

# Analysis of recyclability of M1 automotive products in China based on different material classifications

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**Abstract.** The paper systematically analyzes the recyclability of more than 10000 M1 automotive products in China. The application of automotive materials is studied from five aspects: the average level of vehicle recyclability, different lines, different categories, traditional and new energy vehicles, and the application of different materials. Through comparative analysis of the application of different materials to provide data support for the automotive industry.

**Keywords:** Digital Economy; Corporate Branding; Risk Prevention

## 1. Introduction

After a large number of automotive products are scrapped, if they cannot be reasonably recycled, it will cause a serious waste of resources[1]. In recent years, the international community has paid great attention to the design of easy disassembly and easy recycling from the design side, and promoted the improvement of the comprehensive utilization rate of resources[2~4]. As early as 2005, the European Union proposed that the recyclable rate of M1 and N1 automotive products should reach more than 95% and the recyclable rate should reach more than 85%. Later, South Korea also put forward the same requirements for automotive products sold in its own country. Since 2015, China has issued the requirements for the management of hazardous substances and recyclability of automobiles, which states that from January 1, 2016, the recyclability of passenger vehicles (category M1) with a total seating capacity of no more than nine seats should be calculated according to relevant standards and specifications, and relevant supporting materials should be submitted. The implementation of the policy has promoted the research, development and application of automotive green materials. Up to now, the recyclability rate of most M1 automotive products in China can reach more than 95%, meeting the certification requirements of the European Union.

## 2. Research methods

### 2.1 recyclability rate (Rcyc)

The paper analyzes the material data of more than 10000 domestic automotive products. According to the different material types and quality of the whole vehicle, study the reusable rate of single vehicle. Calculate the recyclability rate of single vehicle according to formula (1):

$$R_{cov} = \frac{m_p + m_d + m_m + m_{Tr}}{m_v} \times 100\%$$

(1)

Where:

Rcyc—recyclability rate,%;

mp —material quality in pretreatment stage, kg;

mm—material quality considered in the metal separation stage, kg;

mTr——material quality considered in the non-metallic residue stage, kg;

mv——vehicle weight, kg.

## 2.2 recoverability rate (Rcov)

Calculate the recoverability rate according to formula (2):

$$R_{cov} = \frac{m_p + m_d + m_m + m_{Tr} + m_{Te}}{m_v} \times 100\%$$

..... (2)

Where:

Rcyc——recyclability rate,%;

mp ——material quality in pretreatment stage, kg;

mm——material quality considered in the metal separation stage, kg;

mTr——material quality considered in the non-metallic residue stage, kg;

mTe——Material quality considered in the non-metallic residue stage, kg;

mv——vehicle weight, kg.

## 3. Results and analysis

### 3.1 weight analysis of M1 automobile products from 2016 to 2021

The weight of M1 vehicles in China from 2016 to 2021 is shown in Figure 1. In 2016, the whole vehicle weight of M1 automotive products in China was the smallest, about 1514.8kg. In 2021, the whole vehicle weight of M1 automotive products in China was the largest, about 1679.1kg. Compared with 2016, the weight of M1 automotive products in 2021 increased by 10.85%. At the same time, the average annual growth rate of vehicle quality is 2.08%, which is mainly due to the gradual trend of large-scale vehicle design. In the past, small cars and mini cars were widely used. But now, the number of multi-function passenger vehicles and SUV vehicles is increasing, and the average weight of vehicles is also increasing.

