ELECTRIC-POWERED TRAILER REFRIGERATION UNIT MARKET STUDY AND TECHNOLOGY ASSESSMENT

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ES EXECUTIVE SUMMARY

Diesel-engine-driven trailer refrigeration units (TRUs) have been the standard approach used for keeping fresh and frozen foods and other goods cool in transport for many years. Keeping a refrigerated load at its correct temperature is critical. These loads are very sensitive to temperature variation and if they spoil, losses can equate to millions of dollars. However, there are problems associated with diesel TRUs, primarily harmful toxic exhaust emissions, greenhouse gas and particulate matter. In addition, operation of the TRU diesel engines creates significant noise pollution. This can be a considerable concern in populated areas, as refrigerated deliveries often occur during the late evening and early morning hours. The on/off cycling of these diesel engines generates the noise most urban areas are attempting to control and as a result, many local communities as well as State and Federal Governments seek to limit their use. Also, refrigerated warehouse districts are typically located in low-income areas, and the high emissions and noise emitted by diesel TRUs have led to environmental justice concerns. These factors illustrate the need to investigate alternative approaches to conventional TRU designs and operating strategies.

Regulations and technology-based idling alternatives help address the truck idling issue, but diesel TRUs continue normal operation without any restrictions. There are currently no regulations in place to limit TRU operation specifically. In fact, regulating these units may be difficult in that the value of many of these refrigerated loads exceeds several million dollars. However, California's Air Resources Board (CARB) has taken the initiative to institute emission regulations specific to TRUs. Currently, the EPA regulates engines rather than the TRU itself. CARB has not only proposed establishing strict limits on small diesel engine exhaust emissions, it also requires warehouse owners to report on the use of TRUs at warehouses with 20 or more loading docks serving refrigerated areas. The new proposed TRU-specific regulations from CARB (effective in 2008) accelerate the introduction of these standards by five years prior to the EPA's emissions limits on these engines.

One approach to minimizing these impacts is to use electricity to power these TRUs. These units can be driven by electricity in two specific configurations, as a hybrid diesel-electric standby TRU (currently available) or as an all-electric TRU (eTRU). The hybrid diesel-electric standby refers to a primarily diesel-driven mechanical TRU with electric plug-in capability while parked. This is different than the configuration of an eTRU; however, they are both similar in operation. The eTRU uses electric powered (versus mechanically driven) components that are powered by either a plug-in connection or, when over-the-road, by a separate diesel generator set providing the required electricity to the eTRU.

As with any new technology, barriers exist that slow the introduction of this technology into the market place. Hybrid diesel electric standby TRUs have been offered in the United States in the past, but were not readily adopted by the refrigerated transport industry. This lack of market penetration was due to several factors including higher product and maintenance costs, lower reliability and limited infrastructure for both electricity and repairs. In addition, electrical connection standards have not been established, preventing the development of standardized systems, which could substantially lower production and design costs for these units.

The eTRUs have been introduced with some success in Europe, where at least 50% of all TRUs are either electrically driven or are equipped with electric standby capability. The European eTRUs are designed specifically for the market they serve and can not be directly exported into the U.S. without a significant redesign. The units sold in Europe are designed for the European electric supply, which does not match that of the United States. Also, the eTRUs being sold in Europe typically refrigerate trailers and straight trucks that are much shorter than the 53-foot trailers common in the United States. Also, these eTRUs are designed to operate on different cooling cycles, as ambient European temperatures generally differ from U.S. temperatures. Also, the trucking industry in Europe is much different, as trucks can often complete a delivery without an overnight stop, therefore offering an opportunity to operate on electricity for many more hours.

As diesel fuel approaches $2.50 per gallon, fleets transporting refrigerated goods are investigating methods to reduce fuel consumption. Using electricity while at the warehouse can substantially reduce their consumption of diesel fuel. For instance, assuming operation six days per week for 50 weeks yearly, and the ability to plug into grid electricity for 10 hours each day, a diesel fuel savings of approximately 2,200 gallons can be achieved annually. At $2.50 per gallon, this equates to an annual savings of $5,500, providing the operator nearly $4,500 per year in net saving when subtracting out the cost of electricity.

Also, eTRUs have substantially lower maintenance costs, which can lead to additional operational savings. Carrier-Transicold estimates that these units reduce the cost of maintenance by 30-40%, which results in approximately $600 annual savings. Furthermore, the eTRUs have a longer expected lifespan and higher resale value, which combine to make the purchase and use of an eTRU even more economical.

In light of these facts, a comprehensive market and technical assessment was undertaken to evaluate the potential for eTRUs in New York State and across the United States. As part of this study, emission reduction potential was investigated, optimal operational specifications were considered and the business cases for current diesel-electric hybrids and redesigned eTRUs are discussed. In addition, contacts were made with potential demonstration phase partners for participation in future eTRU technology demonstration.

Based on the analysis, the study findings can be summarized as follows:

- **TRU systems of the future will have to be cost-competitive on a lifecycle basis relative to the next-best alternative if they are to effectively compete in the marketplace.** These new units will have to be more efficient and more environmentally friendly to comply with future environmental regulations. Further, there is a strong possibility that these new systems will have an electric option to comply with new anti-idling restrictions in key urban markets.

- **eTRUs appear to be a promising technology whose time in the U.S. has arrived.** This conclusion is based upon the operational cost analysis of diesel-driven TRUs, the localized emission and noise elimination benefits, the successful operation of these units in Europe, and the interest demonstrated by the refrigerated transport industry.

- **Warehouses and trailer parking areas can be easily retrofitted to incorporate the electrical service required to operate eTRUs on electricity**. High-voltage service exists at many of these facilities due to the electrical requirements of the refrigeration equipment. The engineering and installation of the electrical distribution and wiring may be provided to the facility at a reduced cost to the owner of the refrigerated warehouse. This conclusion is based on discussions with electric utilities indicating that the increased use of electricity will offset the cost of engineering and installation.

- **Regulations may require the adoption of these units in environmentally sensitive areas.** CARB and EPA have proposed stringent emission regulations and local regions have discussed restricting the operation of diesel-powered TRUs.

- **New York State is an excellent location for the demonstration of eTRUs.** This conclusion is based upon its proximity to major U.S. food distribution centers and the high number of refrigerated warehouses, which makes it an outstanding site for this technology. The ambient conditions in New York State require the TRU to provide heating and cooling, which will ensure the technology is fully proven prior to the final product release.

- **Cost of diesel fuel use and associated maintenance implications of diesel-engine-driven TRUs offer the potential of operator savings and rapid payback of the incremental price difference.** As diesel prices average near $2.50 per gallon, the payback on an eTRU can be obtained in 8 months for an incremental capital cost increase of 10% and up to 23 months for an incremental capital cost increase of 30%. This brisk payback provides a significant economic incentive for the purchase and use of these units. In addition, as the units are more reliable and require less maintenance, additional saving can be achieved through productivity gains. In addition, these units may have the advantage of being allowed to operate in restricted areas, further increasing their value.

- **Electrical connection improvements should reduce market barriers.** Trailers should be equipped with hardware to allow connections to be made from the electrified facility to the eTRU. This will eliminate the requirement of connecting the eTRU directly to the electricity supply, a difficult endeavor for high-voltage cabling.

- **Partnerships have been established to demonstrate eTRUs in New York State.** The targeted demonstration partner, MAINES Paper & Food Service Inc. in Conklin, NY, has expressed interest in participating in a demonstration of eTRUs. The electric utility for the MAINES facility, New York State Electric and Gas, has indicated their interest to participate in this demonstration.

- **An eTRU demonstration should be pursued to confirm the results of this assessment and validate cost assumptions for the installation of the electrical connections and operation of the eTRUs.** This demonstration would provide information on the actual value of eTRUs to the trucking company, the impact of eTRUs on profit margins of the trucking company, and the actual payback period for eTRUs.

1.0 INTRODUCTION

Trailer Refrigeration Units (TRUs), also referred to as "reefer units," play a vital role in delivering fresh, frozen, and perishable food from the field to market and every step in between. In fact, it has been reported that more than 75 percent of the food throughout the Unites States is produced, packaged, shipped and stored under some level of refrigeration (*Bald, 1997*). Typically, TRUs are added to specially designed and insulated trailers to meet a customer's specific needs. Reefer units must have sufficient capacity to maintain the low temperatures needed for cooling fully loaded trailers. Also, these units are occasionally used to heat cargo such as fresh produce in cold climates. Mainly, the units are used for cooling, as heat build-up inside closed metal containers is significant throughout much of the United States during summer months. This is due primarily to solar radiation and asphalt heat soak (heat absorbed from the roadway). In addition, warm outside air can infiltrate through door gaps, and heat transfer through trailer walls, floors, and ceilings. Perishable foodstuffs also emit latent heat while being cooled. For obvious reasons, these specialized trailers are insulated to reduce various forms of heat transfer. However, there are insulation limits, as thinner trailer walls increase the overall capacity of the trailer, which equates to higher shipping profits.

Reefer units can be run under a number of different operating conditions (to cool fresh produce and/or keep products frozen or deeply frozen); certain configurations contain multiple climate zones to accommodate different products and temperatures in a single trailer. However these multi-temperature loads are generally used for local distribution; larger, long-haul, 48- to 53-foot trailers routinely carry single temperature cargo. When selecting a TRU, the capacity and type of unit chosen is highly dependent on the size of the trailer, operating conditions, geographic region, method of transport, size of the load, and the commodity to be hauled.

There are also a number of alternative types of TRUs that may offer more economical and environmentally beneficial scenarios depending on the particular type of refrigerated business operation. Various technologies such as cryogenic methods and hybrid electric units (discussed later in this report) are currently available, while others, such as fuel cell powered units are currently in development. The problem of harmful diesel exhaust emissions is a real issue facing local communities and the nation as a whole. Thus appropriate steps and initiatives must be put into place to promote and realize the full economic and environmental benefits and potential of alternative technologies.

1.1 TRU Capabilities

To keep a load fully chilled or frozen, so as not to compromise valuable cargo, a TRU must be designed to reliably deliver adequate air-cooling capacity (measured in Btus), sufficient airflow (in cubic feet per minute or cfm), and enough velocity to circulate air throughout the trailer. In fact, the entire volume of air inside a trailer should be exchanged approximately once every minute (*Abelson, 2001*). The "capacity" of a reefer unit quantifies its ability to cool or heat a given amount of space/cargo. A typical over-the-road TRU's capacity can range from less than 20,000 Btu/hr to more than 65,000 depending on the product to be hauled and the operating conditions. For reference, one Btu (British Thermal Unit) is defined as the energy required to increase the temperature of 1 pound of water by 1 degree Fahrenheit. "The term *capacity* is a measure of the number of [Btus] the reefer can remove at a certain desired interior temperature [commonly quoted at 35ºF, 0ºF, and -20ºF] while the outside ambient air is at 100 degrees Fahrenheit" (*Thomas, 2002*). Various factors, such as the size of the trailer, type of trailer insulation, and cargo requirements can determine what style of reefer unit is needed. This report focuses on the larger capacity reefer units used with 48- to 53-foot trailers.

> An over-the-road 53-foot high-cube reefer trailer with thin walls and 1.5 inch of insulation might require a 22,000-Btu reefer unit to maintain lower temperatures. A 45-foot local distribution trailer with 2.5 to 4 inches of sidewall insulation might need a reefer rated at 14,000 to 16,000 Btus. The ability to move chilled or heated air is also part of a unit's specifications; this is expressed in cubic feet per minute, and gets into the thousands (Thomas, 2002).

For the most part, TRUs should be selected to provide at least 50% excess Btu capacity, allowing for rapid trailer cool-down when the trailer is first loaded (referred to as "pull-down" operation). This type of operation differs from "temperature maintenance" mode, wherein the unit cycles on and off to keep the interior within a desired, narrow temperature range. In addition, TRUs must generally have the capability to provide heat to keep fresh loads warm in cold climates. TRUs must have the capacity to provide 35ºF to 65ºF interior trailer temperatures at zero degree ambient to meet minimum requirements. Typically, units must be able to maintain a very narrow temperature range (±3ºF) for as long as the product is loaded in the trailer. As can be seen from **Figure 1-1**, in a survey of refrigerated shipping companies the vast majority of respondents required that their loads be kept within a range of 0°F to ±5°F.

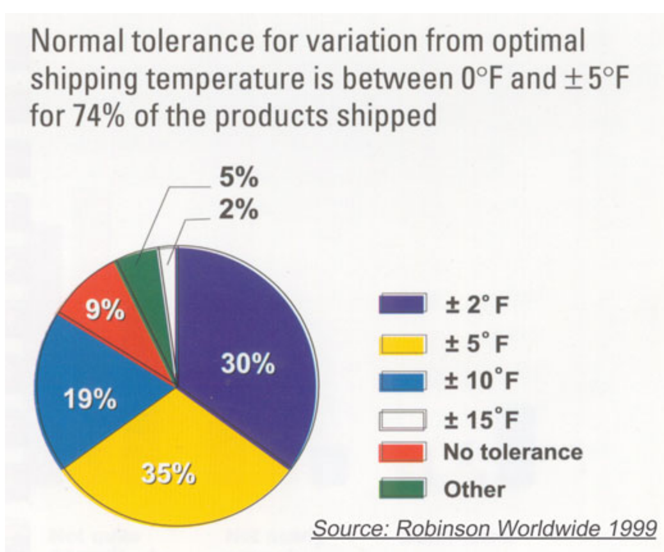

FIGURE 1-1: TOLERANCE FOR SHIPPING TEMPERATURE VARIATION

To help ensure that these precise requirements are met, today's TRUs use computer-controlled thermostats and real-time monitoring of the climate within the trailer. These units not only have the ability to control the interior trailer climate precisely, they also have the ability to notify the driver or shipper if an abnormality is detected. Remote monitoring and control using satellite-based or microwave communication technologies are new features in the marketplace. Advanced diagnostic functions quickly and easily display issues in need of attention. Handheld printers that interface with the reefer units can also be used to generate documentation and verification of temperature control during transport. This will become increasingly important as Federal HACCP (Hazard Analysis Critical Control Points) standards are established for refrigerated transport (*Wilson, 2001*).

Trailer refrigeration units are designed to keep loads chilled, frozen, or deeply frozen during over-the-road travel and when parked in transport overnight. Thus, any competing technology must perform these functions reliably. Not only do reefer units have to overcome heat transfer into the trailer from the road, solar radiation, and the ambient air, they must also handle heat generated by the load itself. For example, "…ice cream is one of the worst heat generators, as any experienced dairy hauler will tell you. [Also], the sugars in foods react and give off heat, and [in addition] chocolate has a biological reaction. Other notorious exothermic (giving off heat) foods are broccoli and beans" (*Abelson, 2001*). Some products also undergo a respiration process and generated gases can spoil loads, necessitating adequate air circulation. Thus, providing sufficient airflow is mandatory to the operation of any TRU. In order for heat transfer to occur between the cargo and conditioned air (to remove heat from the cargo), adequate air circulation around the cargo must be provided. The design of reefer units and trailers, along with proper TRU operation and appropriate cargo stacking, must account for such factors appropriately. Most trailer units blow conditioned air directly to the rear of the trailer through a fabric air duct that hangs from the trailer ceiling.

> Airflow can be restricted if the load is stacked too high. Pressure builds towards the rear. The air from the evaporator, seeking the path of least resistance, flows down through the front and middle of the trailer. Circulation to the rear ceases, and loads are ruined. That's why airflow and velocity are important. Btu capacity is the ability to remove the heat absorbed by the air, so it can again remove heat from the load. It is also the measure of how much heat can be added to the air to keep the [fresh] product from freezing (Abelson, 2001).

1.2 Trailer Insulation

Insulation is an important component of specially designed refrigerated trailers. However, insulation can realistically only be a portion of the design, due to market pressures to keep insulating walls as thin as possible and thus maximize cargo volume. Essentially, space inside any trailer is limited by the thickness of the walls and overall exterior dimensions (which are regulated by the federal government). A larger load directly translates into added revenue for shipments, which creates a push towards thinner insulation. In turn, reefer units are required to have an even greater cooling capacity. Typical reefer trailer walls, floors, and ceilings are anywhere from 1 to 4 inches thick.

Standard pallet sizes, used by the grocery industry, fit exactly inside existing trailers with 2.5-inch wall thickness (*EPRI, 2004*). While this range of thicknesses may seem small, a uniform increase of 1-inch thickness in a 40-foot long trailer can decrease overall cargo capacity by 100 cubic feet, which is approximately 4% less volume (*ASHRAE, 2002*). The more robust refrigerated trailer designs call for complete isolation of heat-conducting metal between the storage area and the outside world. These trailers have "internal structures for rub-rails and E-tracks, separated and insulated from the outside walls" (*Abelson, 2001*).

> Because the external dimensions of trailers are fixed by the Department of Transportation, any increase in wall thickness due to insulation results in a decrease in internal volume and less cargo capacity. Because the payloads are typically not high density, [trailers] usually fill completely before their weight limits are reached, making any decrease in internal volume a decrease in cargo capacity (EPRI, 2004).

1.3 TRU Engines

The small 2-liter engines that run reefer units at 1,800 to 2,200 RPM (and generally range anywhere from 7-36 hp) are reliable and fairly efficient, but are also high emitters of pollutants and noise (*EPRI, 2004*). These small diesel engines are not as strictly regulated as large truck engines and therefore emit substantially greater amounts of pollutants per unit of work (hp-hr) performed. In addition, the units consume large amounts of diesel fuel, increasing the nation's dependence on petroleum imports. "A semi-trailer diesel TRU engine can emit more oxides of nitrogen (NO_X) than the truck's main engine when idling…" (*EPRI, 2004*). To "pull-down" the temperature of a trailer load of perishable cargo rapidly, these engines must also be designed to produce more power than is normally required during most standard operating conditions. In fact, the power required from the TRU to provide air circulation inside the trailer and maintain temperature (maintenance operation mode) is potentially only 15% of its rated maximum (*Lavrich, 2005*). The engine continues to operate and consume fuel at a high rate even though less than a sixth of its rated power is required. Unfortunately, optimizing the system for all anticipated cooling requirements is difficult, since the majority of refrigerated trailers are used at various times for fresh, frozen and deeply frozen products. Multi-temperature trailers also have the ability to hold different portions of the same load at various temperatures.

> Most transport refrigeration systems appear to be much less energy efficient than other refrigeration equipment – primarily because of engineering tradeoffs between efficiency and the ability to adapt to temperature extremes, to cool as well as heat, to control humidity, to ventilate cargo gas buildup, and to provide fast pull-down (EPRI, 2004).

Noise pollution from reefer units is significant and has been a major issue in the European market to the point that a unit's noise emissions are strictly regulated. More important to health concerns, diesel TRUs emit large quantities of carbon monoxide, oxides of nitrogen, and particulate matter. These emissions have been proven in many studies to negatively affect the health of those who are exposed. Alternative technologies that can help reduce or eliminate exhaust emissions have an opportunity to make a positive impact. The estimated market size (as of the year 2000) of refrigerated trailers nationwide is over 225,000 and in New York, there are 15,200 registered reefer trailers (*ATA, 2004; EPRI, 2004*). Many engines that power reefer units conform to Tier 2 EPA emission standards, and stating 2008 all new diesel powered TRUs will conform with Tier 4 standards. Therefore, using these EPA standards, the annual emissions for a diesel TRU can be readily determined, as shown in **Tables 1-1 and 1-2**. For example, a Tier 2 diesel TRU generates 110.2 kilograms per year of PM emissions. Thus, national and New York State totals are 27,322 tons per year and 1,846 tons per year, respectively. Therefore, a large positive environmental impact can be made to significantly reduce noxious emissions would be to impose regulations and introduce incentives that encourage alternative technologies to flourish in this market.

TABLE 1-1: ANNUAL EMISSIONS FROM AVERAGE OPERATION OF DIESEL TRUS

Annual Emissions for a Standard 34 hp Diesel TRU
operating 24 h/day, 6 day/wk, 50 wk/yr

	CO			NMHC + NO_x			PM		
Rating	(g/hp-h)	(g/h)	(kg/yr)	(g/hp-h)	(g/h)	(kg/yr)	(g/hp-h)	(g/h)	(kg/yr)
Tier 2	4.1	139.4	**1,004**	5.6	190.4	**1,371**	0.45	15.3	**110.2**
Tier 4	4.1	139.4	**1,004**	5.6	190.4	**1,371**	0.22	7.5	**53.9**

TABLE 1-2: TOTAL ANNUAL EMISSIONS FOR ALL REGISTERED TRUS

Total Annual Emissions From 34 hp TRUs

Emission Type		U.S. (tons/yr)	NY (tons/yr)
CO	Tier 2 & 4	**248,930**	**16,817**
NMHC + NOx	Tier 2 & 4	**340,002**	**22,969**
PM	Tier 2	**27,322**	**1,846**
PM	Tier 4	**13,357**	**902**

2.0 BACKGROUND

To address the inefficiencies associated with regular diesel-driven TRUs, manufacturers have developed hybrid diesel-electric units and other alternative technologies. Many hybrid units are belt-driven mechanical models with additional electric motors that allow the diesel engine to be switched off when the unit is plugged into grid-based electricity (shore power). This is referred to as "standby" operation. Some new all-electric TRU models (eTRU) have fully electric components that can use shore power or be powered by small diesel generator-sets for over-the-road use. The eTRU models are currently not available in the United States. Shore power plug-in infrastructure is also unavailable at most truck stops, and standards have not been developed to ensure uniformity across the industry. In addition, standby-capable reefer units (whether hybrid mechanical or eTRU) generally require three-phase electricity input for large capacity trailer models due to high power requirements. Most deployed shore power infrastructure to date provides only single-phase power for engine block heaters and hotel loads from the cab. However some refrigerated warehouses and distribution centers do have installed electricity connections. Therefore, at the current time, the potential ability to plug-in to shore power electricity is limited. Yet another major advantage of eTRU technology is the reduced number of mechanical components they contain, reducing maintenance costs and fuel consumption while increasing product life, reliability, and unit resale value. Hybrid diesel-electric standby units, however, do not offer such benefits, only the potential economic savings when plugged into shore power. Currently available diesel-electric-powered standby TRUs have not been successful in the United States for a number of reasons, including the additional upfront capital cost (10% incremental cost), limited availability of adequate electric shore power infrastructure, and the conceptual change in technology away from the standard diesel TRU to which fleets and technicians are accustomed. Yet, for the eTRU, when analyzing the potential for market acceptance, maintenance cost savings and increased lifespan, all-electric units more than pay for their incremental capital cost, even without widely available shore power infrastructure.

