UNIVERSITY OF CALIFORNIA
SANTA BARBARA

ENVIRONMENTAL AND ECONOMIC PERFORMANCE ANALYSIS OF OAKWOOD DISTRIBUTION CENTERS

A Group Project submitted in partial satisfaction of the requirements for the degree of Master's in Environmental Science and Management
for the
Donald Bren School of Environmental Science and Management

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The mission of the Donald Bren School of Environmental Science and Management is to produce professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principal of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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Table of Contents

List of Tables and Figures

Figures

Tables

EXECUTIVE SUMMARY

Introduction

Oakwood Worldwide is the largest temporary housing company in the world with operations in North America, Europe, and Asia. The company offers customers furnished and unfurnished accommodations for short-term and extended stays. To remain flexible to demand, it leases properties near locations requested by customers. Oakwood operates regional distribution centers (DCs) and service centers (SCs) to service these housing units. Each DC and SC maintains an inventory of furnishings and supplies, and most DCs operate washers, dryers, and dishwashers for cleaning inventory, such as linens and dishes. Home furnishings and supplies are regularly transported between units, DCs, and SCs.

In July 2007, Oakwood Worldwide consolidated three distribution centers that service 1,800 apartment units in the San Francisco Bay Area into one, centrally located DC. From the consolidation, Oakwood expected to achieve long-term cost savings and improve environmental performance. At the time of the consolidation however, Oakwood lacked reliable tools to estimate the impacts of a DC network reconfiguration. Therefore, this decision was made without conducting a thorough analysis of the potential changes to Bay Area DC performance.

The Bay Area consolidation is not a unique situation. In order to effectively respond to changing customer demand, Oakwood must constantly reconsider the configuration of its regional distribution networks. Furthermore, business and environmental pressures require managers to thoroughly evaluate the potential impacts before implementing DC reconfiguration decisions. To address this decision-making need, the objective of this group project was to develop a DC reconfiguration model. The purpose of this model is to predict the changes in environmental and economic performance that would result from a potential DC reconfiguration, and to retroactively measure changed performance after a reconfiguration is implemented. In addition, we conducted a thorough analysis of the Bay Area consolidation that was critical in the development of the model, thereby allowing Oakwood to evaluate its decision. Finally, we used the model and the Bay Area consolidation analysis to identify opportunities to reduce the environmental footprint of Oakwood's overall DC operations.

As the largest temporary housing company, identifying opportunities to reduce Oakwood's environmental footprint can lead to considerable environmental benefits. Understanding the correlation between the financial and environmental impacts of the Bay Area consolidation is an important first step for incorporating environmental considerations in future DC reconfiguration decisions.

The use of this DC reconfiguration model will improve the effectiveness of Oakwood's future reconfiguration decisions. This model will also allow Oakwood to better understand the various aspects of its DC operations such as transportation, energy, and waste management. Oakwood's use of the model could reduce its environmental footprint throughout its worldwide operations. In addition, a model that evaluates environmental performance simultaneously with economic performance is significant to the field of environmental management because many companies face similar decisions with their distribution centers. With appropriate modifications, this model and the concepts of this project can be reapplied to distribution networks of other industries.

Methodology

This project involved five major steps: data collection, analysis of the Bay Area consolidation, development of the DC reconfiguration model, model validation, and the development of recommendations. Data collection, the Bay Area analysis, and model development focused on the aspects of Oakwood's DC operations that would change as a result of network reconfiguration. The major aspects of DC operations include transportation, onsite operations, and potential reconfiguration investment.

Data collection ranged from the beginning of 2006 through November 2007 and included the 2008 budget. In an attempt to account for variations in seasonal and customer demand, we focused our data collection on August-November 2007 (a four-month period immediately following the consolidation), February-May 2007 (a four-month period immediately prior to consolidation), and August-November 2006 (the corresponding four-month period from the prior year). We limited data collection to the Bay Area's DC operations.

The first step in developing the DC reconfiguration model was to conceptualize it, whereby we defined the following parameters:

1. <u>Model inputs</u>—the information the user puts into the model;
2. <u>Data processing</u>—the calculations that convert input to output; and
3. <u>Model outputs</u>—the key financial and environmental impacts of DC and SC operations that our model will report.

The Bay Area analysis focused on the same aspects of Oakwood's DC operations that are evaluated by the reconfiguration model. The understanding gained from performing the Bay Area analysis was then used for developing the model. The model uses Microsoft Excel, with which most users are already familiar.

The DC reconfiguration model involves two separate components with distinct objectives. The DC performance prediction component estimates the difference in performance between an existing DC configuration and potential reconfigurations. With this information, a manager can compare the environmental and economic performance of a current DC configuration in a given region to proposed, alternative configurations. The DC performance evaluation component compares the actual performance of DCs before and after a reconfiguration. This component allows managers to evaluate the environmental and economic performance of DCs using actual data after a decision to reconfigure has been implemented.

The development of the DC reconfiguration model was divided into three major categories of impacts that represent a change in performance. The first, onsite DC operations, includes performance indicators relating to employees, rent, equipment, utilities, and solid waste management. The second, transportation, encompasses travel between DCs, SCs, and apartment units. The third category, reconfiguration investment, captures the non-operational costs associated with a potential reconfiguration. Data relating to these impacts must be entered into the model for every current (and in some cases potential) DC involved in a reconfiguration scenario.

The majority of the impacts calculated by the DC reconfiguration model can be derived from data that Oakwood currently tracks. However, some critical aspects of the model will require Oakwood to collect new data, such as the mileage of Oakwood-owned vehicles. Therefore, our recommendations not only focus on data necessary for the model, but also on data collection that can assist in improving overall environmental performance.

Once the Bay Area consolidation analysis was complete, the results and findings of this analysis were used to test and refine the DC reconfiguration model. This step involved entering pre-reconfiguration data from the Bay Area consolidation into the prediction component of the model, and comparing the model predictions to the results and findings of the Bay Area analysis. This comparison was then used to iteratively identify deficiencies in the model and to improve its accuracy.

The final step in this project involved using the DC reconfiguration model, the Bay Area consolidation analysis, and our understanding of Oakwood's operations to make recommendations for improving environmental performance. These recommendations relate to overall DC performance, including transportation and onsite operations.

Findings

The analysis of the Bay Area consolidation reveals the potential for substantial long-term cost savings attributable to changes in onsite DC operations, despite an increase in transportation costs. According to this analysis, transportation costs rose by $13,839 while onsite DC operating costs decreased by $471,466 annually. Annual rent savings and reduced employee costs were the main drivers of the onsite DC operating cost savings. Combining the change to transportation and DC operating costs, the consolidation will produce an overall cost-savings of $457,627 annually which is expected to cover the consolidation investment of $683,320 in 1.5 years.

Environmentally, the Bay Area analysis shows a modest decline in environmental performance. Air emission increases ranged from 0%-10% across all pollutants measured, including a 4% increase in CO_2 emissions. A breakdown of 2006 operations shows that transportation produces 52% of the total CO_2 emissions in the Bay Area. As a result, a 6.8% increase in post-consolidation fuel consumption accounts for the majority of the rise in CO_2 emissions. Environmental performance improved with respect to electricity consumption and emissions, though not enough to offset transportation impacts. The Bay Area analysis also shows a slight increase in natural gas consumption and emissions, but these results are inconclusive since they rely upon level of laundry service for clients and highly volatile natural gas prices.

The purpose of the reconfiguration model is to predict results of possible reconfigurations in other regions. Part of the model requires Oakwood personnel to estimate and input investment and operation costs for a potential reconfiguration based on their experience with regional DC operations. However, limited pre-calculations are necessary for projecting potential impacts directly relating to environmental performance in the areas of transportation, utilities, and waste. The accuracy of the DC reconfiguration model was tested by comparing predictions based upon Bay Area pre-consolidation data to actual Bay Area post-consolidation results and the 2008 budget for Bay Area DC operations.

When comparing the model predictions for electricity consumption based on annual 2006 pre-consolidation data, the model outputs were approximately 11% greater than the actual post-consolidation data, and 35% greater in comparison to the 2008 budget. The prediction of natural gas consumption using 2006 data was 9% lower than the 2008 budget and 42% lower than actual consumption. However, the Bay Area analysis shows a substantial unexplained spike in natural gas costs for October 2007, which suggests that a comparison to this period is unreliable. The transportation section of the model was tested using the round-trip mileage between the DCs and every stop because the exact mileage was unavailable. For each period of data tested, the model predicted 129%-178% greater fuel consumption than shown by the actual post-consolidation results. However, this comparison substantially overestimates fuel consumption because the main transportation impacts by the DC should only relate to changes in the distance between the DC and the first and last stops. We expect that the model will provide reliable predictions if actual pre-consolidation mileage is used. Finally, the prediction of solid waste generation was over 150% greater than actual waste generation. In this case as well, the model substantially overestimated waste production because the actual volume of waste generated pre-consolidation was unavailable and we expect improved model accuracy with the use of actual waste volumes.

Conclusions and Recommendations

According to our analysis, the July 2007 DC the Bay Area consolidation is expected to produce substantial long-term cost savings with a slight decline in environmental performance. However, these findings are subject to uncertainty because they are only based on four months of post-consolidation data and the 2008 budget. Therefore, we recommend that Oakwood reanalyze the consolidation using a full year of reliable post-consolidation data for more precise findings. The evaluation component of the DC reconfiguration model can be utilized for this follow-up analysis. In addition, we see the cost-savings realized from the consolidation as an opportunity to embark on additional environmental programs.

Based on an understanding of Oakwood's DC operations and sound environmental management principles, the prediction component of the model is expected to provide reliable projections of potential DC reconfigurations for Oakwood's operations in other U.S. regions. However, insufficient data were available to fully validate the model's predictive capabilities. Therefore, we recommend that Oakwood retest the model with 12 months of reliable pre-reconfiguration data (from the Bay Area or elsewhere) and compare the model projections to 12 months of reliable post-reconfiguration data from the same region. This process should be repeated for other reconfigurations to evaluate model performance and make appropriate adjustments.

The DC reconfiguration model was specifically designed to predict and evaluate the environmental and economic performance of potential reconfigurations. By modifying and limiting the inputs to reflect SC operations, this model can also be applied to SC site selection and reconfiguration. We recommend that Oakwood apply this model proactively to other regional DC and SC networks to identify and take advantage of opportunities for improving overall performance. This model and the concepts provided by this report can also be applied to other businesses and industries facing similar reconfiguration issues to improve the environmental and economic performance of their network operations.

INTRODUCTION

Oakwood Worldwide is the world's largest temporary housing company with operations in North America, Europe, and Asia. The company provides guests with high-quality furnished and unfurnished accommodations for both short-term and extended stays. In order to remain flexible to fluctuating demand, Oakwood leases most of their apartment units.

Oakwood operates approximately 1,800 individual housing units throughout the San Francisco Bay Area, including apartments in Mountain View, San Jose, Walnut Creek, Livermore, and San Francisco. Apartment units are divided into several distribution regions that are serviced by their respective distribution centers (DCs). Prior to July 2007, these units were serviced by 130 employees at three DCs (San Francisco, Livermore, and San Jose). Oakwood currently utilizes multiple distribution facility systems in many major U.S. cities including Chicago, Los Angeles, Boston, and New York.

Oakwood operates distribution centers and service centers (SCs) to service the housing units they offer. Home furnishings and supplies are regularly transported between units, DCs, and SCs. Each DC maintains an inventory of furnishings and supplies, and most operate washers, dryers, and dishwashers for cleaning inventory, such as linens and dishes. DCs also house regional and branch offices where move-ins, move-outs, maid services, and other operations are coordinated. SCs operate as intermediate storage facilities temporarily holding furnishings and supplies that are transported between a DC and a particular set of units. SCs are utilized for highly concentrated or remote units to reduce the number of trips and mileage that would be required to service these units directly from DCs. The provision of large furnishings, such as beds, couches, and entertainment centers is outsourced to local furniture suppliers.

PROBLEM STATEMENT

In July 2007 Oakwood Worldwide consolidated three distribution centers (DCs) that service apartment units in the San Francisco Bay Area into one, centrally located DC (see Figure 1). Based on limited information, Oakwood personnel expected that the consolidation would result in long-term cost savings and beneficial environmental consequences. The decision to consolidate was based on a consideration of rent, employee costs, unit locations, and potential benefits due to economies of scale. The company anticipated potential environmental improvements resulting from improved transportation routing, the use of more energy- and water-efficient equipment, and the operation of fewer facilities. However, Oakwood lacked the tools to thoroughly analyze potential impacts prior to making the consolidation decision or to measure the actual impacts after the consolidation was implemented.

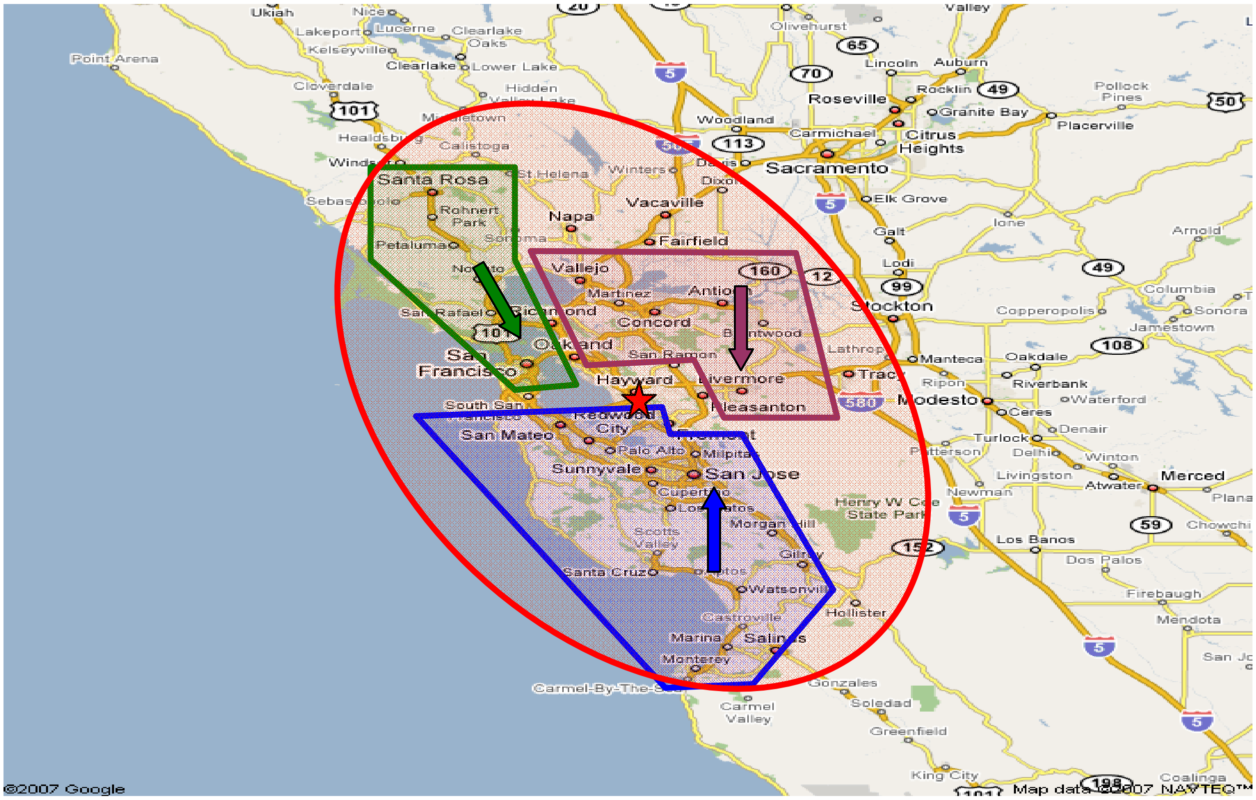

Figure 1: Map of Oakwood's Bay Area Pre- and Post-Consolidation DCs

OBJECTIVES

To address Oakwood's need for a tool to estimate and evaluate changes that would result from a DC network reconfiguration, the goal of this project was to develop a model that quantitatively predicts and retroactively measures changes in environmental and economic performance resulting from DC reconfigurations. In addition, we analyzed the Bay Area consolidation to assist in developing the DC reconfiguration model and to evaluate Oakwood's decision to consolidate. Finally, we used the model and the Bay Area analysis to identify opportunities to reduce the environmental footprint of Oakwood's overall DC operations.

SIGNIFICANCE

The Bay Area analysis will allow Oakwood to better understand its decision to consolidate. The evaluation portion of the model provides Oakwood with a tool that will facilitate the same environmental and economic analysis of future DC network reconfigurations. The opportunity for Oakwood to explore the correlation between financial and environmental performances is an important first step for incorporating environmental considerations in future DC reconfiguration decisions. In addition, creating the mindset of tying together environmental and financial analyses will set the foundation for Oakwood to incorporate additional environmental considerations in their business strategy.

The predictive portion of the model forecasts the environmental and economic performance of potential DC reconfigurations and compares these projections to existing operations. These predictions will facilitate the DC reconfiguration decision-making process and should improve the environmental and cost efficiency of Oakwood's operations. Because the tool analyzes both economic and environmental factors, Oakwood will be able to effectively identify and evaluate tradeoffs. In addition, by isolating particular sections of the analysis, the model can be used to identify non-reconfiguration opportunities for operational improvements. If the model is applied proactively and diligently, it will allow Oakwood to substantially improve the overall environmental and economic performance of its DC operations. As the largest temporary housing company, reducing the overall environmental footprint of Oakwood's DC operations will lead to considerable environmental benefits.

The development of a model that estimates and measures the environmental and economic performance of DC reconfigurations is also significant to the field of environmental management. DC site selection and performance evaluation are not unique to Oakwood. Any company with a distribution network is faced with reconfiguration decisions as its business evolves. While businesses traditionally base decisions on financial factors, a recent increase in pressure from the public, competitors, customers, and legislators is forcing companies to seek new ways to improve environmental performance. The DC reconfiguration model and the concepts provided in this report can be applied to improve the environmental and economic performance of similar distribution networks managed by companies in other industries.

As public awareness of environmental issues has heightened in recent years, trends show that consumers prefer environmentally and socially conscious businesses, and many large companies are initiating strategies that improve their environmental performance (Fister Gale, 2007). Oakwood has instituted a greening initiative to address the environmental impacts of its operations, which includes installing energy-efficient light bulbs in its housing units and educating guests about actions that can reduce energy and water consumption. These efforts have been similar to initiatives undertaken by many other companies in the hotel industry in recent years. The company, however, realizes its impacts go beyond its apartment units and identified its network of DCs as an opportunity for making environmental improvements.

Effective environmental management at DCs has a potential for influential improvements throughout a company's operations; since the DC is the focal point of the supply chain. A number of companies, such as IKEA, FedEx, and Hitachi, have initiated environmental programs at their DCs (IKEA, 2005; Baraldi, 2003; Ribaudo et al., 2006; E2Open U.S.A., 2005). While environmental initiatives are traditionally seen as costly investments, many firms have found efficient operations and other initiatives that result in cost savings linked to environmental improvements without compromising the quality of the goods and services.

DC site selection within a transportation network plays a critical role in the DC's environmental and economic performance by reducing fuel consumption and vehicle emissions. Most commercially available DC site selection and network models focus on minimizing transportation time and cost and increasing accessibility of low-wage labor and low-cost transportation. Literature shows that centralized consolidation of DCs tends to provide an opportunity for cost saving from a streamlined site operation, but usually results in an increase in transportation since the centralized location would be further away from certain destinations than if there were several DCs in the network (Matthew and Hendrickson, 2003). Typically, environmental impacts from transportation outweigh the environmental impacts from onsite operation activities; therefore DC consolidation is often not seen as an environmental choice.

We found that Oakwood's particular situation may be different than a typical distribution center's case. For one, the consolidation of its distribution centers would result in the abolishment of regional zone restrictions to transportation routes. In the case of the pre-consolidated Bay Area network, certain apartment units nearby may not have been serviced by a particular driver servicing others en route, if they were in another branch's region. In addition, Oakwood can optimize the use of SCs so that transportation of stored inventory can be reduced. Finally, Oakwood's laundry and dishwashing operations at the DCs make the facilities more energy intensive than a typical DC that simply stores and delivers inventory. Therefore, there is potential for a consolidated Oakwood DC to improve the company's environmental performance. Our analysis and model, introduced above, builds on these concepts and provides managers with a mechanism to evaluate and compare holistic assessments of the environmental impacts from the transportation network and facility operations.

APPROACH AND METHODOLOGY

This section describes the methodology of this project. The first step was to roughly conceptualize the DC reconfiguration model and the Bay Area analysis to identify our data needs and formulate a data collection strategy. Next we worked with Oakwood personnel to collect data for specified periods of time. After data collection, we conducted a thorough model conceptualization to better understand the relationships between inputs and outputs and the specific calculations the model must perform. We then analyzed the DC consolidation in the Bay Area and developed the DC reconfiguration model. To the extent possible, we adjusted and tested the validity of the model using Bay Area data and findings. Finally, we developed a set of recommendations based on our Bay Area analysis and modeling creation. Each of these aspects of our methodology is described in greater detail below.

Rough Model Conceptualization and Identification of Data Needs

The first part of our project involved conceptualizing the processes that the DC reconfiguration model would be expected to perform. Through conceptualization, we determined the model inputs, outputs, and the relationships between the two. The model inputs represent the data that will be entered into the model for analysis. The outputs are the results of the analysis that assist a decision-maker in predicting or evaluating the impacts of a DC reconfiguration. The conceptualization focused on aspects of Oakwood's DC operations that would change as a result of a reconfiguration.

The conceptualization step also served to identify our data needs for the Bay Area consolidation analysis since this analysis reflects the evaluation component of our model. Therefore, for each model input, we also listed potential sources for this information relevant to the Bay Area consolidation. These sources included the Bay Area regional branch offices, Oakwood's Corporate Headquarters, or internet resources. After determining the scope of our data collection, we formulated a strategy for retrieving the required data. Data requests were then forwarded to the regional branch offices and Oakwood's Corporate Headquarters.

Data Collection

Our data collection for the Bay Area analysis was limited by our proximity in time to the consolidation. Since the consolidation occurred in July 2007 and the bulk of our analysis had to be completed by December 2007, we only had four whole post-consolidation months to analyze. Therefore, the post-consolidation period of analysis ranges from August 2007 through November 2007. To account for annual variations we compared this period to a four-month period immediately prior to the consolidation, February 2007 through May 2007. June 2007 was not included in the analysis because the relocation was originally planned for this time. Although the relocation date was postponed, we expected that relocation preparation and other factors taking place during this month may have made the time period less representative of normal operations. To account for seasonal variation we also compared the post-consolidation period to the corresponding four-month period from the prior year, August 2006 through November 2006. Figure 2 shows these periods.

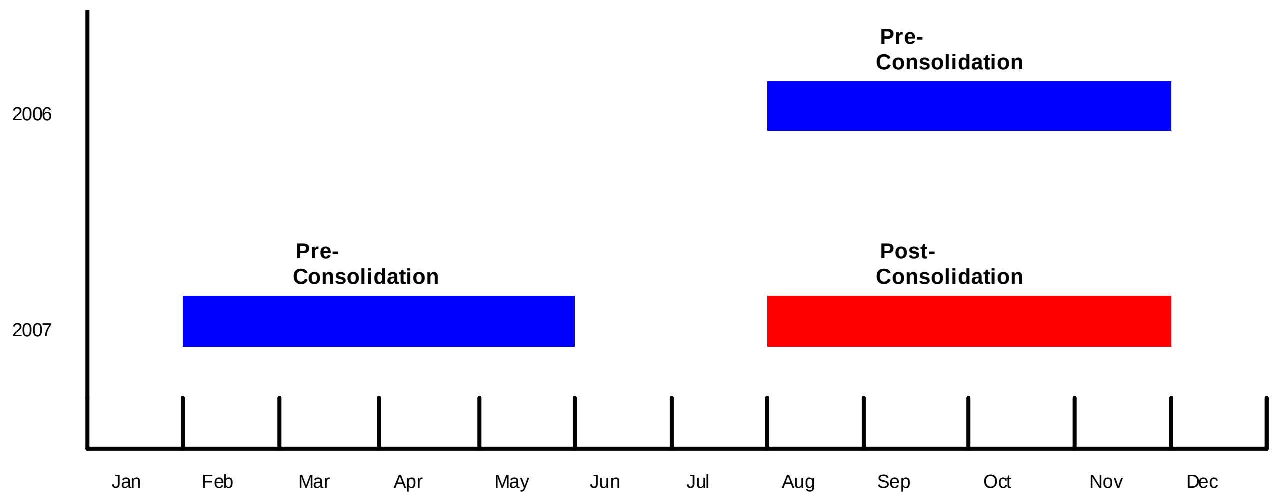

Figure 2: Data Collection Time Periods

As we gathered data, we realized the four-month period data had the following limitations:

1) Regularly occurring expenses, such as rent and utilities, were sporadic in the expense reports because of Oakwood's cash-basis accounting system, which does not capture lag times between consumption (e.g., utilities), receiving invoices, and paying the bills.
2) Oakwood experienced some transitional irregularities during the months before and after reconfiguration.
3) Certain expenses do not accrue on a monthly basis.

