THE EMBEDDED ENERGY FOOTPRINT OF EFFICIENT REFRIGERATORS

A Lifecycle Assessment from Cradle to Consumer

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Introduction: As we progress through the age of sustainable development, consumers are becoming more aware of how energy efficient technology can help their homes operate more effectively and economically. Governments at the provincial and federal level along with local utilities are implementing energy efficiency standards and regulations for new appliances coupled with incentives and rebates that encourage local businesses and residents to invest in technologies that not only save consumers money, but reduce their impact on the environment and on energy grids. As a result, major home appliance firms are continuing to invest important R&D into energy efficient innovation. But as technology becomes more efficient and new refrigerators replace older models at a more rapid rate, very rarely is the embodied energy footprint associated with upstream operations considered. By exploring these stages in the supply chain, one can begin to understand whether or not it makes economic and environmental sense to invest in ENERGY STAR® appliances that replace perfectly functioning 30-year-old models.

Objective:

- Calculate the energy footprint from cradle to consumer
- Determine if the energy savings at the consumer end justifies the energy cost of upstream operations

Figure 1. Weight (kg) of Base Case Refrigerator Materials

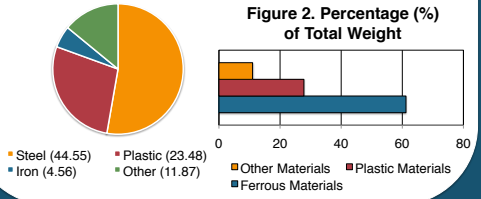
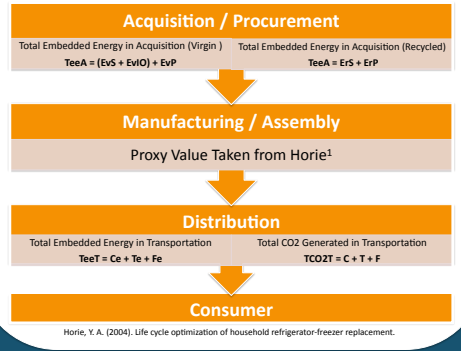


Figure 2. Percentage (%) of Total Weight

Methodology:

- Equation to calculate the embodied energy at each stage in the supply chain



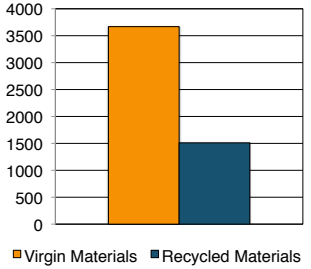
Horie, Y. A. (2004). Life cycle optimization of household refrigerator-freezer replacement.

Results:

Acquisition

- The embodied energy in producing the ferrous and plastic materials for an 84.46kg refrigerator made of 100% virgin components is **3668.13MJ**
- The embodied energy in producing the ferrous and plastic materials made of 100% recycled components is **1509.86MJ**

Figure 3. Embodied Energy in the Processing of Virgin vs. Recycled Materials (MJ)



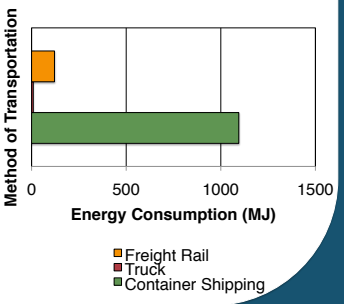
Manufacturing

- Since the energy invested in manufacturing processes is dependent on the type of machinery used and is subject to firm disclosure, this research uses a proxy value of **4930MJ** – determined in research conducted by Horie

Distribution

- Using Shunde, China as the starting point of the functional unit and York University as the destination and assuming that the unit travels by land and sea exclusively, the total energy in transportation is **1225MJ** and the total GHGs generated are **222.8kgCO2**eq

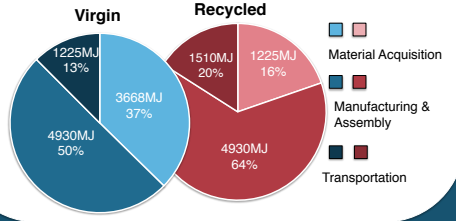
Figure 4. Energy Consumed in Sea, Rail and Truck Transportation



Conclusion:

- The EROEI of an ENERGY STAR® appliance made from recycled and virgin materials would be **2.3 years and 2.9 years respectively**
- **It makes sense economically and energy-wise to invest in an ENERGY STAR® appliance**
- Several environmental impacts show that new appliances may not be the most responsible option

Figure 5. Energy Consumption from Cradle to Consumer



Recommendations:

1. Implement a province-wide minimum percentage requirement for locally sourced materials coupled with incentives (tax breaks, rebates) to drive local economy and minimize energy and carbon footprint
2. Reform existing eco-efficiency and ENERGY STAR® regulations by mandating the use of recycled materials in new-appliance production
3. Reform existing ENERGY STAR® standard regulations to extend to energy efficiency and accountability in the supply chain
4. Fund disruptive innovation so refrigerator parts can be replaced on a piece-by-piece basis thereby avoiding the disposal of an entire unit