OCTOBER 2008

LIGHTENING THE LOAD

The Global Warming Impact of eBay Infrastructure and Transactions Parts I and II

cooler

Books

CONTENTS

SINCE 1995...

eBay has provided a platform for customers to trade new, used and salvaged goods through their online auction and shopping website. Millions of products, including collectibles, appliances, computers, furnishings, and equipment are listed, bought, and sold daily. Some items are rare and valuable, while many others would simply have been discarded if not for the millions of eBay buyers.

eBay commissioned Cooler to analyze the cumulative global warming impact of eBay's trading platform. Cooler is a for-profit social venture whose mission is to connect every purchase to a solution for global warming. To do this, Cooler has developed a unique combination of technologies and expertise for calculating and reducing the global warming impact of customer goods and services. This study uses those tools to document the global warming benefits of eBay's business model.

1.0
EXECUTIVE SUMMARY

Over the last decade, eBay's unique business model has profoundly changed global warming impact of commerce. Lightening the Load analyzes how eBay's peer-to-peer platform, along with its robust marketplace for used and overstock goods, significantly reduces greenhouse gas emissions by increasing the useful life of commercial products and changing retail infrastructure

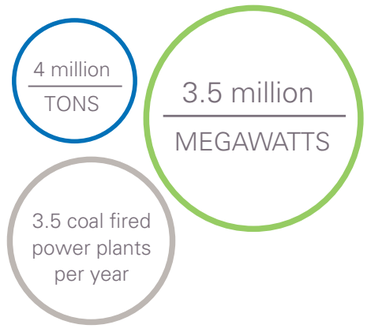
The global warming impact of the eBay platform was assessed in to two broad categories:

Infrastructure
Buildings, Transportation, Data centers

Consumption
New and used goods, Resale behavior, Macroeconomics

CASE STUDY FINDING
Total Avoided Emissions from eBay

The construction of all commercial retail floor space required 270 million megawatts of energy each year between 1990 and 1995, according to the Energy Information Administration. By bypassing the need for constructing retail stores, eBay's peer-to-peer model saves customers 3.5 million megawatts of energy. That is the equivalent of avoiding 4 million tons of greenhouse gas emissions per year, or displacing three and a half coal fired power plants per year.



Cooler's analysis shows that eBay has reduced the global warming impact of the retail industry in two important ways:

01 Eliminates much of the greenhouse gas emissions (GHGs) associated the wholesale and retail phases of a good's lifecycle.

In eBay transactions, goods do not follow the traditional path from warehouses to retail stores and on to the customer's home, but instead travel from peer to peer. This eliminates the need for retail space and distribution warehouses, and avoids significant GHG emissions from construction and electricity use. eBay also reduces the net impact of transportation between manufacturers, wholesalers, retailers, and customers.

Compared to a chain of 150,000 square foot big box stores, the $28.2 billion in gross merchandise sold on eBay in the United States from Q3 2007 through Q2 2008 produced 66 fewer tons of greenhouse gasses (in CO2-equivalents). This suggests that since 1995 eBay has displaced emissions equivalent to operating 3.3 coal-fired power plants for a year.

02 eBay reduces the global warming impact of retail by extending the useful life of a wide array of products.

eBay reduces the costs of buying and selling used and overstock goods, making product purchase and resale more attractive to customers. This delays the production of additional new goods and their associated GHGs. Some examples:

- Through the sale of used golf clubs, eBay in the last two years has reduced the amount of GHGs equivalent to taking 22,000 cars off the road for a year, reducing gasoline consumption by 13,600,000 gallons, planting 3,000,000 trees, or providing renewable electricity to 16,000 homes.
- For handbags alone, over the last two years eBay purchasers have reduced the amount of GHGs equivalent to taking 17,000 cars off the road for a year, reducing gasoline consumption by 10,600,000 gallons, planting 2,400,000 trees, or providing renewable electricity to 12,400 homes.
- The sale of used laptops on eBay over the last two years resulted in a reduction of over 66,400 tons of GHG emissions. That is equivalent of saving 426 acres of forest.

These three cases obviously reflect a small fraction of eBay's total impact. Cooler's analytic and software tools developed for this study and peer reviewed by experts in climate change and life cycle analysis make it possible to extend this analysis across the entirety of eBay's offerings in order to further quantify the impact of eBay's trading platform.

FAST FACT

Lightening the Load documents how eBay's activities have changed the climate impact of commerce, how eBay's operations today help reduce overall greenhouse gas emissions, and how the optimism and engagement of the eBay 's employees and broader community can make commerce part of the answer in a carbon-constrained world.

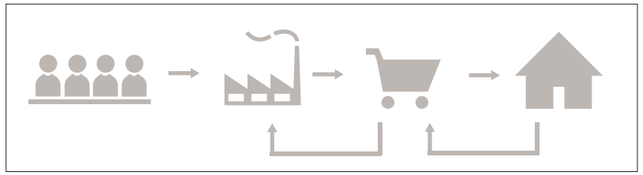
2.0
ANALYSIS AND FINDINGS: RETAIL, ONLINE, AND EBAY INFRASTRUCTURE AND TRANSACTIONS

INFRASTRUCTURE: BUILDINGS

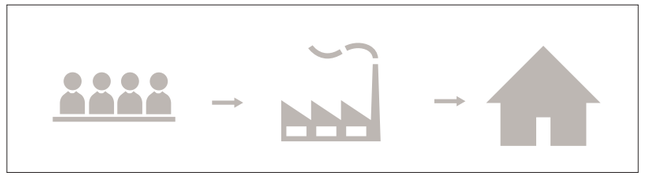
FAST FACT

Refrigerators are the classic example of an appliance where taking an older model out of commissivon has greater benefits than reusing the product. Refrigerators have an average lifetime of 20 years, but new more efficient models can cut energy use by 60% (Meir, 1995).

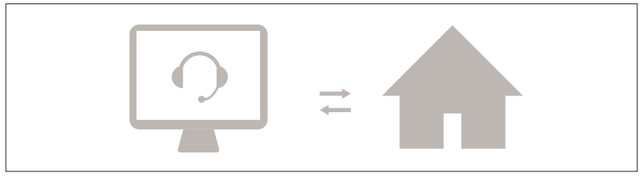
The global warming impact of major brick and mortar retailers is generated by the construction and operation of warehouse and retail facilities. The construction industry is one of the most carbon intensive industries in our economy. Cement manufacture has long been known to emit substantial greenhouse gases. In fact, for every ton of concrete created, close to 1 ton of CO_2 is released into the atmosphere (CSI, 2001). Other inputs, including materials and transportation, further increase the global warming impacts of retail building construction. There are also operational impacts from ongoing operations and maintenance. Warehouses and retail stores require energy for lighting, heating, and cooling.



Transportation in Brick and Mortar Retail



Transportation in Online Retail



Transportation in eBay Trades

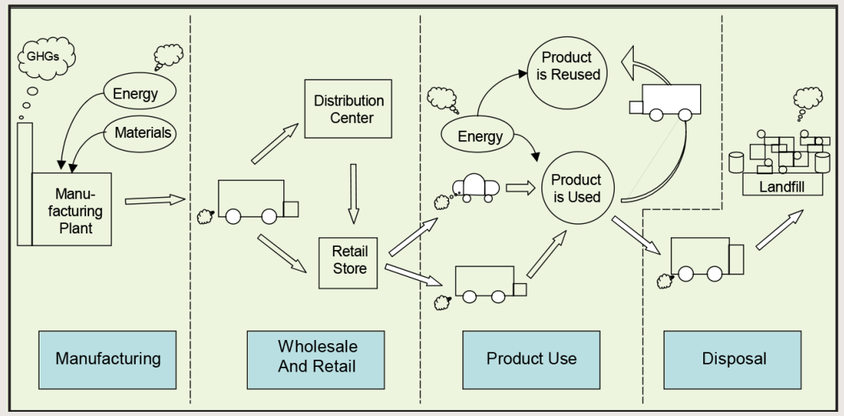
E-commerce and Dematerialization

Companies need raw, physical materials to conduct everyday business. Using less materials, or dematerializing, reduces energy use. E-commerce dematerializes retail by eliminating physical storefronts in favor of central warehouses, decreasing the energy and space needed per item. It leads to reductions in inventories and overproduction and a greater reduction in waste. E-commerce also reduces the need for paper transactions, saving energy and precious natural resources. All of these changes have led to ongoing structural and efficiency gains which are critical to climate mitigation strategies.

eBay takes dematerialization one step further. Their peer-to-peer platform makes eBay unique in the world of online retail because it requires no stand-alone warehouses or retail stores.

"eBay takes dematerialization one step further."

LIFE CYCLE PHASES



MANUFACTURING

Technological innovation and efficiencies in materials and manufacturing often deliver today's products with fewer GHG emissions. However, sometimes older products produce fewer GHGs than newer products. In the Manufacturing phase, the amount of GHG emissions generated is dependent on where a product is made, the environmental regulations and the mix of energy sources in that locale, the energy efficiency of the factory, and the average distance the product is shipped to the customer.

In recent years, manufacturing has increasingly shifted overseas to locales with lax environmental standards and carbon-intensive energy mixes. This has increase the global warming impact of some new products. As a result an older vintage product that has been made in a locale with stricter standards, such as the United States, may at times be more carbon-efficient than a newer product.

USE

Goods sold on eBay can be grouped into three categories in the Use phase:

1. High Emission Goods:
produce GHG emissions when they are used, such as refrigerators and air conditioning units. In addition to a share of emissions generated in the Manufacture phase, these goods would generate additional emissions in the Use phase through energy used in the resale process and while being used by the new owner.

2. Practical Goods:
goods that produce no GHG emissions during use. These goods would be allocated a share of emissions generated in the Manufacture phase, as well as additional emissions generated by the resale process. Practical goods include items such as golf clubs and handbags.

3. Collectable Goods:
goods that usually produce no GHG emissions during use. These goods would be allocated emissions generated by the resale process. Collectables are traded so frequently that emissions from repeated trading usually are much greater than those associated with manufacturing. Also, collectables avoid emissions from disposal.

INFRASTRUCTURE: DATA CENTERS

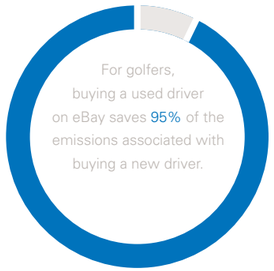
Although construction and operations of a building demand much more energy, data centers and computers also demand significant energy. For a major online-only retailer, computer usage and data center energy requirements can be a considerable portion of their total global warming impact.

However, energy requirements of data centers are often overestimated by corporations because their energy usage is calculated by looking at the power indicated on equipment nameplates. Reports show that even at peak demand more systems never draw more than 80% of the nameplate power (Mitchell-Jackson et al. 2001). According to their own estimates, eBay's data centers are responsible for 53,000 tons of CO2e.

CONSUMPTION: NEW AND USED GOODS

The Global Warming Impact of Product Reuse

eBay's trading platform has clearly reduced the global warming impact of retail through the reductions in infrastructure. But eBay makes its biggest reductions in impact through their robust marketplace for overstock, used, recycled, and salvaged products. Many existing assessments of the global warming impact of commerce leave out exchanges of used goods. Given the importance of trading on eBay and other used-goods channels, this is a major omission.



CASE STUDY FINDINGS For the tech-savvy, buying a used HP Pavilion laptop on eBay saves over half the emissions associated with a new one.

Life cycle analysis is a useful framework to consider the reduced GHGs from sales of overstock, recycle, used, and salvaged goods. There are four primary phases of a product's life cycle that can produce greenhouse gas emissions: Manufacturing/ Production, Wholesale/Retail, Product Use, and Disposal. The facing page illustrates each of these emissions phases.

Using life cycle analysis, Lightening the Load quantifies the magnitude of savings generated by eBay's model in the Analytic Frameworks section of the Appendix. Two key methodological innovations are presented: a GHG emissions allocation framework for reused products, and the concept of a net present emissions value which estimates the global warming impact of displacing the purchase of new products into the future.

CONSUMPTION: RESALE BEHAVIOR

Allocating the Footprint

More and more consumers are aware of the environmental impacts of the products they purchase. Some consumers even choose to offset the GHG emissions that are associated with their products by purchasing carbon offsets. As more consumers voluntarily choose to take responsibility of the emissions of their products, an approach for allocating emissions to used products needs to be established. Cooler has developed three methods of allocating emissions to used goods: the Net Zero method, the Net Life method, and the Net Value method.

Choosing one of these methods depends on the circumstance of the purchase and the resale intent of the customer. If there is only one owner of a good, all of the emissions could be allocated to that owner. However, when a good is used by multiple owners, it may not be appropriate for the first owner to take full responsibility for those emissions. See the Analytic Frameworks and Case Studies in the Appendix for more information on how to allocate emissions to used goods.