Although only several months had passed since the reconfiguration had taken place, we had to extend the scope of our analysis beyond these four-month periods. As a result, the full scope of our data collection included all of 2006 and 2007, and the annual budget for 2008. Although actual expenses are likely to vary from the budget, Oakwood planned its 2008 budget after the relocation. We therefore determined that in some cases the budget would be the best source to represent post consolidation costs since managers had already adjusted to new practices and had a fairly good idea of the new costs incurred in the reconfigured network when budgeting, and there would not be costs associated with the transition.

Thorough Model Conceptualization

Once data were collected and we had a better understanding of their limitations, we conducted a thorough model conceptualization. This conceptualization included a series of inputs and outputs for all changes in performance we intended to analyze according to the data available to us. Figure 3 shows a simplified version of this conceptualization. The performance measures were separated into three main categories. These categories include transportation impacts (red), onsite DC operations impacts (blue), and relocation/reconfiguration capital costs (yellow). Our results and findings are also explained according to these categories. The outputs of the model, which also reflect the outputs of the Bay analysis, are shown in green.

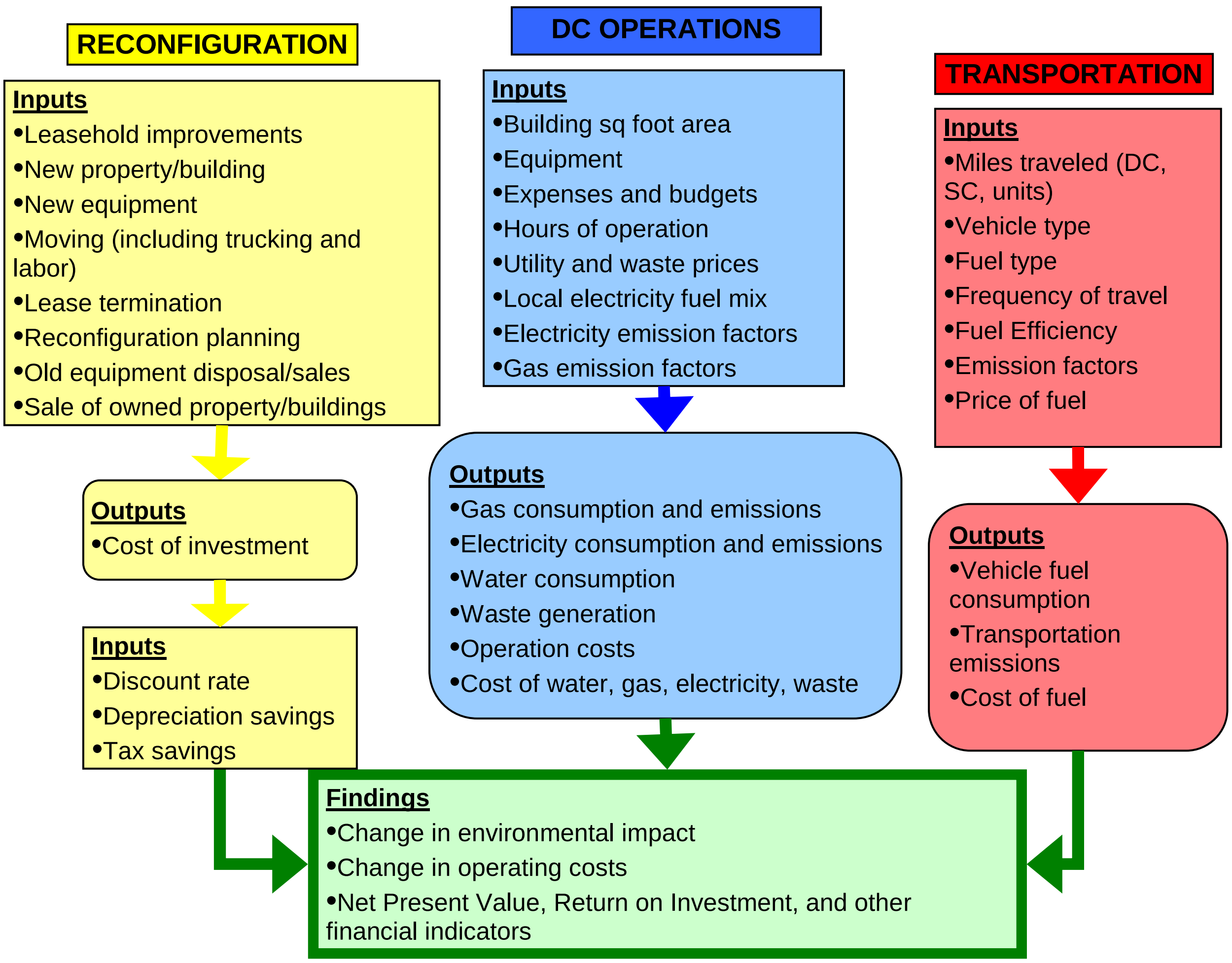

Figure 3: Model Conceptualization

Bay Area Analysis and Model Development

Following the thorough model conceptualization, we analyzed the Bay Area consolidation and developed the DC reconfiguration model. The reconfiguration model consists of two components, one for prediction and one for evaluation. The prediction component allows the user to forecast the change in performance that would result from a potential DC reconfiguration. The evaluation component provides the decision-maker with a mechanism to measure the actual changes in performance from a reconfiguration that has been implemented. The Bay Area consolidation analysis, which measures and evaluates the change in performance between the three pre-consolidation DCs and the one post-consolidation DC, provided the basis for developing the DC reconfiguration model.

The Bay Area analysis compares pre-consolidation periods to post-consolidation periods for each category of impacts shown in Figure 3. However, our analysis is more broad and different in some respects from the analysis to be performed by the model. The Bay Area study analyzes many of the impacts using several different approaches. The model, on the other hand, may only utilize one or two of these approaches, or a different approach. The scope of the Bay Area analysis and model differ because we were able to test and determine the relationships between the inputs and outputs by conducting the Bay Area analysis using different methods. The model then utilizes the best method(s) for predicting and evaluating impacts. In some instances, particularly with respect to the prediction component of the model, certain necessary data were not available for the Bay Area analysis but will need to be collected for input into the model for future analyses.

Data from the Bay Area consolidation were also used to test, modify, and validate our model to the extent possible, as described in specific model development sections below. In doing so, we were able to adjust our model or select the best possible method for analysis. With the knowledge gained from the Bay Area analysis and model creation, we developed recommendations on how Oakwood can reduce its environmental footprint. We also imbedded additional inputs and outputs in our model so that Oakwood can evaluate the impact of implementing some of these recommendations into its operations.

BAY AREA ANALYSIS AND MODEL DEVELOPMENT

As mentioned above, we divided our analysis and model development into the categories of transportation, DC operations (including energy use, waste generation, and operational costs), and reconfiguration investment. In this report we go through these categories individually. We describe our Bay Area Analysis and findings and model development methodology and findings in each respective section.

Transportation Network

Bay Area Analysis Methodology

There are two major aspects of Oakwood's transportation impacts in the Bay Area. The first is the impact from vehicles transporting home furnishings and other supplies to and from DCs, SCs, and apartment units. Most of these vehicles are diesel-fueled trucks. The second major aspect is the impact associated with the provision of maid services at apartment units. The maids typically use small to midsize passenger cars that run on regular, unleaded fuel. Appendix C: Transportation provides a list of the vehicles utilized in the Bay Area for 2006 and 2007.

The amount spent on fueling these vehicles is tracked for each DC in Oakwood's monthly expense schedules. While cost information is important, data on the amount of fuel consumed in gallons are more useful for determining environmental impacts from Oakwood's transportation fleet. To determine the amount of regular and diesel fuel consumed for each period, Oakwood estimated the percent of reported expenses spent on each fuel type for their Bay Area operations. We then divided the amount spent on each type of fuel for each month by the average monthly fuel costs to calculate the number of gallons consumed. Average monthly fuel prices were taken from a database provided by the U.S. Energy Information Administration (EIA, 2008a; EIA, 2008b). While the EIA database provides prices specific to the San Francisco region for regular gasoline, it only provides California statewide prices for diesel.

The volume of fuel consumed over each period analyzed was then multiplied by air pollutant emissions per gallon. These emissions factors were calculated using GaBi Life Cycle Assessment Software. Calculating emissions per gallon for both regular and diesel fuel required several assumptions about the Oakwood vehicles and their use. Diesel emissions per gallon were calculated using a 3.3 ton payload truck with a mix between highway and city travel that would be typical for Oakwood's transportation operations. Regular emissions were calculated for a regular passenger car with a similar mix between highway and city travel. These assumptions are explained in greater detail in Appendix B: Energy and Life Cycle Assessment. Air emissions were measured for key pollutants including carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur dioxide (SO_2), methane (CO), particulate matter (PM), heavy metals, and volatile organic carbons (VOCs). Descriptions of these pollutants are presented in Appendix A: Emissions.

The total cost of fuel, gallons of fuel consumed, and emissions were calculated separately for each DC pre- and post-consolidation. For transportation impacts, we found it was best to compare the three four-month periods mentioned in the data collection section of this report. Unlike some other aspects of DC operations, transportation operations are based on customer demand, and expense reporting should not have been affected by the process of relocation. Because the number of vehicle trips is directly related to the number of guests, we accounted for client count in the Bay Area for both move-ins and maid services. However, these fluctuations were slight in the Bay Area and of no consequence. Table 1 summarizes the calculations that were performed for each facility during each time period.

Table 1: Transportation Analysis Performed for Each Bay Area DC

EXAMPLE			
Inputs	**Outputs**	**Inputs**	**Outputs**
Total Fuel Cost % Regular % Diesel Price Regular Price Diesel	Diesel Gallons Regular Gallons Total Gallons	Emissions Factors: CO_2 NOx SO_2 CO PM	Total Emissions: CO_2 NOx SO_2 CO PM

To further analyze the change in transportation impacts of the consolidation, Oakwood performed maid service and move-in/out trip studies for July through September 2006 (pre-consolidation), March through June 2007 (pre-consolidation), and July through September 2007 (post-consolidation). These studies provide the number of trips made to each housing unit and SC per month. They also provide the round-trip mileage between their original DC and the Hayward DC. These data were combined to produce the total round-trip mileage for the pre-consolidation DCs and Hayward. In addition, we calculated and compared cost per trip, gallons per trip, and miles per trip for the two DC configurations.

Although the trip study includes June 2007, this month was not included in our analysis. In order to compare equal time periods we had to remove one month from the period immediately prior to the consolidation. Since there were significantly fewer trips in June than for every other month studied, it made more sense to remove June 2007 from our analysis rather than March 2007. It must also be noted that the post-consolidation trip study performed by Oakwood overlaps the consolidation month (July 2007). This is because the study periods were selected in spring 2007 when the consolidation was scheduled for June 2007. However, since the consolidation process was independent of customer demand, the number of trips should not have been affected in July 2007; therefore this month still provides useful results.

Results and Findings from the Bay Area Analysis

When analyzing the two pre-consolidation periods to the post-consolidation period, we find that post-consolidation monthly average fuel consumption was lower when compared to August-November 2006, and higher when compared to February-May 2007 or both periods combined, as Figure 4 shows. The changes in air emissions are relatively proportionate to fuel consumption (aside from variations caused by differences in diesel and gasoline) since emissions were calculated on a per-gallon basis. The exact changes in fuel consumption, emissions, and fuel costs can be found in Table 12 of Appendix C: Transportation. These results show monthly fuel consumption and emissions for each period. Figure 5 shows the percent change in emissions for each pollutant analyzed when comparing post-consolidation to the combined pre-consolidation periods. Although fuel consumption and emissions decreased when compared to August-November 2006 and increased when compared to the other two periods, post-consolidation costs were higher when compared to all three pre-consolidation periods. This effect is a product of increased fuel prices rather than increased consumption.

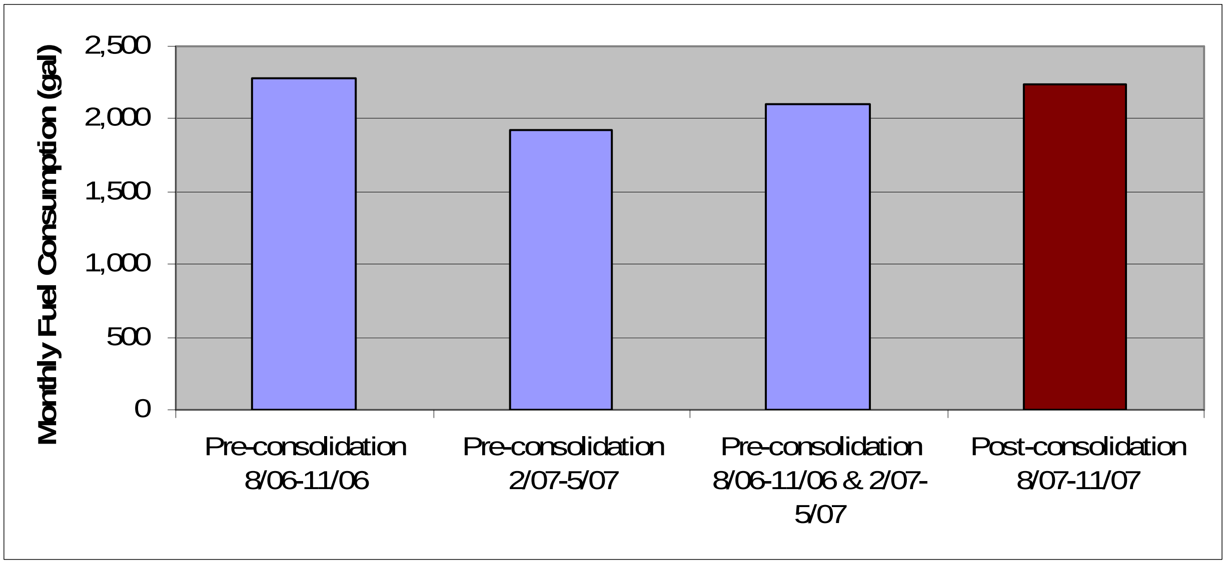

Figure 4: Average monthly Pre- and Post-Consolidation Fuel Consumption in the Bay Area

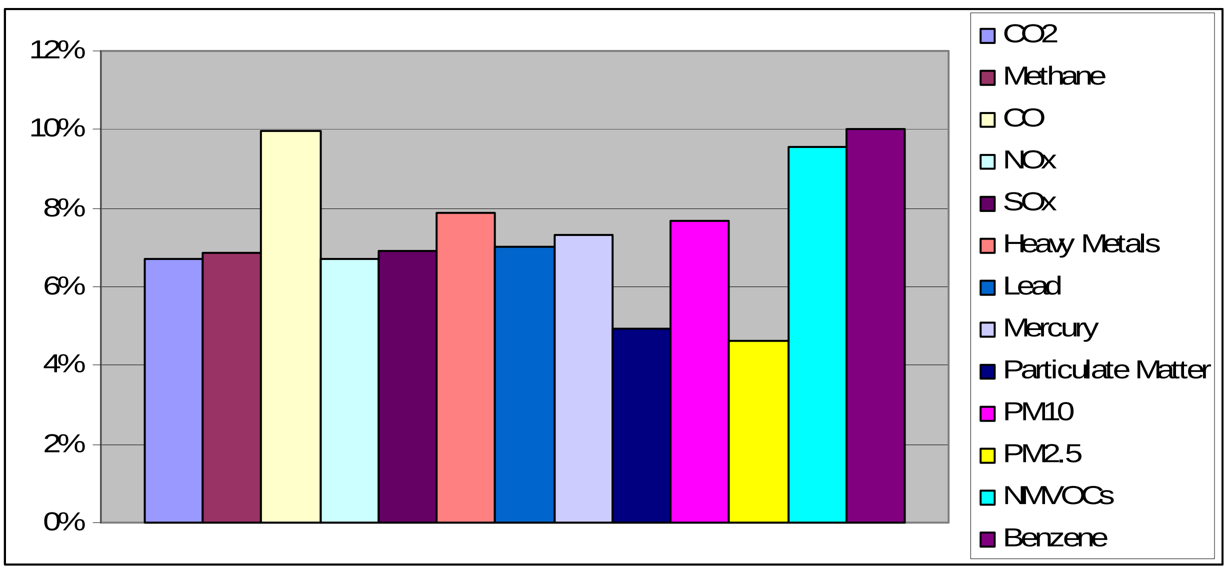

Figure 5: Change in Transportation Emissions Resulting From Bay Area Consolidation

The change in CO_2 emissions can be further analyzed on a per-car basis, or by applying a potential cost on carbon dioxide (CO_2). Currently, there are no U.S. regulations that impose a mandatory cost on CO_2 emissions. However, voluntary CO_2 emissions trading is being offered by the Chicago Climate Exchange. Based on the emissions factors calculated using GaBi, one of Oakwood's regular-fuel vehicles travelling 15,000 miles in one year will consume 620 gallons of gas and produce 6.6 tonnes (metric tons) of CO_2. On March 5, 2008 the Chicago Climate Exchange's voluntary CO_2 emissions trading program valued one tonne of CO_2 at $5.00 (CCX, 2008). Based on these numbers, when comparing post-consolidation emissions to the pre-consolidation period of February-May 2007, Oakwood put an additional 6.4 cars on the road (42 tonnes of CO_2 emissions per year) on the road and would have to pay an additional $211 for their CO_2 emissions annually. When compared to the pre-consolidation period of August-November 2006, 0.7 cars (5.9 tonnes of

CO_2 emissions) were actually removed from the road and the company could be eligible to redeem $24.29 per year. When compared to both periods combined Oakwood put an additional 2.8 cars (19 tonnes of CO_2 emissions) on the road and would have to pay an additional $93 for their annual CO_2 emissions.

The results of the trip studies are summarized in Table 13 of Appendix C: Transportation. The round-trip mileage from Hayward to the housing units and SCs was greater than the round-trip mileage for the pre-consolidation DCs for every period analyzed. Despite the fluctuations in total mileage, the miles per trip were consistent over every period showing approximately 35 miles per trip for the pre-consolidation DCs and 51 miles per trip for Hayward. This analysis also shows that fuel consumption per trip was greater post-consolidation. These results do not support the findings based on Oakwood's expense reports. However, the trip study is not an accurate representation of the transportation changes resulting from the consolidation because travel to housing units and service centers typically occur during routes. Therefore, if the routes stay the same, only the distance between the DC and the first stop and from the last stop to the DC will have changed post-consolidation. As a result, the trip study only provides a general indication of the change in transportation performance.

Limitations

There are a few additional limitations to the Bay Area analysis that are not discussed above. First, prices for regular gasoline were available for the Bay Area while only state-wide average prices for diesel were available. This difference in pricing affects the proportion of diesel to regular fuel purchased. However, this issue is not significant since the original proportion is just an estimate provided by Oakwood personnel, and it is likely that this estimate has at least as much uncertainty as the variability of diesel prices within California. Second, Oakwood's cash-basis accounting means that gas purchases in expense reports may not line up with actual purchases or prices. The error associated with this disconnect is be somewhat minimized by correcting monthly fuel costs for missed and back payments. In addition, fuel prices and costs did not vary from month to month enough to substantially affect the calculated volume of fuel consumption. Lastly, calculating emissions per gallon on a linear basis for some pollutants is inaccurate. For example, the emissions for some pollutants such as NOx will vary even for the same vehicle type depending on driving patterns.

DC Reconfiguration Model Methodology

Evaluation Component

The evaluation component of the DC reconfiguration model is similar to the analysis performed on the Bay Area consolidation. The user enters data from pre- and post-reconfiguration periods for comparison. The model compares up to 12 months of pre-consolidation data and up to 12 months of post-consolidation data. Similar to the Bay Area analysis, the user can compare and evaluate gas consumption, gas costs, and total emissions. In addition, the model allows comparison of miles travelled, mileage paid, and emissions on a per-mile basis. The ability and/or necessity to compare these additional impacts depends on the circumstances of the Oakwood branches being analyzed.

There are two situations where comparing mileage may be desirable or necessary. Comparing mileage will be necessary in regions where mileage is paid to employees who use their own vehicles for the provision of maid services (so long as these employees are required to report directly to a DC each day). The mileage paid to employees for each DC is tracked in monthly expense reports. Mileage was not examined in the Bay Area analysis because all relevant trips are made using company-owned vehicles and fuel purchases were charged to the regional fuel account. To determine the miles travelled, the model divides the cost of mileage paid by Oakwood's mileage rate. Total air emissions on a per-mile basis are calculated using emissions factors provided by GaBi. These emissions factors are based on the same vehicle profile and driving patterns used to calculate emissions on a per-gallon basis. The model assumes that these vehicles use 100% regular unleaded gasoline.

Prediction Component

The prediction component of the model enables the user to forecast the gas consumption, emissions, and fuel cost of a potential DC reconfiguration by entering up to 12 months of pre-reconfiguration data from the region being analyzed. The inputs required by the model include (by month unless otherwise noted):

- The average regional fuel price for all types of fuel purchased (e.g. diesel, regular octane, etc.);
- The estimated percent spent on each type of fuel (over the entire period);
- Total cost of fuel;
- Total mileage of Oakwood owned vehicles (pre- and post-consolidation);
- Mileage from DC to first stop and last stop to DC for Oakwood owned vehicles (pre- and post-reconfiguration);
- The number of months for which pre-reconfiguration data has been entered.

The following user inputs are optional or only apply to special circumstances (by month):

- Oakwood's mileage rate[1];
- The total cost of mileage paid to employees for use of personal vehicles;
- Total mileage of personal vehicles (pre- and post-reconfiguration);
- Mileage from DC to first stop and last stop to DC for personal vehicles (pre- and post-reconfiguration);
- The number of trips made to each unit and SC by Oakwood owned vehicles;
- The number of trips made to each unit and SC by personal vehicles;
- Carbon taxes or cap-and-trade price.

Most of the inputs from the second category only apply if personal vehicles are used for transporting furnishings or for maid services. As noted above, personal vehicles are not used for this purpose in the Bay Area, but other regions operate differently.

As in the Bay Area analysis, Oakwood routinely collects most of the transportation data that need to be entered into the model. External information such as fuel prices and carbon dioxide prices can be found on the internet. Tracking mileage, however, is not a regular part of the company's DC operations but is essential to the prediction model. The Bay Area trip study was conducted strictly

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[1] Oakwood currently uses the federal mileage rate which can be found on the U.S. Internal Revenue Service website at http://www.irs.gov/taxpros/article/0,,id=156624,00.html.

for this project, and we recommend that Oakwood use an alternative method to calculate mileage. Two proposed methods for tracking relevant mileage include utilizing AirTrak or another GPS system, or requiring drivers to record the stops they make each day (in consecutive order). There are also advantages to tracking the mileage of the first and last stops (before returning to a DC) for every route coming out of a DC.

For every method, mileage must be calculated for pre-reconfiguration DCs and for potential post-reconfiguration DCs. Once pre-reconfiguration data are entered into a program such as Microsoft MapPoint or Google Earth, the user can change the DC locations to reflect a potential DC reconfiguration and recalculate. This will produce the potential post-reconfiguration mileage associated with each DC. The pre- and post-reconfiguration mileage can then be entered into the model to predict the change in fuel costs, fuel consumption, and fuel emissions that will result from the reconfiguration.

If Oakwood does not utilize route optimization software to calculate post reconfiguration mileage, tracking the mileage of the first and last stops for every route coming out of a DC is recommended for estimating post-reconfiguration mileage. Rather than recalculate the entire mileage for the new locations, the user can just recalculate the mileage for first and last stops. The difference between the pre- and post-reconfiguration mileage for these segments can then be applied to the total pre-reconfiguration mileage to predict the post-reconfiguration mileage. This method assumes that the routes will stay the same and only the mileage between the DC and the first and last stops will be impacted by a reconfiguration (as demonstrated in Figure 6). This method, however, may not be accurate if post-reconfiguration routes are expected to change dramatically.

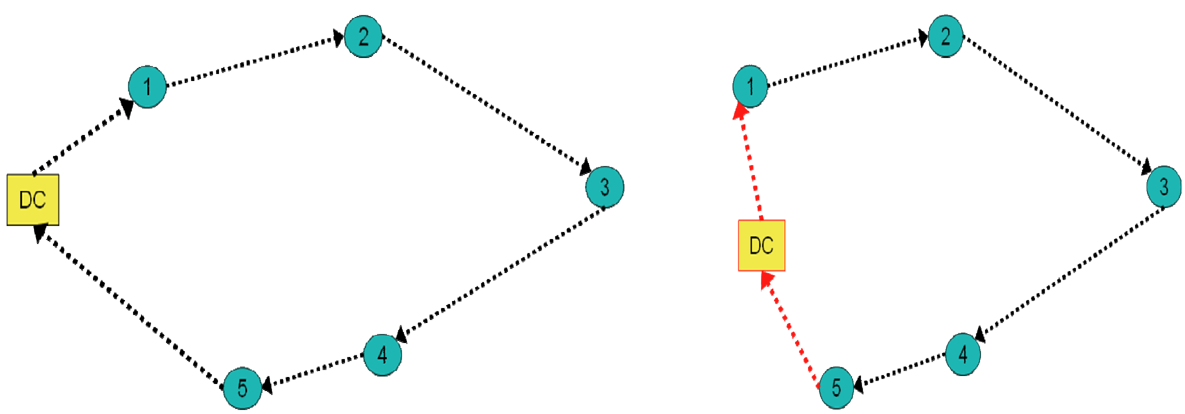

Figure 6: Hypothetical Route Change

If the region being analyzed uses a combination of company owned and personal vehicles to service its units, the transportation tracking or studies should distinguish between the two types of travel. Although mileage is paid for personal vehicle use, pre-reconfiguration mileage needs to be tracked separately so that it can be entered into mapping software. For personal vehicles it is only necessary to track and compare the first and last stop mileage. This difference can then be applied directly to the mileage paid out to predict the mileage costs and emissions that will result from the DC reconfiguration.