The noise and exhaust pollution generated by TRUs is a serious issue confronting many communities and state governments across the United States. Such harm is currently occurring that many states and local governments have adopted anti-idling regulations (*EPA, 2003*). These laws and local ordinances prohibit the idling of over-the-road diesel engines for periods longer than 5-10 minutes. However these regulations pertain to large diesel truck engines, not TRU engines. In addition to curbing diesel emissions, these laws also serve to limit the national dependence on petroleum. The EPA is currently spearheading a series of government and industry collaborations (beginning in May 2005) aimed at standardizing such anti-idling regulations. A current listing of anti-idling regulations nationwide has been included in **Appendix J** of this report.

Efforts are underway to also regulate and limit emissions from small diesel engines including reefer units and auxiliary power units. These regulations will have a direct impact in the TRU market and its growth and dynamic. When these new regulations to limit TRU engine emissions become widespread, the need for standby electric power and capable units will increase dramatically. By shutting down diesel engines and shifting the pollution burden to well-regulated power plants supplying grid electricity, a great benefit to local air quality can be achieved. This is especially important as many anti-idling regulations have been put into place in poor air quality areas known as "non-attainment" regions as designated by the EPA. In addition, emissions can be easily monitored and regulated at the power plant level as opposed to each and every truck and trailer. Thus it can be assumed that more local jurisdictions will begin to adopt anti-idling laws that could be extended to TRUs.

The first such regulation of this type has recently been put into place in California by the California Air Resources Board (CARB) (see **Appendix I** of this report). Not only does this regulation establish strict limits on small diesel engine exhaust emissions, it also places requirements on warehouse owners to report on the use of reefers at warehouses with 20 or more loading docks serving refrigerated areas (*CARB, 2000*). The new regulations from CARB (effective in 2008) set particulate matter (PM) emissions standards on small diesel engines to 0.3 grams per horsepower-hour for units rated up to 25 hp, while those over 25 hp must meet 0.22 g/hp-hr (*Macklin, 2005*). This new measure will help to reduce engine PM emissions by 85-90 percent. In December 2004, CARB took the PM emission reduction figures from the EPA's Tier 4 standards and made them specific to TRUs on an accelerated timeline. For example, by 2010, the PM emission standards for a model year 2003 25 hp or greater diesel engine driving a reefer unit must be 0.02 g/hp-hr or less (*CARB, 2005*).

The following sections describe the current and future technologies and market for trailer refrigeration units. This analysis is necessary to fully understand market dynamics and the factors that will influence widespread acceptance of new TRU technologies.

3.0 METHODOLOGY

Shurepower has been tasked with completing a comprehensive market and technology assessment of currently available products that can perform the operations required of refrigerated transportation equipment. This assessment includes analysis of trends in the industry, future outlooks and direction, a competitive and economic analysis of various technologies, and an infrastructure assessment of plug-in shore power. It also includes an assessment of maintenance and repair issues including qualified technician training, service part availability, and retrofit operation issues. This analysis focuses on the United States in general, and New York State specifically. Additional details outlining the method used to derive the conclusions are described below.

3.1 Scope Modification

The method proposed in the original scope was modified slightly to improve the efficiency and direction of the assessment. During the performance of this assessment, it was deemed more logical that the Technology Assessment be completed prior to the Market Assessment. As the purpose of the Market Assessment was to identify one or more viable alternatives to the standard diesel TRU, it was important to first discuss the various available technologies and determine which of them would be analyzed in the Market Assessment.

3.2 Technology Assessment Methodology

The method used to assess available TRU technologies included evaluating the operating requirements and characteristics necessary to meet future needs, such as cooling capacity, weight, cost, efficiency, noise, reliability, fuel consumption, and exhaust emissions. Once the operating criteria were established, characteristics of existing TRU technologies were analyzed to identify technologies most likely to meet the future needs of the industry. A competitive market analysis was applied to each of the alternatives to determine which has the greatest potential for success. The results of this analysis are presented in Sections 7 and 8 of this report, while a discussion of the particular technologies comprises Section 4.

3.3 Market Assessment Methodology

To complete a full market and technology assessment of the current and future state of the industry for Trailer Refrigeration Units, it was necessary to conduct extensive research. These research activities fell into four basic categories: technical and market inquiries brought to our project partner Carrier-Transicold; general online research and detailed analysis of publicly available industry policies and regulations; surveys of New York State businesses and warehouses involved with refrigerated transport; and specific research and data collection from industry reports and census statistics.

Work with partner Carrier-Transicold has continued from the outset of this project through the final report phase. A preliminary teleconference was conducted to brief project staff on the current status of the industry, requirements of TRUs, consumer demands, and anticipated trends – in particular those efforts focusing on the implementation of electric TRUs. During the completion of the market and technology assessments, further questions and issues arose that were brought to Carrier for comment. As there are only two major U.S. manufacturers in the TRU industry, Carrier-Transicold and Thermo King, it is understandable that certain datasets and other specific market and production information were deemed proprietary and therefore withheld from this analysis. However, Carrier was forthcoming with information that was critical to our assessments. In fact, Carrier was an important asset in providing key data to support analysis of the lifecycle costs, maintenance issues, and analysis on TRUs, current industry trends, and other general information.

The second main category of research fell under general industry and technology research, which was primarily conducted online. Various government and industry Internet portals provided a wealth of information on the trailer industry in general, and more specifically, the refrigerated trailer market. This mode of research was an important component in understanding the current reefer market, industry trends, some limited statistics, and information on alternative technologies and companies involved in refrigerated transportation.

Third, using New York State industry and warehouse data, with Internet research, a number of New York based businesses and refrigerated warehouses were contacted to determine the status of shore power infrastructure. The owners of these warehouses were mostly cooperative in sharing information on the quantities and types of loads coming in and out of their depots. Common to nearly all owners of public warehouses was an understanding of anti-idling provisions and the desire to improve air quality through enforcement of these laws; yet little shore power infrastructure has been implemented to date.

Other sources of data included industry reports and government studies, including Census Bureau data. These sources provided broad categories of information and were supplemented by historic industry data including trailer sales and refrigerated trailer registrations.

Additional sources for information on TRUs, emissions, electrification, and other topics were also used. Extensive studies have not been conducted to quantify unit emissions under varying operating conditions. Specific tests should be performed in standardized operating conditions to analyze the emissions, efficiency, and fuel consumption of various technologies. Some university studies have been successful in measuring emissions in certain test cases. One such researcher is Dr. Christie-Joy Brodrick of the Institute of Transportation Studies at University of California at Davis. The recent study from UC-Davis focused on the potential for fuel cell TRUs, but did include analysis of certain diesel reefer exhaust emissions. While not all emissions were tracked due to funding limitations, this study provides a step toward further understanding the detrimental effects of exhaust emissions. The full report on the UC-Davis study is due to be published this year. Some preliminary results have been discussed with Dr. Brodrick and this information has been incorporated into this report as appropriate.

One point to note concerning the Market Assessment of this report is that there is a difference between two very similar terms. The term hybrid diesel-electric standby refers to a primarily diesel-driven mechanical TRU with electric standby plug-in capability. This is different from a fully electric TRU (eTRU) whose electrical components can be powered by a plug-in connection or, when over-the-road, by a diesel generator set providing electricity to the eTRU. Due to a reduction in the number of moving parts, the eTRU has a significant benefit in cost for on-going maintenance in addition to plugged-in fuel cost savings. While the standby mechanical unit benefits only from fuel savings when connected to shore power. In addition, standby units do not have the capability to perform pull-down operations while plugged into shore power electricity. The eTRU *does* have this capability. As electric TRUs are not presently available in the U.S. (although they enjoy success in the European market), limited figures on eTRU operating parameters exist. In such instances where specific eTRU data was unavailable, figures from similar standby units have been used in place.

3.4 Partnership Methodology

New York fleets with interest in purchasing electric TRUs and installing the infrastructure to support them were evaluated. The method used to accomplish this was to identify New York trucking fleets for their potential to participate in evaluating the advanced electric TRU. A comprehensive list of New York-based fleets transporting refrigerated products via trailers was developed and has been included in **Appendix B**. These fleets were selected from a list provided by both NYSERDA and Carrier-Transicold. Parameters used to finalize the selection of the primary candidates included fleet operating characteristics (long-haul, local, same route, centralized warehousing, etc.), number of refrigerated trailers, and characteristics of TRUs installed on refrigerated trailers. Also important was the level of interest expressed by the trucking company and if their corporate mission supported the testing and integration of improved technologies. In addition, a progressive utility company with interest in demonstrating "new" technologies would be required to supply electricity to these fleets.

4.0 TECHNOLOGY ASSESSMENT

Trailer Refrigeration Units are a critical element of the food distribution industry today. TRUs play a vital role in delivering fresh, frozen, and other perishable food from field to market. Typically, TRUs are added to specially designed and insulated trailers according to a particular customer's specifications, and consist of four primary components: evaporator, compressor, condenser, and control valve. The capacity chosen for the refrigeration unit is highly dependent on the size of the trailer and the commodity that will be hauled. For a typical over-the-road trailer, the refrigeration unit's capacity can range from less than 20,000 Btu/hr to more than 65,000. A TRU's capacity is generally sized 50% larger than required to allow rapid cool-down when the trailer is first loaded. Without this additional pull-down capacity, trailers would have to be pre-cooled.

The vast majority of refrigerated trailers are designed to maintain a uniform steady state temperature throughout the interior. However, some specialized units are designed with multiple temperature compartments so mixed loads can be delivered with a single trailer. Regardless of the type of trailer, the temperature control requirements for a TRU are precise. Typically, units must be able to maintain a very narrow temperature range (±3°F) for as long as product is on the trailer. If the temperature tolerance is not maintained, the product could spoil due to excessive heat or conversely, fresh product could frost over or even freeze at low temperatures. In either case, the carrier could be liable for millions of dollars worth of commodity losses if the refrigeration unit fails to perform properly. **Figure 4-1** illustrates the basics of the refrigeration process.

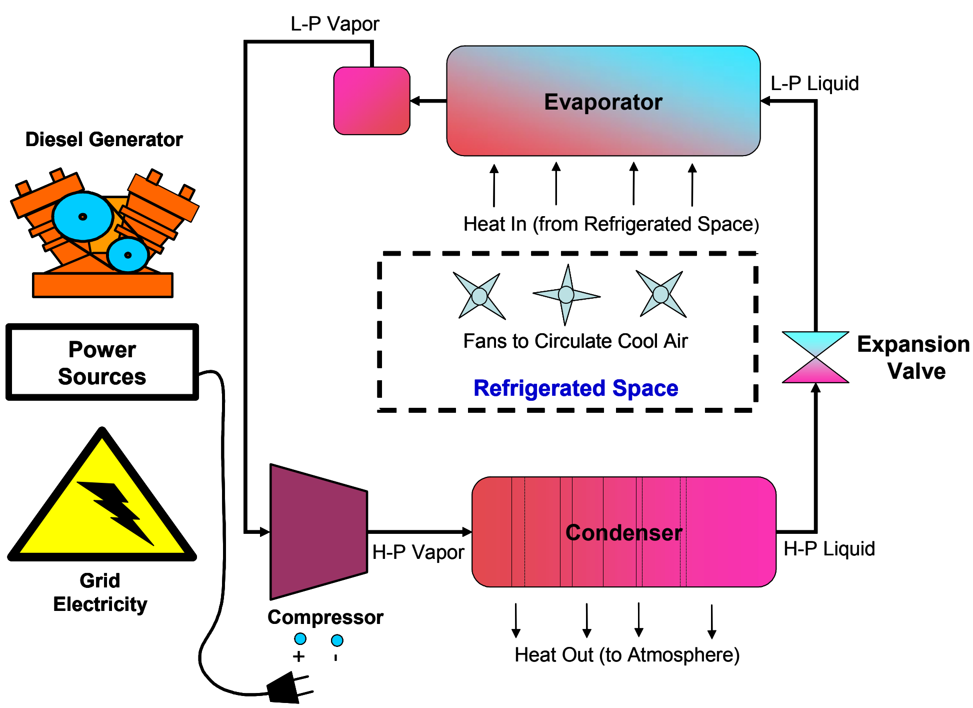

FIGURE 4-1: BLOCK DIAGRAM OF REFRIGERATION CYCLE

Although the functional requirements of TRUs are fairly uniform, today's TRU may use a number of sophisticated technologies to meet these requirements.

4.1 Current TRU Technologies

The currently available technology for advanced TRUs is highly refined and reliable, however often inefficient. Depending on the application, a TRU may be powered by an internal combustion engine (ICE), an electric motor, or utilize the latent heat of disposable cryogenic fluid such as carbon dioxide. Further, depending on the specific mission of the unit, the TRU may use a combination of two or more of these technological approaches as a hybrid TRU system.

This report section will discuss the technological aspects of each approach currently being utilized and will discuss new technologies that may be introduced into the field. Factors including system complexity, weight, noise, emissions, cooling capacity, reliability, and infrastructure requirements will be discussed for typical TRU systems using each of the identified technologies. The analysis will be broken down into five technology areas, ICE-driven TRUs, electrically driven TRUs, cryogenic TRUs, emerging TRU technologies, diesel TRUs with electric standby, and eTRU systems.

4.1.1 Internal Combustion Engine (ICE) Driven TRU

The vast majority of TRU systems in use over the past 20 years have been powered by diesel ICEs because of their high torque, fuel efficiency, and reliability. However, spark-ignition ICEs have also been used, fueled by gasoline or propane.

4.1.1.1 Diesel-Driven TRU

Large-capacity, diesel-powered TRUs use a small (30-40 hp) diesel engine to drive a compressor and power fans required for air distribution within the trailer. These units have sufficient power to generate between 36,000 and 65,000 Btu of cooling capacity and typically have an empty weight of about 1,650 ± 200 pounds. With 50 gallons of added diesel fuel, the system weighs about 350 pounds more. The period that the unit can operate on a full load of fuel depends on a number of variables such as ambient conditions, trailer design, and load requirements. These units are reliable, fuel efficient, and durable. Many of the newer units have been designed to reduce the maintenance requirements by eliminating belts and other high wear items. One such approach includes the direct coupling of the engine to the compressor via a centrifugal clutch, which can selectively engage operation of the TRU.

Diesel-powered TRUs have a number of drawbacks including noise and exhaust emissions. Diesel engines are typically louder than gasoline engines and electric motors. They also tend to generate more particulate matter and NO_X emissions than gasoline engines and electric motors. Due to the noise and emissions associated with diesel engines these units are facing a number of operational restrictions, especially during deliveries in large cities.

Typically, most diesel engines have the capability to operate on alternative fuels such as B20 Biodiesel (a mixture of 80% petroleum diesel fuel and 20% biodiesel) or other synthetic diesel products. However, operators should obtain the manufacturer's recommendations prior to using any alternative fuel in a diesel engine.

4.1.1.2 TRU Driven by Spark-Ignition Engines

As early as the 1970s some TRUs used spark-ignition engines to drive the compressors and generators needed to maintain the trailer climate. These engines have been configured to operate on a number of fuels including gasoline, propane, and natural gas. Spark-ignition engines are generally quieter and emit less particulate matter than their diesel counterparts.

Spark-ignition engines typically do not have the same torque capability of a similar displacement diesel engine and are less fuel-efficient. In addition, the energy storage density of these fuels is significantly lower than diesel, thus requiring a larger fuel tank for equivalent operating time. These spark-ignition units are quieter than diesels however the other disadvantages remain significant issues. Diesel engines also typically last longer and are more reliable than spark-ignition engines. Today, spark systems are very rarely used and only produced on a special-order basis. Spark-ignition TRUs have similar weight characteristics and cooling capacities. However, it should be noted that the fuel tanks needed for the gaseous fuels such as natural gas (CNG) or propane are significantly larger and heavier than their diesel counterparts. The use of non-diesel TRU fuel may mean more frequent stops and more logistical difficulties.

4.1.2 Electrically Driven eTRU

In the United States, electrically driven TRUs are primarily used in shipping containers. An eTRU consists primarily of electrically powered components as opposed to mechanically powered. It should be noted that an eTRU is distinct from a mechanical diesel unit with electric standby plug-in capability. Such standby units lack the capacity to pull down trailer temperatures when powered by shore power electricity. An eTRU does have such capability. These units typically have a 3-phase electric input at 208, 230, or 460 volts, depending on the application and other considerations, and use either hermetically sealed or motor driven compressors. These units are able to generate between 30,000 and 54,000 Btu/hr of cooling capacity, depending on the unit configuration, and typically weigh approximately 1,000 ± 200 pounds. In stationary operations these units can be highly efficient, are extremely quiet, highly reliable, and generate no local exhaust emissions. During marine transport, the ship's electricity generators provide the power necessary for cooling. This allows a single, highly efficient generator system to power numerous TRU systems at one time, minimizing costs while reducing noise and maintenance requirements for the TRU systems. However, for these units to operate in over-the-road applications they must have a mobile source of electric power in the form of a portable Auxiliary Power Unit (APU). The APU typically consists of a generator driven by either a diesel or spark-ignition engine that can provide power when the vehicle is in motion. The need for an APU would add cost, weight, and complexity to an Electrically Driven TRU system.

4.1.3 Cryogenic TRUs

One of the new competitors to the diesel-driven TRU is the cryogenic TRU. These are typically high-capacity, one-piece, front-mount, cryogenic-powered cooling and heating systems (shown in **Figure 4-2**). The unit has no engine and no compressor but rather uses compressed carbon dioxide (CO_2). A vapor motor operated by high-pressure carbon dioxide gas is used to power the evaporator blower and a brushless alternator. A propane-fired heater is also installed to superheat the carbon dioxide for heating and defrost.

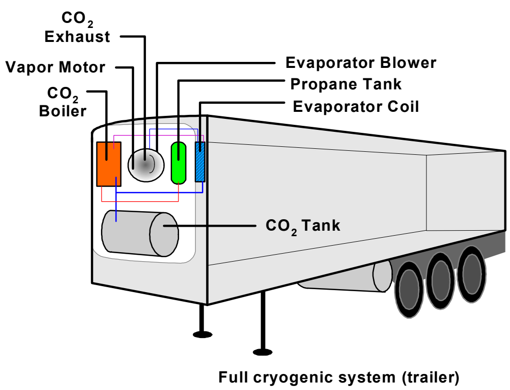

FIGURE 4-2: CRYOGENIC TRU

These units have several advantages over the diesel-powered TRU including near-silent operation, lower emissions, no fluorocarbon refrigerant, and fewer moving parts. However, virtually all of the "fuel" used by these units is released into the atmosphere as carbon dioxide, a greenhouse gas emission that is currently unregulated.

These units typically weigh about 1,200 pounds empty and may carry an additional 1,000 pounds of carbon dioxide. Today, these units are limited to operating in environments that have a ready supply of carbon dioxide such as bottling plants and breweries.

4.1.4 Direct Drive Technology

Direct drive refrigeration powered by the vehicle's engine offers a number of advantages over diesel-powered refrigeration units, including improved fuel efficiency (under some conditions), low noise levels, and somewhat reduced exhaust emissions. This unit is effective for straight truck applications. However, it is not an option for long-haul trucking due to a number of factors. First, the unit requires the main tractor engine to be running for the TRU to function, which could significantly increasing tractor engine idling. Second, the unit would require quick disconnect lines for the tractor to separate from the trailer. This would result in possible refrigerant loss and reduced system reliability. Once separated, the trailer would no longer have cooling capabilities. Finally, each truck that is expected to pull a refrigerated trailer with this system would have to be fitted with a compressor matching the trailer system's requirements. The logistical complexities associated with this type of unit will greatly hinder its acceptance in this market and is the primary reason this type of system has not been adopted by the industry to this day.

4.2 Emerging Technologies

Several technologies are being investigated and developed for the TRU market. Their success is dependent on a number of factors including cost, fuel availability, durability, maintenance requirements, weight, and ultimately, market acceptability.

4.2.1 Fuel Cell-Powered TRU

The fuel cell is potentially a long-term option for this market; however, in this stage of their development fuel cells are heavy, susceptible to roadway-induced vibration/shock damage, not cost effective, and the cell stack lifetime is too short.

Hydrogen has an extremely low volumetric energy density relative to diesel fuel and the tanks for both cryogenic and high-pressure storage of hydrogen are relatively heavy and expensive. It is also unclear if the fuel cell systems can generate sufficient power to support the cooling capacity necessary to meet the requirements of today's TRUs. An additional drawback is the current lack of hydrogen refueling infrastructure. Fuel cell-powered TRUs may be practical if hydrogen becomes commonly used for automobile and truck propulsion, but that eventuality is probably at least 20 years away

4.2.2 TRUs Driven by Advanced Combustion Engines

There are a number of new combustion engines on the horizon that may represent advances in TRU technologies. Combustion regimes such as Homogeneous Charge Compression Ignition (HCCI) and low-temperature combustion engines may offer diesel-like performance with reduced emissions. However, there are a number of technical hurdles that must be addressed before these systems can enter the marketplace.