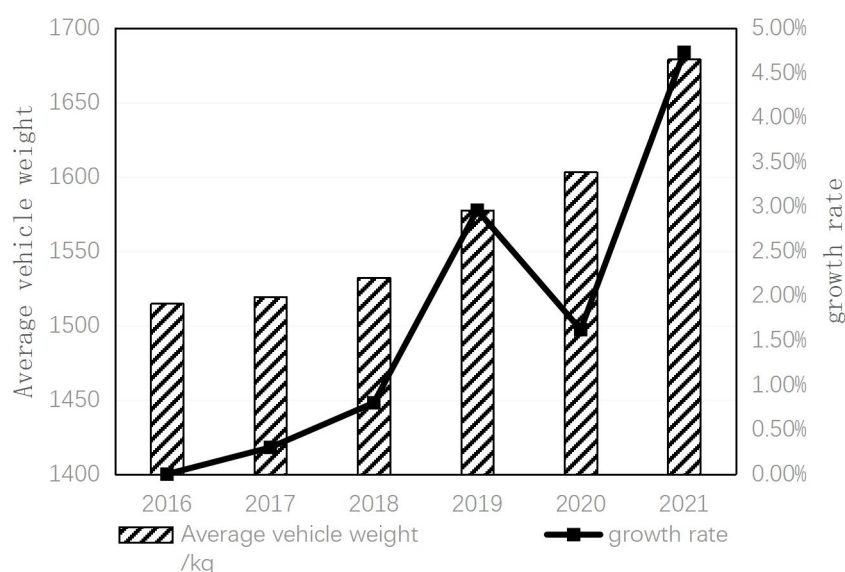


Figure 1. Analysis diagram of vehicle weight from 2016 to 2021

### 3.2 analysis of recyclability level of M1 automotive products from 2016 to 2021

The recyclability level of M1 vehicles in China from 2016 to 2021 is shown in Figure 2. In terms of recyclability rate (rcov), the rcov of M1 passenger cars in China was the smallest in 2016, about 96.4%. In 2021, the rcov of M1 passenger cars in China was the largest, about 97.1%. The recyclable rate shows an annual growth trend. In terms of reusability rate (rcyc), China's M1 passenger cars had the largest rcyc in 2021, about 92.8%. In 2016, the rcyc of M1 passenger cars in China was the largest, about 91.5%. On the whole, the recycling rate of M1 passenger cars in China shows an annual increase. In 2021, compared with 2016, the rcyc of M1 passenger cars in China increased by about 1.42%.

With the implementation of relevant policies, detachable and recyclable materials have been continuously applied and promoted, and rcov and rcyc show an increasing trend year by year.

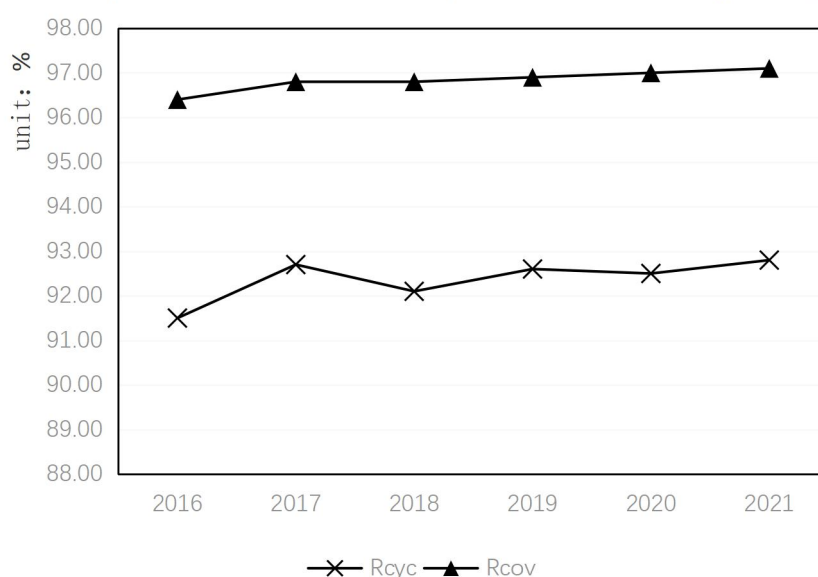
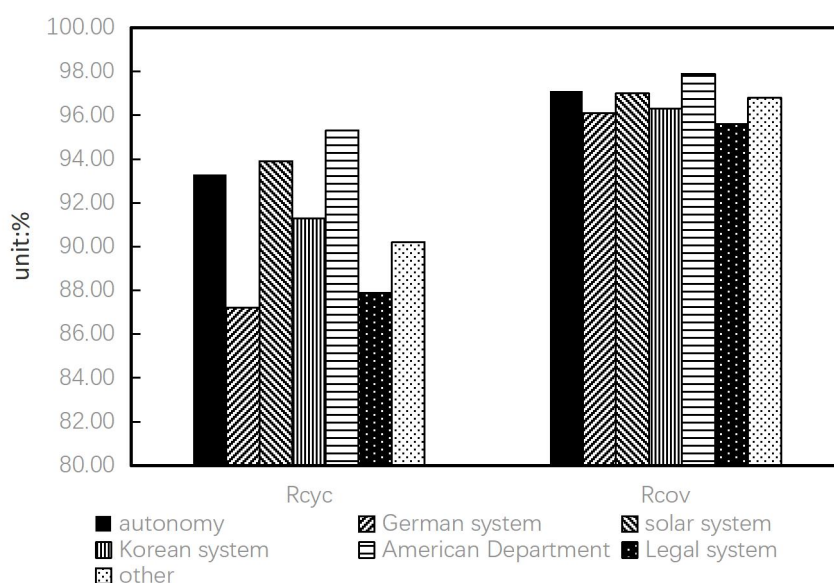