It is also recommended that Oakwood analyze the properties and SCs that receive the most service (i.e., limit data entry to locations that are travelled to at least 10 times per month). The total round-trip mileage for these trips pre- and post-reconfiguration should then be analyzed based on all trips to ensure that a potential reconfiguration remains within reasonable proximity to these high traffic properties.

Results and Findings from the DC Reconfiguration Model

Pre-consolidation round-trip mileage from the Bay Area Trip Study was used to test the predictive capabilities of the DC reconfiguration model (see Table 13 in Appendix C: Transportation). A comparison of the model predictions and actual post-reconfiguration results is provided in Figure 7 below. This figure compares the August-November 2007 post-consolidation data to model predictions that were made using July-September 2006 data, March-May 2007 data, and data from these two periods combined. The closest prediction was based on March-May 2007, which varied from the actual results by 129%. The prediction based on July-October 2007 varied by 178% and the prediction based on both periods combined varied by 154%. These results are not surprising, however, because they are based on the round-trip mileage for every stop, not just the first and last stops. Furthermore, because of consistent over-projections based on improper data, it is reasonable to believe that with proper mileage data, the model will provide reliable projections.

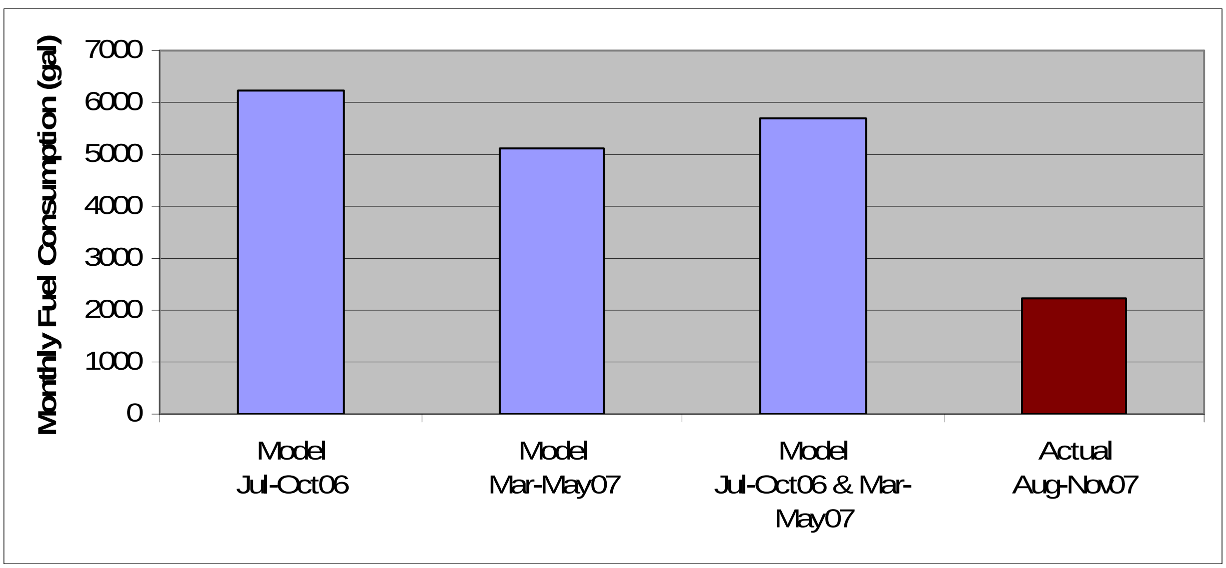

Figure 7: Prediction Model Validation Using Round Trip Mileage

Distribution Center Operations – Energy

Changing facilities results in changes in energy and water use and solid and hazardous waste generation, which have both environmental and cost implications.

Bay Area Analysis Methodology

For energy, we looked at expenses for electricity and natural gas in financial reports because we were unable to obtain a comprehensive set of bills. It is also important to note that the San Francisco facility paid its energy expenses through the facility's Common Area Maintenance (CAM) fees that are included with rent, and therefore these costs were not represented on its expense reports during the time periods of our analysis. Because no large laundry equipment was operated at this facility, we expect this facility's energy consumption to be low compared to the other two facilities. While direct energy expenses were not paid, we found that energy consumption at this site had been accounted for in the budget for 2006. The budgeted amount seemed reasonable for what the facility may consume; therefore we made the assumption that Oakwood managers had estimated this number based on past trends. We decided we could use this number to represent the San Francisco facility's energy consumption for our purposes. These 2006 values were inflated by 0.3% based on Bureau of Labor Statistics data for the calculation of the pre-consolidation February-May 2007 energy use for this one facility as well (BLS, 2008).

Because expense reports reflect the total amount spent to purchase energy, we first subtracted the tax portion. Different counties administer different taxes based on local regulations. Bay Area counties range in their utility tax percentages from 5%-7.5%[2] (uutinfo.org, 2008). We took into consideration each facility's city or county's tax rate as provided by the internet to acquire the amount paid in utility taxes. We then found the average rates charged for service by the local service provider Pacific Gas & Electric Company (PG&E). We used a small, commercial facility rate (G-NR1 for Natural Gas and A-1 for electricity) based on the limited energy bills that we were able to obtain. Based on PG&E's website, base user fees were incorporated in the rates. We divided the expenses (less tax) for each month by the respective monthly price rates and estimated the amount of natural gas (in therms) and electricity (in kWh) for our four-month analyses. Because of the limitations associated with our four-month data, we conducted an annual analysis as well. In the case where 2008 budget data were used, we used PG&E's average projected price rates. Although we used monthly price data, we realize there is some error in our calculations since there is lag time in the expenditures appearing on the expense reports.

Results and Findings from the Bay Area Analysis

Figure 8 and Figure 9 show the estimated average monthly energy consumption from the four month time periods and the annual time periods. As explained, the consumption was calculated based on expenses, except for in the case where the 2008 budget was used to estimate post-consolidation energy use. Further details on expenses are presented in the Operation Costs section.

[2] Livermore Facility – Alameda County: 5.5%
San Francisco Facility –City of San Francisco: 7.5%
San Jose Facility –City of San Jose: 5%
Hayward Facility –Alameda County: 5.5%

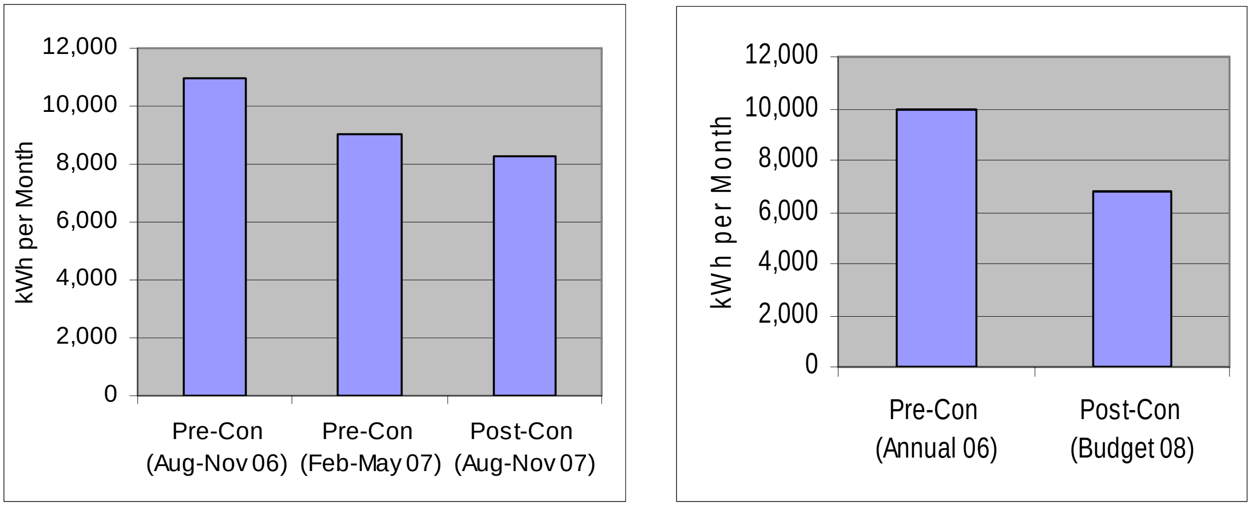

Figure 8: Average Monthly Electricity Consumption Based on Four-Month Data and Annual Data

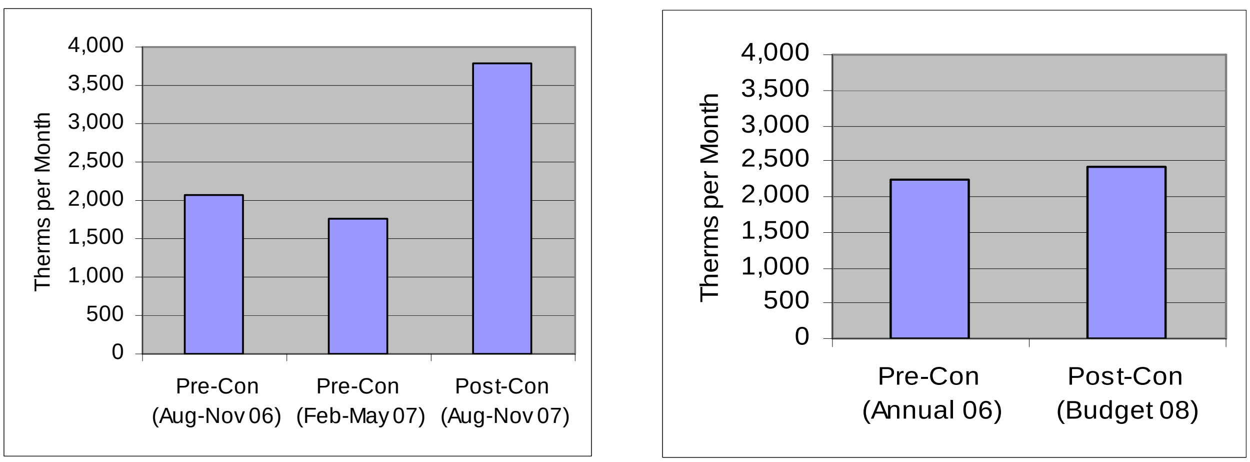

Figure 9: Average Monthly Natural Gas Consumption Based on Four-Month Data and Annual Data

The four-month comparison graphs show that total electricity consumption is lower while natural gas consumption is dramatically higher post-consolidation. The expense reports show that the payment for natural gas was excessively high in October 2007 compared to the other months. This anomaly in natural gas expense could have been due to costs that actually accrued pre-consolidation but were not paid until post-consolidation. As mentioned, this type of variability is a result of the limitations to our four-month data. In our annual analysis, electricity is lower while natural gas consumption is slightly higher post-consolidation. We believe this annual comparison is more accurate. However, as explained in our sensitivity analysis below, gas prices are much more volatile than electricity prices. Therefore, the small magnitude of consumption increase that we calculated may have been a result of price fluctuations that we could not account for.

Additionally, gas consumption at facilities depends highly on laundry equipment use, since gas is used for heating the water and for drying the linens. This slight increase may be the result of increased maid services, which increase the gas use for laundry equipment. In fact, annual maid service client count (MSCC), which is the indicator for the number of clients requesting maid service, is higher post-consolidation (6150 pre-consolidations and 7286 post-consolidation). When normalizing the gas consumption over the MSCC, we find that gas consumption per client is lower post-consolidation as shown in Figure 10 (4.3 therms/MSCC pre-consolidation and 4.0 therms/MSCC post-consolidation).

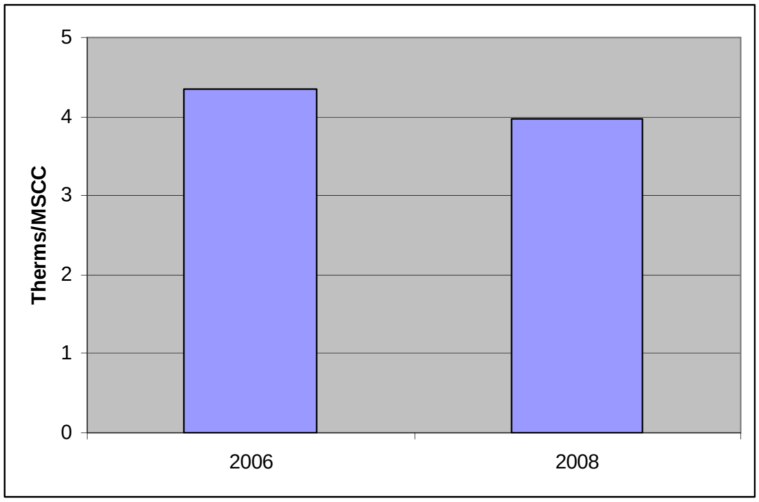

Figure 10: Gas Consumption Normalized Over Maid Service Client Count (MSCC)

In addition to the amount of energy consumed pre- and post-consolidation, we calculated and compared the amount of emissions resulting from the production and use of this energy. Using GaBi Life Cycle Assessment software with inputs specific to the energy mix used by PG&E in the Bay Area, we measured a set of pollutant emissions. The emission factors obtained from GaBi are further explained in Appendix B: Energy and Life Cycle Assessment. We calculated electricity and natural gas emissions separately, and then added them together to see the overall energy emissions. The tables in Appendix D: Distribution Center Operations – Energy show the emissions calculated for each of the four-month time periods and for the annual periods, and the percent change of each pollutant. Figure 11 below illustrates the percentage change of each pollutant for the annual comparison, which seems to be more accurate than the four-month comparisons.

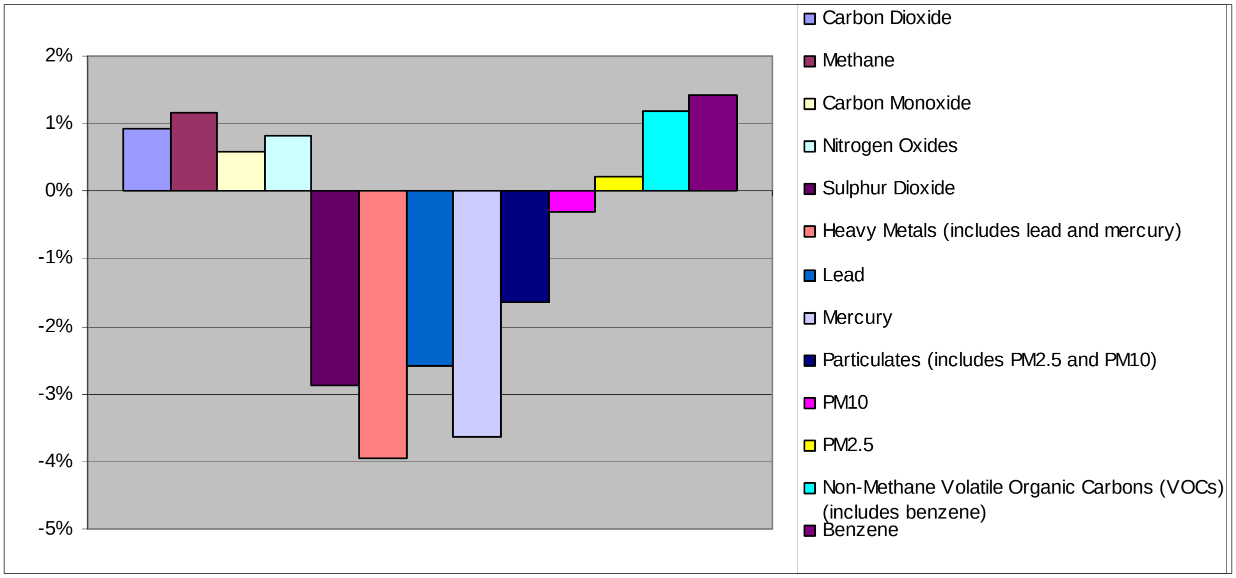

Figure 11: Change in Facility Emissions Resulting from Consolidation (2006 and 2008 data)

Natural gas and electricity consumption have different levels of emissions for each pollutant, which explains why changes in emission levels are not uniform across pollutants. Because natural gas use leads to more emissions for most pollutants, the increases in pollutants from natural gas outweigh the decreases of pollutants from reduced electricity consumption in most cases. Although our annual comparison shows an increase in gas consumption post-consolidation, the sensitivity analysis below explains the possibility of the actual gas consumption being lower. Because Oakwood's gas use contributes more emissions than the company's electricity use, if gas use is in fact lower post-consolidation, then all emissions would be lower as well. An implementation of a polity to track utility bills will help Oakwood overcome this uncertainty in the future.

Sensitivity Analysis

Since we could not account for the lag time between actual consumption and when the energy expenditures appeared on the expense reports, we conducted a sensitivity analysis using the lowest and the highest price rate to assess the range of possible energy consumption based on our 2006 and 2008 annual data. Gas price fluctuations throughout the year were as great as 30% between the lowest and highest rate. Considering only the highest and lowest rates, actual gas consumption estimates may differ from our estimates by up to 44%. Looking at the price trends, however, the highest and lowest rates are incidental and for the most part the prices do not fluctuate to this extent. Therefore our consumption calculations are likely more accurate than what our sensitivity analysis shows. However, given the relatively small magnitude of gas increase found post-consolidation, it is possible that more accurate rates that better correspond to each month's gas expenses could show a decrease in natural gas consumption post-consolidation.

Electricity rates are more constant and the price fluctuation only led to a variation of 5% in estimated electricity consumption. We conducted the same analysis for the four-month comparison and found similar results. However, the calculations based on the shorter four-month period are likely not as robust.

Hypothetical Carbon Cost Analysis

As mentioned in the Transportation section, we assessed the potential impact of a cost on carbon dioxide and used current information from the Chicago Climate Exchange for the hypothetical cost. Appendix D: Distribution Center Operations – Energy provides the hypothetical increase in annual costs for each of our analysis periods due to a CO_2 charge on electricity and natural gas use at the facilities. With a $5/tonn fee, we calculate an increase of $268 in post-consolidation annual costs based on the 2006 and 2008 data.

DC Reconfiguration Model Methodology

Evaluation Component

The evaluation component of the model is straightforward if energy invoices are tracked, but can be based on financial reports as was done in our Bay Area analysis. A manager inputs either the costs reported in the financial reports and the monthly price rates available online orthe information from electricity and gas bills. The model will then produce the amount of emissions that result from the energy use. Electricity emissions differ according the fuel mix used in the area. In our model, we provide emission factors for the Bay Area and the U.S. average energy mix, which the user can select. Emission factors for natural gas are also provided in the model. Emission factors are further explained in Appendix B: Energy and Life Cycle Assessment.

Prediction Component

The prediction component of the model calculates energy emissions and costs for a potential reconfiguration based on past energy use trends, change in total facility square footage and the regional climate zone. The model considers the climate zone of the specific DC network since the intensity of facility cooling and heating would depend on regional weather conditions. The model requires the user to insert past electricity and natural gas consumption (using one of the methods described in the Evaluation Component section above), and the area of each existing facility and future facility. The model will then project electricity and natural gas consumption for the potential reconfiguration along with associated costs and emissions. Energy cost is estimated based on average energy prices of the previous year, and therefore projected costs are subject to uncertainty due to the volatility of electricity and natural gas prices.

We were able to model the change in energy use per change in facility square footage using data available from the Energy Information Administration (EIA) on median warehouse and storage building (hereafter referred to simply as warehouses) energy consumption per square foot. EIA's data are based on the 2003 Commercial Buildings Energy Consumption Survey (CBECS) and data themselves do not constitute a prediction tool; however, reputable non-profit organizations, such as The Climate Trust, also use these data for carbon footprint predictions (The Climate Trust, 2005).

EIA's warehouse category is defined as buildings "used to store goods, manufactured products, merchandise, raw materials, or personal belongings," and includes self-storage buildings and distribution centers (EIA, 2002). While the category also includes refrigerated warehouses, these warehouses made up only 2% of the surveyed buildings (EIA, 2002). Based on this definition, we conclude that an Oakwood DC's energy use would be similar to that of a typical warehouse, plus energy consumption for laundering and dish-washing. Therefore, by making the model predict post-reconfiguration energy consumption based on the *change* in square-footage plus Oakwood's previous energy use, the model is able to account for all of the laundry and other equipment energy use that are client-demand driven and will remain relatively constant post-reconfiguration. Because EIA's data are based on a typical warehouse, we believe the data adequately represent the change in energy use resulting from the change in occupied space.

The median warehouse gas and electricity consumption provided by EIA is based on a survey of nation-wide buildings (EIA, 2003 Table 14 and Table 24). In order to provide climate-specific energy consumption per square foot, we referred to the tables showing the average energy consumption of warehouses in different climates (EIA, 2003 Table 20 and Table 30). Because the numbers provided are averages and not medians, we found the percent difference of each average warehouse climate zone compared to the national warehouse average and applied these percent differences to the national warehouse median number. We assumed that the median value was more representative of a typical warehouse since it would be less affected by extreme outliers.

Unfortunately EIA does not provide the average warehouse gas use per square foot for Zone 5 because their data either had a relative standard error greater than 50% or had fewer than 20 buildings in their sample[3]. In our model, we apply Zone 4 data to Zone 5 since it is the nearest climate region. This coefficient may lead to an overestimation for Zone 5 projections. EIA data show that the difference between average gas use per square foot of all commercial buildings in Zone 4 and Zone 5 is 17%. However, because trends vary between building types, we did not apply this percent difference to approximate Zone 5 warehouse gas use in our model.

Because laundry equipment is a big consumer of energy at Oakwood DCs, we initially thought that energy consumption specifications of these machines should play a large part in the prediction process, particularly if machines are changed after reconfiguration. For example, in the Bay Area consolidation larger machines replaced smaller models. However, assuming that the appropriate amount of laundry is loaded each time, we found that larger machines are not necessarily more energy efficient[4] unless there is a technology upgrade in addition to the size upgrade. Because laundry energy use is primarily driven by amount of linens processed, and a reconfiguration does not change the total quantity of laundry, we found that focusing on change in size of facility was the most representative prediction method. Similarly, the number and use of office equipment would stay fairly constant despite a reconfiguration, and would be accounted for by this prediction approach.

In our projection model, we provide an optional section to assess equipment upgrades, change in practices, or use of renewable energy that will affect total emissions. For example, the user can insert data on amount of laundry processed, temperature to which water is heated, water heater efficiency, and percent of water recycled, should a system be installed that reclaims heat from recycled or drained water. This section calculates energy savings that can then be applied to either the continued configuration or a reconfigured DC network. The theory behind these calculations is described further in the Recommendation section under Equipment. Finally, the user can specify if

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[3] Average electricity use per square foot in Zone 5 was provided.
[4] Equipment specifications show variations in energy efficiency, but these variations are not proportional to equipment size.

and what portion of the facility energy use is offset by renewable energy used or renewable energy credits. The output section will reflect the offset emissions.

Results and Findings from the DC Reconfiguration Model

Model Validation

We tested the model's projection capacity by comparing the projections made based on 2006 annual data from the three old branches to the data we have for Hayward. We compared these model projections against expected annual energy consumption calculated according to the 2008 budget for the Hayward facility and against actual energy consumption based on four months of expense reports, which we multiplied by 3 to extrapolate to a year. As Table 2 and Figure 12 show, we find that our model's projections overshoot electricity use by 11% compared to the actual four-month data and 35% compared to the 2008 budget. For natural gas, our model underestimates by 9% and 42% against the 2008 budget and actual data respectively. Again, the data to which we compare the model projections are not actual annual energy consumption data, but we believe that as Oakwood tracks its energy use, we can better understand the accuracy of our model.