CONSUMPTION: MACROECONOMICS

The Net Present Value of GHGs

Product reuse and recycling contribute significantly to the fight against global warming in two crucial ways:

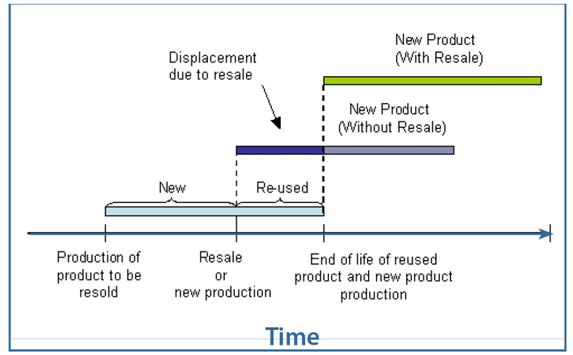
1. Product reuse avoids emissions today by displacing the production of new goods — essential in a world facing a crisis level of new emissions.
2. Product reuse delays the purchase of a new product to sometime in the future when manufacturing and production will be more efficient and have a smaller global warming impact.

Both of these factors highlight the role of time in determining the global warming impact of product reuse. Replacing and delaying the production of new goods has long-term benefits and impacts how emissions are valued. In the future, products will be produced, sold, used, and disposed of more efficiently and the emissions created by those products will be lower. Also, in the future emissions may not pose the same risks as today. We will likely have better technologies to adapt to climate change and a given amount of GHG emissions will have a lower global warming impact.

To incorporate this effect of time in GHG calculations, an analog to net present value or "net present emissions value" could be calculated with a formal discount rate applied. Applying a discount rate to future emissions would reduce their net present emissions value. The selection of a discount rate would need to be carefully considered based on a monetary valuation of emissions, a notion of a risk premium, or the probability that GHG emissions in the future will not contribute to global warming.

Benefits today are more valuable than benefits tomorrow, just as money is more valuable today than money tomorrow. It is for this reason that investments will only be made if a premium can be earned on those investments. People also have a natural risk aversion and often pay insurance premiums to protect against risk. If the premium that people would be willing to pay to compensate for the consequences of climate change could be determined, then this could be adjusted to provide a discount rate applied to future emissions.

"Benefits today are more valuable than benefits tomorrow..."



New Production Timeline With and Without Re-use

FAST FACT

Studies on book retailing show even if all books bought online were shipped via air, online retailing would still have a lower impact than traditional retailing because of the impact of customers' car trips to the store (Hendrickson et al., 2001).

LIGHTENING THE LOAD

Part 1: The Global Warming Impact of Buying Used Goods

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Lightening the Load documents how eBay's activities have changed the climate impact of commerce and how eBay's operations today help reduce overall greenhouse gas emissions. It also explores how the optimism and engagement of the eBay s employees and broader community can make commerce part of the answer in a carbon-constrained world.

ABSTRACT

Since 1995, eBay has provided a platform for consumers to trade new, used, and salvaged goods. This paper develops methodologies for comparing the impact of buying a new product to the impact of buying a used product. eBay's unique online platform has facilitated the reuse of millions of products and resulted in large portion of avoided greenhouse gas emissions. This paper develops a method for quantifying those displaced emissions. Special consideration is given to the "vintage," or year of manufacture, of a good and its effect on calculating total lifetime emissions.

This paper analyzes the global warming impact of buying a used good in comparison with a new good. It takes into consideration how to calculate the emissions avoided by reusing a product as well as how to allocate emissions among multiple sequential consumers of that product. It develops three major calculation and allocation methods for determining the global warming impact of used goods. They include: the net zero method, the net lifetime method and the net value method.

The net zero method allocates all responsibility for the initial production, retail, wholesale, transportation, use, and disposal to the original owner of the good. Under this method, reused products are considered to displace new products on a one-to-one basis. The new owner is allocated only the emissions that occur after the used good has been sold to them. This method is best applied to durable goods with long useful lives and without an associated use phase.

The paper identifies the time value of avoided emissions, mostly heretofore unexplored in published literature.
The purchase of a used product reduces overall greenhouse gas emissions in two critical ways. First, the purchase of a used product delays emissions that would be generated by the production and consumption of new products.
This immediately reduces overall pressure on the climate system. Second, the net effect of delaying the production of new goods is to ensure that those goods are produced with less overall impact as well, since the production of goods is becoming more carbon-efficient with time. This effect is accelerating due to increased regulation of greenhouse gas emissions. For example, an iPod nano bought used on eBay has a net present footprint of 8.55kg CO2e, with significant reductions from displacing a new purchase forward. On the other hand, a new iPod nano contributes 31kg CO2e or 360% more emissions to the atmosphere.

This "net present value" of emissions is captured with the two other allocation methods: the net lifetime allocation method, which bases allocation of emissions on the remaining years of a product life; and the net value method, which bases allocations on the monetary value of the product. These approaches allocate a fraction of total emissions to the purchaser of the used good. Under these methods, the production of a new good is considered displaced for the remaining value or lifetime of the new product. A portion of the emissions that would be generated by that new product are avoided.

In conducting a life cycle analysis of new and used products, this paper finds that only two phases of a product's life have a significant impact on the carbon footprint of a used good: the Use phase, during which the consumer is using the good, and Wholesale/Retail phase,during which the product is transported, warehoused, and sold. For the vast majority of products, a used good purchase on eBay represents a significant benefit for global warming. Certain electrical appliances and other products would be an exception and may have less impact when purchased new. For example, refrigerators are now much more energy efficient than in the past. The reduced emissions from a new refrigerator in the use phase offset those created in the Manufacture phase. Case studies that provide an in-depth examination of a particular products life cycle will provide a deeper quantitative and narrative understanding of the avoided emissions that have resulted from transactions on eBay's platform

CONTENTS

1.
SUMMARY

This paper focuses on the climate impact of new and used goods and develops three new ways of allocating the greenhouse gas emissions of a used good among successive owners:

01 the net zero method,

02 the net life method,

03 the net value method.

The choice of method depends on the type of product being evaluated.

A key finding is that the vintage, or year of production of a product, is an important part of evaluating the emissions of that product. Within the U.S., the trend towards increasingly efficient manufacturing and transportation as well as better product designs has led to a reduced footprint for some newer products. This trend must be weighed against the increased footprint of products produced offshore, particularly if such production occurs in countries with lax environmental laws and dirtier energy mixes, or if off shoring leads to longer, less efficient product transport. For goods which use significant amounts of energy in the use phase of their life-cycle, differences in the energy consumed by used and new products have the potential to offset the advantages of buying used products. Inparticular for products which have experienced vast improvements in energy efficiencyover time, buying a new product can lead to significant emissions reductions over a similar used good purchase.

Overall, however, this paper makes it clear that the purchase of a used product usually minimizes the production of greenhouse gasses emissions compared to the purchase of a new product.

II.
STATEMENT OF THE PROBLEM:

Does Buying a Used Good Reduce Greenhouse Gas Emissions? eBay has revolutionized the market for used goods by creating an efficient marketplace in which the transaction costs in time and money associated with buying and selling used goods has been greatly reduced.
By increasing the ease of shopping and the ability to find particular goods, eBay has allowed transactions that satisfy consumers needs while resulting in a reduced environmental impact. Intuitively, there is considerable climate benefit to increasing the overall utilization of used goods, but quantifying this effect is challenging because no prior framework exists to analyze the global warming impact of used goods. Therefore, many assessments of the global warming impact of commerce simply leave exchanges of used goods out. Given the importance of trading on eBay and other used goods channels, this is a major omission.

For goods and services, life cycle analysis provides a useful way to consider climate and other environmental impacts.
As typically calculated, there are four primary phases of a product's life cycle that can produce greenhouse gas emissions. These four phases are product Production or manufacturing, Wholesale and Retail, Use, and Disposal. The figure below illustrates each of these emissions phases.

> "eBay has revolutionized the market for used goods by creating an efficient marketplace..."

This conceptual framework has never been applied to used products. To do so, this paper examines the allocation of emissions from each phase throughout a used good's lifetime in order to answer the following questions:

- What is the global warming impact of product reuse at the product level?
- What are the emissions reductions associated with purchasing a used good instead of a new good?
- How does the vintage or year of manufacture of a particular good affect the lifetime allocation of emissions within each of the allocation strategies?

This paper remedies a key deficiency in existing literature by creating a precise analytical framework with which to quantify the otherwise intuitive climate benefits associated with used goods.

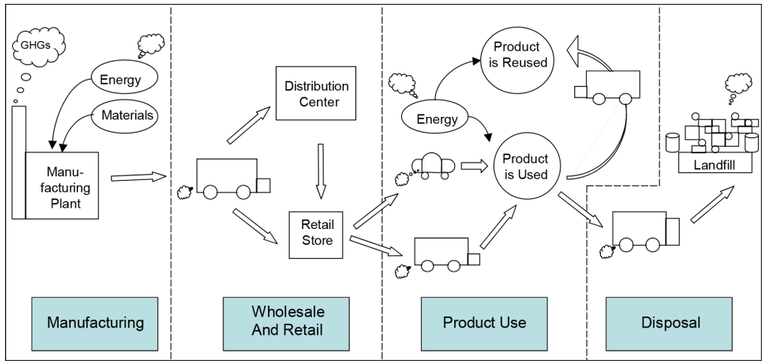

Figure 1: Life Cycle Phases

III.
KEY VARIABLES: PRODUCT CHARACTERISTICS, ALLOCATION, AND ATTRIBUTABLE REDUCTIONS

The key considerations when determining the global warming impact of new, used, recycled, and salvaged goods are:

- The Greenhouse Gas Lifecycle of Used Goods: what factors affect the greenhouse gas emissions of used goods for each phase of the product lifecycle?
- Avoided Emissions: what emissions reductions can be attributed to significant reuse?
- Allocation: how should responsibility for emissions be distributed among diverse owners of a reused product?

This paper assesses the emissions customers save when purchasing used goods on eBay by providing an analysis of emissions produced throughout a used product life cycle and an exploration of the appropriate allocation method for those emissions.

The Greenhouse Gas Lifecycle of Reused Goods

For certain products, the overall global warming implications of buying a used good rather than a new one are largely based upon the year of manufacture, or "vintage" of that particular good. Vintage can affect the carbon footprint of a product in any of the phases in a product's lifecycle: Production, Use, Wholesale/ Retail and transportation, or Disposal. The emissions impact of each of the four phases depends on the nature of the product and which method is used to allocate emissions among the successive owners of the good. The life cycle is used to assess the importance of vintage for each phase of a product. The table below reveals how vintage, along with a number of other key factors, determines the emissions created during each phase of a good's life cycle.

3.1.1 PRODUCTION

The GHG emissions generated during the production phase are dependent upon efforts that manufacturers have made to incorporate efficiency measures into product design and factories, as well as the energy mix where their goods are manufactured. Thus the global warming impact of a good's manufacturing phase can increase or decrease due to a number of factors. These factors include:

- Country of origin's environmental regulations and energy mix
- Improvements in plant efficiency over time
- Introduction of energy efficient equipment
- Differences in brand types and models
- Average distance product shipped

Type of Good / *Life Cycle Stage*	*High Emissions Products*	*Practicals1 (no Use-Phase Emissions)*	*Collectables (no Use-Phase Emissions)*
Production	**Emissions based on:** Manufacturer, Country of Origin, Brand, Model, Age	**Emissions based on:** Manufacturer, Country of Origin, Brand, Model, Age	**Emissions based on:** Manufacturer, Country of Origin, Brand, Model, Age
Wholesale/Retail	**Emissions based on:** Country of Origin, Fuel and Energy Efficiency	**Emissions based on:** Country of Origin, Fuel and Energy Efficiency	**Emissions based on:** Country of Origin, Fuel and Energy Efficiency
Use	**Emissions based on:** Energy Efficiency of Product	No difference based on vintage	No difference based on vintage
Disposal	**Emissions based on:** Brand, Model, Recyclable Materials	**Emissions based on:** Brand, Model, Recyclable Materials	**Zero Emissions:** Theoretically collectables will have no disposal.

Table 1: Vintage, Lifecycle, and GHG emissions

NET ZERO METHOD EXAMPLE

Emissions only from the process of resale and the emissions from ongoing use are attributable to the used good.

100% of manufacturing, initial sale, and disposal emissions allocated to original owner.

NET VALUE EXAMPLE

New car purchased for $20,000. Car is resold for $10,000.

Since the ratio of used to new price is 50%, half of the production, wholesale and retail (including resale), and disposal emissions are allocated to the buyer of the used car.
Any reuse phase emissions are added to the reused good emissions

NET LIFE EXAMPLE

New car is resold after 5 years. Expected useful life is 20 years 1/4 of the initial production, sale, and disposal emissions are allocated to the initial owner 3/4 of the emissions are allocated to the new owner.

3.1.2 USE

For the Use phase, the most important characteristic of a product is whether that product requires energy over its lifetime. Products which require energy during the Use phase include home appliances, electronics, and automobiles. Many other products require energy for repair, refurbishment, or cleaning, but this is often a negligible amount. Any life cycle analysis of products must take into consideration the lifetime energy requirements and the associated GHG emissions of energy production.