4.3 Diesel TRU with Electric Standby

Some traditional diesel TRUs have been designed to incorporate electric standby cooling capability. These units typically have sufficient cooling capacity in electric standby mode to only maintain the preset temperature. Most of these systems do not have sufficient capacity to meet the pull-down requirements of the trailer using electricity alone. In standby mode, these systems typically use an electric motor to drive a reciprocating compressor with belts and clutches and use an internal combustion engine to drive the compressor when electric power is not available. As discussed previously, the diesel TRU with electric standby has many benefits including quiet operation and no localized emissions when operated on grid electric power. The cost per hour of operating using diesel fuel is significantly greater than the cost electric operation. Thus the major economic advantage of running electric standby is the diesel fuel cost savings. The ability to run on either electricity or with an internal combustion engine provides redundancy in areas without electric infrastructure or in areas with unreliable electrical service. However, today these systems face a number of drawbacks including system complexity, unproven reliability (in the U.S.), lack of existing electrical infrastructure, and increased system weight and cost. Typically, standby models weigh about 200 pounds more and cost about $2,000 more (10% incremental capital cost) than their traditional diesel counterparts.

4.4 Electric TRU Systems

This type of fully electrical eTRU system has been discussed in Section 4.1.2. Electric TRUs are popular in Europe; these units use an integrated, diesel-powered auxiliary power unit and full-capacity electric refrigeration system. These systems have sufficient cooling capacity using either power source to meet the trailer pull-down requirements. As discussed previously, eTRU systems have many benefits including quiet operation and no localized emissions when operated on electric power. These systems also possess the capability of using an internal combustion engine to provide power where grid-based electricity is not available. The systems often use high-efficiency rotary or hermetically sealed compressors and are typically more efficient and require less maintenance than mechanically driven units. While the eTRU is economical from the standpoint of maintenance cost savings alone, the full potential for fuel savings cannot be realized unless adequate plug-in shore power infrastructure becomes available.

4.5 Refrigeration Compressors

Today there are three basic compressor designs: the reciprocating or piston compressor, the rotary or scroll compressor, and the hermetically sealed compressor. All TRUs require a compressor to achieve the refrigeration cycle. An external engine or motor is required to drive the input shaft of either the reciprocating or rotary type. However, the hermetically sealed compressor is driven internally by an electric motor and requires no external drive shaft. Unfortunately, these compressors are generally not suitable for large-capacity TRUs. Consequently, an assessment of maintenance for TRUs should focus on the differences between reciprocating and rotary type compressors.

Given the need for an external compressor drive, it is beneficial to examine the ways that rotation is achieved. For diesel-driven units, combustion occurs in a chamber with pistons that, in turn, are pushed through a cycle which eventually leads to crankshaft rotation. This process is subject to efficiency losses of approximately 60 percent. In addition, it requires scheduled maintenance including oil and oil filter changes, timing adjustments and eventually complete overhauls. For electrically driven units the crankshaft rotation is much simpler. In essence, a voltage is applied across an induction motor, which then produces torque, resulting in rotation of the drive shaft. This process has few moving parts, very little maintenance and produces no emissions.

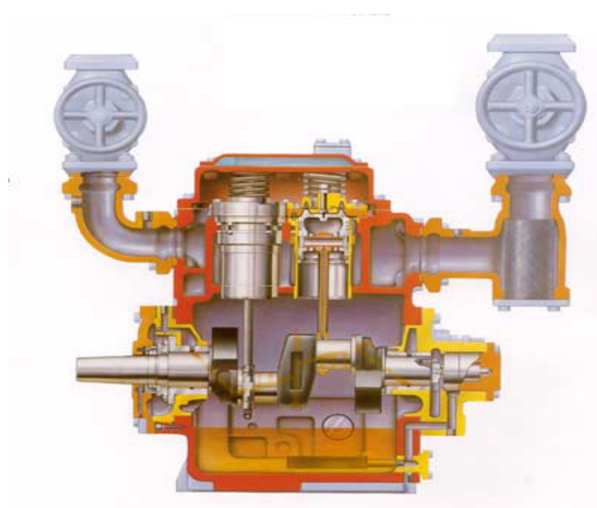

FIGURE 4-3: RECIPROCATING (PISTON) COMPRESSOR

4.5.1 Reciprocating or Piston Compressors

A number of different compressor designs are currently being used with TRUs; three of the systems are based on piston engine designs. An in-line reciprocating or piston compressor typically has 1 to 4 cylinders aligned in a single row similar to an in-line 4 or 6 cylinder engine. **Figure 4-3** shows a cutaway of a two-cylinder in-line reciprocating compressor. Some reciprocating compressors use a "V" configuration with 2 to 6 cylinders split across two banks forming a V arrangement. In addition, there are the radial piston compressor arrangements, whereby the cylinders radiate out from a central crankshaft. All of these configurations are well proven and have a long history in the climate control industry. These compressors require significant maintenance and have sealing issues associated with the piston rings and the crankshaft entry and exit points on the compressor.

4.5.2 Rotary or Scroll Compressors

Rotary compressors use vanes, eccentrics, gears, or screws to compress the refrigerant. Typically, rotary compressors have fewer moving parts, are more reliable, and have higher efficiencies than the piston type compressors. However, rotary compressors also have sealing issues around the drive shafts. Rotary compressors typically are more expensive than reciprocating compressors due to the requirement for precise tolerances and complex components. Today, many premium TRUs use the scroll compressor shown in **Figure 4-4**. The scroll compressor is a highly efficient form of the rotary compressor.

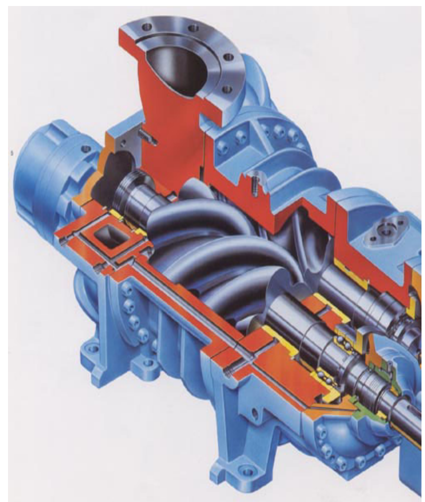

FIGURE 4-4: ROTARY (SCROLL) COMPRESSOR

4.5.3 Hermetically Sealed Compressor Units

Hermetically sealed compressors are factory sealed units driven by an internal electric motor. Both the drive and compressor components are contained in a single unit. Household air conditioners, refrigerators, and freezers typically use hermetically sealed compressors. These units usually require very little maintenance, are highly efficient and very reliable. Most compressors of this type are operated on alternating current electric power. Since no driveshaft penetrates the compressor, there is no need for elaborate sealing measured around the rotating shaft.

5.0 MARKET ASSESSMENT

Refrigerated trailers provide a substantial market opportunity for electrification. Commonly, reefer trailers are thought of as transporting frozen or refrigerated food loads, however non-food loads such as medicines, film, chemicals, machine components, and other commodities (*EPRI, 2004*) also exist in this market. The primary mode of operation for TRUs consists of "holding" a load at a given "set point" temperature. This "**temperature maintenance**" mode of operation accounts for the vast majority of time during which the units are running. A second type of operation, referred to as "**pull-down**" mode, is used to rapidly bring down the trailer's interior temperature. The characteristics of pull-down operation are quite different from temperature maintenance operation. The power requirements (consumption of fuel) and duty cycle for pull-down are much higher. However, pull-down mode is used only a faction of the time since the standard operating condition is temperature maintenance mode. Yet deliveries that involve frequent daily stops will require more pull-down use than long-haul transport. In order to understand the market of temperature-controlled freight and the potential for supplying standby electric power capability for trailer refrigeration, market and equipment research was conducted and is detailed in this report section.

The current market prices for refrigeration units range from $12,000 to $25,000 and up depending on factors such as cooling capacity, airflow design, and other features of electronic control and monitoring capability. Older, manually controlled TRUs can take two hours or more for pull-down, while advanced electronic controls can cut this to 20 minutes (*Thomas, 2002*). Enhancements such as wireless data links via satellite or RF transmission in depot yards are new to the marketplace and are growing in popularity and value. Another optional feature is an added connection and hardware for plug-in capability. Current mechanical TRUs with electric standby capability are priced 10% higher than standard models. Financing options are often provided for purchasing. However new, fully electric TRUs are slated for similar pricing ranges (10-20% higher than standard diesel-only models), and lower maintenance costs along with extended lifetimes make eTRUs an attractive option (*Lavrich, 2005*). Virtually all new reefers use R-404A, which conforms to all existing and currently anticipated laws (*Bald, 1997*). Units using R-404A are definitely the most attractive in terms of utility and resale value. R-22 is another option although it will be phased out by 2030 (both R-12 and R-502 have been removed from new unit production design).

The electric standby option for reefer units is closely tied to another electrification technology, shore power. Shore power allows on-board truck components to run off grid-supplied electricity rather than requiring the main propulsion engine to idle during layovers. Shore power can also provide electricity to TRUs; however the power requirements of these units are very different from shore power cab connections (hotel loads). While it has generally been found that most shore power capable trucks can use either 120V or 208/240V single-phase power to power their hotel loads, TRUs on the other hand require 3-phase power (often at 230V or 460V).

5.1 Market Background

Prior to 1939, when the first refrigeration units were developed, refrigerated transportation amounted to perishable goods kept cool using blocks of ice. The invention of the first TRU dramatically changed the way food was distributed and the units remained largely unaltered until the 1980s. It was at this time when “on-off” switching capability was introduced, allowing unit compressors to shut down when proper temperatures were reached and thus dramatically save fuel. As of 2000, there were approximately 225,000 reefers in operation in the United States and 15,200 registered in New York (*ATA, 2004; EPRI, 2004*) with 25,000-35,000 additional reefers sold each year (*ACT, 2003*). Refrigerated transportation is a $1 billion-a-year industry and continues to grow (*Lang, 1999*). Forty-eight-foot reefer trailers are currently the standard. However, 53-foot (and some 57-foot) trailers are becoming more common. “A 53-foot trailer weighs only 750 pounds more than a 48-footer and only costs around $1,000 more” (*Bald, 1997*). The larger reefer trailers, although restricted in some states, are desired by the industry because temperature-controlled shipping is expanding and larger, consolidated refrigerated tractor-trailer trucking operations are reducing costs by using fewer (yet larger) trucks. Reefer trucks tend to operate in areas with large populations, as the majority of the reefer loads are frozen, processed or fresh foodstuffs. This makes noise and emission pollution from diesel units a politically sensitive, community based issue. Many communities have lodged harsh complaints against idling trucks and reefer units at truck stops and rest areas. While the industry has already accepted anti-idling measures being enacted across the country for diesel truck engines (with new emissions standards coming into effect in the middle of 2007), diesel engines for reefers and other “nonroad” engines are starting to receive additional pressure.

A reefer unit’s operating characteristics are commonly quoted at three shipping temperatures (35°F, 0°F and -20°F). Currently, very few reefer trailers in the United States are equipped with standby electric power plug-in capability. However, many of the straight trucks, medium trucks, and small trucks that are reefer-equipped do have the standby electric power option. The standard reefer unit uses a small auxiliary diesel engine driving a conventional refrigeration compressor system. The standby systems use a separate electric motor drive for the compressor and, in some cases, an inverter to supply direct current to the existing DC motor/fan units used in the IC engine-driven system. The standby electric capability is an extra cost option in almost all cases except in the smaller trucks where a hermetically sealed, electrically driven compressor may be supplied as part of the total packaged system. There are two major refrigeration equipment suppliers to this industry. They are Carrier-Transicold, a Division of United Technologies and Thermo King, a Division of Ingersoll-Rand. Third in the running is a smaller company called Advanced Temperature Control (ATC) based in Ontario, Canada. However ATC primarily focuses on straight truck and van systems where the compressor is belt-driven from the vehicle engine crankshaft. As such, the company does not fall within the scope of this market study. Another company that is gaining market share is Zanotti, an Italian company operating its North American business out of Ontario. They are a major European reefer manufacturer and are now making a concerted effort enter into the North American market. A majority of their products are for straight trucks;

however, they are close to releasing a trailer-mounted product to compete directly with Carrier-Transicold and Thermo King. All of these companies produce a wide range of refrigeration equipment for the trucking industry.

Based on our interests in meeting the highest reefer load, we were most interested in the reefer standby power requirement for the full length semi-trailers. We reviewed product literature for the full line of reefer equipment from both major manufacturers, called sales engineers, and obtained product manuals for some of the reefer equipment. The average fuel use for a typical full-length semi-trailer was taken from data supplied by Carrier-Transicold, Wabash National, and other major reefer trailer manufacturers. The typical reefer engine operation is 1,500 to 1,700 hours a year. Hours of engine operation should be distinguished from total hours of operation. While a TRU may be switched on for a large amount of time, the engine and compressor may be active for only a portion of that time. In pull-down mode, the unit is in full operation for 100% of the time. However during temperature maintenance mode, the duty-cycle is only 15-20% (meaning the unit is fully operating for that portion of the time). For the remaining portion, airflow can be provided, however the compressor is not running, drastically reducing the rate of fuel consumption. Thus while a TRU may be switched on and maintaining a given temperature for a large portion of the year, the unit will be operating fully for only 1,500 to 1,700 hours of that time (referred to in this report as "engine/compressor" operating hours).

The beneficial energy and environmental impacts of using electricity to power the trailer TRUs are considerable. As of 2000, an estimated 15,200 refrigerated trailers were registered in the State of New York and 225,000 nationwide (*U.S. Census Bureau, 2000*). Market population data and statistics are based on these figures, however they do not take into account industry growth since 2000. Diesel TRUs use, on average, 0.7-0.9 gallons of diesel fuel per hour to maintain 0°F (a common temperature for refrigerated transport). This fuel consumption rate takes into account the 15-20% duty-cycle for typical refrigerated transportation (temperature maintenance mode). A typical refrigerated trailer is in use on average 6 days a week, 50 weeks per year, which equals 7,200 total hours of use per year (representing 5,000-6,500 gallons of annual diesel fuel use). Often this figure can be higher if pull-down operation makes up a significant portion of normal conditions (such as the case with local distribution as opposed to long-haul). Some of this diesel-powered operation can be replaced by quieter and cleaner electric power. Assuming that this unit can be plugged into an electrical outlet during the mandated 10-hour driver rest period (and/or a portion of loading/unloading time), this would displace 60 hours of diesel operation per week, and save 2,100-2,700 gallons of diesel fuel during a 50-week operational year. To put this number in perspective, it is equivalent to removing three SUVs that travel 10,000 miles per year from the road. The resulting decrease in diesel fuel consumption (nearly 42%), is in addition to the emission and noise reductions obtained by operating the TRU on electricity. Assuming that all refrigerated trailers have the capability to plug into electrical outlets, this could result in the annual displacement of approximately 32 to 41 million gallons of diesel fuel in New York and 472 to 608 million gallons of diesel fuel nationally.

As stated earlier, diesel-electric TRUs are available in the U.S. as a special-order item. However, fleet operators view these units as more expensive and requiring more maintenance than traditional diesel TRUs. Current diesel-powered TRUs weigh less and provide higher cooling capacities than units equipped with electric standby. This can be a significant disadvantage for truck load (TL) carriers to whom every pound of load equals $10 in revenue per year. If the electric standby unit weighs 100 pounds more than the diesel TRU, it could cost the TL carrier $1,000 in revenue per year, if they are carrying weight- and not volume-limited loads. Frozen food loads tend to be weight-limited. However a fully electric reefer unit (eTRU), as opposed to a mechanical standby unit, offers a significant benefit of reduced maintenance costs, as will be discussed later.

Diesel-electric TRUs are commonly used in Europe with much success. A major factor in this is strict control on noise pollution (even more so than regulations of exhaust emissions). Units run off grid electricity eliminate the noise concern. Shore power infrastructure is rarely, if ever, available at truck stops in Europe, however a large portion of warehouses and distribution centers do provide 3-phase grid electricity for TRU hook-ups. In addition, many trucks are partially transported by ferry, aboard which engines are not permitted to idle. Accordingly, shore power is available on these ferries. Approximately 40-50% of European TRUs are capable of being driven by electricity (*CARB, 2003*). Yet recent indicators suggest that figure is today upwards of 70% (*Lavrich, 2005*). While the U.S. market consists overwhelmingly of trailer transport (approximately 90%), only 60% of the European market is trailer based rather than straight truck, direct-drive systems. While electric TRU components have limitations, these do not have to limit the functionality of the unit. The electric components of TRUs have been designed typically to maintain the temperature of the trailer and provide airflow around the trailer's internal load to ensure consistency in load temperature. This electric "plugged-in" option is referred to as standby operation. Mechanical reefer units with standby capability can only run temperature maintenance operation (holding a load at a given temperature). Such operation requires much less capacity than the maximum TRU cooling capability used for pull-down. The electric system is designed only to maintain air circulation and the set point temperature of a pre-cooled load. However new fully electric units (eTRUs) can perform the pull-down operation while plugged into shore power. As the trucking industry begins to consolidate shipments and use larger trailers for food shipments, an opportunity arises to increase the number of TRUs in operation.

It should be noted that the reefer diesel engine, refrigeration compressor, and control system have all been optimized for this mobile refrigeration application. The unique aspect of supplying reefer standby power is the range in the specification of electric power required to meet the needs of the existing refrigerated truck and trailer fleet. In fact, many of the reefer manufacturers consulted in this study explain that their units generally operate under fairly modest 3-phase power requirements, however the inputs are chosen based on the customer's needs. In other words, while a large reefer unit in standby mode may require only 230V (±15%) 3-phase, the input to the unit might actually be 460V 3-phase due to the customer's grid supply at their facility. Thus, the problem with reefer standby power is the diversity of reefer system electrical equipment represented in trailer and non-trailer refrigerated trucks of all sizes. These requirements include 480V/3-phase service at 30 amps; 240V/3-phase service at 50 amps; 240V/Single-phase service at 20 or 40 amps; and 120V/Single-phase service at 30 amps. This makes the design and cost of the reefer hookups much more expensive than shore power connections for a standard sleeper cab hotel load TSE (Truck Stop Electrification) installation. Reefer truck operators tend to spend more than five hours a week, on average, waiting to load and unload at the shipper's location, and another five hours or more waiting at the receiver's dock. Drivers average 3.5 pickups and 4.65 drop offs each week, so they could be spending more than 43 hours each week simply waiting *(Lang, 1999*). From these wait times, it appears that there may be an additional, significant market for a modified TSE approach at large refrigerated warehouses and food distribution centers. In addition, noise regulations may provide an opportunity for the use of shore power by these vehicles when at warehouse locations near dense populations. However, reduced noise, engine-driven reefers are also currently available, potentially dampening demand for electric units based solely on noise-related issues.

The benefits of diesel-electric TRU systems are currently difficult to quantify to the fleet operators. The systems are quieter and emit no on-site pollutants when they operate on electricity. However, these environmental benefits have little influence on truck operators, who work on thin profit margins. At this time, and particularly due to a lack of plug-in infrastructure, truck operators and fleets find it difficult to recapture the incremental cost of the electric units. Users never realize the emissions and noise benefits economically unless their operations are restricted, in which case they may choose less restrictive areas for warehouse operations. It is important that the benefits realized by the community be captured via economic means by the trucking company or warehouse facility undertaking the investment.

Although there are two major manufacturers of TRUs in the United States, Carrier-Transicold and Thermo King, both use different approaches in their diesel-electric TRU systems. These companies compete in the same marketplace and offer similar refrigeration and freight temperature control equipment. In researching potential project partners, it was determined that new Carrier-Transicold product technology is electrically based, thus being a better selection for the future trends identified in this market study. A fully electric Carrier-Transicold product (named the Vector TRU) is currently available in Europe and is slated to be redesigned for the American market. One of the main reasons for the selection of Carrier-Transicold was due to the compatibility of this unit with the goals of the demonstration – to bring an improved and tailored product to the U.S. market. This electric unit can provide full capacity pull-down mode while plugged into shore power (which was identified as an appropriate setup for market penetration). It is also expected that the electrical TRU will have increased reliability and less maintenance requirements due to the reduced number of moving parts as compared to a diesel-driven TRU. As discussed previously, TRUs must be capable of providing heat for defrosting and heating cycles (to keep fresh product from freezing in cold temperatures). This is certainly a requirement for operation in New York State due to the cold climate during portions of the year. The use of electricity during a heating cycle is more effective with Carrier-Transicold's electric TRU (using resistance heating) versus the Thermo King "hot gas" methodology. This alternative approach allows a change in the refrigeration cycle whereby hot coolant from the compressor bypasses the condenser and is delivered directly to the evaporator. For electric standby operation with the hot gas system, the re-circulating gas is often not sufficiently hot at standby and a resistance heater must be added to the system. When required, the electric resistance heating of the Carrier-Transicold unit is more effective and provides better temperature control along with faster defrost cycles than hot gas technology. The unit can achieve the desired temperature faster and will run on a lower duty cycle. In addition, Carrier-Transicold has corporate operations in Syracuse, New York and so would be a better potential partner for a demonstration of electric-supplied reefer power in New York. The company was helpful with the project's data collection effort on reefer characteristics and could use the electrification experience as a way to expand sales of their standby electrical option on their truck and trailer refrigeration system packages. Such sales will not take off without having the shore power and standby electric power readily available when the truck/trailer is parked.