Table 2: Comparison of Annual Energy Consumption at Hayward and Model Projections

	Projected by Model	Expected based on Budget	Model % Difference	Extrapolated 4-month Hayward data	Model % Difference
Electricity (kWh)	109,797	81,608	35%	99,330	11%
Gas (Therm)	26,374	28,936	-9%	45,294	-42%

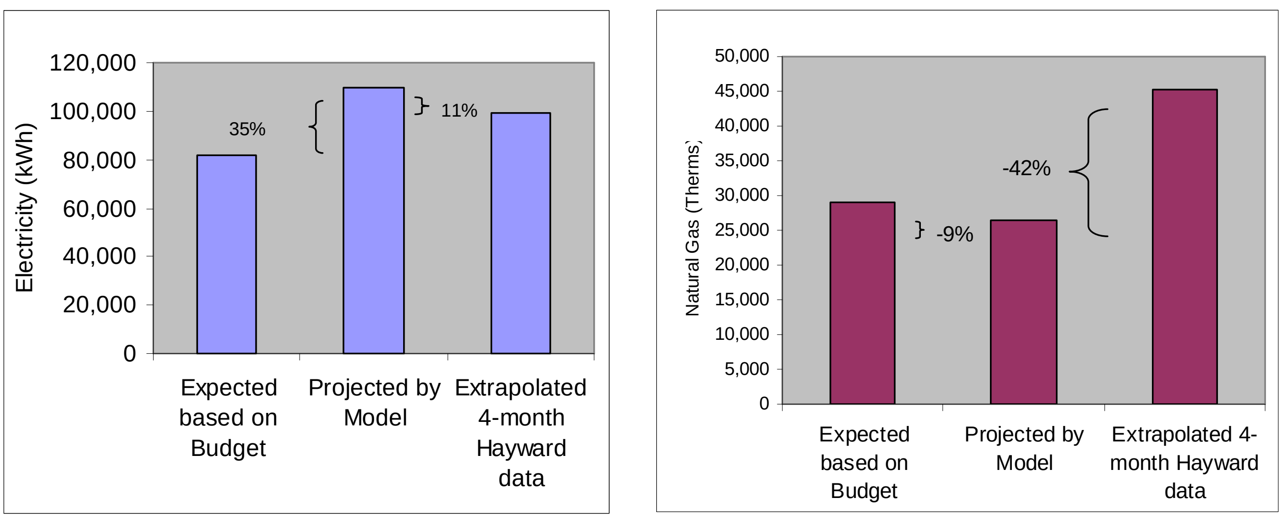

Figure 12: Electricity and Natural Gas Model Projections Compared to Bay Area Data

Limitations

While our model provides a mechanism to estimate emissions and costs from projected energy use post-reconfiguration, actual energy consumption will vary according to how the number of buildings change, building characteristics such as insulation, height of ceiling (therefore space heated), HVAC, windows, wall and ceiling material, number of employees, operating hours, and number and efficiency of lighting, office equipment, and other appliances in the building.

Recommendation for Data Tracking and Model Use

As described in our Bay Area Analysis, energy prices, particularly natural gas prices, may fluctuate drastically. Although we are able to estimate Oakwood's energy use from its expense reports with the help of monthly energy prices, we are faced with the limitation of not being able to account for the time lag. While it may seem like a small limitation, our conclusions may be affected by a shift in the timing of prices. We therefore recommend that Oakwood devise a system to record actual amount of energy consumed based on the bills it receives, in addition to the expenses accrued. These data will also increase the accuracy of the model.

Distribution Center Operations – Solid Waste

Bay Area Analysis Methodology

In order to calculate the change in solid waste production resulting from the Bay Area consolidation, we acquired information on the number of bins on-site, the size of each bin, and the frequency of collection by the trash hauler for each facility. To simplify the estimation, we assume that bins are filled to full capacity when collected by the trash hauler, which results in an overestimation. Similar to our energy analysis, we calculate the waste management costs by analyzing financial reports.

Results and Findings from the Bay Area Analysis

Oakwood's Bay Area waste analysis was limited to solid waste since recyclable material is sorted at the waste management facility and Oakwood does not generate any hazardous waste that requires separate treatment. Table 3 presents information on number of bins, bin size, and pickup frequency. This table also provides our calculations of the total volume of waste generated pre- and post-consolidation, as well as cost information. In general, waste management costs are consistent from month to month in the financial reports.

Table 3: Summary of Waste Volume and Costs

DCs	Number of Bins	Size of Bin (cubic yards)	Number of Pickups per Week	Weekly Volume (cubic yards)	Annual Volume (cubic yards)	Annual Costs ($)
Livermore	1	4	5	20	1,040	-
Silicon Valley	1	4	5	20	1,040	-
San Francisco	1	4	2	8	416	-
Total Pre-Consolidation	**3**	**12**	**12**	**48**	**2,496**	**27,769**
Hayward (Total Post-Consolidation)	**1**	**14**	**1**	**14**	**728**	**20,420**

The table shows that post-consolidation waste generation is about a third of the former volume. Because we assume that all bins were filled to full capacity, there is an overestimation of volume for each bin. In addition, given that more bins per week were used pre-consolidation, it is possible that we overestimated pre-consolidation waste generation more than the post-consolidation waste generation. Table 3 also shows that costs are lower post-consolidation as well. Because price of waste pickup depends on bin size, number, and frequency, we are unable to correlate the costs to volume of waste generated.

DC Reconfiguration Model

Evaluation Component

Similar to the Bay Area analysis, the evaluation component of our model is based on the number of bins, size of bins, and frequency of pickup. This information generates the total volume of waste generated.

Prediction Component

Literature shows that there are two main methods to quantifying waste generation at facilities: waste generation per square foot of facility and waste generation per employee (CIWMB, 2007). With respect to Oakwood's operations, we expect that inventory packaging accounts for the majority of solid waste changes produced by a DC reconfiguration. The amount of inventory and supplies required by a region should remain constant; however, the number of deliveries and the ability to bulk order may change. Therefore, fewer facilities should produce less packaging waste because of a reduction in the overall number of packages from fewer deliveries of larger bulk. While DC reconfigurations also likely result in change in number of employees, leading to changes in paper, food, and personal waste generation, we believe these changes would be negligible. We therefore focus on the change in total square-footage of facilities as a mechanism to predict future waste generation. A model user can input the number and volume of the waste bins at each existing facility, the estimated percentage that bins are filled prior to pickup, and the number of pickups per week at the existing facilities. In addition, the user will input the area of each existing and considered facility.

While the California Integrated Waste Management Board provides average data on waste generation per square-foot of various commercial facilities, including warehouses, these averages did not match the data we had gathered from Oakwood. Therefore, instead of using industry averages, we took Oakwood's waste generation data from pre-consolidation facilities and divided it by the total square feet of all pre-consolidation facilities to find the average cubic yards of waste generated per square foot. We use this number and the change in facility square-footage to predict future waste generation. We realize that this method does not address the reduced packaging waste from streamlined deliveries. However, we consider this mechanism to be the best indirect method for making a prediction.

Although we considered creating a mechanism that would predict the cost of waste management, we concluded that costs would depend highly on the options for different bin sizes and pickup frequency. While we could have made many assumptions on price rates, we decided that it would be best if the regional manager considers the volume of waste predicted by our model, decides on the expected bin sizes and pickup frequency, and makes an estimate based on a quick search on the local waste management's website or knowledge acquired from past trends.

Limitations

This portion of the model predicts change in waste generation using an indirect metric of facility square-footage, which does not accurately capture the change in waste from a change in number of shipments. In addition, while our model provides a tool to roughly estimate amount of solid waste generated, actual waste generation will vary according to facility specifications such as number of shipments received per week, the facility's recycling program, or whether meals are eaten on-site. Furthermore, waste volume alone does not represent the level of environmental impact which depends on the waste material. A formal waste audit[5] would provide better information on volume and waste types, and insight into possible waste reduction options.

Model Validation

Comparing our model output to post-consolidated Bay Area data, we see that while the model predicts a decrease in waste generation, it over-predicts the amount of post-consolidation waste by 150%. This over-projection is a result of using an indirect method to account for the change in waste. In addition, we did not acquire pre-consolidation data on how full (%) each bin was at the time of pickup. For running our validation, we assume that each bin was filled to capacity. Because pre-consolidation facilities had a larger number of bins and more frequent pickups, we believe that we over-estimated the pre-consolidation waste volume, therefore leading to an over-estimation of post-consolidation volume. With further tracking of waste volume generated per week, Oakwood can fine-tune this component of the model. Finally, a waste audit and a tracking of packaging waste generated from shipments may also provide mechanisms for improving this model.

Distribution Center Operations – Water

Bay Area Analysis

Water use is an important environmental indicator; however, Oakwood paid for water through its Common Area Maintenance (CAM) fees included in rent instead of through direct payments at pre-consolidation facilities. Therefore we are unable to analyze the change in water use that resulted from the Bay Area consolidation.

DC Reconfiguration Model Methodology

Water consumption is driven by machine use, restrooms, irrigation, cleaning, and kitchen use, and we expect that use rates vary widely depending on need, technology efficiency, and employee behavior. For this reason, and because we do not have water use data for the Bay Area to guide our analysis, we are unable to build a total water use projection in our model. However, the optional laundry equipment assessment section in the model, mentioned in the energy prediction section, provides a function that will estimate water use for a specified amount of laundry and calculate potential water savings through wash water recycling. In addition, if information is available, the model user can input water use from existing facilities and also the estimated water use at future

[5] A waste audit is a commercially available service. Experts collect the waste accumulated at the facility and take inventory of various types of waste by mass. Typically this type of audit results in recommendations on how to reduce waste generation.

facilities so that water consumption levels can be compared with other environmental performance indicators in the model's output section.

Operation Costs

Bay Area Analysis Methodology

Our goal in comparing expenses of before and after Bay Area consolidation is to understand the magnitude of change in operation costs that result from the consolidation. We examined Oakwood's expense reports to assess the line items that would be affected by the reconfiguration, such as salaries, rent, utilities, and other fees. We were careful not to include line items that would fluctuate solely based on operational changes responding to customer demand. The line items that we selected, along with a justification are presented in Appendix E: Operation Cost.

Results and Findings from the Bay Area Analysis

Once we determined the relevant line items from Oakwood's expense reports, we compared the operational expenses before and after the consolidation. Table 4 presents the aggregate cost incurred during the three four-month periods in the Bay Area. We noticed extreme variability of expenses from month to month even for expenses that should be consistent, such as rent and utilities. We attribute this fluctuation to Oakwood's expense reporting mechanism, which is cash-basis rather than accrual-basis. Accrual-basis accounting is "an accounting practice that records transactions as they occur, whether or not cash trades hands," while cash-basis accounting is "an accounting practice that records transactions only when cash changes hands" (Hayes, 2002, pg 191-192). With a cash-basis accounting system, the expenses reported for a particular month in the expense report may have actually been a cost that was accrued at an earlier time. Line items with no expenses reported in certain months could also be explained by the same reasoning.

The left portion of Table 4 represents expenses as reported while the right side of the table has been modified in the following ways. 1) Due to the cash-basis expense reporting system, many expenses that should be fairly constant varied greatly from month-to-month. Because facility rent (an expense that is consistent but varied in the expense reports to a degree that it did not average out over a four-month period) makes up a large portion of expenses, we replaced it by the actual monthly facility rent and CAM expenses. These numbers were provided to us in late 2007 values. We made the assumption that property managers did not change rent over the time periods we analyzed and therefore did not adjust for inflation. 2) Freight and overhead expenses reported in 2006 are significantly larger than those reported in 2007. Prior to 2007, headquarter expenses were also reported in expense reports in addition to the branch expenses. Because specific branch expenses are the data relevant to our analysis, Oakwood provided us with percentage breakdowns of 2006 expense reports that helped us estimate the portion of the expenses that we needed. Although we made adjustments based on estimated percentages given to us, we suspect that these particular line items are not scaled to be comparable between the years. We therefore omitted these two expenses in the right side of the table. Because taxes are not paid monthly, we determined that capturing the amount in a four-month period was not appropriate for analysis. We therefore omitted tax expenses in the right side of the table.

Table 4: Four-Month Operation Cost Comparison

Client Count (CC)	Aug-Nov 06	Feb-May 07	Aug-Nov 07		Client Count (CC)	Aug-Nov 06	Feb-May 07	Aug-Nov 07
Total CC	4,840	4,830	4,777		Total CC	4,840	4,830	4,777
MS CC	2,017	2,283	2,582		MS CC	2,017	2,283	2,582
Expenses ($)					**Expenses ($)**			
Salaries	513,805	462,068	672,769		Salaries	513,805	462,068	672,769
Benefits	208,565	211,744	185,547		Benefits	208,565	211,744	185,547
Facility Rent	138,184	179,568	48,236		Facility Rent	154,488	154,488	68,176
Security	2,293	2,240	1,150		Security	2,293	2,240	1,150
Equip Rental	2,051	3,434	2,412		Equip Rental	2,051	3,434	2,412
Insurance	18,166	21,296	21,296		Insurance	18,166	21,296	21,296
Freight	32,489	9,484	14,879					
Overhead	887,282	351,150	268,091					
Taxes	10,911	0	23,976					
Subtotal	**1,813,746**	**1,240,984**	**1,238,356**		**Subtotal**	**899,368**	**855,270**	**951,350**
Solid Waste	10,030	9,225	8,408		Solid Waste	10,030	9,225	8,408
Water	61	27	7,592		Water	61	27	7,592
Natural gas	7,992	9,945	19,503		Natural gas	7,992	9,945	19,503
Electricity	6,873	5,822	6,192		Electricity	6,873	5,822	6,192
Vehicle Fuel	25,888	23,338	29,244		Vehicle Fuel	25,888	23,338	29,244
Subtotal	**50,844**	**48,357**	**70,939**		**Subtotal**	**50,844**	**48,357**	**70,939**
Total	**1,864,590**	**1,289,341**	**1,309,295**		**Total**	**950,211**	**903,627**	**1,022,289**
Per Total CC	385	267	274		Per Total CC	196	187	214
Per MS CC	924	565	507		Per MS CC	471	396	396

Not adjusted for inflation. Aug-Nov 07: Post-consolidation
Total Client Count (Total CC): All clients staying in the Bay Area
Maid Service Client Count (MS CC): All clients in the Bay Area requesting maid services
Water expenses were charged through CAM fees pre-consolidation at all facilities (except for minor incidental costs)
Gas and electricity were included in CAM fees pre-consolidation at one facility
Additional contract workers were hired during the post-consolidation time period to make up for employee departures

The right section of Table 4 shows that operation costs post-consolidation are slightly higher compared to both pre-consolidation periods. In order to conduct a fair comparison of the different time periods, it was important to differentiate changes in expenses caused by the reconfiguration from changes in expenses from changing service demand. We therefore collected the client count for each respective month and used it to normalize our analysis. The same observation is made when the total costs are divided by total client count (Total CC) to find the average costs per client. Maid service client count (MS CC) is the number of clients requesting maid services. The average cost per maid service client count in August through November 2006 was higher than the other time periods. However, because the total costs of the three time periods are pretty consistent, these averages simply reflect a lower maid service client count during the four months in 2006 and may support our argument that the changes in these expenses are driven more by the reconfiguration than change in level of service.

When we analyze the subtotals in the right portion of the table, we see that the post-consolidation costs associated with environmental costs during a four-month period are higher than the pre-consolidation periods. While facility rent is lower post-consolidation, it is offset by higher salaries. Oakwood managers reported that several employees unexpectedly left the company at this time and therefore contract workers were hired as replacements, which may have caused the higher salaries in the post-consolidation data. The difference in expenses associated with environmental costs reflect the fact that Oakwood is charged for water, gas, and electricity at its post-consolidation Hayward facility, while the company paid for them through monthly CAM charges included in rent instead of utility bills at some facilities pre-consolidation. We had assumed that maid service client count would be more relevant to our analysis of these expenses than total client count since a lot of energy and water used goes to processing laundry from clients requesting maid service. However, given the changes in payment methods, we cannot analyze this angle based on the expenses. Vehicle fuel expenses are also higher post-consolidation.

After reviewing the expense reports, we determined that the four-month periods may not be entirely representative of actual changes in cost due to the cash-basis expense reporting system and transitional irregularities explained above. In addition, expenses such as tax and freight are paid at infrequent intervals that would not be captured in a four-month comparison.

To overcome these issues, we conducted an annual comparison using the 2006 annual expenses for the pre-consolidation facilities and the 2008 budget for our post-consolidation facilities[6]. In order to make a fair comparison with the 2008 budget, we scaled the 2006 expenses to 2008 dollar equivalents by accounting for inflation during the two years. According to the Bureau of Labor Statistics, the Consumer Price Index rose by 3% from 2006 to 2007 (BLS, 2008). We made the assumption that Oakwood managers would project a similar rise in inflation from 2007 to 2008. We therefore multiplied 2006 dollars by 1.0609 (or 1.03^2).

Table 5 illustrates the annual cost comparison. Because it is annual, tax is included. Freight and overhead costs, however, are not aggregated in the totals for the same reason explained above in the four-month comparisons. Post-consolidation overall costs are lower; however, costs linked to environmental costs (subtotal of utilities, waste, and vehicle fuel) are slightly higher. This reflects the need to pay water at Hayward. The budget for gas is also higher, which is further explained in the Distribution Center Operations—Energy section, but is also because the San Francisco facility paid for its energy costs through CAM expenses. Unlike in the four-month comparison where vehicle fuel expenses are higher, the budget shows a lower post-consolidation vehicle fuel cost.

With further tracking of costs during this post-consolidation year, Oakwood will be able to better understand how their expenses change. We expect that the change in expenses from reconfiguration will lie somewhere between the four-month period analysis and the annual analysis.

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[6] 2007 expenses were not used because they include both pre- and post-consolidation data, reconfiguration costs, and transitional glitches.

Table 5: Annual Cost Comparison

Client Count (CC)	Pre-Consolidation Based on 2006	Post-Consolidation 2008 Projections
Total CC	14,583	13,867
MS CC	6,150	7,286
Expenses ($)		
Salaries	1,474,819	1,426,901
Benefits	674,185	444,677
Facility rent	423,121	205,200
Security Services	7,920	2,940
Equipment rental	8,945	7,440
Insurance	60,621	85,788
Taxes	36,807	25,000
Subtotal	**2,686,418**	**2,197,946**
Waste Management	29,460	20,420
Water	198	27,600
Natural Gas	32,042	36,000
Electricity	19,714	14,400
Vehicle Fuel	71,837	55,324
Subtotal	**153,251**	**153,744**
Total	**2,839,669**	**2,351,690**
Per Total CC	195	170
Per MS CC	462	323
Excluded:		
Freight costs	95,950	65,810
Overhead Costs	2,535,321	974,207

In 2008 Values
Total Client Count (Total CC): All clients staying in the Bay Area
Maid Service Client Count (MS CC): All clients in the Bay Area requesting maid services
Water expenses were charged through CAM fees pre-consolidation at all facilities (except for minor incidental costs)
Gas and electricity were included in CAM fees pre-consolidation at one facility

Limitations

As mentioned above, limitations to operation cost analysis include the change in Oakwood's accounting methods starting 2007, the cash-basis accounting system, and the operational irregularities in the months following the relocation.

DC Reconfiguration Model Methodology

Evaluation Component

The evaluation component uses the same steps described for the Bay Area analysis. A manager inputs the expenses and the model will generate the sum of expenses and compare it to the sum of the expenses recorded from the previous DC configuration.

Prediction Component

Inputs for operation costs in the prediction model are based on budgets of the line items mentioned above for the post-reconfiguration facilities. The model is therefore limited by the manager's capacity to anticipate change in expenses caused by reconfiguration. The model compares the operation expenses projected for the new configuration to those recorded at the current configuration. The manager, however, does not input a budget for projected electricity, gas, and vehicle fuel. The model estimates these costs based on projections made for the use of these resources.

Reconfiguration Investment

Bay Area Analysis Methodology

In order to determine the magnitude of the investment to reconfigure the Bay Area DCs, we collected all the relevant costs from expense reports, fixed asset expenses incurred by headquarters, invoices, and information provided by Oakwood managers. The expenses we considered are further explained in Appendix F: Reconfiguration Investment Calculation.

Results and Findings from the Bay Area Analysis

The consolidation investment was analyzed by calculating the payback period, Net Present Value (NPV), Return on Investment (ROI), and the Internal Rate of Return (IRR), based on the overall operation cost savings. The calculation method for each indicator is described in Appendix F: Reconfiguration Investment Calculation.

After accounting for lease hold improvements, equipment, other reconfiguration expenses mentioned in Appendix F: Reconfiguration Investment Calculation, and rebates from rent and equipment, we found that the investment cost for Oakwood is approximately $687,000. A seven-year time period was used for calculating the ROI, NPV, and IRR, based on the length of Hayward's lease. To find the annual savings based on the four-month time periods, we used the adjusted before and after costs as described in the Operation Costs section and inflated the 2006 values by 3% to 2007 values. This primarily means that freight, overhead, and tax were not summed in the expenses for the reasons noted earlier. While overhead between February-May 2007 and August-November 2007 would have been compatible, we excluded it for the purpose of making a comparison with the August-November 2006 data. Freight was also excluded for the same reason, and additionally, we expect that freight expenses have less month-to-month regularity due to the nature of the demand and therefore data from four-month periods may not be comparable. We multiplied these data by three to obtain one-year-equivalent numbers.

The same steps were followed for the annual comparisons but in 2008 values. Although the line item for annual business tax expenses could be accounted for, we excluded it from these calculations so the outcomes would be relatively comparable to the four-month extrapolated analysis, and so other factors affecting Oakwood's tax payments would not be factored in. The Operation Costs section shows that freight, overhead, and tax expenses are lower in our post-consolidation data. Therefore, had they been included, annual savings would have been greater, making the investment even more attractive.

Although we believe that the 2006 Expenses and 2008 Budget best capture operation costs since they are less subject to the four-month limitations, we found that the transportation portion of our analysis would not be subject to the same variability. Our reason is that the vehicle trips made to the apartment units are based on demand and therefore the four-month expenses should more accurately portray the activity than a budget. We therefore substituted the four-month vehicle fuel expenses (combination of August-November 2006 and February-May 2007 for pre-consolidation and August-November 2007 for post-consolidation), extrapolated to one year and ran our annual calculations. Table 6 shows our results from comparing the four-month post-consolidation data to the two pre-consolidation four month periods, the annual comparison, and the combination of the annual facility operation data with the four-month transportation data.

Table 6: Bay Area Reconfiguration Investment

	Aug-Nov 07 (post) against Aug- Nov 06 (pre)	Aug-Nov 07 (post) against Feb-May 07 (pre	2008 (post) against 2006 (pre)	Combined 2008-2006 (facility operations) and 4-mo (transportation)
Annual Savings	-$130,713	-$355,986	$476,171	$445,765
Payback Period	NA	NA	1.4	1.5
ROI in 7 years	NA	NA	485%	454%
NPV in 7 years	-$811,552	-$1,649,237	$1,445,170	$1,332,104
IRR in 7 years	NA	NA	242%	199%

*Note: Positive numbers denote savings while negative numbers denote an increase in cost.
*No calculations for Payback Period, ROI, or IRR are presented for comparisons without cost savings.

As the table shows, the results vary greatly between analyses. Because we do not know the level of accuracy of the budget or the four-month data, we cannot make a final conclusion until data of at least one year after the reconfiguration (and ideally one year after transitional irregularities are ironed out) can be analyzed. Our best estimate based on data so far, however, is the combined comparison using 2006 and 2008 data for facility operations and the four-month data for transportation, with the stipulation that the investment indicators would reflect the reconfiguration more positively for a period longer than seven years and if freight, tax, and overhead expenses had been included.

DC Reconfiguration Model Methodology

Evaluation Component

The evaluation component of the model for assessing the reconfiguration investment is straightforward. A manager simply inputs the expenses incurred for the reconfiguration. The model will run these numbers along with the cost saving numbers calculated from expenses inputted in the operation costs section and produce the financial indicators as described in the Bay Area analysis.

Prediction Component

We created the financial portion of the projection model under the assumption that an Oakwood manager interested in running the model will have a general idea of reconfiguration expenses and how operational changes will affect the annual budget. The same indicators will be calculated as those mentioned in the Bay Area analysis. The manager will indicate the expected length of business at the new sites so that the NPV, ROI, and IRR can be calculated for the specified amount of time. The estimated number of years can be the duration of the lease or for whatever number of years that will be meaningful to the manager. The current model capability is up to nine years. Obviously in the event that no cost savings are realized, these calculations should not be run.

The model also has input possibilities for expenses that were not incurred in the Bay Area. For example, if a manager decides that some equipment should be sold or discarded, an estimated profit from selling the equipment or an estimated disposal cost can be inserted. Additionally, if old DCs were owned, managers can input an estimated selling price of the property or buildings. Other possible inputs not mentioned in the Bay Area analysis include lease termination costs and new lease fees.

The model also enables a manager to input estimated costs of five-year and seven-year depreciable expenses incurred during the reconfiguration year. These costs will then be linked to a MACRES depreciation schedule before feeding into aggregated yearly costs. We also considered the possibility that Oakwood may purchase property for their DCs. In this case, the manager inputs the cost in the appropriate cell, which will be linked to a 39-year straight-line depreciation schedule for non-residential real estate (IRS, 2006). Financing of these investments is beyond the scope of our project and therefore was not taken into consideration.

If a manager expects to make additional investments related to the reconfiguration in the future and not during the base year, the manager can input the estimated amount and expected timeframe in the designated cells. Based on the number of years indicated by the manager, the model links the expenses to the appropriate year for the aggregate cost calculations.