3.1.3 DISPOSAL

As collective consciousness regarding the environmental impacts of manufactured products has risen, product designers have began to consider the end-of-life fate of their products. Newer vintages are generally designed with a consideration for end-of-life waste streams. Older electronic products contain larger amounts of toxic materials and fewer recyclable parts (EPA, 2000). Part of the overall emissions accounting of a product depends on how much of it can be reused or the extent to which it can be recycled at the end of its life. Our capacity to refurbish products and handle waste in the future may mprove. Later vintages may also have reduced disposal emissions.

3.1.4 ADDITIONAL WHOLESALE, RETAIL, AND TRANSPORT

The year of sale, region of production, and miles traveled all have an important influence on the good's emissions. Improvements in the fuel economy, building energy efficiency, and retail sector have all reduced the emissions of sale and resale of goods as technology has evolved.

IV. ANALYSIS AND FINDINGS

4.1 ALLOCATION: WHICH PURCHASER IS RESPONSIBLE FOR WHICH EMISSIONS?

More and more consumers are aware of the environmental impacts of the products they purchase. Some consumers even choose to offset the GHG emissions that are associated with their products by purchasing carbon offsets. As more consumers voluntarily choose to take responsibility of the emissions of their products, an approach for allocating emissions to used products needs to be established. If there is only one owner of the good, all of the emissions could be allocated to that owner's purchase. However, when a good is used by multiple owners, it may not be appropriate for the first owner to take full responsibility for those emissions. There are two primary approaches that can be used to allocate emissions to each owner:

a. net zero method
b. net life/value

The type of used good will often determine which method is most appropriate.

4.1.1 NET ZERO METHOD

Reusing a good does not create a net increase in the emissions associated with the Production, Wholesale /Retail, or Disposal phases of that good. These emissions have already been produced, or will be produced, regardless of whether or not the good is reused. The only additional emissions created will be due to additional Wholesale/Retail emissions associated with the sale process, as well as any energy consumption the product requires in the Use phase. It is for this reason that much of the literature assumes that one reused good substitutes for one new good (Graedel and Allenby 1996, Curran 1996, Stahel 1994).

The net zero method allocates only the net increase in emissions to the new owner of a good. Under the net zero approach, all of the initial Production, Wholesale/Retail, and Disposal emissions are allocated to the original owner of the good.

Only the additional emissions produced by the resale transaction and use are allocated to the buyer of the used good. This approach is particularly appropriate for goods that can be used many times, such as durable goods and collectables, since they have very long useful lives and will potentially change hands many times. When a durable good or collectable that is still in production is sold as a used product, it eliminates the need to produce another unit of the same collectable. This directly offsets the Production, Wholesale/Retail, and Disposal emissions of that product. Also, any emissions from the Production and Disposal of the product would be negligible, since they would be distributed among multiple owners over the long life of the product.

Consumer intent can also provide a rationale for applying the net zero method. Chu and Liao (2007) identify four types of resale behavior by consumer resellers.

1. Resale of extra purchase occurs when consumers buy extra quantities of goods they plan to consume with the intention to resell the excess, perhaps in order to take advantage of bulk discounts.
2. Resale after temporary ownership includes purchases by consumers that intend to resell after a using the product for a period of time.
3. Unintentional resale includes resale after impulse purchases, mis-purchases, and receiving unwanted gifts.
4. Disposition occurs when consumers simply dispose of their goods in secondary markets when they no longer use them.

The net zero method should also be applied when sellers do not purchase goods with the intention to resell those goods as is the case for resale type 3 and 4. Since those consumers made their purchasing decisions based on their own needs, none of the Production, Wholesale/Retail, or Disposal emissions should be allocated to the new owner of the good.

Under the net zero method, the vintage of a product affects only the Use phase emissions of the remaining life of the product. For goods that use energy, emissions allocation is measured from the point of acquisition through the end the Use phase. However for non-energy using collectibles and practical goods, this effectively allocates zero emissions to the purchaser of the used good, regardless of vintage.

4.1.2 NET LIFE/VALUE APPROACH

While the net zero method is appropriate for many types of goods, it is important tounderstand that many consumers intend to resell upon purchasing new goods (see resale behavior 1 and 2 above).
This is often true of goods that sustain high resale values, but have limited useful lives. It is well understood that online auction platforms like eBay have encouraged consumers to consider resale when making purchasing decisions (Chu et al. 2007, Ghose et al. 2005).

In the era of eBay, when increasing numbers of purchases are made with the understanding that some of the initial costs of the good can be recouped with resale, it may not be appropriate to allocate all of the initial Production, Wholesale/Retail, and Disposal emissions fully to the original owner of a good.

> "For goods that use energy, emissions allocation is measured from the point of acquisition through the end of the Use phase"

When purchasers of a used good receive much of the benefits of that good, they should also be allocated some of the emissions from these phases. For example, it does not make much sense to allocate all of the emissions to an owner that sells a new car after one year and 5,000 miles, since the future owners will get much use out of the car. In order to provide proper incentives to the purchaser to resell the item rather than disposing of it, the price of carbon should be partially passed on to the second hand owner. The net life and net value approaches provide two ways to allocate the emissions to the used good.

The net life method allocates emissions based on the remaining life of the good when it is resold. The simplest way to do this is to use the age of the product. To improve this calculation, various quality indicators could be used to adjust the age comparison. Since the resale value tends to incorporate age and other quality indicators, the net value method uses the remaining value to calculate the allocation of emissions. This may be the better approach when value data is available. The value method is also consistent with the International Organization for Standardization life cycle assessment standards.

Buyer / *Seller*	*Would Purchase Used*	*Would Purchase New*
Would Sell Good in Other Market	**Demand for New Goods Not Reduced by eBay**	**Unknown Impact on Demand for New Goods** There is reduced demand for new good by buyer, but it is unclear if the total number of wasted goods and new good demand declines
Would Dispose of Good	**Unknown Impact on Demand for New Goods** Reused good is not wasted, but it is unclear if the total number of wasted goods and new good demand declines	**Reduced Demand for New Goods** eBay enables 100% avoidance of the production, retail, and disposal of one new product

Table 1: Consumer Decisions in the Absence of eBay

Under the net value method, the new and resale prices of the good are compared. The emissions associated with the used good are subtracted from the seller's footprint and added to the buyer's footprint. This method is consistent with research published in the Journal of Ecology which states that "the extent to which the purchase of used goods replaces the purchase of new goods is an explicit function of the relative value provided by used versus new goods" (Thomas 2003). In this method, each phase of the good's life is taken into account, and vintage is of the utmost consideration in calculating the full emissions of the product since the age of the product impacts the value or price of the product. All factors listed in Table 1 should be considered under this approach.

4.1.3 Choosing Between Allocation Methods

a. **Potential double counting:**
The net life/value methods may overly simplify the number of times a product changes hands. There could be several owners. Anticipating the total number of owners of a product and how much use the product will get under each owner is difficult. Also, the sum of resale prices for goods that do not depreciate quickly could be larger than the initial price, which complicates the basic used price to new price comparison.

b. **Resale potential:**
The net value and net life methods are appropriate when resale is a likely outcome of an original purchase, such as when resale values are high.

c. **High innovation or high turnover products:**
Consumers purchasing products with quicker innovation or turnover rates, or who regularly resell their consumer goods on eBay are more likely to consider resale values with making purchases (Chu et al. 2007). Therefore, the net value and net life methods could be used to allocate emissions to products when resale values by the original purchaser. However, the vast majority of goods purchases are not made with resale in mind. In these cases, it may be most appropriate to use the net zero method.

4.2 Avoided Emissions – The Net Global Warming Benefit of Product Reuse

As mentioned earlier, there are two major approaches to calculating emissions avoided through product reuse: net zero and the net life /net value methods.

4.2.1 Net Zero Method: For Long-Lasting Products

Products that are typically used by any buyer for more than 2-3 years have some unique characteristics that affect the calculation and allocation of their carbon footprint:

1. They are rarely bought for the purposes of resale and hence are most often thrown away when they are no longer needed
2. They may be used indefinitely by subsequent buyers

Any used goods that would have been stored or thrown away by the seller and purchased new by the buyer in the absence of eBay will substitute for new goods. The net zero method is appropriate for these transactions. It is most accurate to assume that the reuse footprint of a long-lasting product is zero. The purchase of such a product in used condition fully avoids the emissions of an otherwise new

It is most accurate to assume that the reuse footprint of a long-lasting product is zero. The purchase of such a product in used condition fully avoids the emissions of an otherwise new product that would have been bought instead. The transaction footprint, of buying on eBay for example, is still incurred.

4.2.2 Net Life/Value Method: For Short-Lived Products and Those with High Resale Values

The relative emissions reduction evaluating the emissions for goods with limited useful lives (typically less than 2 years) is the best approached with the net life/value method. Unique characteristics of these products include:

1. There may be high "churn" in ownership, such as I-pods which purchasers trade up regularly.
2. Manufacturers may incorporate planned obsolescence into product design.
3. Different users may have different standards about the "look" of the product. For example, some people may not willing to wear used shoes or clothing.
4. Use by the original purchaser may degrade the usefulness of the product for subsequent buyers.
5. Some consumers may still place a high value on the good, resulting in relatively high resale values relative to original purchasing price. When a used good with a limited remaining life is sold to a new consumer, the good temporarily replaces and delays the production of a new good. This delay critically shapes the long-term emissions profile of the purchasing process and is illustrated in Figure 2.

Due to increasing efficiency over time and impending greenhouse gas regulation, product lifecycles in the future are likely to be more carbon-efficient than those in the past and present. Some exceptions to this assumption may apply for products of certain vintages. manufacturing has shifted overseas in recent years, the impacts of the manufacturing process may have increased. Older goods which were manufactured domestically will have a different impact than the same good manufactured today overseas because of more lax environmental standards and carbon

	High Emissions Products	*Practicals1 (no Use-Phase Emissions)*	*Collectables (no Use-Phase Emissions)*
Emissions Allocation from Resale	Emissions from resale + Share of New Product Total Footprint based on Remaining Net Value or Life + Use Phase Emissions	Emissions from resale + Share of New Product Total Footprint based on Remaining Net Value or Life	Emissions from resale + Share of New Product Total Footprint based on Remaining Net Value or Life
Emissions Allocation from Disposal	Emissions from resale + Use Phase Emissions	Emissions from resale	Emissions from resale + Share of New Product Total Footprint based on Remaining Net Value or Life - Avoided Disposal Emissions if resold

Table 2: Consumer Decisions in the Absence of eBay

intensive energy mixes in the developing world. This means an older vintage product may, at times, be more carbon-efficient than a new product manufactured in a less carbon-efficient economy. Challenges arise when calculating the impact of products manufactured in less-industrialized countries, since those countries often do not keep account of important indicators that are needed to conduct a life cycle analysis (Brent and Visser, 2003).

The simplest way to perform these calculations would be to proportionally allocate the initial production and transaction footprint to the share of product value or life expected in the reuse phase (see Appendix), but this method ignores some significant additional issues having to do with the role of time in determining the value of greenhouse gas emissions:

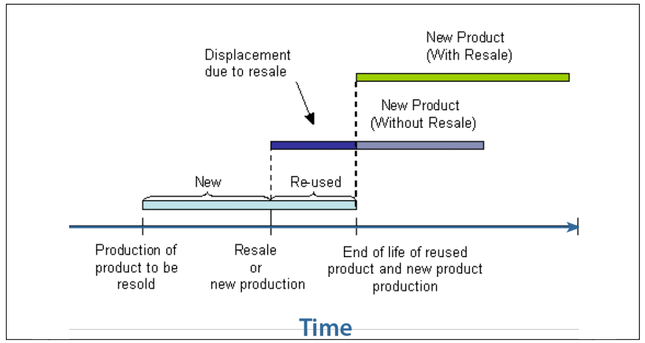

Figure 2: New Production Timeline With and Without Re-use

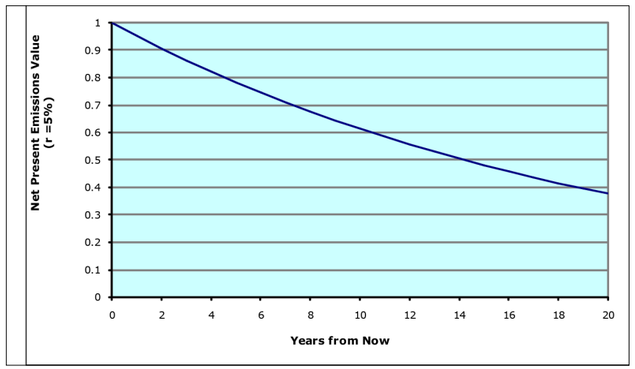

Figure 3: Net Present Emissions Value

1. Products will be produced, sold, used, and disposed more efficiently in the future. Thus, the emissions created by these products will be lower. In order to calculate the relative emissions, emissions produced by products in the future must be projected using expected rates of technological innovation.
2. Emissions today are considered to be a bigger problem than emissions tomorrow. In the future, emissions may not pose the same risks as today, and we will likely have better technologies to adapt to climate change.