Figure 2. Analysis chart of recyclability level of automotive products from 2016 to 2021

### 3.3 analysis of recyclability level of different vehicle lines in 2021

In order to analyze the level of recyclability of different vehicles, automotive products are divided into seven different types: autonomous, German, Japanese, Korean, American, legal and others. According to the statistical analysis of the situation in 2021, in terms of the reutilization rate (rcyc), American brand M1 passenger cars have the highest reutilization rate, about 95.3%; The second is M1 passenger cars of Japanese and independent brands, with the reuse rate of about 93.9% and 93.3% respectively; The reusable rate of M1 passenger cars of German brands is the lowest, about 87.2%. In terms of recyclability rate (rcov), the recyclability rate of American brand passenger cars is still the highest, 97.9%; Followed by independent and Japanese brand cars, 97.1% and 97.0% respectively; Legal brand cars are the lowest, 95.6%.



**Figure 3.** Analysis of recyclability of different vehicle lines in 2021

German and French brands have relatively low rcyc and rcov, which is mainly due to the fact that automobile enterprises in the European Union do not include some materials in the recyclable stage when calculating the theoretical recycling rate, resulting in the low value of the theoretical two rates they calculate. For example, some German enterprises include plastic parts less than 100g in the non recyclable range. At the same time, in the recycling stage of MTR, German brand automobile manufacturers do not include any materials, and the material quality of this part is 0.

### 3.4 analysis of recyclability level of different models in 2021

According to the analysis of the recyclability level of different models in 2021, the results are shown in Figure 4. Among them, cars and off-road vehicles have the highest recycling rate (Rcoy), which is 93.1%; Multipurpose passenger vehicles were slightly lower, at 92.6%. In terms of recyclability (rcov), cars and off-road vehicles are still the highest, 97.3%. Multipurpose passenger vehicles were slightly lower, at 96.9%. Through analysis, the reusability rate (Rcoy) and recyclability rate (Rcov) of multipurpose passenger vehicles are lower than the other two models. The main reason may be related to the large proportion of minibuses in multi-purpose passenger vehicles, the low configuration of minibuses and the use of less recyclable materials. The high recycling rate of off-road vehicles is related to the structural characteristics of off-road vehicles. Off road vehicles have relatively more metal materials and a high recycling rate. Because the car design takes comfort into account, it contains more interior trim and has a relatively high recycling rate[5].