The largest reefer system standby electrical loads based on voltage and power required are those for trailer connections (generally 48- or 53-foot trailers). These larger loads drive the reefer connection design. The design reefer connection requirements found from our reefer unit survey and data gathering are 30-amp service at 460V/3-phase, and 50-amp service at 230V/3-phase.

5.2 Industry Trends

Freight transportation in the United States is a growing industry and one that relies heavily on truck freight. Transportation by truck is easily the most prevalent form of goods movement nationwide. The trend is assisted by the growing consumerism of the American populace and the growth of U.S. industries. In fact, most products consumed in the United States are transported by truck at one point in their distribution. During 2002, trucks hauled nearly 68% of all freight transported in the U.S., representing 86.5% of the capital spent on goods transportation (*ATA, 2003*). The trends are clear – freight transportation in the United States will continue to grow significantly and the majority of this will be accomplished by the trucking industry. Not only is this trend evident, the growth of *refrigerated* transport will also continue to increase. This market is substantial and growing, "…at least 3% of the available trucks on the road are devoted to temperature-controlled shipping" (*C.H. Robinson Worldwide, 1999*). The American Trucking Associations (ATA) has estimated that truck freight will double over the next 25 years. Given that refrigeration units for trailers generally have a 7-12 year lifespan, it is possible that the TRU population could be entirely "electrified" (if the appropriate units are promoted) over the next 25 years.

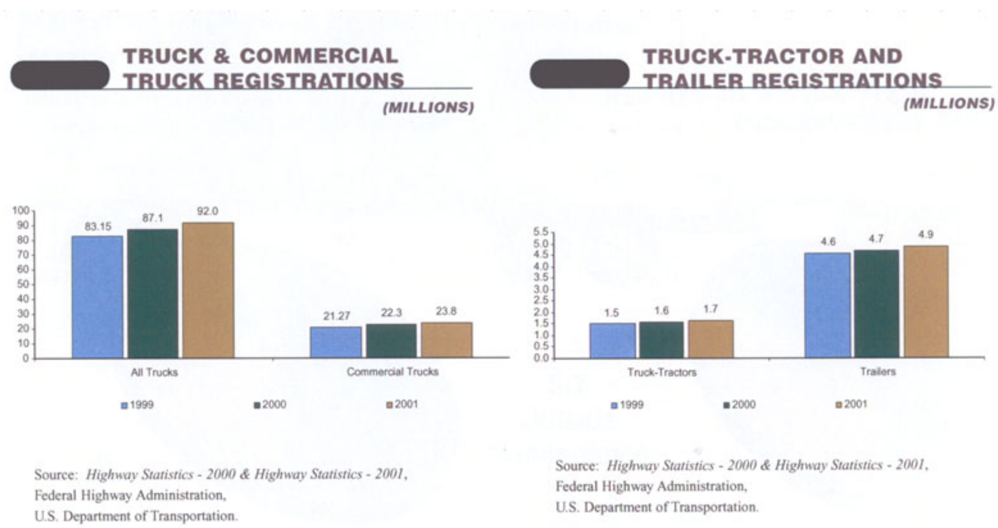

FIGURE 5-1: ANNUAL REGISTRATION OF TRUCKS AND TRAILERS

Source: ATA, 2003

Figure 5-1 demonstrates the growth of truck and trailer registrations in the U.S. for 1999, 2000, and 2001. Clearly the historical trend of growth in the tractor-trailer market is a measured, yet steady increase. The market for refrigerated transportation is substantial and growing. The quantity of refrigerated goods available has increased dramatically over the past few decades. Today, it is evident that the vast majority of purchased foodstuffs are perishable.

> Over the last three years, the number [of shippers] who say there is not quite enough or not nearly enough truck capacity in the temperature-controlled market has grown steadily, from 27% in 1997, to 44% in 1998, to 52% in this year's [1999] report (*C.H. Robinson Worldwide, 1999*).

Figure 5-2 shows an analysis of how consumers spend their dollars at supermarkets, illustrating that over half of an average purchase is on perishable goods.

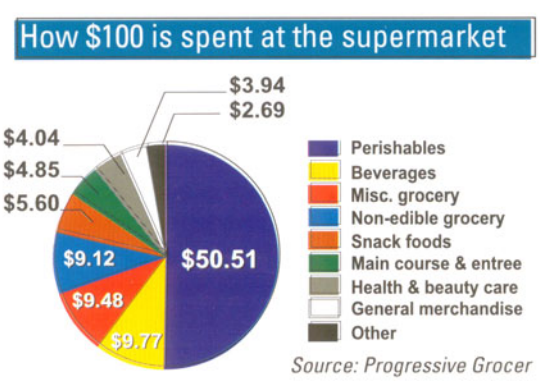

FIGURE 5-2: SUPERMARKET SPENDING

Source: Progressive Grocer, 1998

The analysis of specific trends for refrigerated transport is based on information provided by project partner Carrier-Transicold. Carrier, in tracking sales of its reefer units, has seen a distinct trend toward larger loads per transit. As freight trucking companies look for ways to offset recent declines in profit margins, they have investigated ways to squeeze the most revenue out of each load. The use of thinner insulated walls for the trailers has been pushed and trailer lengths are desired to increase to 57-foot from the 48-53 ft trailers that are currently standard in the industry. Larger trailers and thinner walls mean Carrier has seen a trend toward purchase of higher-capacity reefer units such as the Carrier Ultima XTC as opposed to the medium- and low-capacity Carrier Ultra units. High-capacity Thermo King units include the SB-400, designed for deeply frozen transport, that provides the greatest cooling capacity and a fast temperature pull-down. The X series from Carrier are also improving in maintenance demand, using 18% fewer parts and boasting 23% lower revolutions per minute (RPM). New designs have positioned serviceable parts closer to access points for maintenance (*Deierlein, 2003*). Carrier-Transicold has also indicated that specialized multi-compartment trailers are, and will continue to be, used primarily for local and semi-local distribution. In long-haul refrigerated goods transport, single-temperature trailers will continue to be the standard.

5.3 Environmental Impact

Emissions from TRUs, in the form of greenhouse gases and particulate matter, are currently largely unregulated (as distinct from larger truck engines with strict emission standards and anti-idling laws in place). However, communities are now taking a more vocal stance against the pollution (both exhaust emissions and noise) created by these engines. Of special importance are anti-idling efforts and regulations coming into place. While a majority of these new idle reduction laws are aimed at large truck engines, California and other forward-looking communities are also moving toward limitations on small diesel engines that power TRUs and auxiliary power units. These harmful emissions include carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter (PM), and nitrogen oxides (NO_X). A study (see **Table 5-1**) on contaminants present in diesel exhaust found many harmful compounds. Such emissions reduce air quality locally (at the truck stop and surrounding community) and contribute to state and national air pollution (*CARB, 2003*). It is clear that many communities are very concerned with the reduction of harmful emissions, especially during idle time. Many of the communities along major freight corridors have been the prime sponsors of efforts to introduce anti-idling regulations (both local ordinances and state laws). However the trucking community is also beginning to become more aware of the health issues related to poor air quality at truck stops and rest areas.

TABLE 5-1: TOXIC AIR CONTAMINANTS FOUND IN DIESEL ENGINE EXHAUST

Acetaldehyde	Chlorobenzene	Methanol
Acrolein	Chromium compounds	Methyl ethyl Keytone
Aniline	Cobalt compounds	Napthalene
Antimony compounds	Cresol	Nickel
Arsenic	Cyanide compounds	4-Nitrobiphenyl
Benzene	Dibenzofuran	Phenol
Berillium compounds	Dibutylphthalate	Phosphorous
Biphenal	Ethyl benzene	Polycyclic Organic Matter (including PAHs)
Bis [2-Ethylhexyl]phthalate	Formaldehyde	Propionaldehyde
1,3-Butadiene	Hexane	Selenium compounds
Cadmium	Lead compounds	Styrene
Chlorinated dioxins & dibenzofurans	Magnesium compounds	Toluene
Chlorine	Mercury compounds	Xylene isomers and mixtures

Source: OEHHA, 2001

The Environmental Protection Agency (EPA) uses a specific set of standards to measure emissions from nonroad diesel engines. The standards are divided into several tiers that grow progressively more stringent. The first EPA-enacted standards, the Tier 1 standards, were carried out from 1996 to 2000. Following the Tier 1 standards, the Tier 2 standards, which are current, govern diesel emissions until 2006. These standards were much more demanding than the Tier 1 emission standards. For a nonroad diesel engine of 25-50 hp, the Tier 2 emission standards are 5.5 g/kWh of CO, 7.5 g/kWh of NMHC (non-methane hydrocarbons) + NO_X, and 0.6 g/kWh of PM. While the Tier 1 standard had the same emission limit for carbon monoxide, other pollutant levels were 9.5 g/kWh of NMHC + NO_X, and 0.8 g/kWh of PM. Engines smaller than 37 kW (50 hp) can bypass the Tier 3 standards but are subject to the Tier 4 emission standards taking effect in 2008. The Tier 4 standards set the emission of carbon monoxide the same as the Tier 2/3 standard, but dramatically decrease the PM standard to 0.03 g/kWh and the NMHC + NO_X standard to 4.7 g/kWh (*Diesel.net, 2005*).

Recent studies have shown unacceptable levels of air pollution around truck stops. Particulate matter (PM) emissions from diesel engines are of special concern because PM can cause serious respiratory problems and has been labeled carcinogenic by the State of California. "Diesel exhaust is a complex mixture of thousands of gases and fine particles that contain more than 40 identified TACs [toxic air contaminant]. These include many known or suspected cancer-causing substances, such as benzene, arsenic and formaldehyde" (*CARB, 2003*). Another exhaust pollutant, carbon monoxide, is a poison and often present at unacceptable levels near idling trucks. Carbon dioxide and nitrogen oxides also directly contribute to ground-level ozone and global warming. Localized levels of carbon monoxide in high concentrations can lead to headaches, dizziness and nausea, not to mention long-term health consequences. These issues serve to decrease the quality of a driver's rest period and sleeping conditions, which in turn creates a safety hazard on the roads. A recent report issued by the CARB states that "as many as 14,580 premature deaths in California can be attributed to diesel exhaust annually" (*Macklin, 2005*).

Research of diesel fueled TRUs is being performed at the University of California at Davis. Their focus is to determine the level of NO_X emissions (see **Figures 5-3** and **5-4**) produced by small- and medium-horsepower engines, 11.5 hp and 26 hp respectively, during hot and cold weather condition (100°F and 60°F, respectively). While these TRUs are smaller than the units used for large-capacity trucking, this study is nonetheless useful in defining the temperature-induced emissions performance diesel-fueled systems. Preliminary results found that once these TRU engines warmed up, the ambient temperature had little effect on the level of NO_X emissions that were produced. Additionally, the 26 hp unit had the highest NO_X emission levels, producing 4.3 g/hp-hr. Therefore, it can be assumed that a full-sized 36 hp TRU will have comparable NO_X emissions.

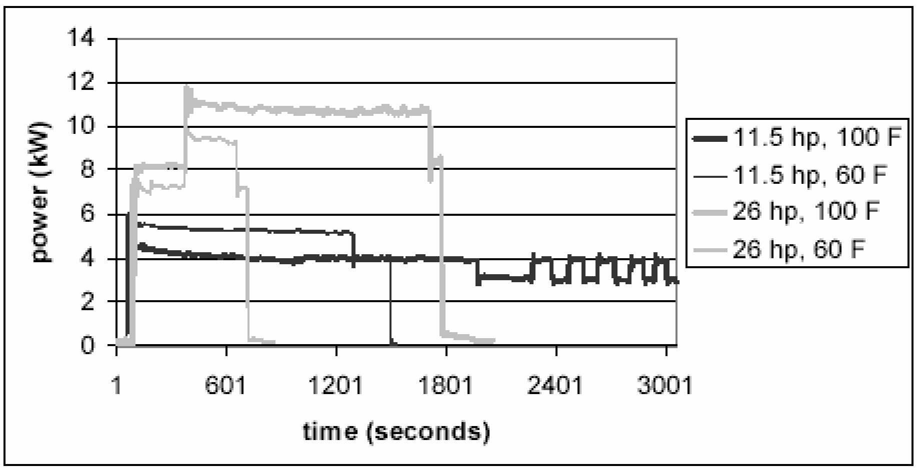

FIGURE 5-3: UC-DAVIS STUDY OF TRUS: POWER

Source: Brodrick, 2005

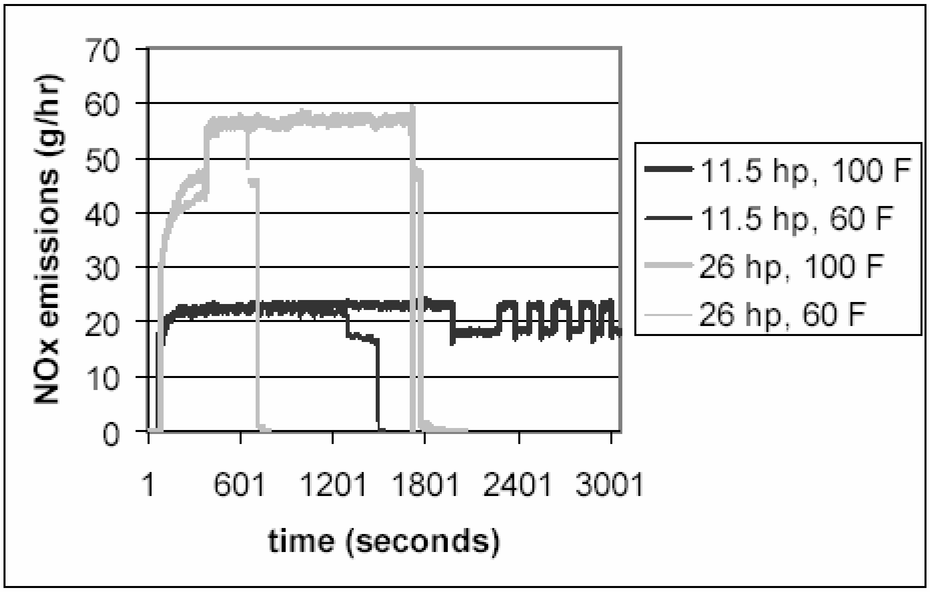

FIGURE 5-4: UC-DAVIS STUDY OF TRUS: EMISSIONS

Source: Brodrick, 2005

Recently, the California Air Resources Board (CARB) approved a ruling regarding the emissions of small diesel engines used for transport refrigeration units (TRUs). The *Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities Where TRUs Operate* (TRU ATCM), became effective December 10, 2004, and can be found in Title 13, California Code of Regulations, Section 2477. Essentially, this measure encompasses all owners, operators and facilities where diesel-fueled TRUs and TRU generator sets are being used in California, regardless of where these companies are based. This is significant because it sets the law to cover all TRUs operating in California, not just those registered in the state. The primary goal of this ruling is to reduce diesel particulate matter (PM) emissions by 65 percent in 2010, and by 92 percent for 2020, with estimated reductions totaling around 3,000 tons by 2020.

The actions of the California Air Resources Board could have a dramatic effect on other states' policies regarding air quality and ultimately the TRU market. The policies enacted for CARB could serve as a model for other states' regulations regarding air quality. Such strict regulations would demand a decrease in the production of diesel exhaust and as a result, the market for the electrification of trailer refrigeration units would greatly increase.

The TRU ATCM implements time-specific guidelines for all in-use diesel engine TRUs based on their horsepower ratings. The eventual goal of this program is to curtail the PM emissions of all operating TRUs by specific dates according to their engine horsepower ratings. The timeline for this project is based on seven-year increments for equipment upgrades that will facilitate each emission stage. **Table 5-2** and **Table 5-3** illustrate the ARB emission standards for each horsepower class and their regulation timelines. **Table**

5-4 illustrates CARB regulations with respect to EPA Tier 2 and Tier 4 standards for all diesel engines ranging from 25 hp to 50 hp.

TABLE 5-2: CARB TRU PERFORMANCE STANDARDS

Proposed TRU and TRU Generator Set Performance Standards

Horsepower Category	PM Emissions Standard (grams/horsepower-hour)	Options for Meeting Performance Standard
Low Emission Performance Standards		
<25	0.30 g/hp-hr	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
= 25	0.22 g/hp-hr	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
Ultra-Low Emission Performance Standard		
<25	N/A	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
= 25	0.02 g/hp-hr	▪ Level 3 verified control strategy (at least 85% PM reduction) ▪ Alternative technologies

Source: CARB, 2003

TABLE 5-3: CARB TRU COMPLIANCE SCHEDULE

Proposed TRU and TRU Generator Set Compliance Schedule

Model Year of Engine	Compliance Date for Low Emission Standard	Compliance Date for Ultra-Low Emission Standard
2001 or older	2008	2015*
2002	2009	2016*
2003	N/A	2010
Future years	N/A	Model year + 7

* Early compliance of low emission standard for model year 2002 or older may extend compliance date for ultra-low emission standard by up to three years

Source: CARB, 2003

TABLE 5-4: COMPARISON OF EMISSION STANDARDS FOR 25-50 HP ENGINES

Emission Standards for Diesel Engines Rated from 25-50 hp					
Regulation	Model Year	Compliance Year	CO (g/hp-h)	NMHC + NO_x (g/hp-h)	PM (g/hp-h)
EPA Tier 2	N/A	2004	4.1	5.6	0.45
EPA Tier 4	N/A	2008	4.1	5.6	0.22
		2013		3.5	0.02
CARB	2001 & older	2008	Same as EPA Tier 4	Same as EPA Tier 4	0.22
	2002	2009			0.22
	2003	model year + 7yrs			0.02

This new ruling specifically targets diesel TRU units operating in the State of California. TRU ATCM encompasses all diesel-fueled refrigeration systems installed in trucks, trailers, shipping containers, and railcars. Therefore, even temporary California operators, those that make pick-ups and deliveries of refrigerated goods to the state, are affected by the ruling. All California sellers, leasers and buyers of TRUs are likewise affected. Additionally, this ruling affects any storage facility in the state with 20 or more loading dock doors that access refrigerated areas.

TRU ATCM regulations require all business that fall into any of the above categories to file a one-time informational report detailing the total size, type and activities performed at those facilities. These reports must include detailed information regarding: the total number of refrigerated trucks, trailers, containers, railcars and TRUs rented or leased by the facility as of December 31, 2005; the total operational hours of each TRU under the facility's control in 2005; the average total number of hours that inbound and outbound TRUs operate at the facility in 2005; the average weekly number of trucks, trailers, containers and rail cars delivering to and from the facility in 2005; the number of refrigerated trailers used for cold storage; the total annual hours of TRU engine operation of these refrigerated trailers; and the total annual hours of operation using electric standby used by these refrigerated trailers. Additionally, all business are required to file follow-up reports upon the addition of any new diesel fueled TRUs to their California-based operations. The initial facility reports are due January 31, 2006.

All in-state diesel-fueled TRUs are now required to have an ARB identification number. To receive an ARB ID number, each facility must submit an application for each diesel-fueled TRU unit used in California. Applications for identification numbers are due by January 31, 2009. The application must include: the TRU and TRU engine make, model (including year), and serial number; all terminals that the TRU is assigned to, including contact information; and compliance status with in-use performance standard according to TRU ATCM, including when compliance was met, what level was achieved (i.e., low-emission or ultra-low emission), how it was achieved, and who did the work.

Penalties for non-compliance of TRU ATCM vary according to circumstances. Failure to report or reporting false information could result in civil penalties. Any violation of in-use requirements could result in penalties that range from $1,000 to $50,000 per day or one year imprisonment, or both (*CARB, 2005*).

Adoption of the eTRU could achieve a great benefit to air quality. As discussed, the small diesel engines that power reefer units emit both exhaust and noise pollution. Small diesels, with no high-pressure injection technology or turbo-charging, are also less sophisticated than truck diesels. There is little, if any, after-treatment of exhaust in these engines and their emissions are not very strictly regulated at this time. Most important, the majority of refrigerated trailers operate in areas with high population densities – the urban areas most at risk of air pollution health effects. Many of these regions are designated as non-attainment zones not meeting acceptable EPA ambient air quality standards. In these non-attainment regions, anti-idling measures are heavily pushed and regulations are often enforced. The concept of idling a TRU is basically the same as for a full heavy-duty truck engine. By electrifying TRUs, and plugging in during layovers and loading times, a major source of pollutant emissions can be removed from these at-risk regions. This shifts the burden of power generation to the grid, supplied by highly regulated power plants. These plants are often located outside of non-attainment zones, providing an additional benefit. More important, emission regulations for power plants are much stricter and can be easily monitored compared to a population of individual reefer units. In a comparison of emissions, those from TRUs were much greater than power plants based on data nationwide and for the State of New York. This can be seen in **Tables 5-5**, **5-6**, and **5-7**.

