



## Research on Reverse Logistics Network Design of Household Appliances Based on Green Logistics

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### Abstract

This paper first introduced the connotation of the household appliances reverse logistics, analyzed the characteristics of the household appliances reverse logistics based on green logistics, followed by comparison between household appliances reverse Logistics and general reverse logistics; Then gave the network construction elements; Finally put forward suitable design methods for such network.

**Keywords:** Green logistics, Household appliance, Reverse logistics, Network design method

### 1. Introduction

China is a big country of production and consumption for household appliances. As a special type of waste, if not properly handled, it will inevitably lead to soil or water pollution, affecting human health, and constraint the sustainable development of appliance industry. It can be an important topic that carries out less pollution green household appliances recycling.

Household appliances are comprehensive industrial products composing of metals, plastics and chemical materials, and are toxic explosive hazardous waste. This shows that it is necessary and imperative to study household appliances reverse logistics. Because household appliances have a lot of toxic substances, in order to protect the environment, in line with today's subject of green development, study of household appliances reverse logistics network design method should also be put forward in the green logistics. At the same time, household appliance is a particular general waste, so the network design ways are also different.

### 2. The definition of meaning

#### 2.1 Household appliances Reverse Logistics

1998 Council of American Logistics Management (CLM) pointed out that "reverse logistics is a process that in order to recycle resources or deal with the waste materials, at a reasonable cost, move items from consumer end to the production point."(Stock J R,1992)

Reverse logistics refers to collection, classification, the demolition of the processing, packaging, re-distribution, etc

(KoPichy RJ, 1993). In accordance with household appliances, transport items to the treatment site to form the articles entities flow. In the household appliances reverse logistics activities, main is the corresponding funds and information. The purpose of the flow is as much as possible to obtain the value of household appliances, and dispose them to avoid waste of resources and to reduce pollution.

### 2.2 Green Logistics

Green Logistics is an environment logistics system which include both from raw material acquisition, product manufacturing, packaging, transportation, storage, to the green logistics process before reaching customers, and waste recycling and reverse disposal. Green Logistics emphasized that the process of inhibition in the logistics will do harm to the environment.

### 3. Reverse logistics flow

In practice, general waste is often carried out by the National Sanitation departments (Fleischmann M, 2001, P.156-173). Under normal circumstances waste are all transported to the nearest waste disposal sites by the sanitation workers, being stored through a series of technical means, the re-use and not re-use material were piled up, and then the two substances were respectively treated. In addition, the value of general solid waste is not very high, and no harm (except hazardous waste, the same below), therefore no law made enterprise take part in.

The flow of reverse logistics based on green logistics in practice is relatively complicated, and its implementation is shown as Figure 1.

### 4. Network design factors

#### 4.1 Network Nodes

Recovery node. Because the source of household appliances is often scattered, so it can not focus on a transfer to the receiving point. According to the source of household appliances and characteristics, what should decision is setting up many dispersed recycle bins, or concentrated small recycle bins, and or different levels of recycle center.

Sorting node. Different types, different quality, different situation household appliances can be used effectively after the necessary sorting. Concentrate sorting can be used to make the household appliances fully utilized through making use of a large scale equipments and high technology, but high transport costs. Sorting can sometimes scattered in the recycle bin, and no value waste can be directly sent to the disposal centers for harmless treatment, using effective way to avoid no use materials to enter the recycling network, saving transport costs.

Re-treatment Center. The recycling of household appliances is the core in the recycling network. It's the key to build an entire household appliance network that decides the site and the size.

#### 4.2 Network Level

General material is not high value, no serious harm (except hazardous waste), and usually basically treatment facilities and equipment can be able to meet the need. General reverse logistics recovery network's core function is disposal, not having many levels.

Household appliances are complex, high-tech, and potentially harmful, so it must be handled by specialized centers or back to manufacturers in order to reduce pollution, and realize the objects of green logistics. So household appliance recycling network has a more layer than the general reverse logistics network, that is, the re-treatment center, which is a different place between the household appliance recycling network and general reverse logistics network. Based on the green logistics household appliance recycling network is as shown in Figure 2 and core function is the deep processing of household appliances.

Insert Figure 1 here

Insert Figure 2 here

#### 4.3 Waste Disposal Site Settings

For general waste, there is no law expressly requested manufacturers to implement waste logistics (Fleischmann M, 2000, P.653-666), so recycle bin is unified required to plan and construct by environmental protection departments. As to the household appliance, whether foreign or domestic, it explicitly required appliance manufacturers to be responsible for recycling of waste treatment, with emphasis on the harm to the environment. At the same time, realize the purification, so that the logistics resources can be fully used.

General waste can be locally destroyed, or transported to the relevant departments. The location of waste disposal can not be considered in the overall network, but choose to directly focus. But household appliances are particular, because there are a large number of toxic substances. Meanwhile it should stick to relevant environmental laws and regulations. Some household appliance should not be carried out to other place, can only be disposed locally.