Results and Findings from the DC Reconfiguration Model

As mentioned earlier, this section of the model relies on the manager's cost estimation and therefore the performance was not assessed.

Limitations and Sensitivity Analysis

Although the periodic expenses related to reconfiguration that are not incurred in the base year can be input into the model, we did not include a separate mechanism to depreciate these expenses even if necessary. We assume that most investments would be made during the year of the reconfiguration and that expenses expected to be incurred in later years would be relatively small. In addition, we assume that the depreciation of these expenses, particularly in the discounted future, would have minimal effect on the resulting NPV. We tested hypothetical $78,000 depreciable expenses incurred the year following reconfiguration (2008) using the Bay Area analysis. In order to test this limitation, we conducted a sensitivity analysis using the Bay Area data. We first ran the model with the 2008 depreciable expenses incurred in the year after reconfiguration without depreciation and then ran the model with the 2008 expenses added to the 2007 expenses and depreciated. We compared both scenarios to our actual calculations. We found that both methods resulted in a negligible difference from the actual calculations.

OVERALL RESULTS AND FINDINGS

OVERALL RESULTS & FINDINGS - BAY AREA CONSOLIDATION ANALYSIS

As shown in Figure 13, the overall cost savings of $457,627 expected to result from the Bay Area consolidation is mainly attributable to rent, benefits, and salaries. Insurance and fuel costs are the notable cost increases, keeping in mind that water and parts of electricity and natural gas were included in pre-consolidation rent, and therefore it is unclear whether these costs actually increased post-consolidation. Figure 13 also shows that changes (for the most part decreases) in the aggregate onsite operational costs substantially outweigh the increases in offsite transportation costs. Combined, the cost savings resulting from the consolidation should cover the investment costs of $687,320 in 1.5 years.

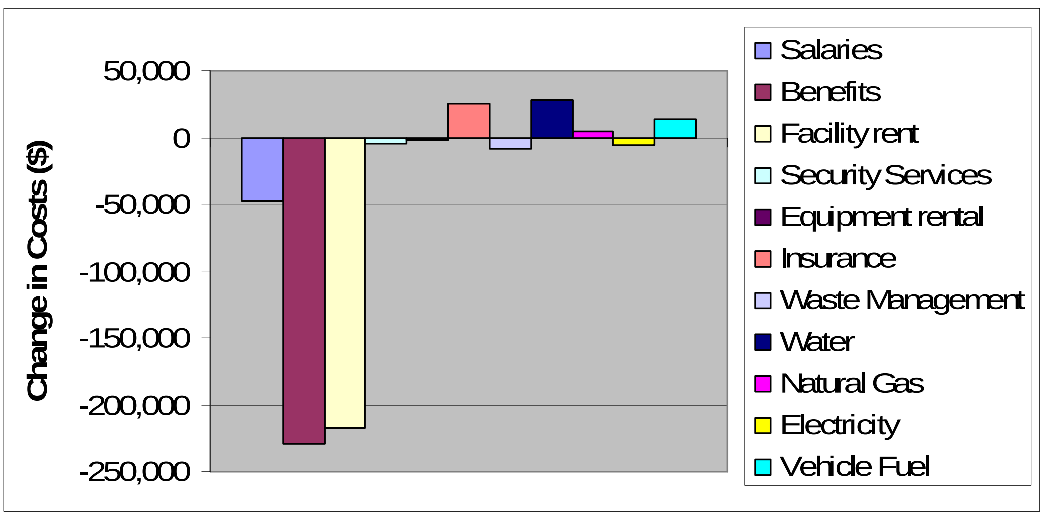

Figure 13: Best Estimate of Annual Change in Costs[7]

Examining the overall environmental impacts of the Bay Area DC operations shows that transportation contributed 52% of the total CO_2 emissions in 2006 (see Figure 14). Natural gas contributed the next highest at 39%, and electricity made up the remaining balance at 9%. Figure 15 provides the overall percent change in emissions resulting from the Bay Area consolidation. This figure shows an overall increase from both transportation and onsite operation in all pollutants by varying degrees. While carbon monoxide, non-methane volatile organic compounds (VOCs), benzene, and heavy metals emissions all increased by at least 7%, CO_2 only increased by 4%.

[7] Based on 2006-2008 data for facility operations and combined four-month data for transportation

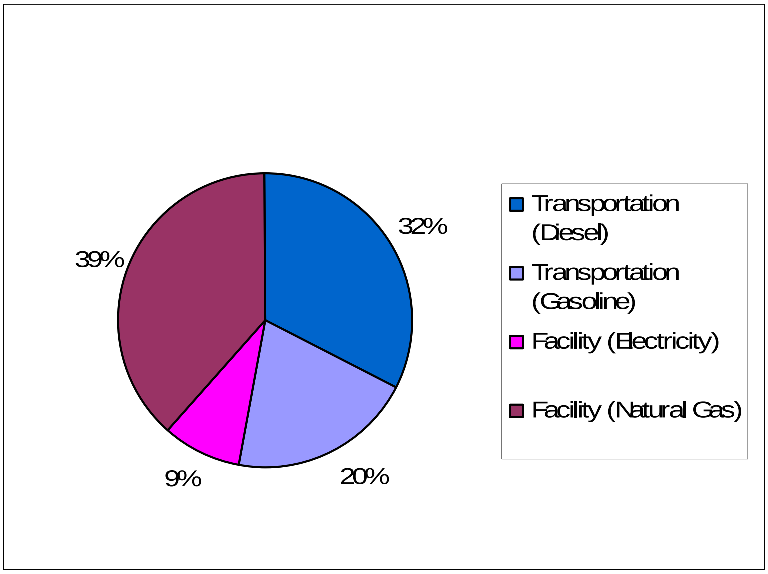

Figure 14: Pre-Consolidation CO_2 Breakdown

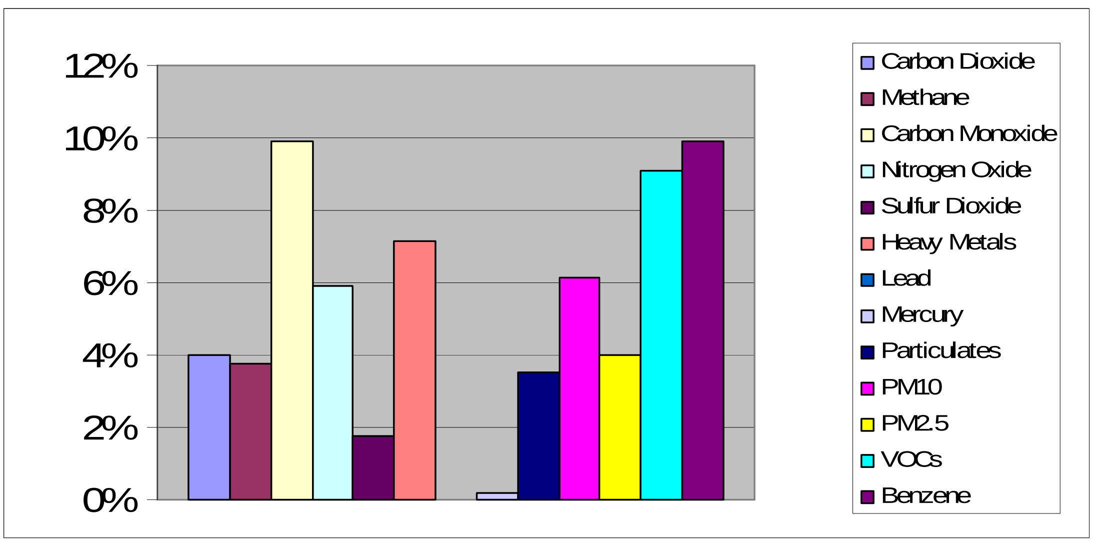

Figure 15: Best Estimate of Annual Change in Emissions (Facility and Transportation)

Recommendations

Systematic Approach to a Company-Wide Environmental Initiative

Communication

For Oakwood to make meaningful environmental improvements within the company, it needs commitment from top-level managers and the associates. Top level buy-in is important so that the associates understand that the environmental movement is not superficial. Associate-level buy-in is equally important so that environmental practices are actually implemented in all aspects.

Like any corporate policy, a company's environmental initiative needs a mission that delineates the direction in which the company is moving, and concrete goals whose achievements can be measured. A task force can be created to develop, steer, and communicate the policy. In order for the goals to have impact, baselines of current practices and guidance for measuring and tracking performance should be established.

Employee workshops can be held to raise awareness and communicate the company's stance on environmental initiatives and methods in which it plans to achieve the goals it has set. These workshops can be an opportunity to articulate the commitment on both ends. In addition to demonstrating the importance of environmental management from top management and spreading awareness throughout the company, training can occur during these workshops so associates are aware of ways in which they can save energy and water and reduce waste while at work as well as at home.

Oakwood could also encourage associates to incorporate sustainability practices into their personal life and create a system/forum (e.g., 10 minutes during monthly meeting, news letters, email list serve) where individuals can voluntarily describe achievements. Wal-Mart initiated a Personal Sustainability Project (PSP) in which associates voluntarily report back on their personal project, which includes a variety of efforts such as healthy diet and exercise, changing household appliances to efficient models, reducing driving by using public transportation, and more, depending on individual interests (Barbard, 2007). This project not only spreads sustainable practices by influencing individuals, but also engages associates in the company's green mission at a personal level.

Along with making internal environmental improvements, Oakwood may find opportunities to influence the environmental performance of its supply chain. The company already makes an effort to reach out to its guests through installing efficient light bulbs and providing information in the units, which can continuously be strengthened. The company can also look upstream of its supply chain for opportunities to influence its suppliers as well. Many large companies have worked with suppliers to create environmental and social standards.

Once environmental baselines are set and Oakwood begins to make measurable achievements, these results may be reported to the public to enhance transparency into the company's environmental activities. Reporting will illuminate the company's position on environmental and social matters and will help build credibility of its social and environmental responsibilities. The Global Reporting Initiative provides guidance on the framework for sustainability reporting, available at www.globalreporting.org, which may be a helpful resource for the company to gain ideas on how to disclose its environmental impact and management activities to the public. Sustainability, corporate social responsibility, and environmental reporting of other companies can be easily found online.

Company brand image can be improved through communicating environmental initiatives. In particular, trends have shown that consumers are increasingly looking for "green" products and services. If Oakwood chooses to market its environmental efforts, the company should clarify what limitations it faces with leased apartment buildings and what it is doing to make the living quarters more environmentally friendly. Any business operation has barriers to becoming completely "green". Therefore caution should be taken to avoid misleading marketing of its efforts. Accusations of hypocrisy can lead to distrust by the public and clients.

Environmental Management System

An Environmental Management System (EMS) helps an organization follow a systematic approach for managing its environmental impacts and attributes through a continuous cycle of planning, implementing, reviewing, and improving environmental efforts. The International Organization for Standards has developed ISO 14001, a certification standard for EMSs. While becoming ISO certified adds credibility to a company's claim, it can be costly and labor intensive. For Oakwood, an informal EMS may be a more sensible step towards creating a framework for examining and improving its environmental performance.

An EMS takes a comprehensive approach to assessing a company's environmental needs and opportunities that may otherwise be overlooked. The first step in implementing an EMS is to create an environmental policy that can be communicated to the employees and possibly the public. Typically an EMS sets objectives, addresses regulatory requirements, trains employees, and provides a process for measuring, assessing, overseeing and auditing the environmental performance of products, services, and activities (EPA, 2007b). The process can also provide transparency to the company's logic and deliberate approach towards its environmental management, therefore enhancing its reputation.

EMS is beneficial because it is a forward-looking, proactive management approach. Opportunities for improving environmental management can be found early and solutions can be thoroughly planned, unlike reaction-oriented management styles. Many of the policies mentioned in this recommendations section could be imbedded in an EMS.

Examples of EMS achievements include decreasing hazardous material mishandling, increasing manufacturing efficiency, and reducing emissions (GreenBiz.com, 2007). Many facilities have voluntarily implemented both certified and informal EMSs. Some examples of industries partnering with the EPA to do so are listed on EPA's website https://yosemite.epa.gov/opei/ptrack.nsf//faMembers?readform. An introduction to how to implement an EMS can be found at EPA's website http://www.epa.gov/ems/info/index.htm. The requirements for the ISO 14001 certification are available for purchase at www.iso.org.

Transportation Network

No Idling Policy

Idling vehicles substantially contribute to local air pollution. Oakwood can potentially reduce vehicle air emissions, fuel consumption, and fuel costs by implementing a no idling policy. The no idling policy will direct Oakwood's drivers to shut off their vehicles when parked. In recognition of the emissions associated with vehicle idling, many local governments and companies such as Wal-Mart have implemented strategies to address this issue. No idling policies are particularly important around schools, hospitals, and other areas where children and other sensitive populations can be exposed to a concentrated level of vehicle emissions. Oakwood's no idling policy does not have to be complex, but should be supported with literature and strategically placed signs. Several no idling policies can easily found using an internet search engine and can provide guidance for Oakwood in developing its own policy.

Transportation Reduction

Route Optimization

Route optimization services and software can help minimize vehicle travel associated with Oakwood's distribution operations. Reductions in travel will lead to decreases in fuel consumption, emissions, and fuel costs. Less travel time can also produce cost savings through increased employee productivity.

Oakwood could utilize route optimization software or services provided by a company specialized in route optimization. There is stand-alone route optimization software and alternative software that utilizes programs such as Microsoft MapPoint. Examples of route optimization software include FleetRoute™ (www.fleetroute.com), Route Advice® (www.idscnet.com), and Tour Solver (www.toursolver.com).[8] Many systems also rely on GPS tracking. This project team has no experience with route optimization software or services and recommends that Oakwood thoroughly consider its route optimization options prior to making a decision.

GPS Tracking

As mentioned above, Oakwood is currently implementing GPS tracking systems provided by Air-Trak into its distribution operations. This system will be integrated into employee cell phones to track employee progress. For more precise transportation tracking Oakwood should consider installing GPS tracking systems directly into company owned vehicles. In addition, route optimization software may require the use of in-vehicle GPS systems rather than handheld devices.

Transportation Logistics Analysis

Oakwood can also benefit from hiring transportation logistics specialists. While Oakwood personnel believed that eliminating branch boundaries and consolidating its DCs into a central location in the Bay Area could result in reduced transportation impacts, a logistics expert may have been able to analyze this hypothesis ahead of time. Aside from DC reconfiguration situations, logistics personnel can also provide useful advice for improving the efficiency of day-to-day transportation operations or other aspects of Oakwood's business.

Strategically Placed Service Centers

In the Bay Area, strategic placement of SCs between the Hayward DC and units may reduce transportation impacts, even beyond pre-consolidation levels. SCs serve as temporary storage facilities for supplies and inventory. When located in proximity to heavily concentrated or remote units, SCs can drastically reduce the travel between housing units and DCs. SCs are generally limited to storage and are not used to service inventory or coordinate travel; therefore operations costs

[8] Softscout also provides several route optimization software options at: http://www.softscout.com/software/Transportation/Route-Planning-and-Optimization.html

should remain low. Furthermore, since the DC reconfiguration model can also be used to predict and evaluate SC reconfigurations by limiting the number of inputs, Oakwood can use it to consider SC reconfiguration options throughout its worldwide operations.

Employee Direct Reporting

Oakwood should continue to pursue having employees that service offsite units report directly to SCs or units, rather than to DCs. This will decrease transportation impacts from employees stopping at DCs merely to check in. Implementing this strategy will produce both environmental and cost savings associated with reduced fuel consumption and increased employee productivity, so long as there are safeguards against employees abusing the system.

Technology

Cleaner Fuels

Utilizing cleaner fuels can reduce Oakwood's overall environmental footprint. Alternative fuels include ultra-low sulfur diesel (ULSD), biodiesel (B5, B20, or B100), other biofuels such as E85, and natural gas. It is important to keep in mind that there are debates about the environmental benefits of using some of these fuels, such as biofuels made from virgin plants or food-crops. There is no debate, however, over the benefits of using ULSD over conventional diesel. At minimum, using ULSD can easily be implemented as a company-wide policy and practice.

Since the prices of these fuels are typically higher than traditional gasoline and diesel and special technology may be required to utilize some of these fuels, currently switching to these fuels will not likely lead to direct cost-savings. However, the use of cleaner fuels can be an effective way to increase environmental public awareness and signal Oakwood's commitment to environmental stewardship.

Cleaner Vehicles

Oakwood can further reduce its environmental footprint by using cleaner vehicles. Cleaner vehicles use hybrid technology or cleaner fuels. Currently owned vehicles can also be retrofitted with technology for reducing emissions or utilizing cleaner fuels. It should be Oakwood's policy to have the emissions technology of its vehicles regularly inspected to ensure it is functioning properly.

Although hybrid vehicles are generally more expensive to purchase than comparable non-hybrid vehicles, the increased fuel efficiency can provide Oakwood with long-term cost savings. Oakwood should periodically run a capital budgeting analysis for each region that compares the costs associated with purchasing and operating a regular vehicle against a hybrid to identify opportunities for environmental and economic savings. The analysis of operating costs should consider vehicle mileage and fuel price trends to compare fuel costs. In addition, since transportation is a significant aspect of Oakwood's operations, the company should continuously monitor developments in vehicle technology.

Buildings and Building Operations

The Leadership in Energy and Environmental Design (LEED) rating and certification is administered by the U.S. Green Building Council (USGBC). This nationally recognized rating and certification processes assess the environmental performance of buildings based on design, construction, and operations. Improving a building's environmental performance is an important measure because buildings in the U.S. account for "65% of electricity consumption, 36% of energy use, 30% of greenhouse gas emissions, 30% of raw materials use, 30% of waste output, and 12% of potable water consumption" (USGBC, 2007a). A recent success story of LEED construction is Toyota Motor Sale's South Campus Office Development in Torrance, CA, which realized $400,000 in annual energy savings and consumes 94% less potable water. Its construction also diverted 95% of waste from landfills. In order to embark on this project, Toyota had to demonstrate a return on investment greater than 10% to its shareholders (USGBC, 2006).

LEED certification is available for new construction, existing buildings, commercial interiors, and more. Although obtaining LEED certification would require extensive planning, documentation, and reporting, LEED criteria can be used as guidelines for feasible improvements that can be initiated in the near term, which can act as building blocks for continued improvements and possible certification in the future. Moreover, LEED certification is like a financial audit in that a third party approves the certification, so this type of greening can be advertised without fear of contradiction. For future construction or renovation of DCs, we recommend that Oakwood obtain LEED certification for those buildings. Generally speaking, preparing new DCs for Oakwood will require additional environmental attention in the area of site selection (utilization of brownfields, conservation of ecosystems, taking advantage of existing urban, commercial, and transportation infrastructure), design, construction procedures and materials, and final building performance (e.g., energy efficiency, roof with capacity to reflect sunlight, etc). Additional detailed guidance on improving a building's energy efficiency is provided in Energy Star's "Building Upgrade Manual" available online at: http://www.energystar.gov/ia/business/BUM.pdf.

Below is a list of general practices that improve building environmental performance. Many of these recommendations were extracted from LEED requirements that were relevant to current or future Oakwood DCs (USGBC, 2007b). Recommendations derived from other sources are specified as such. Many of these recommendations may also be applied to the apartment units. Environmental performance of apartments can be further enhanced through incorporating best practices documented for hotels and living spaces.

Overall Operations

- Ensure that there are no CFCs, HCFCs, or Halons used in building refrigeration, fire suppression, and HVAC systems.
- Reduce heat island effect by increasing shade, open-grid pavement area, and light color materials with high Solar Reflective Index (SRI).
- Switch to native or adaptive vegetation that do not require excessive maintenance, irrigation, fertilizer, and pest control.

Transportation: Encourage less use of private vehicle commuting

- Provide transit passes to employees to encourage use of public transportation at facilities where it is available.

- Provide bicycle storage, showers, and changing rooms.
- Provide priority parking to carpoolers.

Energy

- Apply EPA's Energy Star's Portfolio Manager tool, which guides managers to find ways to achieve energy efficiency for specific types of buildings.
- Meter and track energy use and document baseline
- Set goals and create incentives for reduction of energy consumption.
- Document estimated reduction in emissions from reduction in energy use.
- Ensure that energy-related systems—such as HVAC, lighting, hot water systems, and renewable energy systems—are properly installed, calibrated, and meet performance.
- Implement a system to monitor building and equipment performance and conduct preventive maintenance for optimum operation that does not waste energy.
- Monitor, track, record, and optimize the condition of indoor air, such as temperature and humidity.
- Install daylight responsive controls for lighting.
- Invest in on-site and/or off-site renewable energy (see section on Solar Energy for detailed recommendation).

Water

- Meter and track water use and record the baseline.
- Set goals for reduction in water consumption and implement a water use reduction plan to decrease environmental impacts and protect against rising water prices.
- Create incentives to reduce wasteful water use.
- Use high efficiency equipment, toilets, and dry urinals.
- Implement a storm water management plan that minimizes impervious surfaces, increases infiltration, and captures and treats storm water runoff.
- Employ efficient irrigation technology.
- Reduce the use of potable water for irrigation by using recycled waste water, grey water, or captured rain water.

Diversion of Materials from Waste Stream and Virgin Material Source Reduction

- Conduct a waste audit and establish baseline of non-recycled waste and recycled waste.
    - A waste audit is a commercially available service. Experts collect the waste accumulated at the facility and take inventory of various types of waste by mass. Typically this type of audit results in recommendations on how to reduce waste generation.
    - Organizations such as Recycle America (RecycleAmerica.com) and various consulting companies provide waste auditing services and provide recommendations based on waste composition.
    - EPA's WasteWise program provides detailed strategies for waste reduction (www.epa.gov/wastewise).

- Implement policies that reduce material consumption such as duplex printing, electronic information dissemination instead of paper memos, using reusable mugs for coffee instead of paper cups (EPA, 2008c).
- Set goals to reduce non-recycled waste and track quantified landfill/incinerator diversion.
- Recycle paper, glass, plastic, cardboard, metals, light bulbs, batteries, and other materials in accordance to regional waste management facility guidelines.
- When building debris is generated through renovation, identify markets and processors that can recycle the material.
- Make available recycling receptors in convenient locations for employees.
- Reduce the use of cleaning products and disposal janitorial paper products.
- Consider donation of construction waste to nonprofits such as Habitat for Humanity.
- Use existing building structure, salvaged or refurbished building materials and furniture.
- Work with suppliers to reduce use of packaging. Companies, such as Wal-Mart, have found that cost reductions can be realized through reducing the amount and need for packaging (Westervelt, 2008). These companies have worked with suppliers to decrease the material used per packaging, both through design and through bulk shipping. Another approach is to create a packaging take-back system using the reverse logistics when shipments arrive or a mail-back system so that packaging can be reused.
- Implement a robust electronic waste management strategy. The California Integrated Waste Management Board's "Electronic Product Management Directory" provides a comprehensive list of resources that will help Oakwood select its best management strategy and is available at: http://www.ciwmb.ca.gov/electronics/Collection/RecyclerSearch.aspx. Some additional guidelines are as follows:
    - Donate old but functional electronics to schools, non-profits, nursing homes, and other facilities in the community (EPA, 2008c).
        - Donations can result in tax deductions.
        - Donation is environmentally preferable over recycling because it prolongs the product's lifespan and displaces the purchasing of new products, therefore reducing virgin material depletion and release of toxic materials into the environment.
    - Functional electronic equipment and other reusable items can be advertized using commercial materials exchange systems (EPA, 2008c).
    - Recycle old electronics: Many manufacturers and recycling facilities provide take-back services or collection events. For example, eScraptracker take-back program that allows for the ship-backs of up to 600 lb per shipment (Recycle America, 2006).

Purchasing

- Purchase light bulbs and electronics with low level of mercury and other toxins.
- Purchase environmentally preferable office paper, equipment, furniture, furnishings, and building material (USGBC provides detailed specifications).
- Purchase products that contain salvaged material, post-consumer/post-industrial material, and rapidly renewable materials.
- Purchase products built using FSC certified wood.
- Purchase products that are environmentally certified.

- Purchase sustainable cleaning products such as those compliant with the Green Seal standard.
- Purchase materials and products extracted, harvested, manufactured, and/or recovered locally.
- Purchase energy-efficient equipment.
- The Federal Trade Commission provides a definition for recycled content material in *Guides for the Use of Environmental Marketing Claims, 16 CFR 260.7 (e),* which is available at www.ftc.gov/bcp/grnrule/guides980427.htm.
- Many guides for environmentally preferable purchasing are available online. Below are a several selected sources. Further searches on the internet can be done for specific products and many counties, cities, and states also provide comprehensive information on their websites.
  - EPA's Comprehensive Procurement Guidelines for recycled material products: http://www.epa.gov/cpg.
  - EPA's Environmentally Preferable Purchasing Program: http://www.epa.gov/epp/.
  - Energy Star for energy efficient products: www.energystar.gov.
  - Responsible Purchasing Network: http://www.responsiblepurchasing.org.
  - Electronic Product Environmental Assessment Tool: http://www.epeat.net.
  - American Council for an Energy-Efficient Economy's Online Guide to Energy-Efficient Commercial Equipment: http://aceee.org/ogeece/ch5_office.htm.
  - Commission for Environmental Cooperation's North American Green Purchasing Initiative (guide and database): www.cec.org/nagpi.