TABLE 5-5: POWER PLANT EMISSIONS IN 2000

Power Plant Emissions for the U.S. and NY in 2000			
Emission Type	Total Generation (MWh)	**United States**	**New York**
		3,810,305,466	138,757,783
Carbon Monoxide	tons	484,000	N/A
	g/kW-h	0.12	
	g/hp-h	**0.09**	
Oxides of Nitrogen	tons	5,644,354	101,147
	g/kW-h	1.35	0.66
	g/hp-h	**1.00**	**0.49**
Particulate Matter	tons	687,000	N/A
	g/kW-h	0.16	
	g/hp-h	**0.12**	

TABLE 5-6: BENEFITS OF GRID ELECTRICITY USAGE

Emissions Benefits of Grid Electricity Usage			
Emission	**CO** (g/hp-h)	**NMHC + NO_x** (g/hp-h)	**PM** (g/hp-h)
Tier 2	4.10	5.60	0.45
Power Plant	0.09	1.00	0.12
Reduction	**4.01**	**4.60**	**0.33**
Tier 4	4.10	5.60	0.22
Power Plant	0.09	1.00	0.12
Reduction	**4.01**	**4.60**	**0.10**

TABLE 5-7: COMPARISON OF TRU AND POWER PLANT EMISSIONS

Emissions Reduction Using Grid Supplied Electricity Std. TRU vs. eTRU: each operating in standby mode for 10h/day, 6day/wk, 50wk/yr	CO			NMHC + NO_x			PM		
Unit / Emission / Power Rating	(g/hp-h)	(g/h)	(kg/yr)	(g/hp-h)	(g/h)	(kg/yr)	(g/hp-h)	(g/h)	(kg/yr)
Std. TRU / Tier 2 / 34 hp	4.10	139.4	418.2	5.6	190.4	571.2	0.45	15.3	45.9
eTRU / Power Plant / 15kW (20 hp)	0.09	1.8	5.4	1.0	20.1	60.3	0.12	2.4	7.2
Reduction	**4.01**	**137.6**	**412.8**	**4.6**	**170.3**	**510.9**	**0.33**	**12.9**	**38.7**
Std. TRU / Tier 4 / 34 hp	4.10	139.4	418.2	5.6	190.4	571.2	0.22	7.5	22.4
eTRU / Power Plant / 15kW (20 hp)	0.09	1.8	5.4	1.0	20.1	60.3	0.12	2.4	7.2
Reduction	**4.01**	**137.6**	**412.8**	**4.6**	**170.3**	**510.9**	**0.10**	**5.1**	**15.2**

5.4 Competitive Analysis

Based on trailer registrations, the 2003 trailer population in the United States was over 4.9 million vehicles (*ACT, 2003*). As of 2000, about 225,000 of these were insulated trailers equipped with refrigeration units to allow the shipping of perishable goods (*CARB, 2003*). It is estimated that approximately 15,200 of these vehicles are registered in the state of New York.

The production of new trailers in the United States is based on two factors. The first factor is the growth rate of the industry. From 1992-2002, the population of combination trucks (semi-tractor trailers) has increased an average of 3% per year (*U.S. Census Bureau, 2000; ACT, 2003*). To meet this growth rate, 7,000 new refrigerated truck trailers must be placed into the fleet each year. The second factor influencing the production of new trailers is the replacement of retired vehicles. On average, truck trailers are replaced every 8 to 10 years. In order to maintain the fleet, about 26,000 new refrigerated trailers must be produced each year. This would set the typical average demand for new refrigerated truck trailers at about 33,000 units per year. It should be noted that the replacement of these trailers is extremely sensitive to market conditions, yet is becoming a more common occurrence especially with units that have a greater resale value due to added features.

During times of economic downturn trucking companies may opt to refurbish existing trailers and keep them in service in an attempt to reduce short-term costs. This point is illustrated in the 1999-2002 production figures. In a period, refrigerated trailer production dropped from more than 60,000 units in 1999 and 2000 to about 20,000 units in 2001 and 2002 (*ACT, 2003*). However, by 2003 trailer sales were again approaching 35,000 units per year, with market growth rates similar to the pre-2000 trends. The sensitivity to economic conditions makes it very difficult to accurately project demand for refrigerated truck trailers. It can be stated that on average 35,000 units will be sold per year and that during times of economic decline those numbers can drop to as low as

20,000 units. Further, during times of rapid economic expansion refrigerated trailer sales in excess of 70,000 units can be expected (*U.S. Census Bureau, 2000*).

Although sales of refrigerated trailers can swing significantly depending on the economic environment, the sales of trailer refrigeration units may not follow these trends exactly. This is due to the recycling of trailer refrigeration units once trailers have been taken out of service. For example, if one third of the trailers that were kept in service longer during the 2001 and 2002 downturn were refurbished, the sales of trailer refrigeration units would have been about 25,000 units per year.

Introduction of new technologies into the transportation market is generally met with resistance. The transportation industry is highly sensitive to lifecycle costs and is unwilling to take unnecessary risks. This can be exemplified by new tractor purchases in the period prior to the 2004 model year. The industry was aware that new diesel engines were going to be introduced that would meet new tougher emission standards set by the EPA. Because there was concern over the in-service reliability and operating costs of these newer, more sophisticated engines, sales reached an all-time high as buyers "pre-bought" the last engines certified to the previous, less stringent emissions standards. When the new engines were introduced, demand plummeted. It is expected that as experience and confidence in the new technology increases, demand for the new engines will also increase.

The demand for any new technology will be limited by a number of factors, including:

- Whether the new technology is economically feasible?
- Is the new technology reliable?
- Are sufficient infrastructure deployments available to support the technology?
- Do drivers require the new technology or are there incentive programs to generate interest?

These factors could effectively prevent the new technology from entering the marketplace. For example, if the new technology is not economically feasible, it will not be in the best interests of the consumer to purchase and use the new technology. Even if new technology is shown to be economically feasible, if it requires non-existent infrastructure to function it will achieve little market penetration. If the new technology is not reliable, it may not be able to compete in the market with other more reliable technologies. A good example of this is 1970s trailer refrigeration units operated on gasoline or propane using spark-ignition engines. These were less expensive than their diesel counterparts, but not as reliable. Today virtually all engine-powered trailer refrigeration units use diesel engines because of their fuel efficiency and reliability.

It should be noted that when regulatory policy limits the use of a certain technology, competing technologies often find opportunities to enter that market. An example of this would be EPA hydrocarbon emission regulations on gasoline engines. Prior to 1980, carburetors were found on virtually all gasoline engines, even though fuel-injection systems had been introduced in the 1950s. However, as hydrocarbon emission regulations became more stringent, it became difficult for the engine manufacturers to meet them using carburetor technology. By 1985, almost every new car was delivered with a fuel-injection engine. Today, fuel-injection is used on virtually every gasoline engine in production for sale in the United States.

As successful new technologies enter a market they experience several stages of market acceptance. The first stage represents a period during which sales are mainly to "early adopters" with low market penetration rates (less than 5%). The second stage represents a period of rapid market expansion, and the third stage represents a tapering off to market saturation level. In the transportation sector three technologies (ABS, fuel injection, and catalytic converters) can be used to demonstrate some of the variations possible depending on the market drivers being applied to the technology.

Automatic braking systems represent a technology that was viewed by the market as one with a substantial benefit to the consumer. This may have been a result of insurance deductions for vehicles with the technology, coupled with public information efforts by the industry. The market curve for ABS shows a stage-one period of about 8 years followed by a period of rapid market penetration and then by a slow tapering off. Today virtually all light-duty vehicles are equipped with some form of ABS.

The fuel injection market curve represents a technology that was initially view by the market as having a low cost-benefit ratio. Although the technology was introduced in the 1950s it was not until the 1980s that the technology moved from the first stage of market penetration. During this time fuel injection was viewed as an expensive racing technology that provided only marginal benefits over the less expensive carburetors in common use. However, in the 1980s new, tighter vapor emissions standards were introduced by the Environmental Protection Agency. The industry found it more and more difficult to meet the standards using carburetors, but fuel injection systems could easily meet them. The industry made a gradual transition to the new technology over a period of about 10 years. Today, virtually every new light-duty vehicle is equipped with some form of electronic fuel injection.

The final technology evaluated was catalytic converters. In the early 1970s the EPA mandated new regulations that could only be met cost-effectively by using catalytic converters. Within 10 years catalytic converters had passed through the first two stages of market penetration and were reaching market saturation.

Each of these new technologies represents a different market penetration path; the ABS followed a path of high value market perception, the fuel injection systems followed a path of an industry solution to a pending problem, and the catalytic converters were a technology driven by law. Because of the lack of competitive technologies, each of these technologies reached a market saturation level of near 100%. If there had been acceptable alternatives the saturation level could have been much lower.

In each case the rate of market penetration was a function of the perceived need for the technology by the market/industry. Any new TRU technology can expect to experience similar market penetration phases and the market saturation level will vary according to the perceived value relative to the next-best alternative technology.

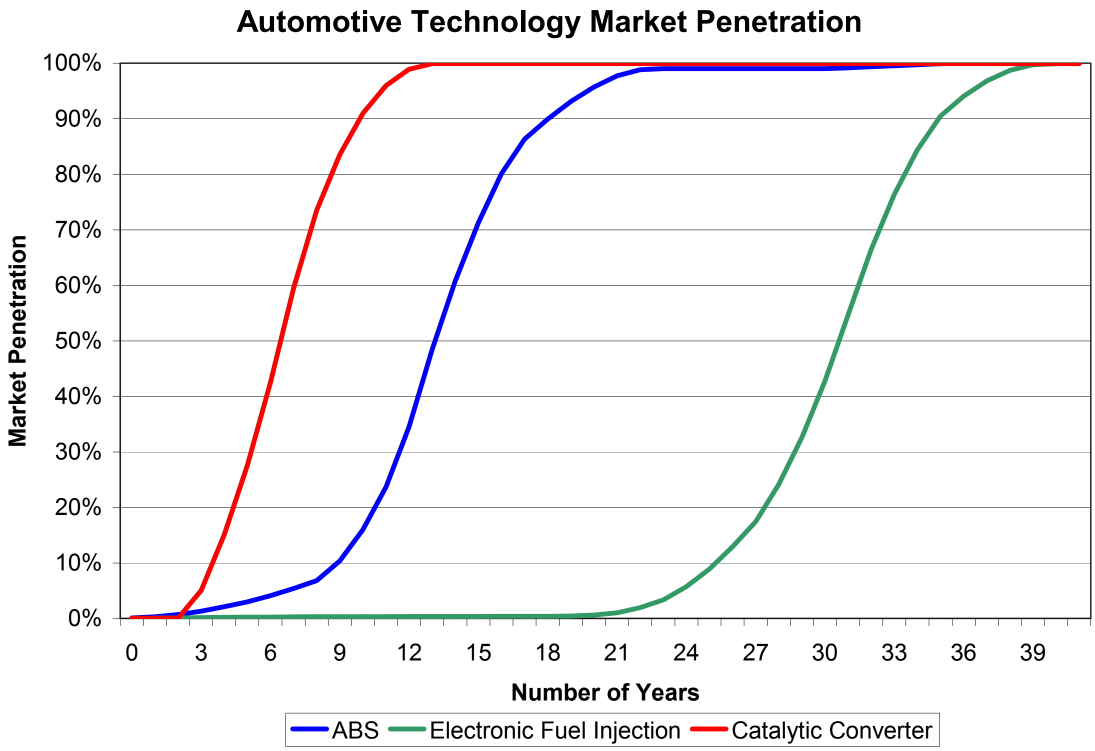

FIGURE 5-5: MARKET PENETRATION OF PAST TRANSPORTATION TECHNOLOGIES

It is expected that a new, cleaner, more efficient TRU technology will follow a curve somewhere between that of ABS and fuel injection, with near-term a market saturation level somewhere between 25 and 75 percent. It should be noted that the length of the first stage of market penetration could be greatly affected by fuel prices and legislation. If fuel prices increase significantly, this stage will be similarly shortened. Similarly, if new legislation makes it difficult for the existing TRU technologies to comply with the regulations while meeting market needs, a new technology will be adopted more readily.

There are a numbers of factors that must be considered when determining the barriers to widespread market acceptance and penetration of eTRU technology. Barriers exist in understanding the issue of idle reduction and emissions from TRUs. Many fleets and operations, especially those outside California, do not recognize the need to reduce exhaust emissions and see EPA mandates as unwarranted regulatory intrusion (*EPRI, 2004*). eTRU purchasing decisions will rarely be made based on energy costs or future benefits. Primary factors that dominate these decisions are the maximization of cargo per load, minimization of time that trailers are empty, and system reliability. Any upfront capital spent for advanced units, including the eTRU, must be seen to provide an immediate economic payback. It appears that most companies do not understand that eTRUs, when compared to conventional TRUs, provide significant operational cost savings. This lack of understanding may be prevalent within the industry since there have not been any widely distributed studies that address operational benefits (lower operational cost and higher reliability) of eTRUs. Electric reefer units also are generally slightly heavier than their counterparts, which negatively affects their perception. Safety issues may also exist, or be perceived to exist with the high-voltage requirements of an eTRU and hazards due to "drive-offs" that could damage equipment. Also, while shore power electricity at rest areas or truck stops would be paid directly by the shipping company, public warehouses or distribution centers are often not owned by the shipping company and the question arises of who bears the cost of electricity.

The TRU market has reached a critical time in the United States. TRUs are currently facing new regulations for engine emissions and noise pollution. These new restrictions may provide opportunities for new technologies to enter the trailer refrigeration unit market. The rate at which the new technologies achieve market penetration will depend on their perceived economics, reliability, and benefits. Early sales of 250 units per year (1% of the current annual sales) for any given new technology should be considered reasonable. Once new technologies have shown their effectiveness, reliability, and economic viability, they should be able to expand their market share based on to their performance and benefits compared to diesel engine powered units.

5.5 Economic Analysis

While everyone can agree that reducing emissions from diesel engines is beneficial on the whole, it is the economics of such efforts that will ultimately drive market penetration. As emissions from the small diesel engines that run TRUs are largely unregulated at present, it is important to focus on economical solutions that will curb these emissions. An economic analysis was undertaken to determine the cost of operating a purely diesel-driven TRU system versus one with electric standby capability (and that of fully electric TRUs). Any savings in fuel must make up for the incremental capital cost of a unit with such capability (a 10% cost increase, approx. $21,700 vs. $19,850 in the New York market).

> The cost of the E/S [electric standby] option adds $2,000 to $2,600 to the cost of a trailer TRU and $350 to $600 to a truck TRU. Adding the power infrastructure at the facilities where TRUs operate is expensive. Loading door outlets cost about $1,250 each if no transformer upgrades are necessary. With transformer upgrades, the cost goes up to $5,000 per outlet for 480-volt and $7,000 per outlet for 208-volt (*Warf, 2003*).

Another important factor to consider are savings resulting from reduced maintenance and extended lifespan. Even without adequate shore power infrastructure, maintenance cost savings alone can provide a payback period in the range of 2-3 years. The conclusions of this analysis clearly indicate that using standby operation in the appropriate manner (i.e., during all Federally mandated rest periods) more than offsets the added unit cost over the period of one year. In fact, the payback period for this incremental unit cost was on the order of half a year.

5.5.1 Fuel Use Cost Analysis

As diesel fuel is currently averaging $2.00-$2.50 per gallon in the United States, and based on projections for these costs to increase, three fuel costs – $2.00, $2.50, $3.00 – were chosen for the basic analysis. Electricity cost was determined to be approximately $0.13 per kilowatt-hour (based on figures from the State of New York). A wide range of fuel consumption rates indicated that consumption varies greatly with operating conditions. Using an average of quoted rates, it was determined that a typical TRU consumes approximately 0.7 gal/hr of diesel fuel in normal operation and an assumed 1.4 gal/hr under pull-down conditions (*Lavrich, 2005*). Electric standby draw, on the other hand, was calculated at 15 kWh per hour for pull-down mode, and 15% (2.25 per kWh) of that for normal temperature maintenance operation. An assumption was made that typical operation would consist of 95% temperature maintenance conditions and 5% pull-down operation (referred to as a 5% PD Operation Profile). Annual use was assumed at 6 days per week (24 hours per day) for 50 weeks during the year. Based on these variables and assumptions, typical average diesel fuel use per hour (including pull-down operation) was set at 0.735 gal while electricity demand would average 2.8875 kWh per hour. The cost of electric standby operation was then figured based on 10 hours mandated rest per day (under electric standby conditions) and the balance under normal diesel operation. This produced an approximate diesel fuel savings of 2,200 gallons annually when using electric standby operation during mandatory rest periods. The results of this analysis are presented in tabular format.

TABLE 5-8: TRU HOURLY ENERGY COSTS

TRU Energy Consumption ($/h) at 5% PD Operation Profile							
Operation	PD	TM	Average	Variable Rate			
Diesel Only		gal/h		$/gal	$2.00	$2.50	$3.00
	1.4	0.7	0.735	$/h	**$1.47**	**$1.84**	**$2.21**
Electric		kW		$/kWh	$0.05	$0.13	$0.15
	15	2.25	2.8875	$/h	**$0.14**	**$0.38**	**$0.43**

TABLE 5-9: TRU ANNUAL DIESEL FUEL USE

Annual Diesel Fuel Use (gal/yr) w/10-hour Daily Standby			
	Hours of Operation (h/yr)		Typical Diesel Fuel Use (gal/yr)
Operation	Diesel	Electric	
Diesel Only	7200	0	**5292**
Electric	4200	3000	**3087**
Difference	3000	3000	2205

TABLE 5-10: TRU ANNUAL ENERGY COST

Annual Energy Cost ($/yr) w/10-hour Daily Standby						
	Diesel Fuel ($/gal)			Electricity ($/kWh)		
Operation	$2.00	$2.50	$3.00	$0.05	$0.13	$0.15
Diesel Only	$10,584	$13,230	$15,876	$0	$0	$0
Electric	$6,174	$7,718	$9,261	$433	$1,126	$1,299
Difference	**$4,410**	**$5,513**	**$6,615**	**-$433**	**-$1,126**	**-$1,299**

TABLE 5-11: ANNUAL ENERGY COST SAVINGS USING ELECTRIC OPERATION

Annual Energy Costs (based on price per gallon)			
Operation	$2.00	$2.50	$3.00
Diesel Only	$10,584	$13,230	$15,876
Electric @ $0.13/kWh	$7,300	$8,844	$10,387
Difference	**$3,284**	**$4,386**	**$5,489**

An economic analysis of reefer operating costs consists of three primary factors: initial capital cost of the unit, fuel use costs, and maintenance costs. As discussed previously, the incremental cost difference of a TRU with standby electric capability is approximately 10% over that of a standard "diesel only" model. Given the current market prices for reefers, this difference equates to approximately $2,000. Thus any savings in fuel use costs must at least offset this difference to make any headway toward market penetration. As the analysis above and presented in **Table 5-9** demonstrates, a TRU operating 6 days per week (full 24-hour operation) for 50 weeks a year and switching to available shore power grid electricity during 10-hour mandated rest periods will realize a diesel fuel savings of approximately 2,200 gallons. When factoring in the straight cost of grid-provided electricity, this represents a potential fuel cost savings of $3,284-$5,489 depending on the price of diesel fuel (see **Table 5-11**). These savings are based on a diesel fuel consumption rate of approximately 0.7 gallons per hour. This is a reasonable average consumption rate; however, based on the type of load and characteristics of operation, this figure could be greater, representing an even larger cost savings.

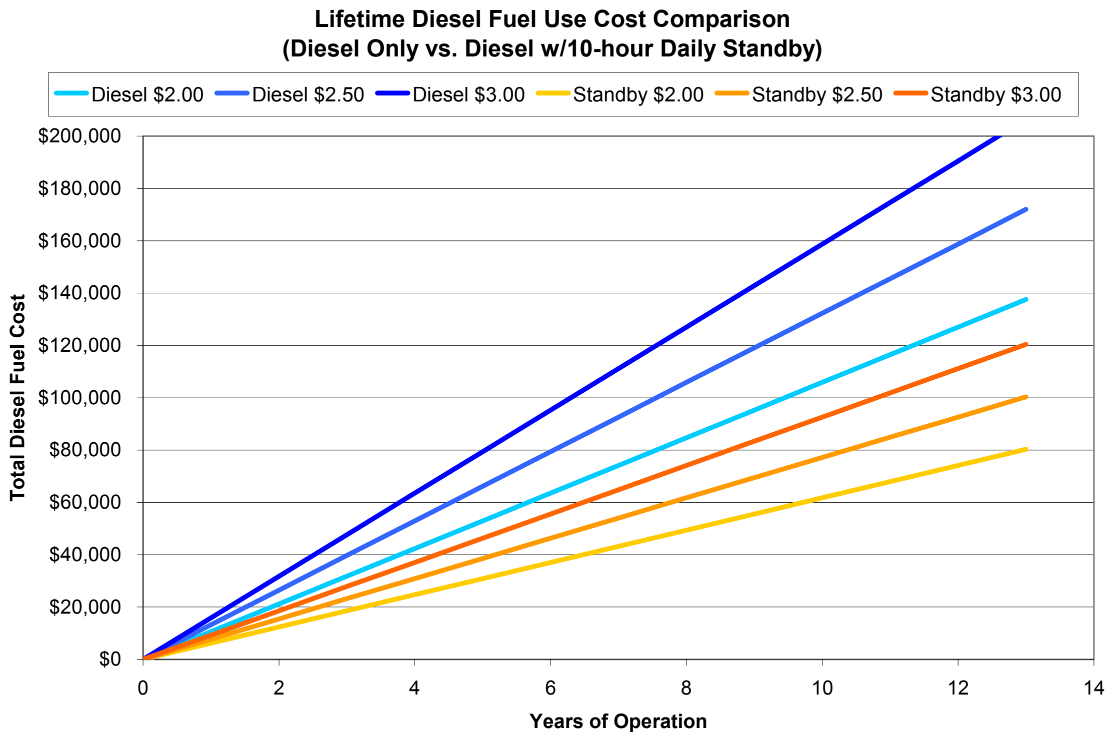

FIGURE 5-6: LIFETIME FUEL USE COST COMPARISON

As illustrated by **Figure 5-6**, given the availability of shore power infrastructure, the potential savings provided with the purchase of an upgraded unit with electric standby capability is significant. The payback period for such a scenario is less than one year. Clearly, over the life of a reefer unit, the fuel savings benefit is an extremely important factor to consider. While the previous analysis focused on a mechanical TRU with electric standby, it also holds for a full electric TRU. The targeted capital cost difference of approximately 10% for standby units is on the same order for an eTRU (approximately 10-20% incremental capital cost). The fuel use savings analysis also holds for the eTRU. Fuel use costs are one of two primary factors determining overall unit operating costs – the other factor is maintenance costs. This is where the main cost difference arises between mechanical TRUs with electric standby and fully electric units. These eTRU reefers contain minimal mechanical components and thus offer a large benefit in maintenance and upkeep. As related to market penetration, this maintenance cost savings is especially critical due to the current lack of available shore power infrastructure. As the section below explores, the economics of electric units based solely on maintenance cost savings make the purchase of an eTRU reasonable.