#### 4.4 Network Openness

Most main aspects of general reverse logistics are simple, easy to handle, therefore the degree of openness is more clear and easy to design.

Household appliance reverse logistics depending on different subjects shows different characteristics in the degree of openness in its network. The recycling for parts and raw materials is generally open-loop structure; that is to say, the end point of household appliance will not be back to the original manufacturers or suppliers, not used by other manufacturers.

In need of repair or renovation it usually points the original source, belonging to the closed-loop structure. In reality, in order to better establish the overall network, a composite structure is used in the household appliance reverse logistics network design. It is as shown in Figure 3.

Insert Figure 3 here

#### 5. Network design methods

Compared to the general reverse logistics networks, household appliances reverse logistics network design based on the green logistics has its own characteristics, so it should not also adopt the general approach in the network design method. It should focus on a new network design method. In this paper, because the study on household appliances reverse logistics network in the hierarchical structure is more complex, at the same time green environmental protection becomes the focus, and therefore, this network design method used the Theory of Constraints (TOC)

Theory of Constraints are about to improve and best implement these management concepts and principles, then it can help enterprises realize the constraints - referred to as "bound" and further pointed out how to use the necessary improvements to eliminate constraints, so as to effectively realize goals (HuTung, 2002, P.457-473). Meanwhile industrial pollution will also make some improvements. According to this article related network characteristics and requirements of Green Logistics, TOC theory emphasize the following three points: (1) to increase effective Throughput; (2) reduce inventory; (3) reduce operating costs; (4) reduce pollution

Assuming that the network has three components, namely the consumer market (recovery point), testing center and the secondary market (demand points). First instruct the involving variables in the following methods.

Symbol:

$i$  — the recovery number after treatment by the test center product

$j$  — Recycling product number

$m$  — Demand point number (secondary market)

$u$  — Recovery point number

$t$  — Testing Center Number

Decision variable:

$X_{im}$  — after treatment the  $i$  product quantity delivering from the  $t$  testing center to the  $m$  demand point

$X_{ju}$  — the  $j$  recycled products quantity delivering from the  $U$  recovered point to the  $t$  testing center

Model parameters Description:

$P_{im}$  — the accept price of the  $i$  recycled product after treatment for the  $m$  demand point

$C_{ju}$  — Unit transportation cost of the  $j$  recycling products delivering from the  $u$  a recovery point to the  $t$  testing center

$C_{im}$  — Unit transportation cost treatment of the treatment  $i$  product delivering from the  $t$  testing center to the first  $m$  demand point

$P_j$  — Unit recycling prices of the  $j$  Recycling Product

$\theta_{ju}$  — Largest supply for recovery point  $u$  to the  $j$  Recycling Product

$\eta_{ij}$  — Into the  $i$  Recycling Product largest supply

$\mu^t$  — the  $t$  testing centers available capacity

$D_{im}$  — the demand for the  $m$  demand point to the  $i$  Products

$V$  — Unit consumption costs needed to deal with pollution in the whole delivering process

Based on the above symbol, we will build the network design model.

$$\max T = \sum_{i=1}^I \sum_{t=1}^T \sum_{m=1}^M P_{im} X_{imt} - \sum_{j=1}^J \sum_{t=1}^T \sum_{u=1}^U (C_{ju} + p_j + V) X_{jut}$$

$$s.t. \sum_{j=1}^J \sum_{t=1}^T X_{jut} \leq \theta_{ju} \quad (1)$$

$$\sum_{i=1}^I \sum_{m=1}^M \eta_{ij} X_{itm} \leq \sum_{u=1}^U X_{jut} \quad (2)$$

$$\min \mu_t \leq \sum_{i=1}^I \sum_{m=1}^M X_{itm} \leq \max \mu_t \quad (3)$$

$$\sum_{t=1}^T X_{itm} \leq D_{im} \quad (4)$$

$$X_{itm}, X_{jut} \geq 0 \quad (5)$$

## 6. Conclusions

Recycling of household appliances is in fact a system of social engineering. This paper proposed several aspects of network design which should be paid attention to, then use TOC theory to design the reverse logistics net, considering pollution factors. Through this method it can solve the particularity of household appliances reverse logistics network design. All provide effective ways to green design for household appliance reverse logistics.