Employee Health, Wellbeing, and Productivity

- Implement an Indoor Air Quality policy that includes measuring and tracking indoor air composition.
- Purchase and use Indoor Air Quality (IAQ) compliant, low-emission products, particularly for paint, coatings, adhesives, and sealants.
- Use carpeting that has low VOC emissions as described by Green Label Plus and the Carpet & Rug Institute.
- Ensure proper ventilation for indoor air quality.
- Ensure that asbestos and PCBs are managed appropriately.
- Minimize dirt and other pollutants entering facility by using mats, grills, and grates.
- Use appropriate particle filters to reduce chemical pollutant intakes from outside air.
- Use separate control systems in different areas of the building for light, temperature, and ventilation in order to enhance comfort and productivity as well as reduce wasteful energy use.
- When necessary, use low environmental impact methods for indoor pest management.
- Document productivity impacts that may be correlated to changes in the building by tracking absenteeism and health care costs, quantifying work accomplishment and errors made.
  - If possible, find and retain old records for comparison.

Energy Efficiency and Energy Sources

Energy management is important for mitigating emissions from burning fossil fuels and the negative environmental impacts from mining. Simultaneous cost savings and improved environmental

performance can easily be achieved through use of energy efficient technology and buildings. PG&E offers rebates to businesses for retrofitting facilities with energy efficient technology. More information is available at: http://www.pge.com/biz/rebates/rebates_assistance/.
Information on tax incentives for businesses to make energy efficient investments is available at: http://www.energytaxincentives.org/business/.
These sites may be helpful as Oakwood considers incorporating new technologies into its business practice.

New technologies that reduce energy use will continue to become available. For example, light focusing devices can be installed to efficiently capture any ambient light and focus it into a facility. This source of light is more effective than traditional sky lights. For example, a Federated Logistics and Operations warehouse in Los Angeles, CA installed close to 800 Solatube Daylighting fixtures to bring in natural light to their facility. Not only does the natural light help the color rendition of their inventory, but reduces electricity consumption (Solatube, 2007; EERE, 2006).

Renewable Energy Certificates/Green Power

The purchase of renewable energy has also become a viable option for decreasing environmental footprints. Renewable energy alleviates the dependence on the limited fossil fuel supply and in most cases provides an energy source that poses a significantly smaller burden on the environment. Sources of renewable energy include sunlight, wind, water, Earth's core heat, and biomass (EPA, 2007c). Green power is defined as a portion of renewable energy that is environmentally preferable by the Center for Resource Solutions (EPA, 2004). Because marketing claims and definitions of environmentally preferable energy may vary greatly, Green-e Renewable Energy Certification Program is helpful for making informed decisions. An organization or an individual can either purchase renewable electricity delivered to it from the grid and/or purchase Renewable Energy Certificates (REC). In doing so, a company can either receive environmentally friendly energy in the electricity delivered to them, or pay for the production of greener electricity that is not delivered to them but can be used elsewhere (EPA, 2007c). More and more businesses, such as Johnson & Johnson and Whole Foods, are purchasing green power (EPA, 2007d).

The price of Green Power varies greatly, depending on the source and the market, and is more expensive than traditional electricity. However, a company can demonstrate its commitment to mitigating its environmental footprint and increase its environmental reputation. EPA has a partnership opportunity to help select Green Power and provide guidance. In particular, the website has suggestions on how to make marketing claims that are not misleading. Information on purchasing Green Power can be obtained from http://www.green-e.org/, Carbon Catalog http://www.carboncatalog.org, Carbonfund.org, the renewable energy certification organization, EPA's website at http://www.epa.gov/greenpower/, or at the Department of Energy's website at http://www.eere.energy.gov/greenpower/. Step-by-step information on purchasing green power is outlined in the document created by the Department of Energy, the Environmental Protection Agency, World Resources Institute, and Center for Resource Solutions titled, "Guide to Purchasing Green Power—Renewable Electricity, Renewable Energy Certificates, and On-Site Renewable Generation." This document is currently available online at the following URL http://www.resource-solutions.org/lib/librarypdfs/Purchasing_Guide_for_Web.pdf.

Onsite Generation

Onsite energy generation with photovoltaic solar panels, geothermal heat pumps, or solar space/water heating would likely be a good investment, especially considering increasing energy prices (EERE, 2006). Sunlight is the strongest during peak energy demand hours, making solar energy an attractive energy source for businesses, such as Oakwood. Leading companies including Google, Honda, FedEx, and others have installed solar panels at their facilities, illustrating that solar power is a viable option for demanding businesses operations (Sharp, 2007).

The state of California has initiated a push for homes and non-residential facilities to invest in solar power through incentives made available through the California Solar Initiative (CSI), which is administered by PG&E, SCE, SoCalGas, and SDREO (SGIP, 2007). Up-to-date information can be obtained from the state government-run website, http://www.gosolarcalifornia.ca.gov and California Solar Energy Industries Association website, http://calseia.org. In addition, tax incentives are available from the federal government. The Database of State Incentives for Renewable & Efficiency (DSIRE) available at www.dsireusa.org provides information on incentives nation-wide.

Tools that calculate potential environmental and financial implications of installing solar panels are available online. For example, the following two websites provide the option to specify calculations for a commercial business. The second webpage is California-specific. While the robustness of the websites are slightly limited, they provide a valuable first step in the decision making process and also provide industry contacts for further guidance.
http://www.findsolar.com/index.php?page=rightforme
http://www.consumerenergycenter.org/renewables/estimator/index.html

Equipment

During laundry, heating the water for the washing machine and then evaporating the water in the dryer are the energy-demanding processes. The following are general recommendations that will save energy during laundry (Jenneman, 2008 and Tinker, 2008):

- Use efficient equipment, particularly in terms of water use, since the more water heated, the more energy consumed.
- Operate machinery in accordance to their design and specifications.
  - Standardize adequate washing machine and dryer loading rates.
    - While underloading wastes water and energy, overloading may mean longer wash time and higher level of chemicals.
  - Verify that ample air flow is available to dryers, boilers, and water heaters so combustion efficiency is not compromised.
- Conduct proper preventative maintenance and cleaning as recommended by manufacturer.
  - Check for leaks in steam and water systems.
  - Check dryer seals.
- Reduce water, chemical, and energy use through softening water.
- Work with chemical supplier to ensure water levels are efficient during pre-flushes, loading, and rinses.
- Discuss with chemical supplier whether switching to lower-temperature-requiring chemicals is an option.

    - Consider tradeoffs such as longer washing time and higher levels of chemicals, and whether applicable to the type of linens being washed.
- Maximize extractor performance so there is less water to evaporate in the dryer
    - Extractors are most efficient when water is warmer since warmer water has lower surface tension that attracts it to fibers. Optimal temperature depends on fabric type but is roughly 140ºF for cotton and 120ºF for polyester. Rinsing water over 100ºF and around 120ºF is the optimal approach; however, it may be necessary to make adjustments if low-temperature chemicals are used (Tinker, 2008).

Retrofitting equipment with heat recovery from waste water or boilers and water recycling systems can drastically reduce energy and water use. Payback period may be as low as six months, but would depend on the specific washing conditions. Some additional floor or wall space may be required depending on the model as well (Industrial Launderer, 2000).

Heat Recovery

Heat that is typically lost in wastewater or boiler flue (exhaust) gas can be recovered to reduce energy use (Kemberling, 2008). This recovered heat is generally used to pre-heat incoming water so that less energy is ultimately required to raise the temperature to the required level. In the case of heat recovery from waste water, the incoming water (on average at 60ºF) would be heated by the laundry wastewater that typically is around 100 to 120ºF (Industrial Launderer, 2000). We presume that dish washing does not take place at the same capacity as laundry at Oakwood DCs; however, heat reclamation could be conducted with dish washer wastewater as well.

Water Recycling

Water reuse systems have the potential to save even more than heat recovery systems through saving energy and water. If rinsing water is recycled, overall water use can be reduced 20 to 50%. If the rinse water is heated (usually it is around 100ºF), then less energy is required to heat the water for the washing cycle (Anderson, 2008; Industrial Launderer, 2000). No energy savings can be gained if cold water is used for rinsing, but water consumption can still be reduced (Anderson, 2008). In addition, little or no filtering is required and ultimately less salt would be needed to soften the tap water (Anderson, 2008). Detergent requirements may also be reduced since dissolved detergents would be recycled through to the wash cycle and because the water would have a lower level of hardness (New Logic, 1999).

Wash water recycling requires some filtering but has potentially high energy savings since a portion of the water will be hot. Although the recycled water cannot be used during the bleach cycle, water use may be reduced by 40% to 60% (Anderson, 2008). High capacity recycle systems have an intensive filtering system so that recovered water can be fed back all subsequent cycles, including bleaching and rising. These systems can reduce water use by 50 to 90% (Anderson, 2008).

Monitor, Track, and Set Goals

As with any management improvements to be made, Oakwood should assess current performance of its laundry in terms of energy and water use, set that performance as a benchmark, and develop appropriate goals. The benchmark could be in terms of therms used per 100 lb of dry laundry (for both washing and drying). Calculating this number requires several steps (described below) since energy use of machines provided on specifications are capacity information and not average energy that is actually used. The amount of energy used per weight of laundry can be estimated by counting the number of cycles of each machine and multiplying it by its laundry dry weight capacity that is indicated.[9] Alternatively, associates could weigh the laundry during a typical week. This approach may be more helpful if moisture retention after extraction is to be calculated as described below in Step 4. Therms per 100 lb weight is typically calculated based on clean and dry weight, but soiled weight can be used as long as it is consistent (Jenneman, 2008).

1. The energy used in the washing equipment is primarily for heating the water. The median water consumption per pound of dry laundry processed for a range of Milnor[10] equipment sizes is 2.5gallons per pound of laundry (average 2.4 gallons per lb), which is consistent with industry experts' descriptions (Jenneman, 2008; Milnor, Date Unknown).
2. Heating water is proportional to the change in temperature. Specifically, it takes 8.33×10^{-5} therms to raise 1 gallon of water 1ºF. Not all cycles in the washing machine use heated water. Based on the settings, one can calculate the percentage of incoming water that is heated. The average U.S. tap water is about 60ºF (Jenneman, 2008). Using the water per laundry weight rate, the amount of laundry processed, the temperature of the water before and after heating, and the amount of water heated, one can calculate the total energy required to wash 100 lb of laundry.
3. It is important to get a good understanding of washing machine energy use through monitoring its accuracy and repeatability of water levels as specified by the controls (Tinker, 2008).
4. Moisture retention can be calculated based on finding the difference in weight of extracted laundry and dry laundry and dividing it by the weight of the dry laundry.
5. The amount of heat needed to dry laundry is proportional to the amount of water. Experts estimate that it takes 0.02 therm to evaporate 1 lb of water in the dryer, accounting for energy required to change water from liquid to gas, the heat used to expedite the process, and loss of heat due to machine efficiency. Energy Star[11] indicates that there is little difference between drying machine capacities (Energy Star, 2008). Therefore the more water that is extracted, the less energy required to dry the linens. Using this drying rate and the moisture retention rate, energy use for drying 100 lb of laundry can be calculated.

There is no benchmark for fuel consumption per pound of laundry in the industrial laundry sector. Depending on the business, gas use per 100 lb of laundry may average from 1.8 therms to over 4 therms (including ironing and finishing) and little consistency has been found. An energy consumption-conscious industrial launderer in the Midwest reported it is decreasing energy use to attain a goal of 1 therm per 100 lb of laundry (Jenneman, 2008). When extrapolating to annual laundry processed, a difference in a few therms per 100lb of laundry can be pretty significant (Jenneman, 2008).

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[9] Based on information of number of loads processed per day and because Hayward facility is open six days per week, we found that 27040 lb of dry weight laundry is processed per week. Because the amount of laundry did not change from the reconfiguration, we assume the aggregate amount at the old branches would have been the same.

[10] Milnor is the washing equipment currently used at Bay Area DCs.

[11] Energy Star is a government-run program that provides standards for and rates appliance efficiency. While there are standards for household and commercial washers, Energy Star does not provide standards for larger equipment, such as those used at Oakwood facilities.

CONCLUSION

Although our analysis shows that Oakwood will realize substantial cost savings from the Bay Area consolidation, the DC network's environmental performance declined marginally due to increased transportation. Oakwood expected that eliminating branch zones would result in more streamlined transportation routes and less transportation impacts. However, the four month post-consolidation data we analyzed challenges this hypothesis. Due to the limited data available to us we recommend that Oakwood continues to track and monitor the Bay Area consolidation impacts using the DC reconfiguration model. Examining up to a full year of data will provide a much more accurate depiction of the exact changes in the DC network's environmental and economic performance. In the meantime, we see Oakwood's cost savings from the consolidation as a new opportunity to invest in additional environmental management programs we recommend in this report. Finally, our model provides Oakwood with a tool that can be applied to other Oakwood regions with reconfiguration opportunities so that the balance between environmental and economic performance can be thoroughly assessed prior to implementing these decisions.

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APPENDICES

Appendix A: Emissions

Below is the list of emissions we considered. These pollutants were chosen for their relevance to consuming energy and their relative importance to public concern. While the mass of each emission is reported in our paper, it is important to note that the type and level of impact differ significantly for each pollutant; therefore the mass of one pollutant cannot be compared to the mass of another. Rather, if one pollutant increases while another pollutant decreases post-reconfiguration, a judgment needs to be made as to what environmental impact is of most concern, and to what degree the pollutants contribute to the impact. In many cases, it will depend on the region or the priorities of the public. In the list below, we describe the environmental consequences associated with each pollutant, and when available, the standards set by the government to illustrate the scale at which these pollutants become a concern.

Carbon dioxide
Carbon dioxide is a greenhouse gas known for its impacts on climate change. While the pollutant is cause for significant global concern, it is currently not regulated under U.S. legislation.

Methane
Methane is a greenhouse gas that contributes to climate change. While the aggregate amount emitted is less than carbon dioxide, its climate forcing power is about 20 times more than carbon dioxide.

Carbon monoxide
Carbon monoxide is regulated under the Environmental Protection Agency's Clean Air Act due to its effects on the ability of blood to carry oxygen in human bodies. Exposure to carbon monoxide is associated with deterioration in physical, visual, and learning capabilities (EPA, 2007a). Carbon monoxide standards are set at 10 mg/m^3 over an 8-hour period and 40mg/m^3 over a 1-hour period (EPA, 2008b).

Nitrogen Oxides
Nitrogen oxides, including nitrogen dioxide, are compounds with nitrogen and oxygen. These compounds contribute to the creation of ground-level ozone (also known as smog), climate change, acid deposition, and nutrient overload in lakes. The compounds also cause respiratory problems. Nitrogen dioxide standards are set at 100$\mu g/m^3$ (EPA, 2008b).

Sulfur dioxide
Sulfur dioxide standards are set at 80 $\mu g/m^3$ for the annual arithmetic mean and 1300 $\mu g/m^3$ over a 24-hour period (EPA, 2008b). Sulfur dioxide produces acid depositions, which lead to deterioration of forest and lake ecosystems and human-made structures such as buildings.

Heavy metals (includes lead and mercury)
Many heavy metals, such as lead, mercury, arsenic, cadmium, and aluminum are toxic to human health. While this category provides an aggregate mass of heavy metals released, we provide specific data for lead and mercury, which are commonly discussed.

Lead
Lead standards are set at 1.5 μg/m^3 for a quarterly average (EPA, 2008b). Lead is associated with adverse effects on organs, the central nervous system, blood pressure, and metabolism. In particular, lead exposure affects cognitive development and physical growth in children. No safe level of lead in blood has been identified for avoiding various health effects. Disabilities specific to cognitive development in children have been associated with blood lead levels of 10 μg/L (CDC, 2005).

Mercury
Exposure to mercury leads to negative effects on various organs and the immune system. In particular, mercury builds up in tissues, therefore life long exposure through drinking contaminated water or eating organisms such as fish, can lead to the mentioned health effects. Mercury is regulated under the Clean Air Mercury Rule, which has required coal-fired power plants to reduce emissions by approximately 70% (EPA, 2007a). Effects on fetal neurodevelopment are associated with blood mercury levels of above 58 μg/L (CDC, 2005).

Particulates (includes PM2.5 and PM10)
The particulates category includes fine particulates such as those under 10 microns and 2.5 microns in diameter (PM_{10} and $PM_{2.5}$, respectively), dust, wood dust, and particulates of metals. Particulate matter is associated with lung disease and respiratory problems. Smaller particulates have been found to travel deeper into the lungs. In addition, many particulates are toxic, particularly due to their high adsorptive levels. While this category is comprehensive, we provide specific emissions data on PM_{10} and $PM_{2.5.}$

PM_{10}
PM_{10} standards are set at 150 μg/m^3 over a 24-hour period (EPA, 2008b).

$PM_{2.5}$
$PM_{2.5}$ standards are set at 15 μg/m^3 as an annual arithmetic mean 35 μg/m^3 over a 24-hour period (EPA, 2008b).

Non-methane Volatile Organic Compounds (VOCs) (includes benzene)
Volatile Organic Compounds (VOCs) include a range of carbon-based chemicals that takes part in photoreactions. In this case we have excluded methane and report it separately. Because the category includes various chemicals, the level of toxicity varies greatly, ranging from sinus, throat, and eye irritation to cancer and damage to organs (EPA, 2008b). VOCs also react with nitrogen oxides in the presence of sunlight (photoreactions) and form ground-level ozone, or smog, which also leads to respiratory problems. EPA regulates levels of this ground-level ozone.

Benzene
Benzene in gasoline is regulated by the EPA. Exposure to benzene is associated with neurological effects, bone marrow damage, chromosomal damage, effects on the reproductive system, and leukemia. While the US EPA has not set a level that defines a chronic exposure, the California EPA has set the chronic exposure level at 0.06 mg/ m^3 (EPA, 2008a).

Appendix B: Energy and Life Cycle Assessment

We used GaBi 4, a Life Cycle Assessment software package licensed by PE International to find emission factors from consuming natural gas, regular gasoline, diesel, and generating electricity. The pollutants we considered were chosen based on relevance and are listed in Appendix A. For this report we focused on emissions to the air, primarily for the purpose of keeping the various emissions comparable. In addition, air emissions are the primary environmental impact due to energy consumption and were greater than emissions from water, soil, or sea water by more than 1000 times. Therefore aggregating these emissions would not have affected the comparative results. We also did not include radioactive waste and extraction waste since comparisons of these tradeoffs would have been difficult to make. We chose GaBi for our source of emission factors because the databases within the software are up to date and are considered a reliable source by experts in the field.

Two sets of emission factors were culled from GaBi for electricity generation. The first set of emission factors were calculated specifically for PG&E's Bay Area fuel mix. Because emissions vary depending on the fuel used, we assigned the percentage breakdown to various fuel types as specified in PG&E's energy mix. The breakdown is as follows.

- Biomass and waste: 4%
- Geothermal: 4%
- Small hydroelectric: 4%
- Solar: <1%
- Wind: 1%
- Coal: 2%
- Large Hydroelectric: 17%
- Natural Gas: 43%
- Nuclear: 23%
- Other: 1%

Unfortunately, not all of these energy sources were in the database of the GabBi version available to us. Therefore we allocated percentage of fuel sources as follows. We believe the reallocated fuel sources make up a relatively small percentage, therefore the affect on emission levels would be negligible.

- Wind: 7%
  - Wind, solar, geothermal, other
- Coal: 2%
- Hydroelectric (unspecified size): 21%
  - Large and small
- Natural gas: 47%
  - Natural gas, Biomass and waste
- Nuclear: 23%

We also culled the emission factors for the average U.S. grid mix so that managers in different U.S. regions can use our model. GaBi's fuel source breakdown for its default U.S. average energy mix is as follows.

- Nuclear: 20%
- Brown coal: 2.4%
- Hard coal: 48.3%
- Blast furnace gas: 0.3%
- Natural gas: 17.7%
- Heavy fuel oil: 2.5%
- Solid biomass: 1.0%
- Gaseous biomass: 0.1%
- Waste: 0.6%
- Hydro: 6.4%
- Wind: 0.3%
- Geothermal: 0.4%

The emission factors calculated in GaBi reflect emissions that occur from sourcing the raw materials through energy production at the power plant. We then scaled up these emission factors by 7.2% to account for transmission and distribution losses, as described by the Leonardo Academy (Leonardo Academy, 2007). The two sets of final electricity emission factors are presented in Table 7. If managers obtain more accurate emission data for their region, they can go into the model and make appropriate modifications. Emissions from natural gas were culled from GaBi as well and are also presented in Table 7.

Table 7: Electricity and Natural Gas Emission Factors

	PG&E Electricity production (kg/kWh)		US Average Electricity production (kg/kWh)		
Selected Pollutants	**Electricity Generation**	**With Distribution Loss**	**Electricity Generation**	**With Distribution Loss**	**Natural Gas (kg/100 Btu)**
Carbon Dioxide	3.57E-01	3.83E-01	7.81E-01	8.37E-01	7.59E-03
Methane	5.67E-04	6.08E-04	8.53E-04	9.15E-04	1.25E-05
Carbon Monoxide	9.24E-05	9.90E-05	2.88E-04	3.09E-04	1.86E-06
Nitrogen Oxides	5.10E-04	5.47E-04	1.43E-03	1.53E-03	1.06E-05
Sulfur Dioxide	3.54E-04	3.79E-04	3.88E-03	4.16E-03	4.38E-06
Heavy Metals (includes lead and mercury)	7.43E-08	7.96E-08	6.71E-07	7.19E-07	8.07E-10
Lead	8.97E-09	9.61E-09	4.71E-08	5.05E-08	1.15E-10
Mercury	6.51E-10	6.98E-10	8.26E-09	8.85E-09	7.35E-12
Particulates (includes PM2.5 and PM10)	1.78E-05	1.91E-05	1.22E-04	1.31E-04	2.58E-07
PM10	8.55E-07	9.17E-07	5.13E-06	5.50E-06	1.50E-08
PM2.5	8.03E-06	8.61E-06	3.70E-05	3.97E-05	1.52E-07
Non-Methane VOCs (includes benzene)	7.17E-05	7.68E-05	7.82E-05	8.38E-05	1.59E-06
Benzene	5.80E-07	6.22E-07	2.61E-07	2.79E-07	1.34E-08

Emissions of regular gasoline and diesel were calculated using GaBi as well. Regular gasoline emissions were calculated for a "conventional" passenger vehicle use. Emission factors were per 1 mile driven and per 1 gallon of gasoline consumed. GaBi provided the standard assumption that a passenger vehicle will be on the highway, outside of town, and within town for approximately 28%, 40%, and 31% of its mileage, respectively, and that the amount of sulfur in fuel is 50ppm. We used these given assumptions for both cases. In order to calculate the emissions over 1 mi, GaBi adjusted the gasoline consumption to 0.041 gallons. In order to calculate the emissions from 1 gallon of gasoline, GaBi adjusted the distance travelled to 30 miles.

For calculating emissions from diesel, we assumed that a 3.3 ton payload truck—the smallest truck size available to us in the software—was driven. GaBi provided standard assumptions that a truck would be on a highway, outside of town, and within town for approximately 27%, 43%, and 30% of its mileage, respectively, and that sulfur content in diesel was 50ppm. We used these given assumptions in our calculations. To calculate diesel emissions per 1 gallon of diesel consumed over a 100-km distance (a default value), GaBi adjusted the cargo weight to 849kg. We found that calculating emission factors for 1 gallon of diesel consumed over 900 km and carrying approximately 100kg of cargo resulted in a negligible difference compared to 1 gallon of diesel consumed with the previous assumptions since the amount of pollutants emitted is proportional to the amount of fuel consumed. To calculate diesel emissions from traveling 1 mile while carrying 849 kg of cargo (adjusted to match emissions per gallon), GaBi adjusted the amount of diesel consumed to 0.016 gallons. We also culled emission factors for 1 mile driven with 100 kg of cargo and 1kg of cargo since more fuel will be consumed with heavy cargo.

For vehicle fuel emissions, GaBi provided emission factors from the use phase (i.e., emissions from driving), the fuel production phase (raw material sourcing and processing at refinery), and for the total life cycle (production and use phases). We primarily use the life cycle emissions for vehicles in order to maintain consistency with electricity and gas emissions, for which only life cycle emissions were provided in GaBi. Emissions from all three phases are reported in Table 8 for passenger vehicles and Table 9 and Table 10 for trucks.