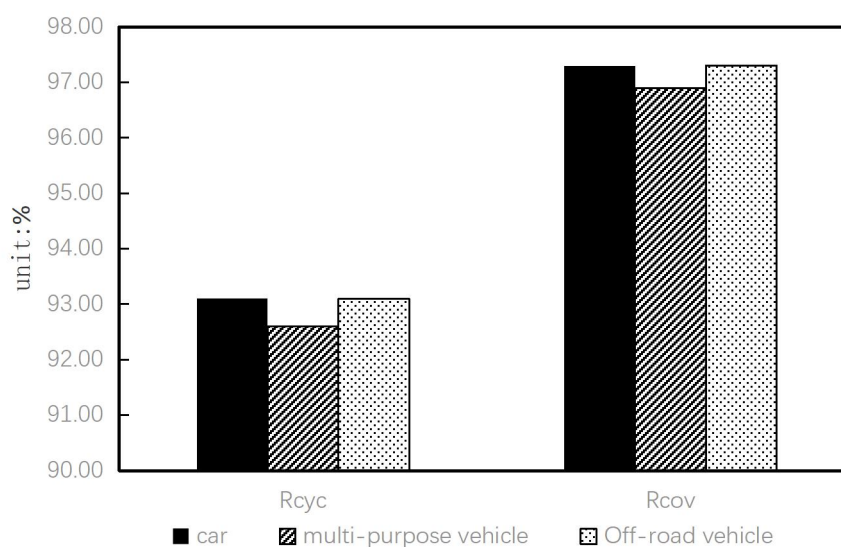


Figure 4. Analysis of recyclability of different models in 2021

### 3.5 analysis of recyclability level of traditional / new energy vehicles in 2021

The recyclability level of traditional and new energy vehicles in 2021 is shown in Figure 5. According to the data, in 2021, the recyclability rate (Rcy) of traditional and new energy vehicles were about 92.4% and 93.4% respectively, and the reusability rate (Rcv) were about 96.9% and 97.3% respectively. It can be seen that the reusability and recyclability of new energy vehicles in 2021 are slightly higher than that of traditional vehicles.

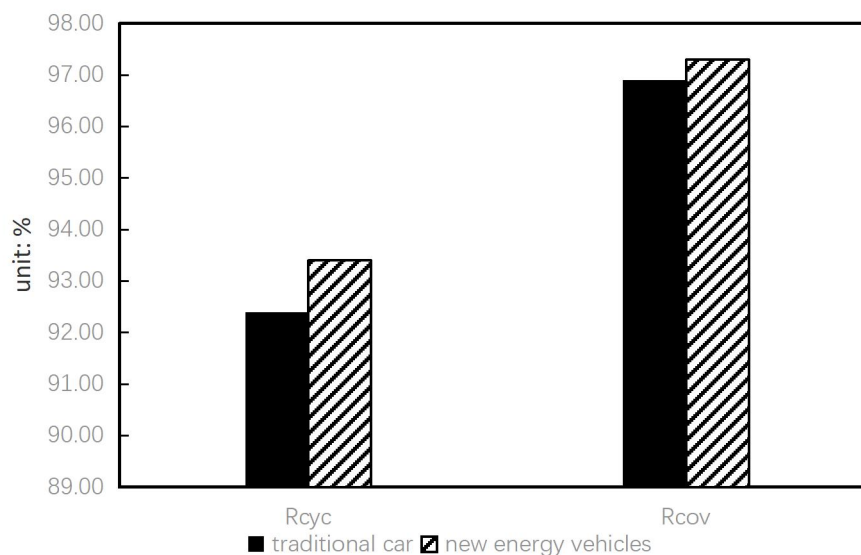


Figure 5. Analysis of recyclability of traditional / new energy vehicles in 2021

On the whole, there is little difference between the reusability and recyclability of traditional cars and new energy. However, at present, domestic M1 new energy vehicles are mainly A00 and A0 minicars, so the level of recyclability is relatively high.