5.5.2 TRU Maintenance Issues and Cost Analysis

Aside from fuel use costs, maintenance expenses are an important factor in the operation of reefer units that can have a significant impact on the bottom line. Over the operational life of TRUs, periodic maintenance costs add up quickly and should be a factor in any decision on unit purchase. Carrier units have a lifetime spec of 15,000 hours, which corresponds to 10 years of operation at 1,500 hours per year. Typical ownership of reefer units is on the order of 10-12 years, with first owners generally accounting for 5-7 years. Often, after 7 or 8 years of operation, the compressors and engines need to be rebuilt but it is still economical to purchase used units that after overhaul can run for another 5-6 years. Fully electric units, on the other hand, will offer significant benefit in terms of compressor and engine maintenance, which also increases the resale value of the reefer. The market for used TRUs is growing, and Carrier has introduced the first factory-backed warranty program on used reefers with less than 8,000 engine hours logged. Engines for the units are manufactured by a third party (Kubota) to Carrier specifications and currently all units conform to Tier 2 EPA emission standards (*Lavrich, 2005*).

Engine maintenance and filter changes are a portion of these maintenance costs, but mechanically driven compressor units will have significantly greater upkeep needs than hermetically sealed compressors. "The [hermetic] design eliminates many parts that require maintenance, repair, or replacement, thereby reducing maintenance costs and improving reliability. Belts, idlers, clutches, compressor shaft seals, solenoid valves, and vibration isolators are eliminated" (*Carrier, 2005*). As such, electric reefer unit maintenance costs are approximately 30-40% lower than standard mechanical units. This percentage reduction also takes into account some operation in plugged-in, grid-powered mode.

Annual maintenance on TRUs is standard and very important. Guidelines generally call for regular maintenance at 1,500 hours, which approximately equates to an average annual unit use as stated by Carrier-Transicold. With these assumptions, an average unit operation per year used in our maintenance costs analysis is 1,500 hours per year. Periodic maintenance is performed at Carrier certified repair shops and maintenance contracts may average $1.25 per operating hour (flat rate, parts and labor included), while electric units are approximately 30-40% lower in terms of maintenance costs (*Lavrich, 2005*). See **Figure 5-7** for a graphical representation of this analysis of maintenance expenses. Without such maintenance contracts, rates alone for service generally range between $150 and $200 per labor hour and servicing often lasts approximately two hours (*Stewart, undated*).

TABLE 5-12: MAINTENANCE COST COMPARISON

Annual Maintenance Costs ($/yr) Engine/Compressor Operating Hours at 1500 h/yr		
Std. Diesel @ $1.25/h	$1,875	Savings
eTRU @ $0.88/h (30% savings)	$1,313	$563
eTRU @ $0.75/hr (40% savings)	$1,125	$750

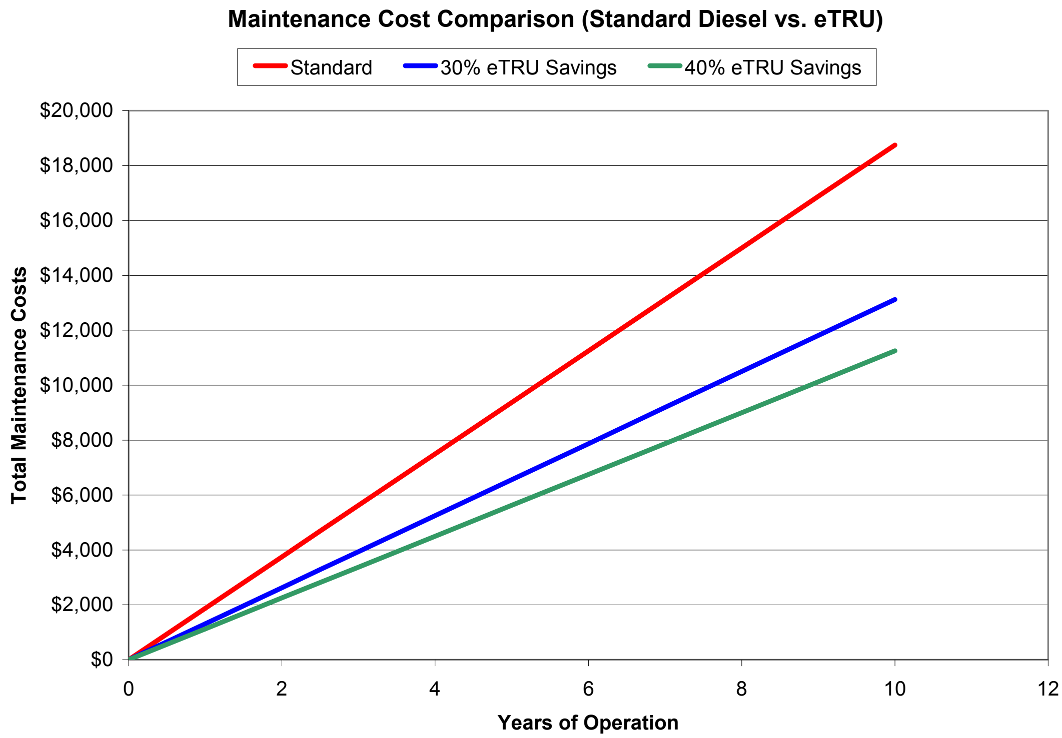

FIGURE 5-7: LIFETIME MAINTENANCE COST COMPARISON

The staple of TRU engine maintenance consists of oil and oil filter changes at every 1,500 hours. Air filters and belts also need frequent periodic maintenance. Several other factors are also outlined in guidelines from Carrier. Inspections should include checks for oil leaks, low oil pressure, fuel system leaks, anti-freeze levels, hoses and connections, water pump function, muffler and exhaust pipes, air intake, battery load, and alternator brushes and output (*Deierlein, 2003*). A full discussion of TRU maintenance issues and procedures can be found in TMC/ATA Recommended Practice 718A. Economic analysis indicates that maintenance costs alone (without factoring in the fuel use savings of shore power operation) will provide a payback to capital cost differences in 2-3 years of operation. This is an important factor because it demonstrates that eTRUs in regular operation are economical based solely on maintenance cost savings. Combined with even limited use of shore power operation, an eTRU can exhibit a great savings in operating costs. While publicly available shore power infrastructure is currently limited, many fleets are refrigerated warehouse operations that would benefit by installing grid electricity at their docks.

5.6 Infrastructure

There are two primary factors that must be addressed to realize the full potential of TRU electrification. First, the TRU units themselves must be replaced or upgraded to provide hybrid capability that will allow them to shut off their diesel engines, yet still cool their load reliably. Second, an adequate network of electrification infrastructure (shore power) has to be deployed across the nation to allow access to grid electricity. Generally, it is accepted that grid electrification is a positive advancement, and with demonstration projects the reliability of an eTRU will be proven. However if available plug-in shore power connections are few and far between, acceptance and market penetration of eTRUs will be a slow, and perhaps unsuccessful process. Yet the realized benefits of electric reefer units are twofold: increased lifetime and decreased maintenance costs can provide a savings greater than the upfront incremental cost of the upgraded unit; and actual fuel savings during shore power use while trucks are parked are substantial (with enough access points). With potential incentive programs, the simple reduction in maintenance costs of the electric units over mechanically driven reefers will allow market acceptance of the eTRU approach. To drive significant market penetration, however, shore power access will be the critical factor. For that reason, an analysis of the current and future status of shore power infrastructure was undertaken and will be summarized in this section.

While shore power and truck stop electrification (TSE) services are a new, growing market in the United States, the primary – if not exclusive – focus has been on providing truck cab power. Traditional TSE efforts have attempted to solve the problem of idling large diesel engines while trucks are parked during rest periods. However, the requirements of cab power are much different than those of electric reefer units. Deployment of shore power to date (IdleAire and Shurepower are the industry leaders) has been exclusively single-phase cab power, generally at either 120V or 208/240V. Electric TRUs, on the other hand, generally require three-phase power, especially the larger units made for trailers rather than small straight trucks. In addition, while the 20-30 shore power facilities through the country (the majority run by IdleAire) have access to three-phase power, plug-in connections for three-phase have not been installed. The trends demonstrated in the TRU industry, as gathered from Carrier-Transicold, Thermo King, and other small manufacturers, indicate that the desired shore power connection is 460V 3-phase electricity. At this point, those requirements are not readily compatible with current shore power TSE deployments. In terms of publicly accessible facilities, since TRUs have a high-power requirement, a greater charge can be assessed for grid electricity use as opposed to the cost for cab power. TRU use is also required year-round for many loads and with truck driver rest rules under review, layover times and reefer fuel costs could increase.

The current availability of shore power infrastructure at public rest areas and truck stops is virtually insignificant. The largest company involved, IdleAire, owns the greatest number of shore power sites nationwide. Yet currently that figure is only between 20-25 fully operational locations. This certainly does not amount to a sufficient network of shore power access points to drive the economics of anti-idling measures for either the truck cab or TRU. In addition, while IdleAire sites can provide 208V 3-phase power for reefer units, very few TRU plug-in connections, if any, have been installed to date due to the associated capital costs. Only single-phase (120V) plug-ins have been installed for block heater connections, cab power, and auxiliary power units. At this point, it would not make sense for the company to upgrade to 3-phase connections due to the limited number of electric TRUs in the market. Eventually, once market penetration begins to occur and/or tougher anti-idling legislation becomes strictly enforced, there will be a market for 3-phase TRU power and a network of infrastructure will begin to form.

Until such time as a significant number of shore power access points become available publicly, the economics of electric TRUs will rely on savings in maintenance and lifecycle costs. As discussed previously, decreased maintenance costs of 30-40%, in addition to a longer lifespan and higher resale value, make the purchase of an eTRU economical. However another factor to consider is private shore power access installed by warehouses, depots, and fleet base operations. Installing private plug-in infrastructure can often make sense financially. The capital cost associated with such installations is a fraction of that for a publicly accessed system. This is due to the need for a public system to be closely monitored and have control-system architecture in place to authorize use of the electricity. As a result, depot yards and warehouses of fleets that specialize in refrigerated transportation can realize fuel cost savings by plugging their trucks and reefer units into grid electricity overnight, while loading and unloading, and during pull-down reefer operation. This last point is important to focus on because it could provide a large savings in fuel. A transportation survey showed that "company drivers and owner-operators spend an average of 42 and 44.5 hours a week, respectively, just waiting to load or unload" (*C.H. Robinson Worldwide, 1999*). More recent figures indicate that shippers are spending an increasing amount of time loading and unloading.

> Shippers report that carriers wait, on average, 86 minutes for an opportunity to load, and say that the actual loading time takes 82 minutes. These figures are up from 69 minutes and 66 minutes, respectively, a year ago. Once at the receiving location, carriers wait 75 minutes for the opportunity to unload, and actual unloading consumes 66 minutes, the same as last year (*C.H .Robinson Worldwide, 1999*).

The most intensive operation performed by a TRU (and its greatest amount of fuel use) occurs in pull-down mode, which rapidly lowers the trailer's interior temperature to be ready to accept refrigerated cargo. New fully electric units – in contrast to mechanical TRUs with electric standby – can perform pull-down operation while plugged into grid electricity. If pull-down operation occurred every morning using grid electricity rather than diesel-supplied power, the fuel savings benefit of an eTRU would increase dramatically. Thus, one can expect the market of shore power infrastructure will take hold at fleet yards and warehouses in order for fleets and warehouse customers to benefit from fuel savings.

The growth of refrigerated warehouse space has also been significant over the past several years. As of October 1997, total public refrigerated warehouse space in the United States equaled 2.044 billion cubic feet. This represents an increase of 17.4% over two years (*C.H. Robinson Worldwide, 1999*). In fact, as demonstrated in **Table 5-13**, refrigerated warehouse space has been growing steadily since 1987.

TABLE 5-13: GROSS U.S. REFRIGERATED STORAGE CAPACITY

Gross refrigerated storage capacity in United States by type of warehouse 1987 - 1997 (In Thousands of Cubic Feet)

	PUBLIC			PRIVATE AND SEMIPRIVATE		
Year	Freezer	Cooler	Total	Freezer	Cooler	Total
1997	1,686,697	357,212	2,043,908	406,111	277,261	683,372
1995	1,444,023	297,562	1,741,585	421,722	252,927	674,649
1993	1,372,005	306,456	1,678,461	405,378	253,516	658,893
1991	1,293,382	279,497	1,572,879	387,602	236,403	624,005
1989	1,128,768	263,132	1,391,901	368,271	235,130	603,402
1987	1,033,677	252,182	1,285,860	396,240	280,128	676,369

Source: U.S. Department of Agriculture, FFA/Freeze Frame

Source: FFA/Freeze Frame,1998

Data concerning the amount, type and location of total refrigerated warehouse space for 2003 was collected by the United States Department of Agriculture's National Agriculture Statistics Service (NASS) in its 43rd biennial *Capacity of Refrigerated Warehouses* report. Data was amassed for each state and compiled to obtain national totals. NASS categorized all warehouses into either public, or private and semiprivate. Additionally, they separated usable warehouse space from gross warehouse capacity.

The United States has 1,482 refrigerated warehouse facilities. Of these, 81 are located in New York State. Thirty-one are public and 50 are private or semiprivate facilities. Thus New York State has 5.47 percent of the total refrigerated warehouses in this country. The national total refrigerated warehouse space is approximately 3.16 billion cubic feet. New York State has approximately 99.3 million cubic feet or 3.14 percent of the U.S. total. The national and New York State gross refrigerated warehouse capacities have been growing steadily every year. Since 1987, the U.S. gross refrigerated space has increased by 157.4 percent, and New York State's has increased by 133.8 percent.

TABLE 5-14: NUMBER OF REFRIGERATED WAREHOUSES

Refrigerated Warehouses: Number by Type, October 1, 2003			
	General Storages		
	Public	Private & Semiprvt	Total
Location	Number	Number	Number
NY	31	50	81
US	827	655	1,482

TABLE 5-15: GROSS AND USABLE REFRIGERATED SPACE

General Storages: Gross and Usable *Refrigerated* Space by State and United States, October 1, 2003						
	Gross Space			Usable Space		
Location	Public 1,000 Cubic Feet	Private & Semiprvt 1,000 Cubic Feet	Total 1,000 Cubic Feet	Public 1,000 Cubic Feet	Private & Semiprvt 1,000 Cubic Feet	Total 1,000 Cubic Feet
NY	59,599	39,679	99,278	49,088	33,075	82,164
US	2,357,080	802,454	3,159,535	1,887,735	622,151	2,509,886

TABLE 5-16: GROSS AND USABLE COOLER SPACE

General Storages: Gross and Usable *Cooler* Space by State and United States, October 1, 2003						
	Gross Space			Usable Space		
Location	Public 1,000 Cubic Feet	Private & Semiprvt 1,000 Cubic Feet	Total 1,000 Cubic Feet	Public 1,000 Cubic Feet	Private & Semiprvt 1,000 Cubic Feet	Total 1,000 Cubic Feet
NY	10,384	20,343	30,727	7,167	17,346	24,513
US	384,779	311,464	696,243	301,630	239,982	541,612

TABLE 5-17: GROSS AND USABLE FREEZER SPACE

General Storages: Gross and Usable *Freezer* Space by State and United States, October 1, 2003						
	Gross Space			Usable Space		
Location	Public 1,000 Cubic Feet	Private & Semiprvt 1,000 Cubic Feet	Total 1,000 Cubic Feet	Public 1,000 Cubic Feet	Private & Semiprvt 1,000 Cubic Feet	Total 1,000 Cubic Feet
NY	49,215	19,336	68,551	41,921	15,729	57,650
US	1,972,301	490,990	2,463,291	1,586,106	382,169	1,968,275

TABLE 5-18: GROSS WAREHOUSE CAPACITY OF U.S. AND NY

Refrigerated Warehouse: Gross Capacity by Type of Warehouse, October 1, 1987-03						
	US			NY		
Year	Public 1,000 Cubic Feet	Private & Semiprvt 1,000 Cubic Feet	Total 1,000 Cubic Feet	Public 1,000 Cubic Feet	Private & Semiprvt 1,000 Cubic Feet	Total 1,000 Cubic Feet
1987	1,306,000	1,171,000	2,476,000	48,897	25,275	74,172
1989	1,414,000	1,158,000	2,571,000	57,910	32,888	90,798
1991	1,600,000	1,208,000	2,808,000	61,128	31,169	92,297
1993	1,700,000	1,272,000	2,972,000	53,487	29,003	82,490
1995	1,765,000	1,323,000	3,088,000	50,364	34,693	85,057
1997	2,068,000	1,359,000	3,427,000	53,708	30,782	84,490
1999	2,168,000	1,437,000	3,606,000	51,096	33,111	84,207
2001	2,266,000	1,501,000	3,767,000	54,048	32,155	86,203
2003	2,370,000	1,526,000	3,896,000	59,599	39,679	99,278
% Change	181.5	130.3	157.4	121.9	157.0	133.8

The sources for **Tables 5-14** thru **5-18** are the *USDA's NASS 2003 Capacity of Refrigerated Warehouses* report. These reported figures on warehouse capacity classify space into public and private facilities. Public cold storage refers to warehouse space leased by the property owner to refrigerated transport companies. Private facilities provide storage exclusively for their own operations. To be categorized as a cold storage facility in this dataset, warehouses must normally store goods for at least 30 days and be cooled to a temperature below 50 degrees Fahrenheit. The categorization of "freezer space" is defined as storing goods at 0ºF or below. "Gross space" refers to the total area under refrigeration, measured wall to wall and floor to ceiling. "Usable space" includes the actual area used for storing commodities not including space for aisles, posts, blowers, and so forth (*NASS, 2004*).

Another aspect of an infrastructure assessment involves unit service and maintenance rather than plug-in availability. This is an important factor to consider due to the fact that electric-driven TRUs are significantly different from mechanical units in their inner workings. This issue is not a large barrier to market penetration; the problem is limited due to available service locations for reefer units in general. As TRUs are fairly complex systems, the vast majority of owners (over 95%) service these units at registered Carrier- or Thermo King-certified repair facilities. This limits the need for training on the electric units to a relatively small subset of technicians. Carrier has already implemented a plan to provide formal training on these new units as they become available and will ensure that service and replacement parts are stocked at all repair facilities. Actual repair and maintenance of the electric reefer units will not be significantly different from normal TRUs, although eTRU maintenance costs are much lower (30%-40%). Carrier-Transicold has indicated that some repair work may involve slightly longer durations, however, not to the extent that it will affect the length of unit downtime. More important, electric units will in fact require less service and maintenance than mechanical units. This is evidenced through study of the European market where a large number of electric units are in operation. The lifespan of electric units will be longer though generally limited by lifetime of the trailer itself and reliability will be greatly improved.

6.0 PARTNERSHIP DEVELOPMENT

To identify the best candidate for partnership, an approach was established to evaluate and reduce the candidates in a systematic fashion, eliminating candidates that would not meet the minimum criteria for a successful demonstration of this technology. To accomplish this, selection criteria were established to assist the down-selection of candidates.

6.1 Developing criteria to evaluate NY trucking fleets transporting refrigerated goods

Identifying the right partner can make or break a demonstration project, so this selection process was heavily emphasized and carefully implemented.

The criteria for this evaluation were established to determine the best partner in several areas. These included fleet location, fleet operations, fleet size, partnership ties with Carrier-Transicold (the subcontractor participating in this development effort) commitment to integrating technology into operations, and electrical capacity at the demonstration site. These six areas of evaluation listed below were converted into logical and quantitative criteria limits, where possible.

TABLE 6-1: NY TRUCKING FLEET EVALUATION CRITERIA

Criterion Number	Evaluation Metric	Comments
1	Fleet is based in New York State	Required for NYSERDA-funded demonstration
2	Fleet uses refrigerated trailers to transport cargo	Required to demonstrate eTRU technology
3	Fleet operates at least 10 refrigerated trailers for cargo transport	Required to compare control and test units
4	Fleet has purchased or plans to purchase Carrier-Transicold Trailer Refrigeration Units (TRUs) for trailer refrigeration	Proprietary information supplied by Carrier-Transicold
5	Fleet is committed to demonstrating innovative high-technology solutions and integrating them into its operations	Qualitative evaluation from past experience (Proprietary information obtained by Carrier-Transicold)
6	Fleet's refrigerated warehouse has high-voltage electric power for eTRU operation	Capacity to install high-voltage service also acceptable

Criterion #1: Fleet is based in New York State

The first evaluation criterion is to identify fleets with operations in New York State. This is required, as this demonstration activity is funded with New York State dollars and the location must be within a reasonable distance of Carrier-Transicold in Syracuse, NY, to enable quick resolution of any demonstration unit issues that require direct support from headquarters.

Criterion #2: Fleet uses refrigerated trailers to transport cargo
This criterion has been specified to ensure all non-refrigerated transporters are eliminated. This also eliminates refrigerated sea containers used for on-site storage. These would be eliminated, as they no longer operate as trailers which can be used to transport cargo.