Thus, the global warming impact of a given amount of GHG emissions will be lower in the future. One way to incorporate these effects is to consider the emissions reductions over an infinite period of time. To do so requires comparing the emissions from the product that would be created now without the resale of the used good with the emissions from the product that would be created when the reused good reaches the end of its useful life (see Figure 2, Displacement due to resale). Using an analog to net present value is one possible way to value the emissions impact of a used good. An impact variable called "net present emissions value" could be calculated with a formal discount rate applied. The selection of a discount rate would need to be carefully considered, and could be based on a monetary valuation of emissions, a notion of a risk premium, or the probability that GHG emissions in the future will not contribute to global warming. Figure 3 below demonstrates how applying a discount rate to future emissions would reduce their net present emissions value. In the figure, a 5% discount rate is applied for illustration purposes.

Benefits today are more valuable than benefits tomorrow, just as money is more valuable today than money tomorrow. It is for this reason that investments will only be made if a premium can be earned on those investments.

If we value emissions reductions similarly to money, the prevailing interest rate could be used as a discount rate to apply to future emissions. People also have a

$$\text{Emissions Reduced Due to Reuse} = \left[\frac{\text{Value of of Reused Good}}{\text{Value of of New Good}} \times \text{Emissions from New Good} \right] - \text{Use and Additional Wholesale and Retail Emissions from Reused Good}$$

natural risk aversion and often pay insurance premiums to protect against risk. If the premium that people would be willing to pay to compensate for the consequences of climate change could be determined, then this could be adjusted to provide a discount rate applied to future emissions.
Finally, the discount rate could be based on the probability that we will have technologies in the future that will reduce the global warming impact of a given amount of GHG emissions. For example, carbon capture and sequestration or other advanced technologies may allow an increase in GHG emissions, without leading to global warming

Further discussion is needed to choose an appropriate discount rate. The Appendix demonstrates how a reduction in both emissions and the net present value of emissions can be combined to quantify the total reduction in global warming impact of future products. The net value approach is similar to the simple net life approach, but instead of using years of useful life as the basis for the calculation the remaining value of the reused good is used as the basis. The equation used for this calculation is below.
This method requires data on:

- the sale price of the reused good
- the sale price of the new good
- the emissions generated by the new good
- the emissions generated by reselling and using the reused good

Both the net life and net value methods provide similar estimates of the emissions reductions associated with reuse.
The availability of data will determine which approach is used. One advantage of the net value approach is that it can incorporate differences in utility of a good. It can account for the fact that new goods often have additional features or improvements over older models, making them more valuable. Unlike the net life approach, the value approach incorporates factors other than age that affect how useful a good is to consumers. Further, since the net value approach is consistent with the International Organization of Standardization life cycle assessment standards, it may be preferable when price data is available. The table below indicates how each approach can be used to allocate emissions from each life cycle phase in order to determine the relative emissions reductions due to product reuse.

4.3 HIGH USE PHASE EMISSIONS:

When buying new makes more sense
Increases in the energy efficiencies of certain appliances have resulted in a complex relationship between the four phases of a product. Although reuse of products is generally more favorable from the global warming perspective, there are certainexceptions to this rule. Gains in energy efficiency may present a greater environmental benefit than displacing the manufacturing of a new good. The following examples illustrate where differences in the energy efficiency across vintages may mean that buying a newer model has a smaller impact than reusing the product.

Type of Footprint *Type of Good*	*Cradle-to-Shelf Footprint*	*Use Phase Footprint*	*Disposal Phase Footprint*
Long Use Phase (Used good substitutes for new good)	**Zero Re-Use Footprint** + Footprint of eBay transaction	Actual emissions from use, if any	**Zero** eBay, buyer, & seller also get credit for goods that would have been disposed of in the absence of trade
Short Use Phase (Used good does not fully substitute for new good)	**Re-Use Footprint calculated using Net Life/Value** + Footprint of eBay transaction	Actual emissions from use, if any	**Disposal footprint calculated using Net Life/Value**
Collectable	**Zero Re-Use Footprint** + Footprint of eBay transaction	**Zero**	**Zero** absence of trade

Table 2: Consumer Decisions in the Absence of eBay

REFRIGERATOR EXAMPLE:

The Department of Energy changed the Energy Conservation Standards for refrigerators between 1993 and 2001.1

Using these standards we can estimate when it might be best to dispose of a used refrigerator rather than resell it. 1993 Energy Standards: 13V + 299 2002 Energy Standards: 8.82AV + 248 Assume the average volume (AV) of both refrigerators is 20 ft3, and the embedded emissions of the new refrigerator is 365 kg.

The emissions of the remaining years of the used product's life exceed the total emissions of the new products life after eight years. After this period of time, the buying that refrigerator used becomes more of a detriment than a benefit to the climate.

1 Department of Energy (2007)

4.3.1 Refrigerators

Refrigerators are the classic example of an appliance where taking an older model out of commission has greater benefits than reusing the product. Refrigerators have an average lifetime of 20 years, but new more efficient models can cut energy use by 60% (Meir, 1995).

Due to the steep energy savings and the large portion of recyclable pieces in refrigerators, the global warming impacts of using a less efficient refrigerator are greater than replacing it with a newer, more efficient model. Many incentive programs have been put into place to encourage the purchase of new refrigerators in order to capitalize on these energy savings.

4.3.2 Automobiles

The automobile industry is a unique example where the use of more energy intensive manufacturing processes can later be offset with greater efficiency gains in the use and disposal phase. The use of lighter aluminum in automobiles in the place of heavier steel initially leads to greater GHG emissions, due to the mining and smelting processes of aluminum. However, lighter vehicle offer greater fuel efficiencies and small gains in the energy intensity of recycling aluminum, reducing the need for raw processing over time (Vyas and Gaines, 1995).

Since 10 percent of vehicles on the road emit more than 50 percent of the pollution (Bishop and Stedman, 1995), there is a need to take less efficient cars off the road and replace them with more fuel-efficient vehicles. About 2/3 of those 10 percent are vehicles older than ten years, but some are brand new. The automobile example underscores the importance of considering both the age and model of a product in conducting a LCA, as both can contribute to the environmental burden of a product in different ways.

4.3.3 Air Conditioners

In the case of air conditioners, Nakamura studied the Japanese market and found that high-end models had a lower life cycle cost while the low-end models had the highest life cycle cost with higher global warming potential and landfill consumption (2007). In this case, the impact of the appliance varies horizontally as well as vertically, with the model being just as important as the products age. Therefore, the product model has a large influence on the benefits of reused over new products.

These examples illustrate the complexity of evaluating products with significant use phases. Future case studies may address incidences where the benefits of buying a new product on eBay may outweigh the GHG savings of buying a used product, depending on the product vintage. Phase II may address specific models and brands that produce fewer GHG emissions.

> "Although reuse of products is generally more favorable from the global warming perspective, there are certain exceptions to this rule. "

V. Research Needs/ Future Directions

Buying a good used, in most cases, will lead to avoided greenhouse gas emissions. Determining the net value of those emissions will help to illustrate a powerful piece of the eBay environmental narrative. In examining the impact of a buying a used product, it is important how one chooses to allocate emissions to the buyer. The most appropriate way depends on the type of good. While a simple net zero method will suffice for collectables, practical goods or goods that require energy consumption may best be evaluated using the net life/value method.

Technological change has a large impact on GHG emissions since products are produced more efficiently over time. This can be formally incorporated into emission value calculations. If we value emissions reductions today more than in the future, then we can apply a discount model to correctly value emissions.

However, some exceptions exist. If the use phase of a product is energy intensive, that will be more important than production emissions— potentially negating any GHG emission benefit gained by buying a used good and displacing emissions from new good production.

The case studies being conducted under Lightening the Load will provide data as to the overall climate savings attributable to the sale of specific used products on eBay. Gathering quantitative data will lead to a more complex understanding of which products have the greatest GHG emission savings. The analysis of a few specific products will provide the narrative and scope for the larger research design that will be undertaken in Phase II. Important data necessary for this process include the expected useful lives of reused and new goods, sale price data for reused and new goods, emissions for each life cycle phase for reused and new goods, and average number of owners for a particular good.

VI.
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LIGHTENING THE LOAD

Part 2: Infrastructure and Consumption in the eBay Marketplace

OCTOBER 2008

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Lightening the Load documents how eBay's activities have changed the climate impact of commerce and how eBay's operations today help reduce overall greenhouse gas emissions. It also explores how the optimism and engagement of the eBay's employees and broader community can make commerce part of the answer in a carbon-constrained world.

ABSTRACT

Over the last decade, the sheer scale of eBay's unique business model has changed the geographic and spatial patterns of shopping and overall consumption patterns. Through the creation of increasingly efficient retail transactions and a robust market for reused, recycled, and salvage/overstock goods, eBay has reduced the global warming impact of the retail industry in two important ways.

1. **eBay eliminates much of the greenhouse gas emissions (GHG) associated with the wholesale and retail phases of a good's lifecycle.** In eBay transactions, goods do not follow the traditional path from warehouses to retail stores, to the consumer's home and back again in cases of returned items. These transactions eliminate the need for retail space and distribution warehouses, which each produce significant GHG emissions from construction and electricity use. eBay has also reduced the net impact of transportation between manufacturers and consumers. The reductions in GHG emissions from reduced demand for buildings and transportation far outweigh eBay's emissions from computer use and data centers.

2. **eBay also reduces the global warming impact of retail by reducing the total number of new products purchased.** eBay reduces the costs of buying and selling used, recycled, salvaged, and overstock goods and thereby reduces the market for new goods. This paper concludes by outlining the future research necessary to further detail the eBay's global warming impacts. Primary data could be collected to further document the emissions related to eBay's infrastructure relative to traditional and online retail as well as to determine eBay's impact on buyer and seller purchasing and sale decisions, respectively.

Infrastructure of Retail	*Retail outlets*	*Warehouses*
eBay	—	—
Online Retail	—	✔
Brick & Mortar Retail	✔	✔

Infrastructure

CONTENTS

I.
SUMMARY

This is the second paper in the Lightening the Load series, focusing on eBay's influence on how people buy goods and the global warming impact or carbon footprint of those changed consumption patterns. eBay has a unique business model which not only reduces the energy consumption associated with retail transactions but also reduces overall net consumption by providing a robust market for reused, recycled, and salvage/overstock goods. Taken together, the changes in both infrastructure and buying patterns reduce the global warming impact of consumers. By shifting shopping online and to a peer to- peer trading system, eBay has created a number of changes in retail that reduce overall environmental impacts. These include:

1. The reduction of traditional brick and mortar storefronts
2. The reduction of wholesale, distribution, storage, and shipping infrastructure, especially warehouses which are required by both brick-and-mortar and online-only stores
3. The elimination of retail space and the reduction in inventories and waste, which has reduced energy consumption across the sector.
4. The replacement of single purpose shopping trips with multiple package delivery systems such as UPS and FedEx

eBay's own operations still generate environmental impacts, most substantially in the transportation of goods sold on eBay and in the energy use demanded by their data centers and offices. However, when analyzed in quantitative detail, eBay's reductions in GHG emissions, attributable to the factors listed above, dwarf these operational GHG emissions.

eBay's trading platform impact the environment at a macroeconomic level as well. By shifting the structure of resale and of shopping itself, eBay impacts overall new product levels. This paper also presents a theoretical framework for determining the impacts of second-hand markets on material consumption and a discussion of the accompanying greenhouse gas emissions reductions. This impact can be assessed by evaluating the resale behavior and intentions of eBay sellers and buyers, the types of items that are sold on eBay, and relevant economic data.

The first paper in this series illustrated how the major benefits of eBay's trading platform come from the reduction in throughput engendered by the sale and purchase of so many items that would otherwise be thrown away. This paper rounds out the picture by looking at the very significant reductions that eBay has engendered by changing the infrastructure of shopping and and behavior patterns more generally.

II.
STATEMENT OF THE PROBLEM: WHAT IS THE GLOBAL WARMING IMPACT OF THE EBAY MARKETPLACE (COMPARED TO TRADITIONAL ON-LINE AND BRICK-AND MORTAR RETAIL?

Over the last decade, eBay has created surprising new ways for consumers to purchase a wide array of goods and services. One of the less pleasant surprises to emerge over the same period is that consumer purchases have leveled at about 40% of the average American household's contribution to global warming. The markets that eBay and its various stakeholders have created are trusted and efficient, and significantly lighten the load that consumer activity places on the environment.
This paper examines how eBay's activities have changed the carbon footprint of commerce, how eBay's operations today help reduce overall emissions, and, finally, how the optimism and engagement of the eBay's employees and broader community can make commerce part of the answer in a carbon constrained world.

E-commerce has reduced US energy intensity. Online retailers, as opposed to brick and mortar establishments, have led the way in increased efficiencies, which has led to overall reductions in energy expenditures and greenhouse gas (GHG) emissions. The US has seen a drop in its overall energy intensity in the past ten to twenty years, even as overall GDP has continued to rise. In 1997 and 1998, the US energy intensity improved by more than 3% per year while the economy grew at about 4% per year (Romm et. al., 1999). Although this drop in energy intensity can be attributed to several factors, the academic literature has attributed a large portion of the decrease to the rise in e-commerce and its subsequent effect on energy consumption (Romm, et. al.,1999, Romm, 2002, Matthews, et. al. 2001).