Table 8: Emission Factors for Passenger Vehicles (regular gasoline)

Selected Pollutants	Emissions (kg/mi) Life Cycle	Emissions (kg/mi) Driving-phase	Emissions (kg/mi) Refinery	Emissions (kg/gal) Life Cycle	Emissions (kg/gal) Driving-phase	Emissions (kg/gal) Refinery
Carbon Dioxide	4.40E-01	3.65E-01	7.44E-02	1.06E+01	8.83E+00	1.80E+00
Methane	5.62E-04	6.08E-05	5.01E-04	1.42E-02	2.06E-03	1.21E-02
Carbon Monoxide	1.17E-02	1.16E-02	8.39E-05	6.59E-01	6.57E-01	2.03E-03
Nitrogen Oxides	2.80E-03	2.63E-03	1.68E-04	8.27E-02	7.86E-02	4.06E-03
Sulfur Dioxide	2.52E-04	1.15E-05	2.41E-04	6.10E-03	2.78E-04	5.82E-03
Heavy Metals (includes lead and mercury)	1.14E-06	0.00E+00	1.14E-06	2.76E-05	0.00E+00	2.76E-05
Lead	2.85E-09	0.00E+00	2.85E-09	6.90E-08	0.00E+00	6.90E-08
Mercury	3.04E-10	0.00E+00	3.04E-10	7.35E-09	0.00E+00	7.35E-09
Particulates (includes PM2.5 and PM10)	9.86E-06	0.00E+00	9.86E-06	2.39E-04	0.00E+00	2.39E-04
PM10	4.88E-06	0.00E+00	4.88E-06	1.18E-04	0.00E+00	1.18E-04
PM2.5	1.96E-06	0.00E+00	1.96E-06	4.74E-05	0.00E+00	4.74E-05
Non-methane VOC (includes benzene)	2.26E-03	2.17E-03	9.35E-05	7.55E-02	7.32E-02	2.26E-03
Benzene	7.92E-05	7.91E-05	1.96E-07	2.68E-03	2.67E-03	4.74E-06

Table 9: Emissions from Trucks (Diesel) per mile driven

Selected Pollutants	Emissions (kg/mi) (849kg Cargo) Life Cycle	Driving-phase	Refinery	Emissions (kg/mi) (100kg Cargo) Life Cycle	Driving-phase	Refinery	Emissions (kg/mi) (1kg Cargo) Life Cycle	Driving-phase	Refinery
Carbon Dioxide	1.83E-01	1.62E-01	2.10E-02	2.16E-02	1.91E-02	2.47E-03	2.16E-04	1.91E-04	2.47E-05
Methane	2.20E-04	1.58E-06	2.19E-04	2.59E-05	1.86E-07	2.57E-05	2.59E-07	1.86E-09	2.57E-07
Carbon Monoxide	3.15E-04	2.84E-04	3.07E-05	3.70E-05	3.34E-05	3.61E-06	3.70E-07	3.34E-07	3.61E-08
Nitrogen Oxides	1.42E-03	1.36E-03	6.52E-05	1.68E-04	1.60E-04	7.68E-06	1.68E-06	1.60E-06	7.68E-08
Sulfur Dioxide	8.94E-05	5.10E-06	8.43E-05	1.05E-05	6.01E-07	9.93E-06	1.05E-07	6.01E-09	9.93E-08
Heavy Metals (includes lead and mercury)	2.10E-07	0.00E+00	2.10E-07	2.47E-08	0.00E+00	2.47E-08	2.47E-10	0.00E+00	2.47E-10
Lead	9.50E-10	0.00E+00	9.50E-10	1.12E-10	0.00E+00	1.12E-10	1.12E-12	0.00E+00	1.12E-12
Mercury	8.05E-11	0.00E+00	8.05E-11	9.48E-12	0.00E+00	9.48E-12	9.48E-14	0.00E+00	9.48E-14
Particulates (includes PM2.5 and PM10)	3.44E-05	3.13E-05	3.09E-06	4.06E-06	3.69E-06	3.64E-07	4.06E-08	3.69E-08	3.64E-09
PM10	1.03E-06	0.00E+00	1.03E-06	1.21E-07	0.00E+00	1.21E-07	1.21E-09	0.00E+00	1.21E-09
PM2.5	3.22E-05	3.13E-05	8.20E-07	3.79E-06	3.69E-06	9.65E-08	3.79E-08	3.69E-08	9.65E-10
Non-methane VOC (includes benzene)	1.05E-04	6.41E-05	4.05E-05	1.23E-05	7.55E-06	4.77E-06	1.23E-07	7.55E-08	4.77E-08
Benzene	1.14E-06	1.10E-06	4.01E-08	1.34E-07	1.29E-07	4.72E-09	1.34E-09	1.29E-09	4.72E-11

Table 10: Emissions from Trucks (Diesel) per gallon consumed

Selected Pollutants	Emissions (kg/gal)		
	Life Cycle	Driving-phase	Refinery
Carbon Dioxide	1.13E+01	9.99E+00	1.29E+00
Methane	1.36E-02	9.72E-05	1.35E-02
Carbon Monoxide	1.94E-02	1.75E-02	1.89E-03
Nitrogen Oxides	8.78E-02	8.38E-02	4.02E-03
Sulfur Dioxide	5.51E-03	3.14E-04	5.20E-03
Heavy Metals (includes lead and mercury)	1.29E-05	0.00E+00	1.29E-05
Lead	5.85E-08	0.00E+00	5.85E-08
Mercury	4.96E-09	0.00E+00	4.96E-09
Particulates (includes PM2.5 and PM10)	2.12E-03	1.93E-03	1.91E-04
PM10	6.34E-05	0.00E+00	6.34E-05
PM2.5	1.98E-03	1.93E-03	5.05E-05
Non-methane VOC (includes benzene)	6.45E-03	3.95E-03	2.50E-03
Benzene	7.01E-05	6.76E-05	2.47E-06

Appendix C: Transportation

Table 11: Bay Area Vehicles

2006			2007		
Year	Make	Model	Year	Make	Model
2001	Isuzu	NPR	2001	Isuzu	NPR
2001	Isuzu	Small Truck	2001	Isuzu	Small Truck
2000	Ford	Large Van	2000	Ford	Large Van
1997	Isuzu	Small Truck	2006	Isuzu	NPR
2000	Ford	Large Van	1999	Ford	Large Van
2003	GMC	Savana	2003	GMC	Savana
2004	PONT	Vibe	2000	Isuzu	Small Truck
2004	PONT	Vibe	2000	Isuzu	Small Truck
2000	Isuzu	Small Truck	2005	Isuzu	Large Truck
2000	Isuzu	Small Truck	2005	GMC	Small Van
2005	Isuzu	Large Truck	2005	GMC	Small Van
2005	GMC	Small Van	2001	Isuzu	NPR
2005	GMC	Small Van	2001	Isuzu	NPR
2001	Isuzu	NPR	2001	Isuzu	NPR
2001	Isuzu	NPR	2000	Isuzu	NPR
2001	Isuzu	NPR	1999	Ford	Large Van
2000	Isuzu	NPR	2004	GMC	SAVANA
1999	Ford	Large Van	2004	GMC	SAVANA
2004	GMC	SAVANA			
2004	GMC	SAVANA			

Table 12: Transportation Analysis Summary

	Monthly Averages			
	Aug-Nov06	Feb-May07	Aug-Nov06 & Feb-May07	Aug-Nov07
Cost of Fuel	$6,472	$5,835	$6,153	$7,311
Gallons of Diesel	1,332	1,193	1262.4945	1,320
Gallons of Regular	945	726	835.40468	921
Total Gallons	2,278	1,918	2097.8992	2,240
Client Count	1,210	1,208	1208.75	1,211
Life Cycle Emissions (kg)				
CO_2	25081	21167	23124	24676
Methane	31.47	26.46	28.967586	30.95
CO	648.87	501.33	575.10021	632.54
NOx	195.16	164.71	179.93237	192.01
SO_2	13.11	11.00	12.055027	12.89
Heavy Metals	0.04	0.04	0.039342	0.04
Lead	0.00	0.00	0.0001316	0.00
Mercury	0.00	0.00	1.24E-05	0.00
Particulate Matter	3.05	2.70	2.8783313	3.02
PM10	0.20	0.16	0.1786949	0.19
PM2.5	2.69	2.40	2.5418472	2.66
NMVOCs	79.93	62.44	71.183202	78.00
Benzene	2.6233151	2.0254126	2.3243638	2.5571226
Use Emissions (kg)				
CO_2	21654	18316	19985	21310
Methane	2.07	1.61	1.8399316	2.02
CO	644.43	497.60	571.01694	628.18
NOx	185.96	156.96	171.46324	182.96
SO_2	0.68	0.58	0.6294582	0.67
Particulate Matter	2.57	2.30	2.4385195	2.55
NMVOCs	74.46	57.82	66.14246	72.62
Benzene	2.62	2.02	2.3172882	2.55

Table 13: Trip Study

	Monthly Averages			
Time Period	7/06-9/06	3/07-5/07	7/06-9/06 & 3/07-5/07	7/07-9/07
Trips	1193	805	999	807
Trip Mileage (Pre)	41513	28106	34809	28320
Miles/Trip (Pre)	34.8	34.9	34.9	35.1
Trip Mileage (Post)	59669	41586	50628	41676
Miles/Trip (Post)	50.0	51.7	50.8	51.6
Mileage Difference	(18156)	(13480)	(15818.20)	(13356)
Miles/Trip Difference	(15.2)	(16.8)	(15.99)	(16.6)
Cost/Trip	$5.76	$7.34	$6.55	$8.56
Gallons of Fuel/Trip	1.87	2.36	2.12	2.77

Appendix D: Distribution Center Operations – Energy

We calculated electricity and natural gas emissions separately, and then added them together to see the overall energy emissions. The results in Table 14 lists the emissions calculated for each of the four-month time periods and for the annual periods.

Table 14: Total Emissions from Facility (kg)

	Aug-Nov 06	Feb-May 07	Aug-Nov 07	2006	2008
Carbon Dioxide	79,330	67,474	127,244	248,502	250,819
Methane	130	110	209	407	412
Carbon Monoxide	20	17	31	61	62
Nitrogen Oxides	112	95	179	350	353
Sulfur Dioxide	53	45	79	162	158
Heavy Metals (includes lead and mercury)	1.01E-02	8.58E-03	1.48E-02	3.11E-02	2.98E-02
Lead	1.37E-03	1.16E-03	2.05E-03	4.22E-03	4.11E-03
Mercury	9.12E-05	7.72E-05	1.34E-04	2.80E-04	2.70E-04
Particulates (includes PM2.5 and PM10)	2.97E+00	2.52E+00	4.53E+00	9.19E+00	9.04E+00
PM10	1.64E-01	1.39E-01	2.57E-01	5.10E-01	5.08E-01
PM2.5	1.63E+00	1.39E+00	2.58E+00	5.09E+00	5.10E+00
Non-Methane Volatile Organic Carbons (VOCs) (includes benzene)	1.65E+01	1.40E+01	2.66E+01	5.17E+01	5.24E+01
Benzene	1.38E-01	1.17E-01	2.23E-01	4.33E-01	4.39E-01

Table 15 shows the relative changes in emissions pre- to post-consolidation. Negative percentage numbers indicate a decrease in emission while positive percentage numbers indicate an increase in emissions. These tables show the vast difference between the different time periods considered, which we attribute to the limitations in using a four-month time period. Figure 11 in the body of this report illustrates the percentage change of each pollutant for the annual comparison, which seems to be more accurate than the four-month comparisons.

Table 15: Relative Changes in Emissions (%)

	Aug-Nov 07 (post) against Aug- Nov 06 (pre)	Aug-Nov 07 (post) against Feb-May 07 (pre	2008 (post) against 2006 (pre)
Carbon Dioxide	60%	89%	1%
Methane	61%	89%	1%
Carbon Monoxide	59%	87%	1%
Nitrogen Oxides	60%	88%	1%
Sulfur Dioxide	49%	76%	-3%
Heavy Metals (includes lead and mercury)	46%	73%	-4%
Lead	50%	77%	-3%
Mercury	47%	74%	-4%
Particulates (includes PM2.5 and PM10)	53%	80%	-2%
PM10	57%	85%	0%
PM2.5	58%	86%	0%
Non-Methane Volatile Organic Carbons (VOCs) (includes benzene)	61%	89%	1%
Benzene	62%	90%	1%

Table 16 shows our calculations of hypothetical increases in annual costs due to carbon charges of $5/tonne.

Table 16: Hypothetical Annual Increases in Facility Operation Costs due to Carbon Dioxide Fees

Time Period (4 months extrapolated to 1 year)	Aug- Nov 06	Feb - May 07	Aug - Nov 07	2006	2008
Additional Cost ($)	1,550	1,418	2,344	1,235	1,503

Appendix E: Operation Costs

The line items that we selected, along with a justification are presented below. Additional notes specific to Oakwood's Bay Area operations are also provided.

Salaries

- Office and Administration Salaries
- Driver and Warehouse Salaries
- Contract Workers
  - A change in the number of facilities may result in increase or decrease of total employees required to run the operations in the region.
  - A change in the location of the DC would result in new routes. New routes may result in a change in amount of transportation time required to complete certain tasks and therefore the number of drivers required.
  - Maid Service salaries were not taken into consideration because although these services may be affected by transportation routes, they depend more on customer demand. In addition, maids typically report directly to units or SCs, therefore the DC reconfiguration would not affect their transportation time.
  - Oakwood managers reported that two management position employees left the company before the consolidation, which was unexpected.

Employee Benefits

- Employee Medical Insurance
- Employee Pension Plan
- Payroll Taxes
- Workers' Compensation Insurance
  - A change in number of employees would affect the amount of benefits paid out by Oakwood.

Monthly Set Fees

- Office Rent
- Security Services
  - Rent and the required security services at each site will differ for each facility. Security services include alarms at warehouses, but also lock boxes for apartment units. We determined that the cost of lock boxes represented in the expense reports would be negligible compared to the alarm systems, particularly because lock boxes are not frequently purchased.
- Equipment Rental
  - The number of total equipment rented may change if the number of facilities changes.
- Insurance Premiums and Expenses
  - Each facility and equipment may require a particular amount of insurance. A change in number of facilities or equipment would affect the amount of monthly insurance costs.
- Parking
  - Commercial campuses may charge an additional parking fee at the DC. In the case of Bay Area, the parking fees incurred were only from parking at units and SCs and

not at the DCs themselves. Therefore parking expenses were disregarded in our analysis.

Other Expenses

- Freight
  - Freight expenses represent the purchase and shipment of various supplies and inventory. While the amount of supplies and inventory purchased fluctuates based on client count and therefore would not be within our scope, a change in number of facilities may affect the number of aggregate delivery trips, which may be reflected in expenses. In the case of California branches, inventory and supplies are stored at a common stock facility in Orange County, from which shipments are made to branches in various regions as needed. Now that one large shipment can be made to Hayward as opposed to separate shipments to three DCs in the Bay Area, we assume that there will be a decrease in costs. A decrease in environmental impact associated with transportation may also be realized; however, at this point in time we were unable to quantify the changes.
- Overhead
  - A change in number of facilities may affect general charges through changes in number of employees or change in processes, which may be reflected in overhead.

Taxes

- Property Tax
  - If DCs are owned, then amount of property tax would be affected by number of value of the properties.
  - This tax did not apply to the Oakwood Bay Area analysis since all DCs were rented.
- Licenses and Business Tax
  - Licenses and Business Tax would be affected by number of facilities operated.

Expenses that have Environmental Costs

- Electricity
- Gas
- Water
- Rubbish Removal
- Vehicle gas and oil
  - These expenses are linked to environmental impacts and will change as a result of new operation practices at new facilities after a reconfiguration. In some cases, utilities are included in Common Area Maintenance (CAM), which are facility maintenance costs added to monthly rent by the building manager and include other costs such as landscaping. In these cases, direct expenses are not incurred for these line items. Further analyses of these line items are presented in the sections above.

Others line items that may change according to a DC reconfiguration but were not included in our analysis are as follows.

Repair and maintenance

- Warehouse
- Automobiles
- Equipment

    - Repair and maintenance costs would change according to number, age, and condition of warehouse, automobiles, and equipment. The older these items get, the more frequently they require maintenance. Because we were unable to determine an estimated schedule and price of repair and maintenance from just the expense reports or from descriptions by managers, we did not take these cost fluctuations into consideration.
    - Oakwood managers stated that warehouse maintenance costs were negligible.

Inventory and Supplies

- Inventory
    - We initially thought that less inventory surplus would be needed if inventory is stored in fewer locations. Our logic was that Oakwood would want an excess amount of inventory at each DC to maintain the ability to quickly respond to changes in customer demand in each service region. If surplus inventory is kept all at one DC as opposed to numerous DCs, then fewer surpluses would be needed to maintain flexibility. Oakwood managers, however, informed us that inventory surplus is determined as 10% per stock per client count. Therefore the amount of surplus stored would not be affected by number of DCs.
- Office Supplies
    - Amount of office supplies needed may change according to change in number of employees. However, office supply expenses are negligible compared to other changing expenses and therefore we omitted these line items from our consideration.
- Laundry and Kitchen Chemicals
    - We initially thought that economies of scale in linen and dish washing may be achieved if larger laundry and kitchen equipment were used. We therefore thought that economies of scale in the chemicals used may be achieved that reflected the fewer loads processed by the larger machinery. However, Oakwood managers informed us that the amount of chemicals used was determined by the amount of linens and dishware processed and an economy of scale would not be achieved.
- Uniforms
    - The amount of uniforms required would change to reflect the number of employees. However, we omitted this line item from our analysis since we conjectured that uniforms were purchased on a needs-basis, and an immediate change in purchasing patterns would not be reflected in the expense reports.

Appendix F: Reconfiguration Investment Calculation

In order to determine the magnitude of the investment to reconfigure the Bay Area DCs, we collected all the relevant costs based on what was reported in the expense reports, fixed asset expenses incurred by headquarters, invoices, and information provided by Oakwood managers. The expenses we considered are explained below.

Lease Hold Improvements

- Includes expenses such as construction work; permits; installation of sinks, pipes, and sewer system.

Laundry Room Equipment[12]

- Removal of old equipment and transfer to new Bay Area DC
  - A few machines were transferred to Oakwood DCs in other regions. This cost was not incurred by the Bay Area region and therefore was not included in our analysis. No equipment was discarded and therefore no disposal costs were incurred.
- Purchase, delivery, and installation of new equipment

Vehicle Rental

- According to Oakwood managers, vehicles were rented for moving from the three old branches to Hayward. Vehicle rental expenses incurred in July 2007 were culled from expense reports.

Other Professional Services

- Oakwood managers indicated that legal fees were incurred for the reconfiguration.

Overlap Rent

- We calculated the amount of rent that overlapped, either because rent continued to be paid at the previous facilities or because rent at the new facility was paid before the move-in. In the case of the Bay Area, the leases at the three old facilities had already terminated; therefore no additional rent was paid after moving out. Oakwood began rent payment at Hayward starting June 2007, therefore there was only one months worth of rent for one facility that was incurred as part of the reconfiguration transitional costs.

Rubbish Removal

- Oakwood managers indicated that an additional expense for rubbish removal was incurred after moving out of the three branches. An estimated amount was teased out of the expense report based on outstanding spikes in the trend.

Warehouse Relocation Expense

- Additional minor expenses were reported on the expense reports.

A new telephone system was installed after the consolidation and fixed asset expenses were reported. However, telephone system upgrades were taking place in other regions as well and would have taken place in the Bay Area with or without the consolidation. Therefore these expenses were not included in our analysis. No new office equipment was purchased for the Bay Area consolidation. Oakwood managers reported that employees helped with the move over the weekend. The overtime expenses incurred from this additional work could not be teased out from the expense reports and therefore were not included in our analysis. Table 17 shows the total costs incurred from the reconfiguration.

[12] Dishwashers are rented

Table 17: Reconfiguration Costs

Reconfiguration Investment Costs ($)	
Laundry Room Equipment	152,514
Lease Hold Improvements	739,038
Relocation Expenses	872
Vehicle Rentals	5,852
Overlap Rent	17,044
Legal Fees	5,000
Rubbish removal	3,000
Rent and Utility Rebate	-230,000
Water Heater Rebate	-6,000
Total Reconfiguration	**$687,320**

The consolidation investment was analyzed by calculating the payback period, Net Present Value (NPV), Return on Investment (ROI), and the Internal Rate of Return (IRR), based on the change in overall operation costs. The calculation method for each indicator is described below.

Cost Savings

Cost savings will simply be in present value and will be the difference in the first year's operation costs.

Payback Period

The payback period was calculated as the total investment divided by cost savings in the first year.

Net Present Value (NPV)

The Net Present Value (NPV) calculation took into account the reconfiguration expenses that were incurred[13] and operation costs savings that resulted from the reconfiguration for the project length. In this case we chose the duration of the lease (7 years), although reconfigured operations are likely to last longer that the first lease duration. Some of the reconfiguration expenses were depreciable. Oakwood uses the Modified Accelerated Cost Recovery System (MACRES) for their depreciation schedules. Based on Internal Revenue Service (IRS) guidelines, the equipment purchase by Oakwood was depreciated over seven years using the half-year convention (IRS, 2006). We made the assumption that the purchased equipment would be used for the full extent possible and therefore would not be sold at any point. This assumption was based on the fact that Oakwood relocated unwanted equipment from its old facilities to other regions rather than selling them. Therefore we did not account for future salvage values.

We inflated business as usual operation costs and reconfigured operation costs by 3% each year, based on the assumption that subsequent inflations will be similar to the change in CPI index from

[13] Additional equipment was purchased in 2008 and was depreciated separately (one year after those purchased in 2007).

2006 to 2007. State and Federal tax rates (8.84% and 35%, respectively) were determined based on Oakwood's income bracket using resources available online (FTA, 2007; Qbalance.com, 2007). The tax rates were used to determine the after-tax cash flow, since investment costs would lower the company's revenue, and therefore the amount of taxes paid. The cumulative difference resulted in the cost savings that we used in the NPV calculation. The discount rate applied to the calculation was Oakwood's borrowing rate, which is 6.8%.

Return on Investment (ROI)

The Return on Investment (ROI) was calculated as the cost savings over the expected lifetime of the reconfiguration divided by the total investment. The cost savings over the expected lifetime of the reconfiguration was calculated based on the present value of cost savings multiplied by the number of years of reconfiguration lifetime specified. Inflation, depreciation, tax, and discounting are not factored in.

Internal Rate of Return (IRR)

Internal Rate of Return (IRR) was calculated as the discount rate at which the NPV equals zero.

For the Bay Area analysis, we ran these investment calculations for the various data we gathered. We made the assumption that there would be no investments in new equipment in the near future.
1. We extrapolated the four-month data for February to May 2007 (pre-consolidation) and August to November 2007 (post-consolidation) to one year-equivalent data by multiplying the expenses by three and assessed the investment.
2. We followed the same process as mentioned above with the August to November 2006 data and compared them to the extrapolated post-consolidation four-month data. In this case we inflated the 2006 expenses to 2007 values.
3. We compared the 2006 expenses to 2008 budget as described in the operation costs section. In this case, we inflated 2006 data to 2008 values by multiplying by $(1.03)^2$.

Appendix G: User Manual for Reconfiguration Model

The Reconfiguration model is an Excel workbook. There are thee types of worksheets in the model workbook: inputs, outputs, and data processing. The user inserts data in the input pages and will view results in the output pages. There will be no need to visit the processing pages unless better data on certain rates, emission factors, and other coefficients become available. "Branch A", "Branch C", etc refer to separate Distribution Centers (DCs). Each section and sheet is further described below.

Inputs

There are three input pages: "Inputs-Facility", "Inputs-Transport", and "Inputs-Reloc&Op Cost". Each of these sections requires the user to input a particular set of data. Each input page requires information both for making predictions pre-reconfiguration, and for making retroactive evaluations, after sufficient information can be gathered post-reconfiguration. Certain cells are programmed to reject data that seem incorrect. For example, if a user inputs a negative number for facility square-footage, the model will reject this input. If error messages pop up, it is necessary to reread what data is required in the cell and make sure it is typed correctly. In some cases, the user can select the cell by clicking on it and acquire additional guidance. All required input cells are colored in light yellow. Optional cells are light blue. Cells with assumptions that the user can adjust are pink. Grey cells should not be altered since they process some calculations.

Facility Inputs ("Inputs-Facility")

Time period for data:

- One year pre-reconfiguration for prediction
- One year pre-reconfiguration and one year post-reconfiguration data for evaluation

The data input section is organized from January to December. If the reconfiguration takes place mid year, such as during the month of May, then the user can rename the months so data can be inserted from May (previous year) to April. Alternatively, the user can maintain the month labels and simply input January through April of that calendar year, and then input May through March of the previous year, keeping in mind that the order is no longer chronological. The outcome will not be affected by the method chosen.

<u>Prediction</u>

First the user will look at the map provided in the sheet and determine the number of the climate zone in which the facility is located[14]. This selection will adjust the model to reflect energy-consumption patterns typical to the climate region (in particular, heating and cooling), which will be

[14] The 5 categories of climate zone were developed by the National Oceanic and Atmospheric Administration (NOAA) to group climatically homogeneous regions. The categories are used along with Energy Information Administration's Commercial Buildings Energy Consumption Survey (EIA's CBECS) (EIA, 2003). The color coded, numbered categories reflect each region's Cooling Degree Days (CDD) and Heating Degree Days (HDD), which captures the number of days each region experiences cooler temperatures and hotter temperatures than a baseline set by the agency. Further information on this metric is available online (http://www.eia.doe.gov/emeu/cbecs/climate_zones.html).

applied to the facility energy consumption calculations. The user will then select the location in which the network is located. This step will enable the model to apply the energy mix typical to the location[15]. Currently the model has two choices: California Bay Area and U.S. Average.