Criterion #3: Fleet operates at least 10 refrigerated trailers for cargo transport
For this demonstration, a fleet must operate at least 10 trailers that use trailer refrigeration units. For the next phase, at least 5 demonstration units and 5 control units will be required for data collection, which sets the minimum number of refrigerated trailers needed.

Criterion #4: Fleet has purchased or plans to purchase Carrier-Transicold Trailer Refrigeration Units (TRUs)
As Carrier-Transicold is a key participant in this activity, it is critical that a current or possible future client of theirs be identified as the demonstration host. Criterion #4 was established to ensure such fleets are the only ones considered. However, this evaluation is not to be shared to ensure that all business-confidential marketing data remains confidential.

Criterion #5: Fleet is committed to demonstrating innovative high-technology solutions and integrating these into its operations
It is important that the fleet selected be familiar with advanced technology and has participated in beta testing of technology previously. Selecting a fleet that has experience with new technology will improve the data collection, as a fleet that has gone through this activity previously would be more likely to understand the many anticipated and unanticipated actions required outside normal operating procedures.

Criterion #6: Fleet's refrigerated warehouse capable of installing high-voltage electric power for eTRU operation
A less important criterion, but one that will enable the effective selection of the participating fleet is the availability of high-voltage (460V 3-phase) power at the warehouse facility. This level of electrical service will be needed to power the electric TRU units; however, existing capacity is not absolutely required; if a facility is willing to work with the local utility to install this additional electrical capacity, it, too, would be considered (although not preferred) for the fleet demonstration.

6.2 Process and Evaluation

Several sources of information were used to assemble a detailed list of possible partners for eTRU demonstration and deployment. Information sources used include FleetSeek, ATA Fleet database and internet researching. From these sources, a table was developed summarizing the fleets that met the Criteria 1 and 2. This detailed list is provided in **Appendix B**. From this list, a review was performed to determine which fleets met the third criterion, refrigerated trailer fleet size. These fleets, identified in **Appendix C,** were discussed with Carrier-Transicold personnel to determine, first, which of these purchase Carrier-Transicold TRUs (Criterion 4) and from this pared-down list, Carrier helped to identify fleets that have expressed interest in advanced TRU technology (Criterion 5). A single candidate was identified at this point and Criterion 6 was applied. The high-voltage electrical infrastructure for the required 460-volt, 3-phase connections was confirmed as acceptable by New York State Electric and Gas, the electric utility for the warehouse of the identified candidate. Thus, after all criteria were applied, one candidate was identified as the best possible choice, MAINES Paper & Food Service Inc. headquartered in Conklin, NY.

6.3 Down Selection and Justification

Criterion #1: Fleet is based in New York State

MAINES is headquartered in New York State and transports refrigerated cargo across the Mid-Atlantic and Northeastern United States. They operate a major refrigerated distribution warehouse in Conklin, NY, 80 miles south of Syracuse, NY.

Criterion #2: Fleet uses refrigerated trailers to transport cargo

As can be seen in **Appendix B2**, MAINES transports beverages, processed foods, and other materials via refrigerated trailers.

Criterion #3: Fleet operates at least 10 refrigerated trailers for cargo transport

As can be seen in **Appendix C2**, MAINES has a total of 125 trailers, far exceeding the minimum of 10 trailers needed for this demonstration. Although the data we were able to collect do not segregate the non-refrigerated trailers from the refrigerated trailers, we are assuming that MAINES does have more than 10 trailers equipped for transported refrigerated goods. This assumption will be confirmed prior to proceeding on to the final selection.

Criterion #4: Fleet has purchased or plans to purchase Carrier-Transicold Trailer Refrigeration Units (TRUs) for trailer refrigeration

Carrier indicated that MAINES is a current customer of theirs and possesses in excess of 10 refrigerated trailers. Therefore both Criterion #3 and #4 are confirmed.

Criterion #5: Fleet is committed to demonstrating new and innovative high-technology solutions and integrating these into operations

MAINES states as their mission "This mission is being pursued by drawing on the synergies between the skilled and dedicated MAINES workforce and the *utilization of leading edge technologies and equipment.*" In addition, information technology (IT) is a core competency at MAINES Paper & Food Service Inc. MAINES uses state-of-the-art technologies and facilities to achieve operational excellence and to "deliver the best customer service in the industry." MAINES works very closely with their foodservice operator and vendor partners to improve system integration and to increase efficiencies in their supply chain. This is an indicator of their ability to act as a beta test fleet for the Electric Trailer Refrigeration Units. Their ability to participate as a test fleet for this technology was confirmed by Carrier-Transicold and through subsequent discussions with MAINES' management. Also, MAINES has been at the forefront on technology integration as demonstrated by the many technology assessment case studies performed on this organization. They have integrated logistical and scanning application technology and have been commended by the Governor of New York. These two case studies are provided in **Appendices D and E** and the press release on the commendation from the Governor's Office is provided in **Appendix F**. In addition, this technology adoption has permitted MAINES to experience exceptional operational growth. MAINES is ranked as the number 6 food distributor in the nation and is one of the fastest-growing national food distributors (third-fastest in percent sales increase and fifth-fastest in dollar sales increase), which is illustrated in **Appendices G and H**. All data show that MAINES has been willing to test and integrate new technology in their operations and their operations have improved as a result. MAINES Paper & Food Service Inc. thus meets criterion #5.

Criterion #6: Fleet's refrigerated warehouse has or can install high-voltage electric power for eTRU operation

The high-voltage electrical infrastructure required for the 460-volt 3-phase connections was confirmed acceptable by New York State Electric and Gas, the electricity supplier for MAINES. Therefore the existing infrastructure is satisfactory for the installation of high-voltage electric power for operation of eTRUs. Therefore, the sixth and final criterion was successfully met by MAINES.

6.4 Detailed Information on Targeted Demonstration Partner

MAINES Paper & Food Service Inc. is the nation's second-largest independently held foodservice distributor. With over 85 years in the foodservice industry, MAINES has annual sales in excess of $1.6 billion. MAINES services restaurants, healthcare and educational facilities, and other foodservice customers in 35 contiguous states throughout the Northeast, Mid-Atlantic, Gulf States and Mid-West from nine distribution centers. Corporate Headquarters is located at 101 Broome Corporate Parkway, Conklin, NY 13748. Phone: 607-779-1200

Floyd L. Maines, Sr. founded Maines Candy Company in 1919. Maines sold nickel candy such as Milky Ways, Reese's Peanut Butter Cups, Hershey Bars and Candy Cupboard Chocolates to local grocers. The average order was $20 and resulted in first year sales of $30,000.

Floyd L. Maines, Jr. joined the business in 1947 after serving five years in the Navy. His first choice was to go into the FBI, but his father convinced him to join the family business. Floyd Jr. initiated an expansion into fountain supplies, toys, and paper including napkins, straws, and paper cups. He was able to persuade a couple of his friends to become salesmen for the company now named Maines Candy Company, and they expanded the business four-fold.

Floyd Jr.'s sons David and Bill joined the family business in 1970 and 1978 respectively. They expanded the business into foodservice and extended the product offerings to include frozen and canned goods, beverage items, and cleaning chemicals. With this product line expansion, the company name was changed to MAINES Paper & Food Service, Inc.

MAINES began pursuing the casual dining segment of the industry which powered the company's growth through the 1980s. By the mid-80s MAINES broke into the Top 50 of food distributors in the nation, and was ranked 43rd by Institutional Distributor magazine.

In 1984, a Cash & Carry store was opened to serve independent operators and the public. Today, MAINES has two Cash & Carry locations that each have a federally-inspected fresh meat center, and stock a wide variety of dry, frozen, and fresh food items as well as cleaning chemicals, paper, plastic, and party goods.

Due to unprecedented growth, a second distribution center was opened in Cleveland, Ohio in 1987. This facility serviced the mid-west region of multi-unit accounts.

In 1990, an equipment supply contracting company was acquired to add a full line of smallwares and equipment, contract design services, full HVAC and refrigeration installation and service.

By 1996, it was becoming evident that there was real need to maintain a professional and well-trained staff of drivers. The fleet had grown in the early nineties by 14 additional tractors bringing the total fleet to 39. As a result, the MAINES Driver Training Institute was established to help provide MAINES with well-trained drivers. The school provides the necessary training for a CDL license, and has a reputation as one of the finest in the northeast. It was selected by Institutional Distributor magazine as Innovation of the Year by a foodservice distributor.

A 360,000 square foot, world-class distribution center was constructed in 1999 and became the Corporate Headquarters for MAINES Paper & Food Service, Inc. This state-of-the-art facility has five temperature zones and temperature controlled shipping/receiving docks. It is equipped with a fully functional Test Kitchen and Learning Center for product cuttings, menu roll-outs and training sessions.

The largest growth in MAINES history took place in 2000 when MAINES opened four new distribution centers in Oxford, MA; Oakwood Village, OH; Farmingdale, NY; and Conklin, NY to service over 1,700 Burger King restaurants. Today, MAINES is the nation's largest foodservice distributor in the Burger King system.

In 2001, after 82 years and three generations, the MAINES family appointed a non-family member as President and CEO of MAINES Paper & Food Service, Inc. Chris

Mellon had been with the company since 1998 and served as Chief Financial Officer prior to his new appointment. This change allowed Bill and David to become co-chairmen of the board of directors and Floyd, Jr., chairman emeritus.

Currently, MAINES is the fifth largest foodservice distributor in the country, and is poised for further growth.

7.0 RESULTS AND DETAILED ANALYSIS

The data gathered and results generated from the market study and technology assessment were integrated to look at the economics of the eTRU. The market penetration of the eTRU is studied considering several diesel fuel prices. In addition, the payback period of the initial cost of changing to an eTRU is discussed and compared to the payback period of a standard, diesel-driven TRU.

7.1 Market Penetration Analysis

The eTRU has reached a significant level of acceptance in Europe because of its quiet operation, lack of point-source emissions, high reliability, and reduced maintenance costs. Estimates using existing data indicate that, even with limited infrastructure availability, these units can have a positive lifecycle (4-year cycle) impact with $2.00 per gallon diesel fuel.

However, fuel prices, anti-idling regulations, and incentives can have a major impact on the projected market penetration for these systems and, with annual replacement rates of about 6%, it will take a long time (15 years) to have a major impact on the fleet. The following graph illustrates that under current conditions eTRUs could reach market penetration levels of 30 percent by 2020. The graph also shows the strong impact of diesel prices on the probable market penetration of these new systems.

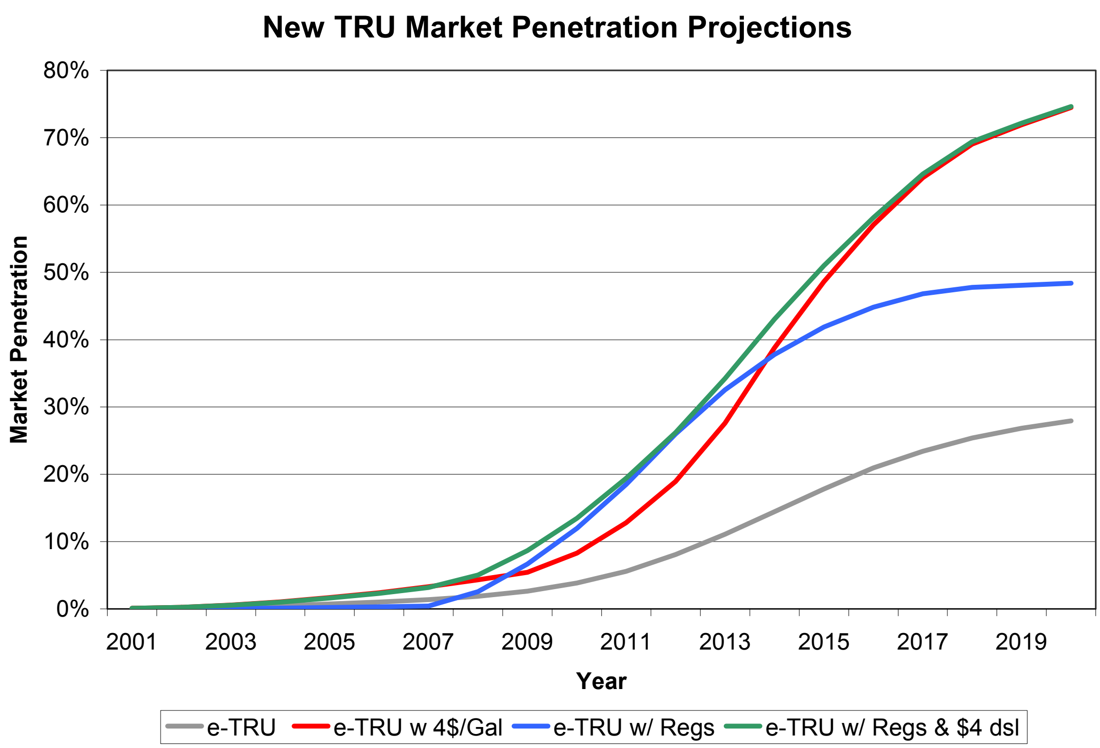

FIGURE 7-1: NEW eTRU MARKET PENETRATION PROJECTION S-CURVES

The graph shows that if diesel fuel prices climb to $4.00 per gallon, electric TRUs could have penetration rates in excess of 70% by 2020. This is due to the fact that the net 4-year lifecycle return would increase from $400 to $4,500 as a result of the increase in fuel costs.

In order to assess the potential impact of regulations on electric TRUs, it was assumed that New York and California initiate TRU anti-idling legislation in 2006. These states were chosen because, combined, they originate or receive approximately 50% of the refrigerated truckloads in the United States. The graph shows that it would take approximately one year after the regulations were implemented before significant market penetration could be realized. However, after the first year the market penetration would increase at a rate of between 2 and 5% per year, peaking about 15 years after the initial regulation implementation. The overall market penetration would be primarily due to refrigerated trailers servicing terminals in the New York and California markets.

The final curve in the graph illustrates how the combination of high fuel prices and regulations could result in earlier adoption of the new technology and higher total market penetration levels. Under this scenario it is projected that eTRU market penetration levels could approach 80% in the 2020 timeframe.

7.2 Operation Parameter Sensitivity Analysis

Through assessment of the various cost parameters associated with standard diesel TRU and eTRU operation, comprehensive sensitivity analyses of all single parameters was performed. These analyses take in account all known and anticipated costs affecting the operation of either the standard TRU or the eTRU. The aim of these analyses is to determine the sensitivity of the cost of TRU operation to different parameters. It can thus be determined if the price of diesel fuel, for example, has a greater or lesser effect on operating costs compared to unit maintenance costs or another cost variable. To perform these analyses, unified cost equations were constructed to generate operating costs for these two types of TRUs based on various assumptions (parameters in the equation). Baseline assumptions were determined, factoring in market statistics and unit operating characteristics, to give best estimates of these operating costs. Minimum and maximum limits for the various parameters were then chosen based on anticipated differences in operating conditions. Before discussing the actual cost equation, a definition of these parameters is necessary.

7.2.1 Definitions

The parameters investigated include: diesel fuel cost (based on fuel consumption rates, diesel fuel cost per gallon, and operational profile); electricity costs (based on standby grid usage, electricity rates, and unit power consumption); and maintenance costs (based on engine/compressor hours and maintenance costs per engine hour).

- **Engine/Compressor Operating Hours** – the annual sum of hours the TRU is actively cooling cargo with the compressor running. In pull-down mode (PM), the compressor is running continuously; in temperature maintenance mode (TM), the compressor might run only 15-30% of the time (its duty-cycle). This is due to the unit's cycling on and off to maintain an interior trailer temperature (within a range of ±5°F generally).

- **TRU Usage** – total annual hours during which the TRU was cooling or maintaining a set temperature within the trailer. This figure includes time when the unit is actively cooling cargo with the compressor running (*Engine/Compressor Operating Hours*) and idle time when the unit has cycled off temporarily.
- **Pull-down Operation Profile** – operation consists of two modes, temperature maintenance and pull-down. The *Pull-down Operation Profile* refers to the percentage of time in pull-down mode. Hence, the remaining percentage represents temperature maintenance mode.
- **Fuel Consumption Rate** – indicates the average amount of diesel fuel being used by the TRU per hour. There are two rates, one for pull-down mode and a second, lower rate for temperature maintenance mode.
- **Per Gallon Fuel Cost** – represents an average of current diesel fuel prices nationwide.
- **Electricity Consumption Rate** – the average power consumption of the TRU in kilowatts. There are two rates, the higher being for pull-down mode and the lower for temperature maintenance mode.
- **Electricity Rate Cost** – represents an average of current electricity costs in New York State.
- **Grid Electricity Usage** – refers to the annual number of hours during which the unit will be plugged in and run off grid-supplied electricity. This figure consists of waiting time at warehouses, loading/unloading time, and driver rest periods during travel.
- **Maintenance Charge/hour** – the dollar cost to provide routine TRU maintenance based on *Engine/Compressor Operating Hours*.

Using single variable sensitivity analysis, the primary cost parameters that affect the annual TRU operational costs of both the standard TRU and the eTRU were investigated. The upper bound, baseline, and lower bound of all parameters were identified and operating expenses calculated using these cost equations:

Std. TRU Operating Cost = {TRU Usage * Per Gal. Fuel Cost * [(Fuel Consumption Rate: PD) * (Op. Profile: PD) + (Fuel Consumption Rate: TM) * (Op Profile: TM)]} + {TRU Operating hours * Maintenance Charge/hr}

eTRU Operating Cost = {(TRU Usage - Total Elec. Standby Usage) * Per Gal. Fuel Cost * [(Fuel Consumption Rate: PD) * (Op. Profile: PD) + (Fuel Consumption Rate: TM) * (Op Profile: TM)]} + {Total Elec. Standby Usage * Elec. Rate Cost * [(Elec. Consumption Rate: PD) * (Op. Profile: PD) + (Elec. Consumption Rate: TM) * (Op. Profile: TM)]} + {TRU Operating hours * Maintenance Charge/hr}

Table 7-1 and **Table 7-2** illustrate the variables applied to the sensitivity analysis.

TABLE 7-1: STANDARD TRU SENSITIVITY ANALYSIS VARIABLES

Annual Cost of Operating a Standard TRU			
Variable	Base	Min.	Max.
TRU Usage (h/yr)	7200	5200	8736
Pull-Down Operation profile (%)	5%	0%	30%
PD Fuel Consumption Rate (gal/h)	1.4	1.0	1.7
TM Fuel Consumption Rate (gal/h)	0.7	0.4	1.0
Per Gallon Fuel Cost ($/gal)	$2.50	$1.50	$4.00
Engine/Compressor Operating Hours (h/yr)	1500	1000	3000
Maintenance Charge/hour ($/h)	$1.25	$1.00	$1.50
Total Operational Cost per Year	$15,105		

TABLE 7-2: eTRU SENSITIVITY ANALYSIS VARIABLES

Annual Cost of Operating an eTRU			
Variable	Base	Min.	Max.
TRU Usage (h/yr)	7200	5200	8736
Pull-Down Operation profile (%)	5%	0%	30%
PD Fuel Consumption Rate (gal/h)	1.4	1.0	1.7
TM Fuel Consumption Rate (gal/h)	0.7	0.4	1.0
Per Gallon Fuel Cost ($/gal)	$2.50	$1.50	$4.00
Grid Electricity Usage (h/yr)	1800	400	6000
PD Electricity Rate (kW)	15	10	20
TM Electricity Rate (kW)	2.25	1.5	3.0
Electricity Rate Cost ($/kWh)	$0.13	$0.05	$0.30
Engine/Compressor Operating Hours (h/yr)	1500	1000	3000
Maintenance Charge/hour ($/h)	$0.88	$0.75	$1.25
Total Operational Cost per Year	$11,911		

The variable rates for baseline, minimum, and maximum were derived from various sources, and through in-house calculations.

- TRU Usage was determined from information garnered from various shipping companies. The baseline assumption of 7200 h/yr is for a unit operating for 24 hours a day, six days a week for 50 weeks a year. Likewise, the minimum and maximum values come from 24-hour, 6 days per week periods, but with the units running from 36 and 52 weeks per year, respectively.
- Pull-Down Operation Profile is based on refrigerated transport data from individual shipping firms. It is based on the number of deliveries a shipper has to make for their particular cargo. The baseline value focuses primarily on long-haul shipping.
- PD Fuel Consumption Rate comes from the operational characteristics of an average small diesel engine used for TRU operation. The baseline value of 1.4 gal/h relates to the engine running at ¾ capacity, while the minimum and maximum values relate to ½ and full capacity operation, respectively.
- TM Fuel Consumption Rates are based on data from industry reports and information gained through Carrier-Transicold.
- Per-Gallon Fuel Costs come from current diesel prices for the baseline value, as well as future price projections.
- Grid Electricity Usage comes from a combination of projected wait times at delivery locations, as well as rest periods for long-haul trucking. The baseline value of 1800 h/yr incorporates an average delivery wait time of 5 h/day*6 day/wk*50 wk/yr, as well as rest periods of 10 h/day*6 day/wk*50 wk/yr. The minimum and maximum values are calculated similarly: Min. has wait time at 1.3/6/50 and rest periods at 0/6/50; Max. has both wait time and rest periods at 10/6/50 each.
- Electricity Rates are based on information obtained from Carrier-Transicold regarding electric standby units. The TM rates were derived by taking the PD baseline of 15 kW and using percentage rates of 15% for baseline, 10% for the minimum and 20% for the maximum.
- Electricity Rate Cost was determined using electricity cost information from the DOE. The baseline value of $0.13/kWh is the New York commercial rate. The minimum value of $0.05/kWh is the Kentucky commercial rate, and the maximum value of $0.30/kWh is a future energy rate projection.
- Engine/Compressor Operating Hours is based on information gained through Carrier-Transicold. The baseline value is based on the average TRU operating life of 10 years and 15,000 hours. The minimum and maximum values are projections based on the TRU usage hours.
- Maintenance Charge/hour is the flat rate Carrier-Transicold provided, based on a Penske maintenance plan for a standard diesel TRU. Therefore, the baseline figure of $1.25/h for the std. TRU is the actual rate. Whereas, the baseline value of $0.88/h for the eTRU is based on a projected savings of 30% due to the simplicity of the unit.