### 3.6 Usage of materials in different categories of M1 models

By analyzing the consumption of metal, polymer (except rubber), rubber, glass, liquid, improved organic natural substances, and other materials in M1 automotive products [6~8], it can be seen that at present, the consumption of metal materials in automotive products is the largest, with an average of 1180.kg, accounting for 70.3% of the vehicle mass. The second is polymer (except rubber), with

an average mass of 230.5kg, accounting for 13.7%. The consumption of rubber and liquid is similar, 68.5kg and 61.0kg respectively, accounting for 4.1% and 3.6% respectively. The amount of improved organic natural substances is the least, accounting for only 0.4%.

Table 1. Material usage of M1 automotive products in 2021

Material category	Weight/kg	Proportion
Metal	1180.1	70.3%
Polymer (except rubber)	230.5	13.7%
Rubber	68.5	4.1%
Glass	48.9	2.9%
Liquid	61.0	3.6%
Improved organic natural substances	5.9	0.4%
Other	84.2	5.0%

### 3.7 Different recycling stages of M1 models

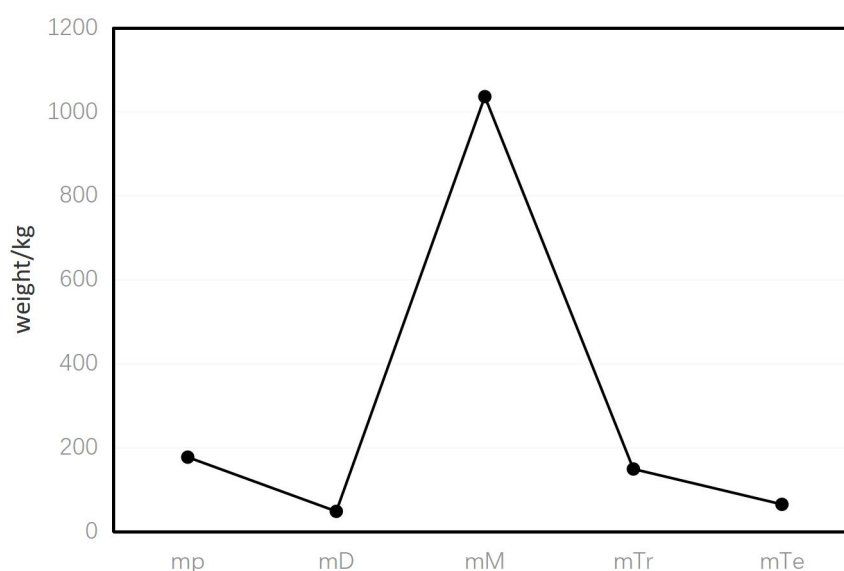


Figure 6. Material weight analysis diagram of M1 automotive products at different recycling stages

By analyzing the weight of materials in different recycling stages of M1 automotive products, it can be seen that at present, the proportion of Mm stage in automotive materials is the largest, with a weight of 1035.9kg. Secondly, the materials in MP and MTR stages, with weights of 176.9kg and 148.7kg respectively. The material consumption in MD stage is the least, about 47.8kg. This is also because the materials in the MM stage are mainly metal materials, which are used most in automotive products, followed by some liquid and plastic materials. In the disassembly stage, fewer parts are included, so the weight is relatively small.

## 4. Conclusion

This paper analyzes and studies the recycling rate (rcyc) and recyclability rate (rcov) of more than 10000 M1 automotive products, as well as the use of different types of materials. The following conclusions can be drawn:

- 1 ) From 2016 to 2021, the weight of M1 vehicles in China basically showed an upward trend year by year, and the recyclable rate and recyclable rate gradually increased.
- 2 ) The reusability and recyclability of cars and off-road vehicles are higher than that of multipurpose passenger vehicles.

3) In 2021, the reusability and recyclability of new energy vehicles are slightly higher than that of traditional vehicles.

4) Among different automotive materials, metal materials account for the largest proportion, followed by polymers (except rubber), and improved organic natural substances account for the smallest proportion.

To sum up, the release and implementation of national policies has guided the industry to continue to pay attention to the application of automotive green materials, the level of recyclability has been continuously improved, and the theoretical two rate values have also shown an increasing trend year by year.

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