Data that the user needs to collect for this section are as follows:

- Square footage of each facility (existing and future)
- Electricity and utility gas expenses from current facilities and monthly rates (price per kWh and price per therm)
  - These expenses are ideally culled from utility bills, but can also be culled from financial reports. Make sure any base charges are subtracted from the monthly inputs. Tax can be subtracted out prior to inputting data (in which case no additional input is needed). If tax is not subtracted out prior to data input, then indicate the appropriate amount of tax in the cell to the very right, and the model will account for this number. Whatever method is selected, it is necessary to be sure no double counting occurs.
  - If bills are unavailable, then price rates can be obtained from the energy supplier's website.
  - When price rates are inserted, be sure that no cell indicates that the rate is $0/therm or kWh for any particular month, unless the entire facility category does not have any entries.
  - If expenses for a particular facility are unavailable because they were paid through Common Area Maintenance (CAM) fees, then a best estimate needs to be made.
- Number of solid waste bins
- Size of solid waste bins
- Percentage to which solid waste bins are filled prior to pickup
- Number of pickups per week
- Number of gallons of water consumed at each facility per month[16]
- Number of gallons of water estimated to be consumed at future facilities

<u>Prediction-Optional Section</u>

This section is optional but may be helpful for regions considering recycling and heat reclamation equipment or energy-efficient equipment (on average). Note that many of these average numbers are not provided on equipment specification sheets and close collaboration with the manufacturer or installer may be necessary. If the user decides to fill in the optional section, not all information listed below is necessary. The user can choose the options listed below that are applicable to the region's interests and insert only the information necessary to the particular option.

Information needed for all options

- Dry weight (lb) of laundry processed per week at all facilities

Option 1 (Electricity-efficient equipment)

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[15] Depending on the location, electricity is generated using different proportions of energy from coal, nuclear, solar, hydro, biomass, and other sources, all which have different levels of emissions. By selecting the location, the model will be able to apply the appropriate emission factors.

[16] The section on water consumption is not fully developed because no data were available for the Bay Area facilities. However, if records are available, a user can input the data so comparisons can be made.

- Average kWh of electricity use per 100lb of dry-weight laundry processed for old set of machines and new set of machines (washer and dryer)

Option 2 (Water and/or heat recycling)
- Water heater efficiency (%)
- Amount of combined hot and cold water recycled (%)
- Estimated temperature (ºF) to which water is pre-heated from heat or water recycling
- Average combined price of water and sewage charges across facilities ($/1000gallons)
- Percent of washing water that is heated

Option 3 (Adjustments to hot water temperature)
- Percent of washing water that is heated (same cell as the cell mentioned in Option 2)
- Temperature to which hot washing water is heated (ºF)
- Possible new temperature to which hot washing water is heated (ºF)

Option 4 (Improved water extraction)
- Percent of linen dry weight moisture retention after extraction
    - % moisture retention = (weight of laundry going into the dryer – weight of dry laundry)/ (weight of dry laundry)
- Reduced percentage of linen dry weight moisture retention after extraction from improved extraction technology

Option 5 (Energy offsets)
- Percent electricity use offset through renewable energy or credit purchase
- Percent natural gas use offset through renewable energy or credit purchase

Option 6 (Hypothetical or actual carbon dioxide (CO_2) tax or tradable permit rate)
- Estimated price per tonne of carbon dioxide from Chicago Climate Exchange or other applicable sources

The outputs from this optional section will be provided separately so the user can apply them to pre- or post-reconfiguration performance. Although the section is specifically designed so that a user can compare the environmental performance of recycling water and reclaiming heat, a user could also adjust inputs such as water heater efficiency or water per pound of linens (in the case where water efficient equipment are considered) to view the changes energy use[17]. The outputs will not make a side-by-side comparison of these numbers, but a user can easily note how energy consumption changes by clicking back to the output page.

Evaluation

The evaluation section requires the user to gather the same information explained in the required portion of the Prediction Section, except the inputs would also be for the data gathered during the one year after the reconfiguration. Both data for the pre-reconfiguration (at the top of the worksheet) and for post-reconfiguration (at the bottom of the worksheet) need to be entered. The

[17] The less water used for washing, the less energy consumed to heat the water.

guidance for the additional Evaluation section is the same as the corresponding inputs in the Prediction Section.

Inputs-Transportation ("Inputs-Transport")

Similar to the Facility section of the model, the Transportation section can take up to 12 months of data. The chronological order of the data input does not matter, and the user should just enter data that corresponds with each month. Neither the prediction nor the evaluation section requires a full 12 months of data entry. However, more months of data entry should produce greater accuracy.

Important note: FOR EACH SECTION, MONTHLY DATA ENTRY HAS TO BE ALIGNED THROUGHOUT THE ENTIRE SECTION. Therefore, if the user inputs data for March through December for any DC in the prediction section, data entry for all other applicable DCs, fuel prices, and mileage rates in that section must mirror this period exactly. If data for any other applicable DC, fuel price, or mileage rate extends beyond March through December, or does not include any of these months, the model will produce erroneous outputs. The same rules apply to the evaluation section; however this rule does not apply across sections. Therefore, a user can input March through December data in the prediction section and January through June data in the evaluation section, and still get accurate results.

Optional transportation inputs are shown by "<optional>". However, entering data for optional inputs may require entry of data for other optional inputs for a complete analysis. Transportation inputs for which there are alternative methods for entering data are also noted in this section of the manual.

Data entry in the Transportation Inputs worksheet should be limited to the YELLOW cells. DO NOT MODIFY GREY CELLS unless the user intends to modify the overall capabilities of the model. It is recommended that the user save a separate, unmodified version of the model before modifying or entering data into the model.

<u>Prediction</u>

Overall inputs:

- Fuel breakdown
  - The user must specify the percent (using decimals) that is spent on each fuel type under "gas & oil – trucks" for applicable DCs (line item #73710). The summation of all numbers entered under this column must equal 1.0 (100%).
- Average Monthly Fuel Price
  - For every fuel type that has a value greater than 0 under the fuel breakdown column, the regional average monthly fuel price must be entered for each applicable month.
- Mileage Rate <optional>
  - This is only applicable if personal vehicles are used for move-ins, move-outs, maid services, or other services that require travel originating from a DC, and mileage is paid out for personal vehicle use. If personal vehicle mileage is applicable and the user wants to include this in the transportation projections, the user must input the monthly mileage rate for each applicable month.
- Price of carbon dioxide (CO_2) <optional>

    - If the user wants to include an applicable (hypothetical or actual) CO_2 tax or tradable permit rate, the price or tax per tonne of CO_2 must be entered for each applicable month.
- Number of pre-reconfiguration months of data entered
    - The number entered here must equal the number of months for which monthly data has been entered throughout the rest of the section. This number must be between 1 and 12.

(Reminder - monthly inputs must correspond throughout the entire section)

There are three different scenarios that require different DC inputs. The first reconfiguration scenario covers DC consolidation (converting to less DCs). The second reconfiguration scenario covers DC division (converting to more DCs). The third reconfiguration scenario covers relocating the same number of DCs. Each scenario will be described for one DC. To enter data for additional DCs (for up to 3 total) follow the same instructions for each additional DC.

DC inputs (DC consolidation):

- Total Cost of Gas
    - Enter the applicable pre-reconfiguration monthly fuel costs of the Oakwood vehicles (line item #73710) for the DC.
- Total Mileage of Oakwood Vehicles (pre)
    - Enter the applicable monthly pre-reconfiguration mileage of Oakwood vehicles for the DC.
- Total Mileage of Oakwood Vehicles (post) <NOTE: alternative methods available>
    - Enter the total estimated post-reconfiguration monthly mileage of Oakwood vehicles for travel that was associated with the pre-reconfiguration DC. This mileage can be entered directly OR by subtracting the "Oakwood Mileage DC→First Stop, Last Stop→DC (pre)" input from the "Oakwood Mileage DC→First Stop, Last Stop→DC (post)" input (if available), and adding the difference to the "Total mileage of Oakwood vehicles (pre)" input.
- Oakwood Mileage DC →First Stop, Last Stop→DC (pre) <optional>
    - Enter the applicable total monthly pre-reconfiguration mileage for travel between the DC and the first stop and for travel between the last stop and the DC by Oakwood vehicles.
- Oakwood Mileage DC →First Stop, Last Stop→DC (post) <optional>
    - Enter the applicable total estimated monthly mileage for post-reconfiguration travel between the DC and the first stop and for travel between the last stop and the DC by Oakwood vehicles for travel that associated with the pre-reconfiguration DC.
- Trips – Oakwood Vehicle <optional>
    - Enter the applicable monthly number of pre-reconfiguration trips made by Oakwood owned vehicles for travel associated with the DC.
- Total Cost of Mileage <optional>
    - Enter the applicable monthly pre-reconfiguration cost of mileage paid out for personal vehicle use (line items #74040) by the DC.
- Total Tracked Mileage of Personal Vehicles (pre) <optional>
    - Enter the applicable total tracked monthly pre-reconfiguration mileage of personal vehicles for the DC.

- Total Estimated Mileage of Personal Vehicles (post) <optional>
    - Enter the applicable total estimated post-reconfiguration monthly mileage of personal vehicles for travel associated with the pre-reconfiguration DC.
- Personal Mileage DC→First Stop, Last Stop→DC (pre) <optional>
    - Enter the applicable total monthly pre-reconfiguration mileage for travel between the DC and the first stop and for travel between the last stop and the DC by personal vehicles.
- Personal Mileage DC→First Stop, Last Stop→DC (post) <optional>
    - Enter the applicable total estimated monthly mileage for post-reconfiguration travel between the DC and the first stop and for travel between the last stop and the DC by personal vehicles for travel that associated with the pre-reconfiguration DC.
- Trips – Personal Vehicles
    - Enter the applicable monthly number of pre-reconfiguration trips made by personal vehicles for travel associated with the DC.

(Reminder - monthly inputs must correspond throughout the entire section)

DC Inputs (DC division or relocation):
NOTE: When the DC reconfiguration will result in a division of one or more current DCs (i.e., there will be more DCs post-reconfiguration) or will result in the relocation of current DCs, the inputs must correspond to the post-reconfiguration DCs. For example, the pre-reconfiguration Oakwood Vehicle Mileage (pre) input for DC-A must be divided and entered as an input according to the post-reconfiguration DC with which the mileage is to be associated. So if routes 1 through 6 currently originating from pre-reconfiguration DC-A will originate from DC-D post-reconfiguration, and the remainder of the routes will originate from DC-E post-reconfiguration, then the mileage for routes 1 through 6 should be entered for DC-D and the rest of the mileage should be entered for DC-E. This rule applies for every input and will require Oakwood to consider post-reconfiguration vehicle routes, trips, and mileage BEFORE entering data into the model. For inputs such as cost, which cannot be readily allocated among different post-reconfiguration DCs, the user will need to reallocate the cost to each post-reconfiguration DC by the proportion in which associated mileage was allocated. Each input is described in more detail below.

- Total Cost of Gas
    - Enter the applicable pre-reconfiguration monthly fuel costs of the Oakwood vehicles (line item #73710) for the corresponding post-reconfiguration DC. The proportion of costs entered for each post-reconfiguration DC should equal the proportion of pre-reconfiguration total mileage of Oakwood vehicles that was allocated to the same post-reconfiguration DC.
- Total Mileage of Oakwood Vehicles (pre)
    - Enter the applicable monthly pre-reconfiguration mileage of Oakwood vehicles for the corresponding post-reconfiguration DC.
- Total Mileage of Oakwood Vehicles (post) <NOTE: alternative methods available>
    - Enter the total estimated post-reconfiguration monthly mileage of Oakwood vehicles for travel associated with the same post-reconfiguration DC. This mileage can be entered directly OR by subtracting the "Oakwood Mileage DC→First Stop, Last Stop→DC (pre)" input from the "Oakwood Mileage DC→First Stop, Last Stop→DC (post)" input (if available), and adding the difference to the "Total mileage of Oakwood vehicles (pre)" input.

- Oakwood Mileage DC→First Stop, Last Stop→DC (pre) <optional>
    - Enter the applicable total monthly pre-reconfiguration mileage for travel between the DC and the first stop and for travel between the last stop and the DC by Oakwood vehicles for the corresponding post-reconfiguration DC.
- Oakwood Mileage DC→First Stop, Last Stop→DC (post) <optional>
    - Enter the applicable total estimated monthly mileage for post-reconfiguration travel between the DC and the first stop and for travel between the last stop and the DC by Oakwood vehicles for the corresponding post-reconfiguration DC.
- Trips – Oakwood Vehicle <optional>
    - Enter the applicable monthly number of pre-reconfiguration trips made by Oakwood owned vehicles for travel associated with the corresponding post-reconfiguration DC.
- Total Cost of Mileage <optional>
    - Enter the applicable monthly pre-reconfiguration cost of mileage paid out for personal vehicle use (line items #74040) for the corresponding post-reconfiguration DC. The proportion of costs entered for each post-reconfiguration DC should equal the proportion of total mileage of pre-reconfiguration personal vehicles that was allocated to the same post-reconfiguration DC.
- Total Tracked Mileage of Personal Vehicles (pre) <optional>
    - Enter the applicable total tracked monthly pre-reconfiguration mileage of personal vehicles for the corresponding post-reconfiguration DC.
- Total Estimated Mileage of Personal Vehicles (post) <optional>
    - Enter the applicable total estimated post-reconfiguration monthly mileage of personal vehicles for the corresponding post-reconfiguration DC.
- Personal Mileage DC→First Stop, Last Stop→DC (pre) <optional>
    - Enter the applicable total monthly pre-reconfiguration mileage for travel between the DC and the first stop and for travel between the last stop and the DC by personal vehicles for the corresponding post-reconfiguration DC.
- Personal Mileage DC→First Stop, Last Stop→DC (post) <optional>
    - Enter the applicable total estimated monthly mileage for post-reconfiguration travel between the DC and the first stop and for travel between the last stop and the DC by personal vehicles for travel associated with the pre-reconfiguration DC for the corresponding post-reconfiguration DC.
- Trips – Personal Vehicles
    - Enter the applicable monthly number of pre-reconfiguration trips made by personal vehicles for travel associated with the DC for the corresponding post-reconfiguration DC.

(Reminder - monthly inputs must correspond throughout the entire section)

<u>Evaluation</u>

The evaluation component of the model utilizes both the prediction and evaluation sections of the model. Therefore, the user will be required to enter pre-reconfiguration data into the prediction section and post-reconfiguration data into the evaluation section of the transportation inputs worksheet. Monthly pre-reconfiguration data entry (Prediction section) does not have to correspond with the post- reconfiguration data entry (Evaluation section). However, monthly data entry needs to be consistent within each section. Directions for entering data for one DC are explained below. Repeat the same steps for additional DCs.

Pre-reconfiguration overall inputs:

- Fuel breakdown
  - The user must specify the percent (using decimals) that is spent on each fuel type under "gas & oil – trucks" for applicable DCs (line item #73710). The summation of all numbers entered under this column must equal 1.0 (100%).
- Average Monthly Fuel Price
  - For every fuel type that has a value greater than 0 under the fuel breakdown column, the regional average monthly fuel price must be entered for each applicable month.
- Mileage Rate <optional>
  - This entry is only applicable if personal vehicles are used for move-ins, move-outs, maid services, or other services that require travel originating from a DC, and mileage is paid out for personal vehicle use. If personal vehicle mileage is applicable and the user wants to include this aspect in the transportation projections, the user must input the monthly mileage rate for each applicable month.
- Price of CO_2 <optional>
  - If the user wants to include an applicable (hypothetical or actual) CO_2 tax or tradable permit rate, the price of tax must per tonne of CO_2 must be entered for each applicable month.
- Number of pre-reconfiguration months of data entered
  - The number entered here must equal the number of months for which monthly data has been entered throughout the rest of the section. This number must be between 1 and 12.

(Reminder - monthly inputs must correspond throughout the entire section)

Pre-reconfiguration data (enter in the Prediction section of Transportation Inputs worksheet):

- Total Cost of Gas
  - Enter the applicable pre-reconfiguration monthly fuel costs of the Oakwood vehicles (line item #73710) for the DC.
- Total Mileage of Oakwood Vehicles (pre) <optional>
  - Enter the applicable monthly pre-reconfiguration mileage of Oakwood vehicles for the DC.
- Oakwood Mileage DC→First Stop, Last Stop→DC (pre) <optional>
  - Enter the applicable total monthly pre-reconfiguration mileage for travel between the DC and the first stop and for travel between the last stop and the DC by Oakwood vehicles for the DC.
- Trips – Oakwood Vehicle <optional>
  - Enter the applicable monthly number of pre-reconfiguration trips made by Oakwood owned vehicles for travel associated with the DC.
- Total Cost of Mileage <optional>
  - Enter the applicable monthly pre-reconfiguration cost of mileage paid out for personal vehicle use (line items #74040) by the DC.
- Total Tracked Mileage of Personal Vehicles (pre) <optional>

- Enter the applicable total tracked monthly pre-reconfiguration mileage of personal vehicles for the DC.

- Personal Mileage DC→First Stop, Last Stop→DC (pre) <optional>
  - Enter the applicable total monthly pre-reconfiguration mileage for travel between the DC and the first stop and for travel between the last stop and the DC by personal vehicles.
- Trips – Personal Vehicles
  - Enter the applicable monthly number of pre-reconfiguration trips made by personal vehicles for travel associated with the DC.

(Reminder - monthly inputs must correspond throughout the entire section)

Post-reconfiguration overall inputs:

- Fuel breakdown
  - The user must specify the percent (using decimals) that is spent on each fuel type under "gas & oil – trucks" for applicable DCs (line item #73710). The summation of all numbers entered under this column must equal 1.0 (100%).
- Average Monthly Fuel Price
  - For every fuel type that has a value greater than 0 under the fuel breakdown column, the regional average monthly fuel price must be entered for each applicable month.
- Mileage Rate <optional>
  - This is only applicable if personal vehicles are used for move-ins, move-outs, maid services, or other services that require travel originating from a DC, and mileage is paid out for personal vehicle use. If personal vehicle mileage is applicable and the user wants to include this in the transportation projections, the user must input the monthly mileage rate for each applicable month.
- Price of CO_2 <optional>
  - If the user wants to include an applicable (hypothetical or actual) CO_2 tax or tradable permit rate, the price of tax must per tonne of CO_2 must be entered for each applicable month.
- Number of post-reconfiguration months of data entered
  - The number entered here must equal the number of months for which monthly data has been entered throughout the rest of the section. This number must be between 1 and 12.

(Reminder - monthly inputs must correspond throughout the entire section)

Post-reconfiguration data (enter in the Evaluation section of Transportation Inputs worksheet):

- Total Cost of Gas
  - Enter the applicable post-reconfiguration monthly fuel costs of the Oakwood vehicles (line item #73710) for the DC.
- Total Mileage of Oakwood Vehicles (post) <optional>
  - Enter the applicable monthly post-reconfiguration mileage of Oakwood vehicles for the DC.
- Oakwood Mileage DC→First Stop, Last Stop→DC (post) <optional>
  - Enter the applicable total monthly post-reconfiguration mileage for travel between the DC and the first stop and for travel between the last stop and the DC by Oakwood vehicles.

- Trips – Oakwood Vehicle <optional>
    - Enter the applicable monthly number of post-reconfiguration trips made by Oakwood owned vehicles for travel associated with the DC.
- Total Cost of Mileage <optional>
    - Enter the applicable monthly post-reconfiguration cost of mileage paid out for personal vehicle use (line items #74040) by the DC.
- Personal Mileage DC→First Stop, Last Stop→DC (post) <optional>
    - Enter the applicable total monthly post-reconfiguration mileage for travel between the DC and the first stop and for travel between the last stop and the DC by personal vehicles.
- Trips – Personal Vehicles
    - Enter the applicable monthly number of post-reconfiguration trips made by personal vehicles for travel associated with the DC.

(Reminder - monthly inputs must correspond throughout the entire section)

Inputs-Relocation and Operation Costs ("Inputs-Reloc&Op Cost")

Requirements:

- Data for full year prior to reconfiguration (calendar year or 12 months up to reconfiguration date) for prediction and evaluation.
- Data for full year of post-reconfiguration for evaluation.
- All numbers should be inserted as positive numbers (both costs and gains), unless there are special circumstances in which the user determines that a negative number needs to be used. Since the model focuses on the costs, it will keep those positive, while gains (e.g., from selling old equipment) will be converted to a negative number.
- Grey cells have equations imbedded in them and should not be altered.

The user first indicates the expected duration of operations under reconfiguration network. This number is used to calculate the Net Present Value (NPV), Internal Rate on Return (IRR), and Return on Investment (ROI). While this number may be unknown, the user can input the length of a typical lease or the number of years for which an investment analysis will be useful.

<u>Prediction</u>

To use the model as a prediction tool, three sections of this worksheet must be filled: "Pre-Reconfiguration Operation Costs", "Projected Post-Reconfiguration Operation Costs", and "Reconfiguration Costs." Data that the user needs to collect for this section are as follows:

- Pre-reconfiguration operation costs that will change as a result of the relocation. Suggested costs to consider are presented by category, such as salaries, benefits, and rent.
    - When certain cells are selected, they will further indicate specific line item(s) that should be considered. Each region has its own specifications, and therefore the user should consider what costs will actually change due to the relocation before entering the numbers.
- Estimated operation costs after relocation

    - The categories of inputs are similar to the pre-reconfiguration inputs; however, the user needs to take into consideration the change in business dynamics that will ensue after a reconfiguration and make estimations.
    - Electricity, natural gas, and vehicle fuel will be predicted by the model. These cells are therefore grey and the user should not insert estimations.
    - The volume of waste that will be generated after a reconfiguration will be estimated and appear in the worksheet "Outputs-Facility" described below. The user should look at the estimated volume, consider possible pickup frequencies and bin sizes at each new facility and insert an estimated cost based on the local prices.
- Reconfiguration costs should be estimated and inserted into the appropriate sections as labeled based on whether the expenses are depreciable or not.
    - If certain reconfiguration costs will not be incurred until a later time, they can be inserted in the cells labeled "Reconfiguration Costs Accrued After Reconfiguration Year."

<u>Evaluation</u>
The user must fill the "Pre-Reconfiguration Operation Costs", "Relocation Costs", and "Post-Reconfiguration Operation Costs" sections in this worksheet. Post-reconfiguration operation costs should be based on expenses incurred during the year following the reconfiguration. The guidance for this section is the same as the guidance outlined in the Prediction section.

<u>Assumptions</u>
- The discount rate (which is Oakwood's borrowing rate), tax rates, and inflation rate has been pre-set in the model, but can be adjusted by the user.

Data Processing

Calculations ("Emission Factors" and "Coefficients")

These worksheets contain transitional parameters and calculations. A user need not visit these pages, unless up-to-date, accurate data become available. For example, the model currently has emission factors for the Bay Area and U.S. average electricity. However, if specific emission factors are obtained for a particular region, a user may want to add these numbers to the model. The body of this report explains the theory behind many of the calculations undertaken by the model and can be used for making these types of updates.

Outputs

Facility Outputs ("Outputs-Facility")

The user can view levels of energy consumption (electricity and gas), emissions from energy, waste generation, and water consumption from pre-reconfiguration facilities, and compare the levels to either levels predicted for the aggregate post-reconfiguration network or to the evaluative post-reconfiguration values. The differences between the pre- and post-reconfiguration will also be displayed. In the case where the user inputs optional data, potential savings projections will also be available.

Transportation Outputs ("Outputs-Transport")

The Transportation Outputs worksheet allows the user to compare several transportation performance indicators between pre- and post-reconfiguration DCs according to actual and projected performance. Specifically, there are three options for comparing performance. First, the user can compare actual pre-reconfiguration to predicted post-reconfiguration performance to assist in deciding whether to reconfigure. Second, the user can compare actual pre-reconfiguration to actual post-reconfiguration performance to evaluate a reconfiguration decision after implementation. Third, the user can compare predicted post-reconfiguration to actual post-reconfiguration performance to evaluate the model's performance. Performance indicators are shown for each DC and for each period on a monthly and annual basis. Hypothetical or actual costs associated with carbon dioxide are also displayed if the user elects to insert this data in the input sheet.

Overall Outputs ("Output-Overall")

The user can to view the aggregate emission levels from both the facility and the transportation fleet for pre-reconfiguration and either predicted or actual post-reconfiguration. In addition, the output will provide cost of electricity, natural gas, and vehicle fuel. The differences between the pre- and post-reconfiguration will also be displayed. Finally, for both the predicted post-reconfiguration output and the evaluation post-reconfiguration output, the worksheet will show annual cost savings, payback period, Return on Investment (ROI), Net Present Value (NPV), and the Internal Rate of Return (IRR).

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