility (EPR) have become more common [6]. In Australia, landfill levies have been used to dissuade landfill use which has had particular impact on Construction & Demolition and Commercial & Industrial waste flows [6]. In Europe there has been a move towards EPR, a policy type that puts greater onus for disposal upon manufactures [7]. Out of a sample of emerging nations (seen in Table 1) there are indications that Brazil is putting greater emphasis on material recovery, including EPR type commitments in their 2010 Solid Waste Policy [8]. In contrast, China show indications of placing greater focus on waste-to-energy disposal, in the form of incineration [9].

Table 2. Summary of status of federal and state government policies (state policies are considered when they exist in a majority of states)

| | Environmental Protection Laws | Material Recovery Incentive | Landfill Disincentives | EPR |
| --- | --- | --- | --- | --- |
| Mauritius[10] | ✓ | ✗ | ✗ | ✗ |
| China[9] | ✓ | ✗ | ✗ | ✗ |
| Brazil[8] | ✓ | ✗ | ✗ | ✓ |
| Nepal[11] | ✓ | ✗ | ✗ | ✗ |
| Vietnam[12] | ✓ | ✗ | ✗ | ✗ |

Municipal waste policies are generally controlled by local governments in developed nations. Policy types typically fall under four main categories; education, system enhancement, rewards and punishments [13].

### 2.2. Technology and Human Resources

The availability and effective use of technology and the human workforce are also potential influences on recycling levels. This relates to the presence and efficiency of formal or informal collection and separation by scavengers, the municipality, or private contractors. It is also necessary to consider the state of assessment of generation and recovery rates, to determine the composition of waste stream.

There is contrast between generic MSW system structures in emerging and developed countries. Emerging nations tend to have a single waste flow with general waste and recyclables combined [14]. There is often an informal recycling sector, which may separate waste by buying recyclables directly from households, or scavenging from a transfer station or landfill [14]. Poor average wages and low prices for products and services create viable profit margins from collecting and selling recyclable waste [15]. The importance of the technical component of recycling is greater in developed nations, whereas human labour cost component is significant in developed countries [15].

Waste characterization is a necessary process in order to understand and subsequently improve material recovery. Waste characterization involves the assessment of generation, recovery rates, and composition of the waste stream [16]. This is well established in developed nations but not in emerging economies. This can prove a major obstacle when planning the introduction of a recycling procedure. This data is necessary to determine the 'best-fit' MSW system. Existing waste audits indicate that emerging and developed countries consistently show different waste compositions [16]. Emerging nations have higher proportions of organic waste and lower levels of dry recyclables.

Table 3. Summary of key technology and human labour influences

| | Emerging | Developed |
| --- | --- | --- |
| Waste collection system | Single stream[14] | Dual stream (Minimum)[15] |
| Separation system | Informal[14] | Formal[15] |
| Waste characterization | Rare[16] | Present (Annual audits)[16] |