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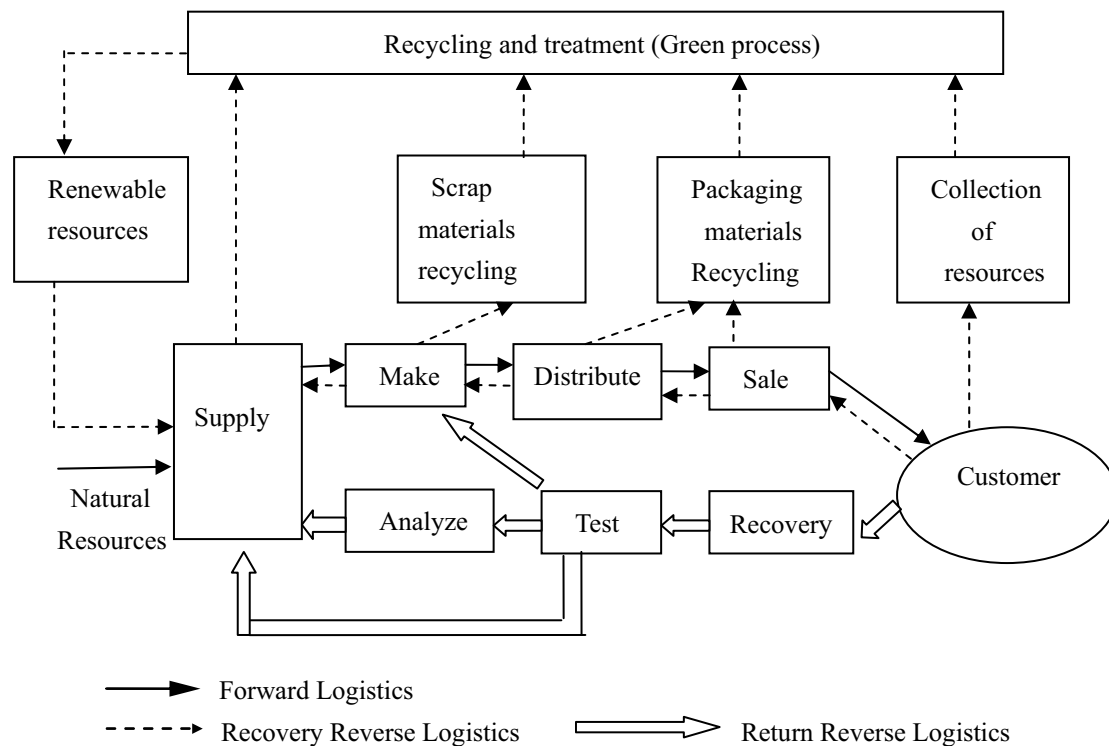


Figure 1. Flow of Reverse Logistics Based on Green Logistics

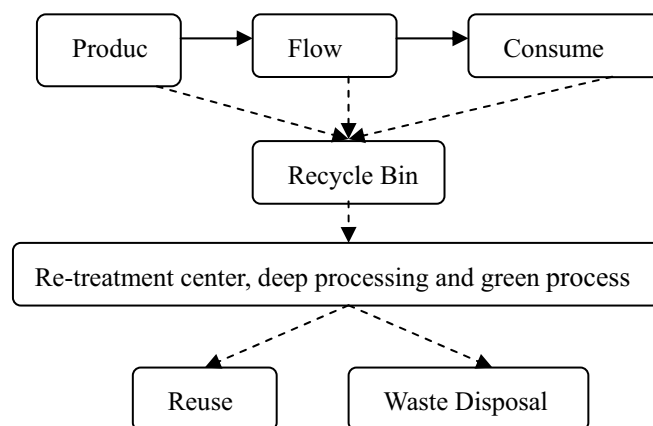


Figure 2. Reverse Logistics recycling network of waste home appliances based on Green Logistics

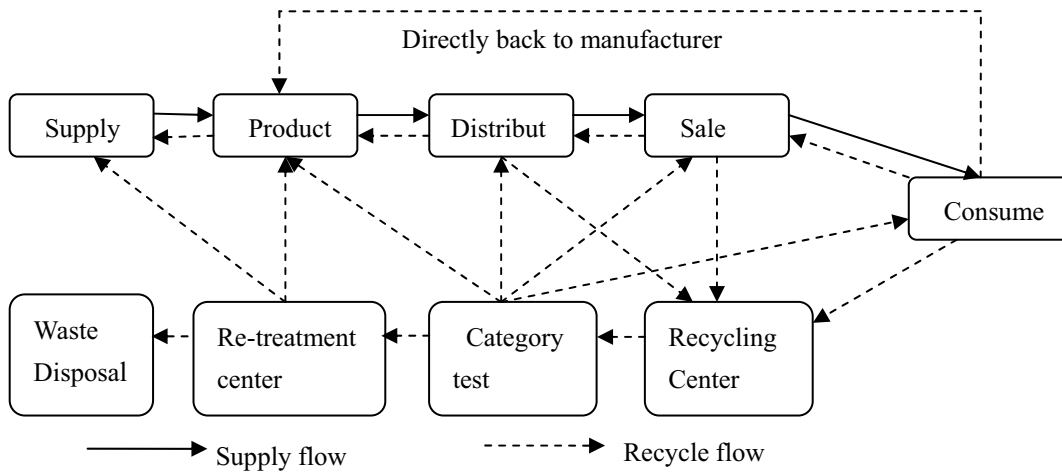


Figure 3. Compound recycling network of household appliance reverse logistics