Dematerialization, or the overall reductionof the raw, physical materials needed in order to conduct business, is an important factor contributing to this decrease in energy intensity. Computers have enabled an important shift to dematerialization by moving many paper files to electronic files. The internet has contributed to dematerializing offices by increasing the practice of telecommuting, allowing more individuals to work from home and reduce or eliminate GHG emissions on their daily commutes to work. In the retail sector, E-commerce has reduced the need for paper transactions and brick and mortar establishments, decreasing the area of space needed per item and leading to ongoing structural and efficiency gains which are critical to climate mitigation strategies. Moreover, e-commerce has led to reductions in inventories and overproduction, which has in turn led to greater reduction in waste products.

"Moreover, e-commerce has led to reductions in inventories and overproduction, which has in turn led to greater reduction in waste products."

FAST FACT

Ghose et al. (2005) examine the used book market and find that new book prices increase with used book prices. This suggests that strong used good markets can stimulate demand for new goods.

All the effects of dematerialization are embodied very efficiently in the eBay marketplace. By connecting individuals and retailers through its peer-to-peer online platform, eBay has increased overall efficiency in the retail sector, decreased GHG emissions associated with consumer trips to brick and mortar stores and helped to reduce the waste associated with overstock.

To map the positive global warming impact of eBay's effect on how people buy goods, this paper uses the typical traditional and online retailer as a comparison to eBay's platform. It examines eBay's relative advantages in building construction, operation and maintenance, and transportation. The paper also addresses the roles of data centers and computer use and suggests some methods of calculating the energy usage of online transactions.

In a traditional retailing world, many goods that could be reused or salvaged are not. The time and money required to sell or buy a reused or salvaged good may be greater than the value of the good to many people. eBay has revolutionized and grown second-hand and salvage good markets. Buyers and sellers of goods can easily find one another on eBay's platform. This increases good reuse, reduces waste, and potentially reduces new good production as reused, salvage, and overstock goods replace new goods. Reduced or delayed production of new goods leads to a reduction in GHG emissions.

Some goods are better suited to substitute for new goods than others. For example, salvage and overstock products, collectables still in production, durable goods, goods with low resale values, goods consumed in limited quantities, and goods that provide limited additional benefit by being new all can substitute for consumption of new goods and contribute to reducing the GHG profile of retail. However, one countervailing effect is that eBay has also probably increased the resale value for a number of categories of products, and this increased value has driven increased demand for a limited number of new products.

This paper also examines how resale behavior, consumer intentions, and the types of goods sold on eBay can reveal eBay's impact on consumption patterns. Finally, it presents a framework for assessing resale behavior and buyer and seller intentions to determine how eBay has affected consumption patterns.

III. KEY VARIABLES: HOW EBAY CHANGES THE WAY GOODS ARE BOUGHT AND SOLD

The key variables that influence the difference in environmental impact between eBay and other retail channels fall into two broad categories:

1. Infrastructure
- Buildings
- Transportation
- Data Centers

2. Consumption
- Market for reused, recycled, and salvaged goods
- Resale behavior and wasted goods
- Macroeconomic consumption effects

3.1 "BUILDING" A RETAIL EMPIRE

eBay has encouraged dematerialization in building construction and building operation,transportation, and data center use through its innovative online trading platform.

3.1.1 BREAKING DOWN THE BUILDINGS

For major brick and mortar retailers, a large amount of energy is expended both in the process of constructing retail facilities and operating them. The construction industry is one of the most energy intensive industries in our economy. Cement manufacture has long been known to emit substantial greenhouse gases. For every ton of concrete created close to 1 ton of CO_2 is released into the atmosphere (CSI, 2001). Other inputs such as the steel and transportation of materials make global warming implications of retail building construction even more significant.

In addition to the one time energy cost of constructing retail stores, there are ongoing implications of operating and maintaining them. Typically, retail stores require energy for the day-to-day lighting, heating and cooling. Of course some eBay sellers are actually brick and mortar establishments

There are even retailers that have been established specifically to help aggregate individual sellers and auction their goods on eBay. Further research into the affect of eBay brick and mortar establishment should be the subject of Phase II research.

3.1.2 TRACING THE TRANSPORT

Comparing the climate impacts of individual car trips of consumers traveling to retail stores to the delivery systems of online retailers is challenging, as evidenced by conflicting assessments in the academic literature. Overall, it depends on the individual characteristics of the car trip and delivery method. Some of the most important variables to consider are as follows:

- The average length of trip taken by individuals
- The average distance a package is sent
- Whether the package was sent by air or overland
- The overall distance of a product's complete transportation stream

3.1.3 DATA CENTERS: COMPUTERS WORKING HARD

One of the main energy requirements of an online retailer is computer usage and corresponding data centers. Although many retailers implement online ordering systems, the energy requirements of a major online-only retailer can be a significant portion of its total global warming impact. In the popular press, data system energy consumption is seen as a major drawback of online retail, and the Internet is often reported to be pushing the demand for energy use. These claims are largely exaggerated (Koomey, 2003). In particular, the energy requirements of data centers are largely overestimated, even by the corporations who operated them, largely because their energy usage is calculated by looking at the nameplate power consumption of the electronic systems. As Mitchell-Jackson et al. (2001) report, even at peak demand more

systems never draw more than 80% of the nameplate power. Their study outlines a comprehensive method of evaluating the total computer room density by calculating all the power drawn by the computer and supporting equipment (HVAC, lighting, PDUs and UPSs) and dividing by the total computer room square area. Similar, if slightly less exact, results can be extracted from utilizing the billing data from the data center's energy supplier and dividing the total energy use by the square area.
3.2 e-Bay As a Marketplace for Reused, Recycled, and Salvage Goods

Overall, future research in Phase II of this project will be able to clearly indicate if eBay has led to a reduction in new good consumption by creating a market for reused, recycled, and salvage goods, thereby reducing GHG emissions. The first paper in this series addressed the product-level impact of this trade. The next section of this paper examines the market-wide or macro-economic effects of eBay trading.

3.2.1 Creating a Used Good Market Through Reduced Transaction Costs

When used or salvage products substitute for or delay the production of new products, GHG emissions are reduced. There is a substantial body of literature that assumes that reusing an item reduces demand for new products on a one-to-one ratio (Graedel and Allenby 1996, Curran 1996, Stahel 1994). This literature suggests that every good that is salvaged prevents the production of one new good. However, there is competing literature which suggests that second-hand markets for used goods can increase total consumption of new products (Chu and Liao 2007, Ghose et al. 2005, Thomas 2003, Scitovsky 1994, Kursten 1991, Fox 1957).

Strong second-hand markets allow consumers to recoup some of the initial costs of purchasing a new product. When resale values increase due to a strong second-hand market and consumers become aware of the resale values, consumers will value new products more. This leads to an increase in new product purchases. Further, when consumers are able to purchase used goods at lower prices than new goods, they may have more income available for new good purchases, thereby increasing demand for new goods.

Thomas (2003) provides a framework for understanding when second-hand markets will increase or decrease demand for new goods. When there are very high resale transactions costs, the market for reused goods will be small and many reusable goods are wasted.

When resale transactions costs are reduced, more goods are reused rather than wasted. When transaction costs associated with resale are very low, the demand for used goods may exceed the supply of used goods that are typically wasted. This will result in an increase in reused good prices and could increase the value of new goods as well. When this occurs, the thriving second-hand market stimulates demand for new goods since resale values are high. Figure 2 below demonstrates this effect.

By reducing resale transactions costs, eBay may have either increased or decreased demand for new goods. As shown on the figure above, when transaction costs are below a certain point (CL), this will increase the number of new goods. When costs are within a particular range (CL to CH), the second hand market reduces the production of new goods. The lowest consumption of new goods occurs when demand for reused goods exactly equals the supply of used goods that would have been wasted in the absence of eBay, which would occur at Q*. Understanding how people make purchasing and resale decisions is the first step in determining whether or not the reused good market on eBay has decreased or increase total new good consumption levels.

Infrastructure of Retail	*Retail outlets*	*Warehouses*
eBay	—	—
Online Retail	—	✔
Brick and Mortar	✔	✔

Figure 2: New and Used Good Purchases with Increasing Transaction Costs Source: Adapted from Thomas (2003)

In Phase II of Lightening the Load, surveys can be designed to evaluate why eBay buyers and sellers trade used goods on eBay, and what they would have done in the absence of eBay. As further discussed in Section 4 of this paper, this information can reveal how many goods are no longer wasted due to eBay's platform.

3.2.2. Changing Resale Behavior

When people resell used goods simply after they are finished using them, then a more robust second-hand market may decrease demand for new goods. However, when people plan to resell new goods, they will value new goods more. If most eBay sellers incorporate resale values into purchasing decisions, then eBay may actually increase demand for new goods. Evaluating what eBay buyers and sellers would have done in the absence of eBay reveals whether or not eBay has decreased demand for new products. If less is thrown away because of eBay, then there will be a decrease in new good production. However, if the same number of used and salvaged goods would have been sold in other markets, such as second-hand stores, garage sales, and factory outlets, then eBay has not decreased new good production and reduced the GHG emissions associated with producing, selling, using, and disposing of those new products.

3.2.3 Changing Consumption Behavior

eBay has impacted consumer shopping propensity and behavior. eBay not only serves as a marketplace for trading goods, but also serves as an alternate form of "hobby" shopping. eBay also allows cultivation of unique shopping hobbies that may be less GHG intensive than prior hobbies. For example, what did the average Pez dispenser collector on eBay do prior to building that collection through online shopping? If the answer is that they collected Harley-Davidson motorcycles, then the shift to online shopping created a net decrease in GHG emissions. If people purchase less energy intensive goods and spend less time participating in energy intensive hobbies as a result of eBay, this would further reduce GHG emissions.

3.2.4 Extending Useful Product Life

eBay not only provides more robust markets for reused and salvage/overstock products, but also provides a market for recycled products,and facilitates the sale of complements that extends the useful life of existing goods.

3.2. Looking To The Economy For Answers

Many of the questions about eBay's impacts on consumption must be answered with economic data. By looking at the new markets that have emerged due to eBay and isolating the impact of eBay on retail and used good sales through surveys, it's possible to gather further information on eBay's effect on new good production.

"Further, when consumers are able to purchase used goods dat lower prices than new goods, they may have more income available for new goods purchases, thereby increasing demand for new goods."

IV.
ANALYSIS AND FINDINGS:

By increasing the efficiency of retail and product use, eBay is decreasing retail's global warming impact

4.1 REDUCING EMISSIONS BY CUTTING OUT THE MIDDLEMAN

4.1.1 NO RETAIL BUILDINGS OR WAREHOUSES NECESSARY

Not only does eBay eliminate the need for retail stores for its own platform, its very existence may be leading to the reduction in the need for retail stores overall.
The process of dematerialization attributed to e-commerce is exemplified and amplified by eBay. Romm (1999), in his discussion of book sales, found that the ratio of energy use of retail bookstores compared to online retailers was on the order of sixteen to one. The savings from the elimination of warehouses and all remaining brick and mortar infrastructure engendered by eBay are even greater. What really sets eBay's of online retail is the lack stand-alone warehouses. Although online retailers do not require traditional brick and mortar retail stores, most online retailers still require warehouses to store goods prior to shipping. The EIA estimated that the total energy use per square foot for a retail store is about 11.8 kWh/sq ft. Warehouses require significantly less energy per square foot, using about 6.4 kWh/sq ft (EIA 1998). Although major online retailers can claim significant energy savings over a brick and mortar establishment, eBay can claim even more since they have no warehouses and generate zero emissions from warehouses. In 1995 warehouses made up approximately 8.5 billion square feet of commercial floor space, utilizing a total of 51 billion kWhs of energy. Based on these numbers we can estimate 6.4 k. Whs of energy are required to operate for each square foot of warehouses constructed. A typical major online retailer's distribution center is between 93,000 and peer-to-peer platform apart in the world 700,000 square feet. Taking these two warehouses as the opposite extremes for US warehouses, we can estimate that each warehouse avoided has reduced energy demand by between 600,000 kWhs and 5 million kWhs of energy.

RUNNING THE WAREHOUSES

A first-order estimate of avoided emissions. Warehouse average energy: 6.4 kWh/sq ft1 per year Emissions from a coal fired power-plant = 1 ton CO2/1,000 Kwh A large online retail warehouse is 770,000 sq ft x 6.4kWh/sq ft x 1 tonsCO2e/ 1,000 kWh = almost 5,000 tons CO2e per year or about 1 day of operationfor a coal fired power plant for each year of operation.

FAST FACT

Academic studies on book retailing have shown that even assuming that all books bought online are shipped via air, online retailing still has a lower impact than traditional retailing when a private automobile is utilized. This is true with or without the expected 35% return rate expected with traditional book retailing (Hendrickson et al., 2001).or about 1 day of operation for a coal fired power plant for each year of operation.

