

A SYSTEM DYNAMICS APPROACH TO DOMESTIC REFRIGERATORS' REPLACEMENT IN COLOMBIA

Jenny Ríos

Depto. Ciencias Computación y Decisión
Universidad Nacional de Colombia
Cra. 80 No.65-223 Medellín, COLOMBIA

Yris Olaya

Depto. Ciencias Computación y Decisión
Universidad Nacional de Colombia
Cra. 80 No.65-223 Medellín, COLOMBIA

ABSTRACT

Upgrading refrigerators is one of the strategies for increasing energy efficiency in the residential sector in Colombia. We examine alternative policies for promoting the substitution of low efficiency for higher efficiency models that will reduce power consumption and CO₂ emissions. The evaluated policies include increasing awareness of efficiency labels, rebates and tax reductions. We simulate the impact of these policies combining discrete choice and dynamic diffusion models. Our results show that simultaneous application of financial incentives and information programs over a 20 year period can reduce power consumption and carbon emissions by more than 174,000 GW/h and 50,000 Ton CO₂ with respect to the current program.

1 INTRODUCTION

Major appliances like refrigerator-freezers, TVs, washing machines and air conditioners account for most of the electricity consumed by the household sector (Mahlia & Saidur, 2010). As this appliances are durable, early replacement and improvement in energy efficiency can be achieved by offering different incentives to the consumers. Among the incentives that can remove the economic and information barriers for replacement are rebates, subsidies, tax deductions (Tasaki, Motoshita, Uchida, & Suzuki, 2013; Wijaya & Tezuka, 2013) and awareness campaigns for energy labelling programs (Wiel & McMahon, 2005). Understanding the substitution process is key to devise and evaluate policies that increase energy efficiency. We propose a system dynamics model that captures the information delays and feedback loops of appliance substitution and apply the model to analyze the Colombian case.

2 SIMULATION MODEL

This model aims to analyze the replacement of domestic refrigerators in Colombia under different policies and scenarios. The dynamic hypothesis is shown in Figure 1. As the balancing loop B1 in Figure 1 shows, forced replacement occurs when an appliance becomes obsolete. Appliances can also be replaced before reaching their end of life as shown in balancing loop B2. Rebates, tax discounts and other financial incentives affect the operating and investment costs that determine early replacement of appliances. The effect of policies increases as consumers perceive the energy savings. This is shown in reinforcing loop R1. A discrete-choice model finds the probability of replacing existing refrigerators with one of three efficient models. We use historical data as well as results from related research to estimate parameters for the model.

3 SIMULATION RESULTS

In the base scenario there are no financial incentives and a basic labeling program is implemented. We test seven policies to increase the adoption of energy-efficiency refrigerators. In policy 1, VAT (16%) is

eliminated. Policy 2 consists of a 50 USD rebate. Policies 3 and 4 offer soft loans. Policy 5 increases information through campaigns advertising efficiency labels and ratings. Finally, policies 6 and 7 combine economic incentives and increased information.

The results show that a combination of economic and information incentives increases replacement by 338,000 refrigerators, reduce the power consumption in 174,000 GW/h and carbon emissions in 50,000 Ton CO₂ compared to the base scenario in 20-year simulation time. In the case of individual incentives, it is possible to identify that advertising campaigns of efficiency labels can be as effective as soft loans.

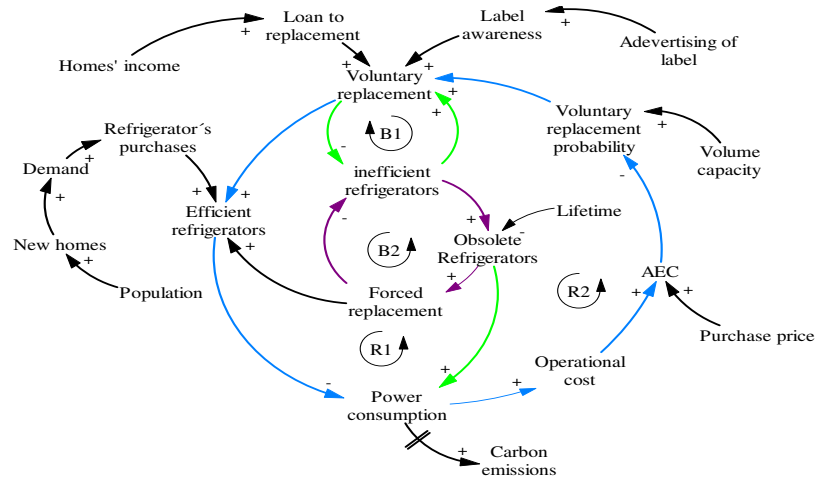


Figure 1. Dynamic Hypothesis: voluntary and forced replacement of domestic refrigerators

4 CONCLUSIONS

In Colombia, low-income households are a major part of total households. Financial incentives that improve access to credit, such as soft loans, can accelerate the replacement of inefficient refrigerators. However, in order to be effective, these strategies need to be accompanied by a recycling program that removes older appliances from the stock in use. Although less effective, information campaigns also have an impact on consumer behavior, and depending on their cost, they can improve the results of efficiency programs.

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