REDUCED RETAIL INFRASTRUCTURE: TOTAL AVOIDED EMISSIONS FROM EBAY

The EIA estimates that about 70% of all commercial buildings existing in 1995 were constructed prior to 1980. However, in the five years between 1990-95 4.6 billion square feet of commercial retail floor space was constructed in the US, an average of .92 billion sq ft/year.

The energy required for construction of the buildings was 293 kWhs per sq ft and the energy intensity of the average retail store was equal to about 11.8 kWhs per square foot per year. That means that 270 million MWhs/yr of energy was consumed in the construction phase for these buildings and about 10 million MWh of energy were consumed by these buildings each year for a total of 280 million MWh/yr.

Overall it has been estimated by the OECD that a decline of about 12.5% of building use will come about as a result of e-commerce, a potential energy savings of roughly 35 million MWh/yr (In Romm, 1999).

If we assume eBay contributes10% of the online effect, we can estimate that eBay could be responsible for saving 3.5 million MWhs of energy in the construction sector.

To put this in perspective, a coal-fired power plant produces about 1 ton of CO2 for every MWh of energy product. That is 4 million tons CO2/yr or about three and a half coal fired power plants per year. eBay's GHG emissions for all of its facilities worldwide total only 88,000 tons CO2e/yr.1 Even when you add in transportation emissions of 23,000 tons CO2e/yr2, the mission savings from eBay are much greater than their own footprint.

[1]Based on eBay internal data

[2]Based on eBay internal data. Average package 0.06 kg CO2e for ground transportation, 1.3 kg CO2e for air freight.

Assume 50% packages shipped ground, 50% air freight.

4.1.2 A DIFFERENT TYPE OF TRANSPORT

For a brick and mortar retailer, a product's transportation stream begins with the manufacturer and ending with the consumer. In between, the product must travel from the manufacturer to a distribution center or warehouse, from the warehouse to the retailer and then must be picked up by the consumer who makes a round trip from his or her house. In addition, we can consider return streams in the instances when consumers return a product or when products not sold at the retailer may make an additional trip back to the warehouse and then to an outlet store or waste disposal facility. Figure 3 illustrates these transportation streams.

An online retailer's transportation stream is conceptually more efficient in that it eliminates the flows to and from the retail store. In addition, with online retailers fewer items are returned (Matthews and Hendrickson, 2001), leading to a further reduction in the transportation streams. Figure 4 demonstrates this reduction. eBay may represent the most structurally efficient of all of the retail platforms in that it requires only one transportation stream per product transaction. This assumes that the seller originally purchased the product to get some benefit from using it, and did not just buy it to resell it as a middleman. However, these are generalized transportation streams for each scenario. The specific impact of a particular transportation stream depends on the method of transport used in each step of the trip. The global warming impact is greatly influenced by the transportation utilized in each stream. For instance, shipping by airfreight has about 20 times the global warming impact than shipping by truck or rail (eBay internal data).

4.1.3 LOOKING TO DATA CENTERS

A relative comparison of eBay and other online competitor's data center energy requirements can be evaluated in a number of ways. One way to consider the life cycle of a given product is to examine the billing information from eBay's data centers in order to evaluate the energy intensity of the building in W/m2, and then to utilize information regarding the local energy mix used by the data center to determine the net global warming effect.

Difficulties may arise in attempting to compare the size and effect of competitors' data centers with that of eBay's, as many companies prefer to keep information about their data centers internal. However, Mitchell-Jackson's average estimation of the upper bound limit of 430 W/ m2 for a typical Silicon Valley data center can be used as an adequate matrix of comparison for eBay's own power requirements. According to their own estimates, eBay's data centers are responsible for 53,000 tons of CO2e.

An appropriate comparison requires a detailed comparison of data center energy use at eBay and its competitors. This kind of data may be available in the future as companies share their energy data to benchmark their progress and learn from each other. The EPA (March 2008) estimates that energy efficiency in data centers could improve as much as 70 percent with the adoption of state-of-the-art technologies. Evaluating the current emissions and efficiency of eBay's data centers would allow eBay to take the first step in reducing its energy footprint.

4.2 Reducing Emissions by Creating New Markets for Used Goods

Section 3.2.2 above highlights the interactions between seller/buyer intent and potential impacts on goods consumption. This section analyses the interactions in more detail. There are two ways to evaluate eBay buyer and seller intentions in order to predict the effect of eBay on new good consumption patterns. The first approach is to determine whether or not the sellers planned to resell when purchasing new goods. The second approach is to determine what eBay buyers and sellers would have done in the absence of eBay.

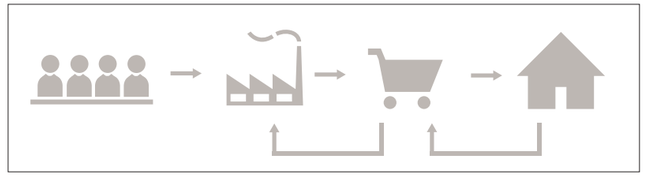

Figure 3: Transportation in Brick and Mortar Retail

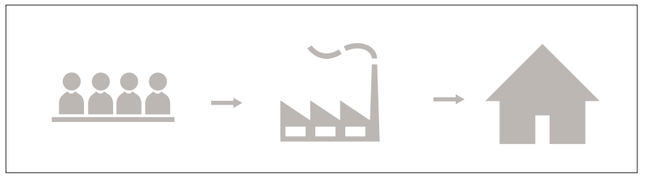

Figure 4: Transportation in Online Retail

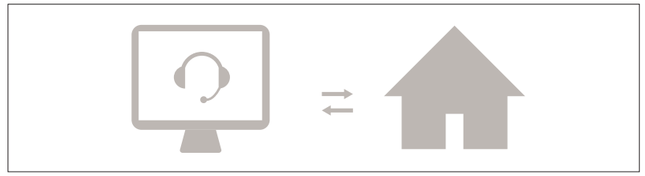

Figure 5: Transportation in eBay Trades

4.2.1 Deciphering Resale Behavior to Determine the Demand for New Goods

There are two types of sellers on eBay: consumer sellers and professional sellers. It is clear that professional sellers consider resale values when building their inventory. However, most professional sellers that sell used goods purchased them used and have not used the product themselves. When professional sellers trade reused goods, they encourage product reuse and potentially reduce demand for new goods. This is particularly true of sellers that find reusable goods in alternative used good markets and then list them on eBay. By selling a used good at a higher price, professional sellers ensure that those who value used goods most receive the good. These same buyers are more likely to purchase the good new if they are unable to purchase it used.

Chu and Liao (2007) identify four types of resale by consumer resellers.

1. Resale of extra purchase occurs when consumers buy extra quantities of goodsthey plan to consume with the intention to resell the excess, perhaps in order to take advantage of bulk discounts.
2. Resale after temporary ownership includes purchases by consumers that intend to resell after a using the product for a period of time.
3. Unintentional resale includes resale after impulse purchases, mistaken purchases, and receiving unwanted gifts.
4. Disposition occurs when consumers simply dispose of their goods in secondary markets when they no longer use them

Consumers who resell extra purchases or plan to resell after temporary ownership, explicitly consider resale values when making purchasing decisions. These consumers purchase more new products when resale potential increases. When they sell their goods on eBay they are not reselling products that otherwise would have been wasted. Therefore, these transactions may not lead to a reduction in new good production. Survey data collected from eBay sellers could be used to characterize the types of resale activity that occurs on eBay and the implications for new good production. Table 1 below indicates when good reuse increases the demand and production of a new good

Consumers with greater experience on eBay are also more likely to have planned resale than eBay novices. Therefore, it may be appropriate to assume that sellers with limited listings on eBay did not consider resale value when purchasing many types of new goods, and sales by these sellers are more likely to reduce demand for new goods.

4.2.2 What Would Have Happened Without eBay?

According to a survey conducted by Nielsen, only 36% of households plan to sell some of their unused items (2007). This suggests that many reusable goods are wasted. eBay buyers and sellers could be further surveyed after eBay transactions in order to determine what they would have done in the absence of eBay. Table 1 below indicates how the survey results could be used to determine eBay's impact on consumption patterns.

CASE STUDY FINDINGS

4.2.3 What Types of Reusable Goods do People Waste?

Different types of reused goods are more or less likely to substitute for new goods. Chu and Liao (2007) find that Chinese eBay users who consistently purchase the latest technologies or fashion are more likely to incorporate resale values when purchasing new goods. These consumers prefer brands that have higher resale values. This suggests that eBay's market for recent models of electronics and brand named fashion items may actually increase demand for new versions of these used good products. Collectables that are no longer in production or that derive their value from their vintage also do not substitute for new goods (see paper 1 in this series). Expensive items, such as homes and cars that benefit from a strong secondary market may substitute for new goods, but the ability to resell these goods also increases demand for new goods, so their resale may not reduce new good consumption.

Thomas (2003) argues that goods with steady long-term values and goods that do not derive most of their value from being new are likely to reduce demand for new goods. Durable furniture and jewelry, unbranded or less expensive clothing, home goods CDs, DVDs, and books are likely to substitute for new products. Since consumers who buy items with low second-hand prices rarely expect to recoup their expenses, these goods also reduce the demand for new goods. Table 3 below hypothesizes which transactions on eBay may reduce demand for new goods based on the type of buyer and item. An exploration of this hypothesis would be the basis of Phase II research. The most likely items to be discarded by a household are clothing, toys, handbags, and furniture (Nielson, 2007). These items may substitute for new goods.

FAST FACT

Browsing or trading items on eBay has a smaller climate impact than many other ways consumers spend time. For example time spend on eBay with produce fewer GHG emissions than driving to a mall to window-shop, riding a motorcycle, or visiting a theme park.

4.2.4 Considering eBay's Impact on Consumer Behavior

Consumers who spend time on eBay instead of participating in energy intensive activities have a reduced global warming impact. It is likely that eBay has allowed people to trade in their old hobbies, for less energy intensive ones. This effect on GHG emissions could be assessed with a survey of eBay users. People visiting the eBay site should be asked what they would have been doing with their free time in the absence of eBay. This would reveal if eBay has had a significant impact on people's shopping propensity and behavior.

4.2.5 Evaluating Changes in US Consumption Patterns since eBay

The effect on U.S. consumption patterns likely varies across eBay's categories. To isolate the effect of eBay on total consumption, Phase II research is needed to first indentify then consider changes in retail and used good sales. For instance, controlling changes in the state of the economy, other online sales, and other related factors is critical. An evaluation might prove challenging given that e-commerce retail including eBay, though growing rapidly, accounted for less than three percent of retail sales in the US in 2006 (US Census, 2008). Nevertheless, the advantages of evaluating macro-economic data to measure eBay's impact may be worth the effort if it is more precise than using survey data from eBay's users or could potentially capture indirect impacts of eBay's markets.

V. Future Research/ Next Steps

From an infrastructure standpoint, eBay has a much smaller global warming footprint than traditional retail due to two primary mechanisms: dematerialization and reduction of new consumer products. In particular, eBay's unique consumer facing infrastructure represents a structurally efficient platform that has eliminated the need for retail structures and warehouses, with their associated footprint, as well as cut down on the transportation streams associated with purchasing a product. The most substantial portion of eBay's global warming impact is the energy use associated with their data centers. However, when quantified fully, the reductions in GHG emissions attributable to the reduced construction, operation and maintenance of major structures will far outweigh the electricity demands associated with computer use and data center requirements.

eBay has potentially reduced consumption for many types of new products by providing a market for reused, recycled, and salvaged goods. Phase II of Lightening the Load will study the consumption effects on consumer behavior to further quantify these reductions. Although the sale of some items will not reduce the demand for new goods, many other eBay transactions will reduce new good consumption. The sale of goods on eBay with steady long-term values, that do not derive most of their value from being used as new, or with low second-hand prices are likely to substitute for new goods and reduce new good production. Products such as high fashion and technology goods, collectables that are no longer in production, and products that derive much of their value from being new do not. Unless eBay sellers incorporate resale values into purchasing decisions, eBay has only decreased new good consumption by reducing the waste of reusable and salvageable goods.

Moving forward, both internal and external data can help define eBay's climate impact further. Emissions reductions related to eBay's infrastructure relative to traditional retail and other online retail stores should be readily quantifiable. Surveys can be used to characterize the behavior and intentions of eBay users and predict consumption impacts of eBay and macroeconomic data on changes in retail patterns can show how eBay impacts markets and buying habits. When eBay's impact is isolated from other factors influencing consumption, economic trends should provide conclusive evidence about how much eBay has reduced new good production in the past and will continue to reduce in the future.

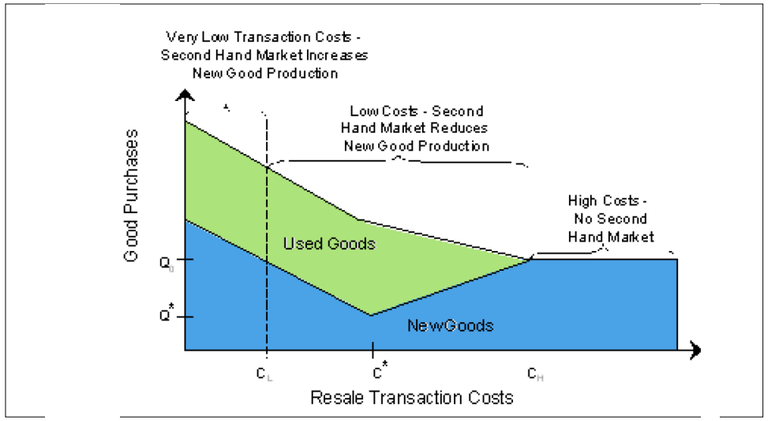

Table 2: When Does Resale Reduce Consumption & GHG Emissions?

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LIGHTENING THE LOAD

Case Study: The Global Warming Benefits of the Resale of Golf Clubs on eBay

OCTOBER 2008

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Lightening the Load documents how eBay's activities have changed the climate impact of commerce and how eBay's operations today help reduce overall greenhouse gas emissions. It also explores how the optimism and engagement of the eBay's employees and broader community can make commerce part of the answer in a carbon-constrained world.

I.
SUMMARY

In the last three years, nearly 3.5 million golf clubs were sold on eBay, worth at least $250 million. The majority of the golf clubs sold were used. The global warming benefits of buying used golf clubs on eBay are two-fold. First, buying a used club often prevents a new club from being produced. Second, eBay provides one of the most efficient options for purchasing items, since it does not involve a physical network of warehouses and retail stores.

The purpose of this case study is to estimate the greenhouse gas (GHG) emissions reductions from the resale of golf clubs on eBay. Golf clubs nicely illustrate that used goods can substitute for new goods. Most golfers only use one of any particular type of golf club. Few golfers need multiple five irons for example. Therefore, when consumers choose to buy a used five iron, this usually prevents a new five iron from being produced. In order to estimate the reductions from all used golf clubs sold on eBay, the reductions resulting from the resale of steel irons and graphite drivers are calculated using the "Net Zero" method presented in Lightening the Load, Phase I, Part I: The Global Warming Impact of Buying Used Goods.

The analysis reveals that resale of an iron on eBay reduces GHG emissions by over 16 kg CO2 and resale of a driver on eBay reduces GHG emissions by over 100 kg CO2e.

CASE STUDY FINDING

Through the sale of used golf clubs, eBay in the last two years has reduced the amount of GHGs equivalent to:

Taking 22,000 cars off the road for a year

Reducing gasoline consumption by 13,600,000 gallons

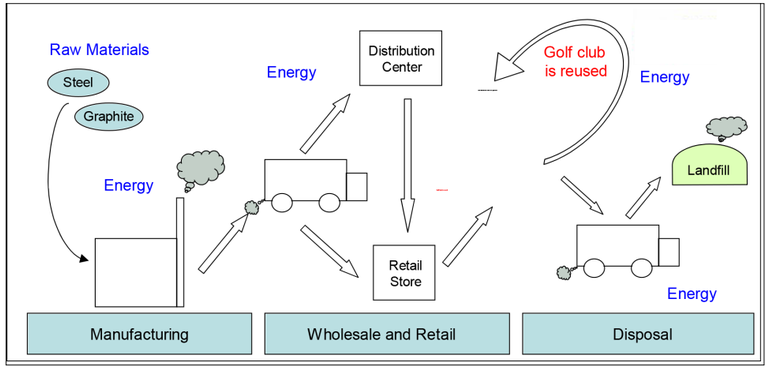
Planting 3,000,000 trees

Providing renewable electricity to 16,000 homes

II.
HOW DO USED GOLF CLUBS SOLD ON EBAY REDUCE GHG EMISSIONS?

There are four primary phases of a product's life cycle that can produce GHG emissions: Production, Wholesale /Retail, Use, and Disposal. Production of raw materials such as steel and graphite, transportation of raw materials, and energy use at the manufacturing plant all produce emissions. Wholesale and retail emissions are created as the golf clubs are shipped and stored in distribution warehouses and/or retail stores. Golf clubs do not have any use phase emissions. When the golf club reaches the end of its life, it is transported to a landfill for disposal. Figure 1 below illustrates each of the emissions phases for the lifecycle of a golf club. The sources of emissions are written in blue.

One important characteristic of golf clubs is that most consumers need only one set of clubs at a time. For example, people typically have limited use for duplicate clubs. Therefore, it can be said that used clubs substitute for new clubs. When a used golf club is purchased on eBay instead of a new one, this prevents the production, wholesale and retail, and disposal emissions of a new golf club. The eBay transaction is the only source of GHG emissions. Since eBay does not require a large physical infrastructure of warehouses and retail space, the transaction emissions are likely to be much smaller than traditional retail.



Lifecycle GHG Emissions of a Golf Club

III.
CALCULATING THE GHG

Emissions Reductions for Reused Golf Clubs The Net Zero method identified in the Lightening the Load, Phase I, Part I: The Global Warming Impact of Buying Used Goods is applied to calculate the GHG savings from reusing golf clubs. The Net Zero method assumes that the emissions associated with the production, wholesale and retail, and disposal of an existing good have, or will be, produced regardless of whether or not the good is reused. Under this method, only the emissions generated through resale are allocated to the reused good.

WHY THE NET ZERO METHOD?

The Net Zero approach is well suited for used goods that are likely to substitute for new goods. Golf clubs are ideal for this approach since:

1. They have long useful lives
2. They may be reused by many subsequent buyers
3. The additional benefit derived from a new club versus a used one can often be small
4. A particular type of club is often consumed in limited quantities, so buying used displaces the production of a new club

APPLYING THE NET ZERO METHOD

In the last three years, almost 750,000 used graphite drivers were sold on eBay. Similarly nearly 200,000 used steel irons were sold on eBay. Together, these two types of golf clubs made up almost half of total sales of used golf clubs on eBay. The GHG emissions reductions from used graphite drivers and steel irons sold on eBay are calculated. These calculations illustrate that input materials are a key component of the global warming impact of a product, and are used to estimate the total emissions reductions associated with all used golf club transactions on eBay. The GHG emissions prevented by reusing a graphite driver or steel iron are simply calculated as the global warming impact of a new driver or iron, adjusted by any additional emissions generated by the eBay transaction. Each phase of a golf club's life cycle can be evaluated as follows:

Manufacturing
Cooler's Goods and Services calculator can be used to estimate the production emissions of a consumer good based upon the dollar value of the product. The calculator is based on adjusted EIO-LCA values generated by Carnegie Mellon for the year 2002.

Retail/Wholesale/Transportation
Emissions from this category are based upon embodied emissions/transaction for the seller platform (traditional wholesale/ retail, and eBay), average distance traveled/ delivered, and means of transportation. The emissions from the used golf clubs sold on eBay are based on the average shipping value of used handbags on eBay, which are considerably smaller than the emissions generated from traditional brick-and-mortar retail.

Disposal
Emissions from this category can include end-of-life transport, landfill emissions, and/ or the emission resulting from the recycling of materials. Data from the EPA and the average eBay shipping weight of each type of golf club are used with Cooler's calculator to estimate the emissions from disposing of golf clubs. most important variables to consider are as follows:

- The average length of trip taken by individuals
- The average distance a package is sent
- Whether the package was sent by air or overland
- The overall distance of a product's complete transportation stream

IV.
RESULTS

Using the Net Zero method, selling a used graphite driver on eBay saves the global warming equivalent of over 100 kg of carbon dioxide (CO2e).

A used steel iron sold on eBay saves over 16 kg of CO2e.

Emissions by Phase (kg)	*Manufacture*	*Retail/ Wholesale/ Transportation*	*Disposal*	*Total GHG Per Driver*
New Driver	83.7	20.4	.5	104.5
Used Driver	-	3.6	-	3.6
GHG Savings	83.7	16.8	.5	100.9

Emissions by Phase (kg)	*Manufacture*	*Retail/ Wholesale/ Transportation*	*Disposal*	*Total GHG Per Driver*
New Driver	12.7	5.1	1	18.8
Used Driver	-	2.7	-	2.7
GHG Savings	12.7	2.4	1	16.1

VI.
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LIGHTENING THE LOAD

Case Study: The Global Warming Benefits of the Resale of Handbags on eBay

OCTOBER 2008

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Lightening the Load documents how eBay's activities have changed the climate impact of commerce and how eBay's operations today help reduce overall greenhouse gas emissions. It also explores how the optimism and engagement of the eBay's employees and broader community can make commerce part of the answer in a carbon-constrained world.

1.
SUMMARY

Nearly 22 million handbags have been sold on eBay in the last three years. This case study examines the greenhouse gas (GHG) emissions reductions from the resale of handbags on eBay. The reductions resulting from the resale of two types of handbags are examined in detail:

1. Higher-priced handbags with resale values over $100
2. Lower-priced handbags with resale values less than $100

For each handbag price category, one specific brand and type of handbag is chosen to help estimate the GHG reductions for all used handbags sold on eBay.

As outlined in the white paper Lightening the Load, Phase I, Part I: The Global Warming Impact of Buying Used Goods, there are multiple ways to calculate emissions reductions arising from different products in the eBay marketplace.

Handbags are a great illustration, and the two price categories highlight the differences. The Net Zero approach is applied to the lower value handbags since these handbags can often substitute for new handbags and the initial owner did not likely consider resale when making the initial purchasing decision. On the other hand, when consumers purchase luxury handbags high resale values they may consider resale, making the Net Value approach more appropriate. Both owners in the transaction are then allocated some of the GHG emissions associated with that bag.
The analysis reveals that resale of a lower–price handbag on eBay reduces GHG emissions by 12 kg per CO2e per bag, resale of a higher-price handbag on eBay reduces GHG emissions by 285 kg CO2e, and the sale of all used handbags on eBay in the last three years has reduced GHG emissions by nearly 94,000 tons of CO2e.

CASE STUDY FINDING

For handbags alone, over the last two years eBay has reduced the amount of GHGs equivalent to:

Taking 17,000 cars off the road for a year

Reducing gasoline consumption by 10,600,000 gallons

Planting 2,400,000 trees

Providing renewable electricity to 12,400 homes

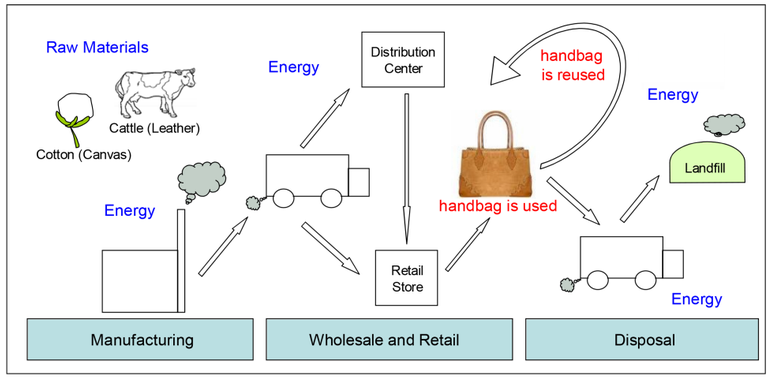

Figure 1: Lifecycle GHG Emissions of a Handbag

II.
How do used handbags sold on eBay reduce GHG emissions?

There are four primary phases of a product's life cycle that can produce GHG emissions: Production, Wholesale /Retail, Use, and Disposal. Production emissions stem from production of raw materials such as leather and cotton, transportation of raw materials, and energy use at the manufacturing plant. Wholesale and retail emissions are created as the handbags are shipped and stored in distribution warehouses and/or to retail stores. Since handbags do not require any energy when they are used, they do not have any use phase emissions. Finally, when the handbag reaches the end of its life, it is transported to a landfill for disposal. Figure 1 below illustrates each of the emissions phases for the lifecycle of a handbag. The sources of emissions are written in blue.

When a used handbag is purchased on eBay instead of a new one, this prevents the production, wholesale and retail, and disposal emissions of a new handbag. The only new emissions that are created from reusing a handbag are from the eBay transaction. These emissions are likely to be much smaller than traditional retail since eBay does not require a large physical infrastructure of warehouses and retail space. The purpose of this case study is to estimate the GHG emissions reductions associated with the resale of handbags on eBay by comparing the emissions of selling a reused handbag on eBay and producing a new one.

III.
Calculating the GHG emissions reductions for reused handbags

The Net Zero and Net Value methods identified in the Lightening the Load, Phase I, Part I: The Global Warming Impact of Buying Used Goods are applied to calculate the GHG savings from reusing handbags. The two approaches highlight the inherent differences in consumer behavior when purchasing goods with varying resale values, and thus change the method applied.

3.1 Using the Net Zero approach for lower value handbags

The Net Zero method assumes that the emissions associated with the production, wholesale and retail, and disposal of an existing good have, or will be, produced regardless of whether or not the good is reused. Under this method, only the emissions generated through resale are allocated to the reused good.

The net zero approach is well suited for used goods that are likely to substitute for new goods, including used handbags sold on eBay for less than $100 since:

1. They have long useful lives
2. They may be reused by many subsequent buyers
3. They are rarely bought for the purposes of resale and hence are most often thrown away when they are no longer needed

The most commonly sold used handbags on eBay for under $100 are Coach brand and made of leather. In the last three years, over 1.1 million Coach handbags were sold on eBay for less than $100, nearly half of which were used. These bags sell for just over $30 on average. The GHG emissions prevented by reusing a leather Coach handbag are simply the global warming impact of a new Coach handbag, with adjustment for any additional emissions generated by the eBay transaction. Each phase of a handbag's life cycle can be evaluated as follows:

Production/Manufacturing
Cooler's Goods and Services calculator can be used to estimate the production emissions of a consumer good based upon the dollar value of the product. The calculator is based on adjusted EIO-LCA values generated by Carnegie Mellon for the year 2002. The estimates generated by this analysis are specific to the value and type of Coach handbag.

Retail/Wholesale/Transportation
Emissions from this category are based upon emissions from the sales (brick and mortar, online retail, or eBay), average distance traveled fordelivery, and means of transportation. Cooler's Goods and Services Calculator uses data from the US Bureau of Economic Analysis to estimate the emissions for a traditional and sale of a new leather Coach handbag. The emissions from the used handbag sold on eBay are based on the average shipping value, or weight and shipping distance, of used handbags on eBay, which are considerably smaller than the emissions generated from traditional brick-and-mortar retail.

Disposal
Emissions from this category can include end-of-life transport, landfill emissions, and/ or the emission resulting from the recycling of materials. Data from the EPA and the average weight of a handbag is used with Cooler's calculator to estimate the emissions from disposing of a handbag in a landfill.

CASE STUDY FINDING

The total emissions savings rom selling 1.6 million used handbags for an average price of $30 and 320 thousand handbags with an average price of $300 on eBay is nearly 94,000 tons of CO2e That's the equivalent of:

Taking 17,000 cars off the road for a year

Reducing gasoline consumption by 10,600,000 gallons

Planting 2,400,000 trees

Providing renewable electricity to 12,400 homes

3.2 USING THE NET VALUE APPROACH FOR HIGHER VALUE HANDBAGS

The Net Value method does not simply assume that the reused bag substitutes for the new bag. Instead, some of the production, initial sale, and disposal emissions are allocated to the reused handbag. This method accounts for the fact that some consumers intend to resell their bags after using them for a temporary period of time. Since the new owners clearly benefit from buying used bags that still have high values, both owners are held responsible for the handbag's emissions. The net value approach is appropriate for higher value used luxury handbags since they can substitute for new goods, but may be purchased with resale in mind.

The primary difference between handbags with low resale values and those with high resale values is the likely consumer intent when purchasing and then reselling a handbag. Without resale potential, fewer bags would be produced and sold, and fewer overall emissions would occur. For goods with high resale values, the Net Value method provides a more conservative estimate of emissions savings of used goods than the Net Zero method.

A commonly sold used handbag on eBay for over $100 is a Louis Vuitton handbag, which sells for over $370 on average. Over 100,000 used Louis Vuitton handbags were sold on eBay in the last three years. A typical new Louis Vuitton handbag sells for $1030. The emissions reductions from each phase of a handbag's life cycle can be evaluated similarly as for handbags under $100. However, under this approach, some of the initial manufacturing, retail/wholesale/ transportation, and disposal emissions are attributed to the used handbag.

Emissions by Phase (kg)	*Manufacture*	*Retail/ Wholesale/ Transportation*	*Disposal*	*Total GHG Per Bag*
New Bag	10.8	2.7	.4	13.9[2]
Used Bag	0	1.9	0	1.9
GHG Savings	10.8	.8	.4	12

Emissions by Phase (kg)	*Manufacture*	*Retail/ Wholesale/ Transportation*	*Disposal*	*Total GHG Per Bag*
New Bag	360.3	89.0	1	450.32[2]
Used Bag	130.2	35.2	.4	165.8
GHG Savings	230.1	53.7	.6	284.4

2 Totals may not add up across rows and columns due to rounding.

IV. RESULTS

Using the Net Zero method, reusing a $30 leather Coach handbag saves the equivalent of over 12 kg of carbon dioxide (CO_2e) per bag sold on eBay Using the Net Value method, reusing a $310 leather Louis Vuitton handbag saves nearly 285 kg of CO_2e per bag sold on eBay.

VI. REFERENCES

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LIGHTENING THE LOAD

Case Study: The Global Warming Benefits of the Resale of Laptops on eBay

OCTOBER 2008

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Lightening the Load documents how eBay's activities have changed the climate impact of commerce and how eBay's operations today help reduce overall greenhouse gas emissions. It also explores how the optimism and engagement of the eBay's employees and broader community can make commerce part of the answer in a carbon-constrained world.

I. SUMMARY

This is the third case study in Phase I of Lightening the Load. This case study will analyze the greenhouse gas impact of buying a used laptop on eBay versus buying the same model new on eBay or another retail platform. The paper assesses the greenhouse gas emissions attributable to the sale and purchase of a typical used Hewlett Packard Pavilion dv8000 model through elementary life cycle analysis. Buying a used laptop reduces the emissions associated with purchase by displacing the purchase of a new laptop into the future.

One used laptop bought on eBay saves about 150 kg of GHG. Extrapolating the emissions reductions for this typical laptop model results in a total savings of 66,400 tons of GHG emissions between 2006 and 2008.

II. STATEMENT OF THE PROBLEM

Since 1995, three quarters of a million laptops have been sold on the eBay platform, resulting in almost eighteen million dollars in net revenue. Of those, roughly 60% of those listings were used laptops, the sale of which displaced the need for production of a new laptop for the remaining duration of their useful life. By evaluating the life cycle emissions of a Hewlett Packard dv8000, which represents a very typical laptop, an average emissions/laptop is determined and treated as representative of the computers sold on eBay (see table, opposite page).

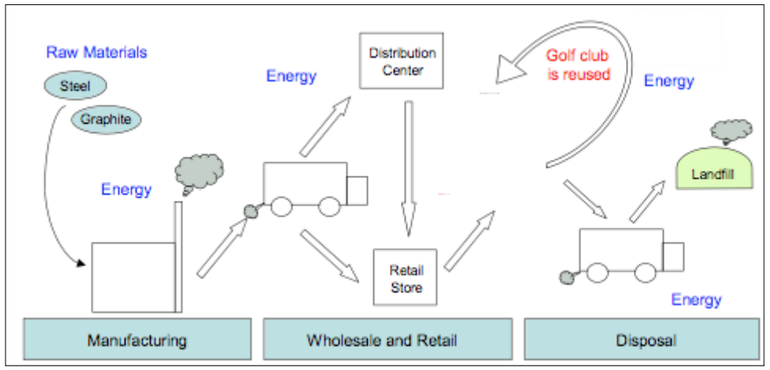

Figure 1: Lifecycle GHG Emissions of a Handbag

III.
METHODOLOGY
NET LIFE EMISSIONS

The Net Life Method, explained in detail the Lightening the Load, Phase I, Part I: The Global Warming Impact of Buying Used Goods white paper, is applied in this paper to calculate the GHG savings from the reuse of a laptop computer.

Cooler uses the EIO-LCA approach, which calculates emissions intensity per dollar based on calculations from the Carnegie Mellon 2002 EIO-LCA values and adjusted for inflation. Detailed information concerning the calculations and methodology used is located in the Appendix.

3.1 THE NET LIFE METHOD

A number of factors make the Net Life Method the ideal approach for assessing the allocation of emissions and savings from buying a used laptop on eBay. They include:

- The short use phase of a laptop (4-6 years), which indicates that some portion of the production, retail and disposal of the product should be allocated to the end consumer of the used product.
- Relative unlikelihood that the laptop will be resold more than once (no double counting).
- The need for electricity in the use phase, leading to GHG emissions during its product life.
- Displacement of new laptop production, increasing emission savings due to gains in production and energy efficiency over time.

"...the other half are considered avoided emissions."

3.2 APPLYING THE NET LIFETIME METHOD

This case uses the example of a used HP Pavilion dv8000 notebook as a proxy for used laptops sold on eBay. The notebook has an average lifetime of four years, but in our caseis sold after only two years, with half of its liferemaining. Using the Net Life Method, half of the original emissions from the production, retail/wholesale and disposal phases are allocated to the end purchaser of the used good, while the other half are considered avoided emissions.

The remaining two years of use phase emissions are also allocated to the end buyer of the used laptop. The emissions at each phase for a new and used laptop can each be evaluated and then compared in order to assess the total emissions from the purchase of each product. Additionally, similar calculations for a refurbished laptop are shown to demonstrate the global warming benefits of buying salvaged products on eBay's platform.

Each phase of a laptop's life cycle can be evaluated as follows:

Condition	*Successful Listings*	*GMV*	*Disposal*
Total	**782,140**	**377**	**481**
New, Sealed in Box	119,559	127	1063
Refurbished	128,439	60	464
Used	445,286	148	333

Table 1: Laptop Sales on eBay and Nielson Estimated Values

Manufacturing
Cooler's calculator can allocate production emissions of a consumer good based upon the dollar value of the product.
The emissions intensity for a laptop computer is 229 g GHGeq/$.

Retail/Wholesale/Transportation
Emissions from this category is based upon embodied emissions/transaction for the seller platform, average distance traveled/ delivered and means of transportation.
Use: The HP Pavilion has a nameplate energy expenditure of 65-90 Watts.
Taking an average wattage and estimating a usage of 4 hours/day over the course of four years, Cooler calculated the use phase emissions associated with the product over its lifetime.

Disposal
Emissions from this category can include end-of-life transport, landfill emissions, and/ or emissions resulting from the recycling of materials.

IV.
RESULTS

The emissions savings from buying a used laptop is calculated with equation 6.1 from Lightening the Load Phase I Part 1:
The GHG emissions saved from the sale of just one used laptop on eBay equal approximately 149 kg. If we consider the HP model as an average across the laptop category, the sale of used laptops on eBay is responsible for over 66,400 tons of GHG emissions. That is equivalent of saving 462 acres of forest.

V.
NET PRESENT VALUE OF EMISSIONS

The selection of the HP model is useful for demonstrating the importance of displacing the production of a new laptop into the future. Hewlett Packard has recently set stringent energy efficiency goals, both for their products and for their data centers and production facilities. An HP computer bought 2-4 years from now can easily expect to embody fewer embedded emissions per product, perform at a higher energy efficiency and be designed for easy recycling and disposal.

A few of HP's1 goals are:

- 2006 introduction of more energy efficient servers that use 33% less power than regular rack mount servers
- 50% reduction in energy use by cooling fans
- Early compliance with the US EPA's Energy
- Star 4.0 requirements, which will result in desktop business PC's with 80% efficient power supplies.
- Cooling energy management system is designed to deliver 20 to 45% savings in cooling energy costs or allows additional equipment to be added to the data center while keeping net power costs constant.

Using equation 6.2 from Lightening the Load Phase I Part 1 gives us a rough idea of the value of future emissions from the production of a new laptop:

$$\text{Emissions Reduced Due to Reuse} = \left(\frac{\text{Years of Remaining Life of Reused Good}}{\text{Expected Useful Life of New Good}} \times \text{Emissions from New Good} \right) - \text{Use and Additional Wholesale and Retail Emissions from Reused Good}$$

Emissions Phase	Manufacture	Retail/ Wholesale/ Transportation	Use Phase	Disposal	Total
HP Pavilion dv8000 (new)	131 kg	377	377	377	481
HP Pavilion dv8000 (refurbished)	81g	98 kg	380 kg	127	1063
HP Pavilion dv8000 (used on eBay)	66 kg	61 kg	380 kg	60	464
Allocated to former user	66 kg	98 kg	190 kg	0.06 kg	355 kg

Figure 1: Lifecycle GHG Emissions of a Handbag

$$E_t = \frac{E_0}{(1+i)^t}$$

In our case, t=2 years, E0 = present day value of emissions saved (149 kg), and i is estimated at 1%. Substituting our numbers into this equation, we find an additional emission savings value of 3 kg of GHG, equivalent to20% of the shipping emissions from an average eBay transaction. Phase II of Lightening the Load can assess and evaluate the net present value of these emission savings to create a more nuanced approach to understanding the value of displaced production.

Conclusion

For used laptops alone, eBay is responsible for saving over 66,400 tons of GHG gas emissions. Buying a used laptop on eBay not only avoids GHG emissions from the immediate production of a new laptop on the market, the displacement of that laptop's production allows time for innovations and energy efficiency measures to be implemented. Hewlett Packard is currently undertaking aggressive measures that will ensure that the embodied emissions in its products are decrease along with the products energy usage. If one of the major leaders in computer technology is taking such great strides towards energy efficiency, other companies will follow suit.

When the reused laptops are eventually replaced at the end of their lifetime, the products replacing them will be produced more efficiently, be designed for greater recycling potential and require less energy over the course of their lifetime.

With the recent increase in both voluntary and regulatory GHG reduction programs, a few years of displaced production is likely to lead to even greater emission savings. Buying a used laptop on eBay pushes the production of harmful emissions into the future, where their impact will be lessened.

[1]*See HP Energy Solutions at the Pew Center for Climate Change. Accessed August 18, 2008. http://www.pewclimate.org/companies_leading_the_way_belc/company_profiles/hewlett_packard_company/energysol.cfm*