From these data, 'tornado' diagrams were developed to illustrate the effect each parameter has on the annual operational cost for each type or TRU. In the case where operational data for an eTRU was unavailable, data from a standby model was substituted. These diagrams can be found in **Figures 7-2** and **7-3**. The bars in these diagrams represent the ranges in the expected annual operating costs that each specified variable will have as it is moved through its respective range of values, while holding all other variables at their base values. For example, the effect that the total TRU usage has upon the operational cost is derived by holding every other variable at its baseline value, and using the minimum and maximum TRU usage hours per year to obtain this variable's weighting effect on the annual total. This method is then repeated until every variable has been used, while holding every other variable constant. Therefore, the length of the bar for each variable represents the degree to which annual cost is susceptible to this variable. Upon completion of all calculations, these bars are then stacked on top of each other in descending order of importance. Therefore, using this method, it is easy to determine which variables have the most significant effect on the annual operating cost, because they are the ones closest to the top.

It can be seen that per-gallon fuel cost has the most significant effect on the annual operational cost of both the standard TRU and the eTRU. For the eTRU the second most important variable is the grid electricity usage. It is interesting to note that these two variables have the most effect on the operational cost, because they are closely related. For the eTRU, periods spent using grid-supplied electricity cut the amount of fuel used. Additionally, it is surprising to find that the least significant variables are associated with the electrical efficiency of the unit when operating in either temperature maintenance mode, or pull-down mode. In other words, if an eTRU was extremely inefficient in utilizing power, it would still be more cost-effective using grid-supplied power than if was using diesel fuel to generate the required amount of electricity.

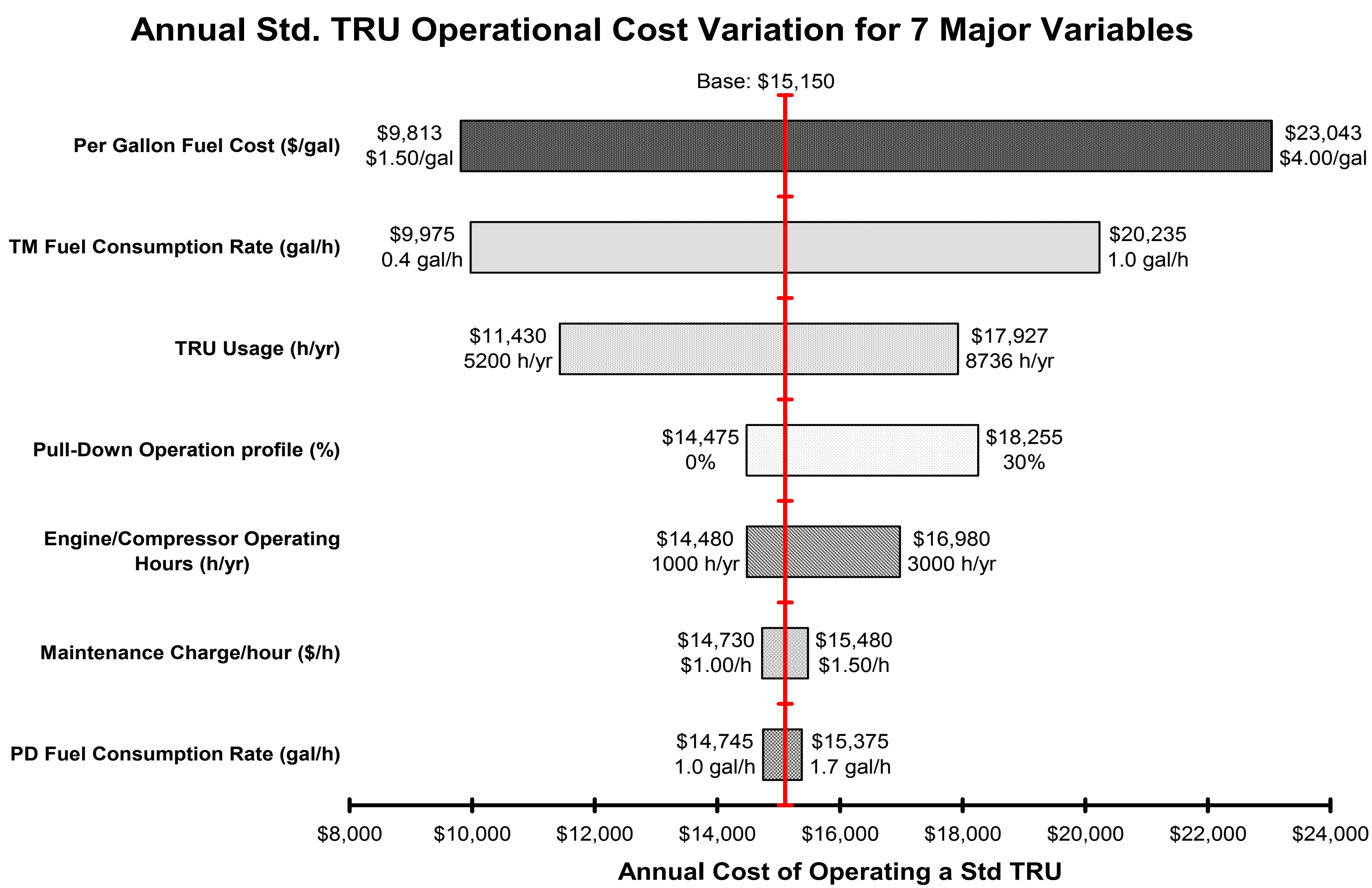

FIGURE 7-2: STANDARD TRU TORNADO DIAGRAM

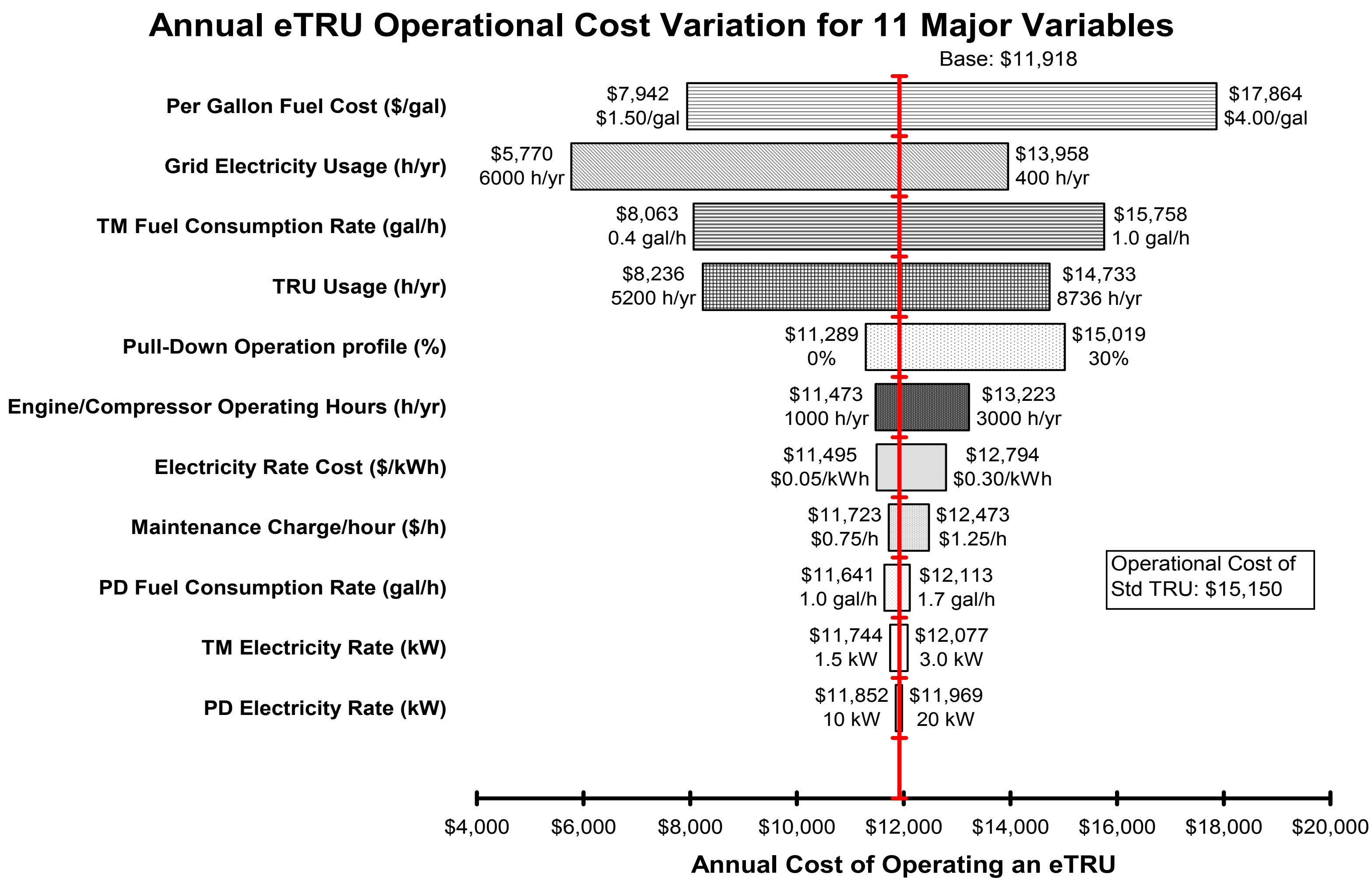

FIGURE 7-3: ETRU TORNADO DIAGRAM

7.3 Break-even Analysis

Break-even analysis is a method used to compare the cost-benefit of a particular product or service. In the case of an eTRU, the new technology has a greater initial capital cost however, the unit provides operational cost savings over its lifespan. The break-even analysis can determine when economic payback of the initial capital cost difference will occur. A break-even analysis was performed using the two most influential variables in the sensitivity analyses for the annual costs of operating both an eTRU and the standard TRU. The variables used were per-gallon fuel cost and grid electricity usage. The break-even method involved using the operational cost variations (highest to lowest) associated with these variables for each TRU type. These cost variations were subtracted from each other to gain the yearly operational cost differences between the two systems. Then these values were divided by 12, resulting in the operational cost differences per month. Per month costs were extrapolated for the requisite number of months to reach the purchase price difference for upgrading to an eTRU. It was assumed that the purchase price variation could swing from 10% to as high as 30% greater over the standard TRU retail price of $19,855. Therefore, the minimum payback period would have to entail the operational time in months in order to reach $1,985, while the maximum would need to reach $5,956.

The per gallon fuel cost variation was based at $2.50/gal, with the minimum being $1.50/gal and the maximum at $4.00/gal. The grid electricity usage variation was base-lined at 1800 h/yr, with a minimum of usage of 400 h/yr, and a maximum usage of 6000 h/yr. By using these values and the requisite payback range, the break-even periods were calculated, and can be found in **Table 7-3**. Graphically, these can be seen in **Figures 7-4** thru **7-5**.

TABLE 7-3: BREAK-EVEN ANALYSIS FOR 2 MAJOR VARIABLES

	Time in Months			Retail %
	Base	low	high	Variation
Per Gallon Fuel Cost ($/gal)	8	13	5	10
	23	39	14	30
Grid Electricity Usage (h/yr)	8	21	3	10
	23	63	8	30

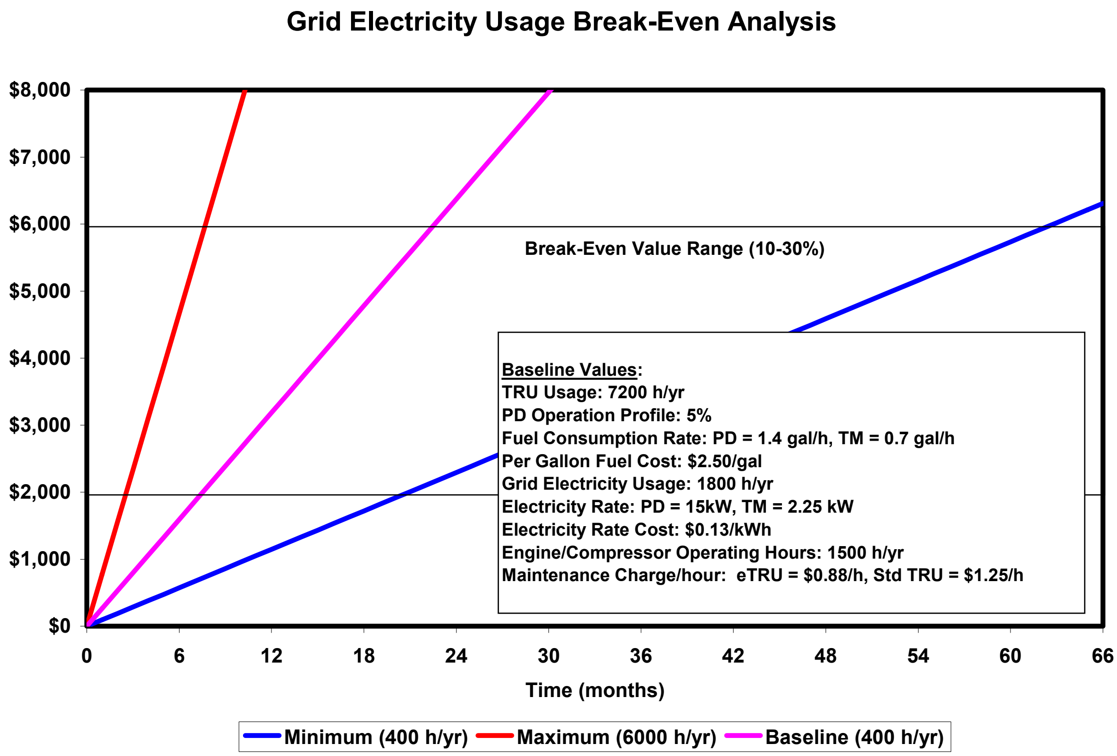

FIGURE 7-4: GRID ELECTRICITY BREAK-EVEN ANALYSIS

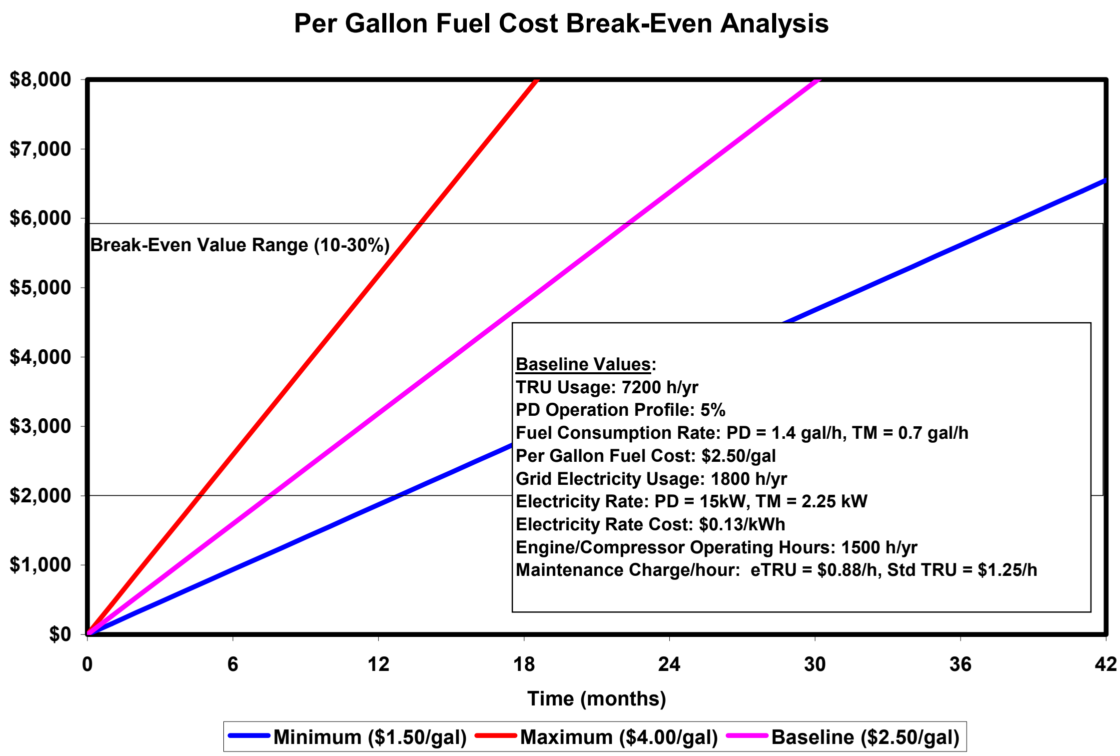

FIGURE 7-5: PER-GALLON FUEL COST BREAK-EVEN ANALYSIS

8.0 CONCLUSIONS

Based on the analysis, the study findings can be summarized as follows:

- **TRU systems of the future will have to be cost-competitive on a lifecycle basis relative to the next-best alternative if they are to effectively compete in the marketplace.** These new units will have to be more efficient and more environmentally friendly to comply with future environmental regulations. Further, there is a strong possibility that these new systems will have to have an electric option to comply with new anti-idling restrictions in key urban markets.

- **eTRUs appear to be a promising technology whose time in the U.S. has arrived.** This conclusion is based on the operational cost of diesel-driven TRUs, the localized emission and noise elimination benefits, the successful operation of these units in Europe, and the interest demonstrated by the refrigerated transport industry.

- **Warehouses and trailer parking areas can be easily retrofitted to incorporate the electrical service required to operate eTRUs on electricity**. High-voltage service exists at many of these facilities due to the electrical requirements of the refrigeration equipment. The engineering and installation of the electrical distribution and wiring to the electrical connections may be provided to the facility at reduced cost to the owner of the refrigerated warehouse. This conclusion is drawn based upon discussions with electric utilities indicating that the increased use of electricity will offset the cost of engineering and installation.

- **Regulations may require the adoption of these units in environmentally sensitive areas.** CARB and EPA have proposed stringent emission regulations and local regions have discussed restricting the operation of the diesel-powered TRUs. These local governments are considering implementing these restrictions to improve local air quality and quality of life for their citizens.

- **New York State is an excellent location for the demonstration of the eTRUs.** This conclusion is based upon New York's location relative to major U.S. food distribution centers and the high number of refrigerated warehouses, which makes it an outstanding locale for this technology demonstration. The ambient conditions in New York State require the TRU to provide both heating and cooling, ensuring the technology is fully proven prior to the final product release.

- **Cost of diesel fuel use and associated maintenance of diesel engine-driven TRUs offer the potential of operator savings and rapid payback of the incremental price difference.** As diesel prices average near $2.50 per gallon, the payback on the eTRUs can be obtained in 8 months for an incremental price increase of 10% and in 23 months for an incremental price increase of 30%. This brisk payback provides a significant economic incentive for the purchase and use of these units. In addition, as the units are more reliable and require less maintenance, savings can be achieved in productivity. These units may also have the advantage of operating in restricted areas, increasing their value even more.

- **Electrical connection improvements should reduce market barriers.** Trailers should be equipped with hardware to allow connections to be made from the electrified facility to the eTRU. This will eliminate the requirement of connecting the eTRU directly to the electricity supply, a difficult endeavor for high-voltage cabling.

- **Partnerships have been established to demonstrate eTRUs in New York State.** The targeted demonstration partner (MAINES Paper & Food Service Inc. in Conklin, NY) has expressed interest in participating in a demonstration of eTRUs. The electric utility serving the MAINES facility, New York State Electric and Gas, has also indicated their interest to participate in this demonstration.

- **An eTRU demonstration should be pursued to confirm the results of this assessment and validate cost assumptions for the installation of the electrical connections and operation of the eTRUs.** This demonstration would provide information on the actual value of eTRUs to the trucking company, the impact of eTRUs on its profit margins, and the actual payback period for eTRUs.

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APPENDIX A

CARRIER-TRANSICOLD TRU PRODUCT BROCHURES

VECTOR 1800 E

The ultimate in reliability and simplicity,
for cold-storage applications.

VECTOR 1800 E

VECTOR 1800 E is an all-electric unit specifically designed for portable cold storage and warehouse applications.

VECTOR 1800 E provides a powerful, low noise solution for cold storage temperature control, bringing all the advantages of our exclusive VECTOR technology:

- **Ultimate performance** for unmatched temperature control and pull-down, resulting in improved product quality
- **Exceptional reliability** for dependable performance and less servicing
- **Superior ease of use** with the exclusive LogiCOLD® microprocessor for advanced downloading capability and safer operation
- **Optimum profitability** for lower total cost of ownership and more cost-effective operation.

R model

- HFC R404A refrigerant
- 06D semi-hermetic compressor 670 cc
- Electrical heating and defrost system
- Door switch
- Automatic phase reverser 400/3/50 Hz
- Return and supply air sensors
- LogiCOLD® microprocessor control system:
  Remote keypad
  Message center, choice of 8 languages
  Data recorder
  Programmable hourmeters
  Advanced Supply Air regulation (product freshness)

Accessories:

- Additional temperature sensors
- Control panel
- 24V tail lift battery charger
- PCMCIA flash card (for microprocessor upgrading and data downloading)

Weight

637 kg
1 404 lb

Dimensions

2 050 x 430 x 2 228 mm
80.7 x 16.7 x 87.7 "

Refrigeration capacity

Evaporator return air temperature	Standby (watts)
0 °C	15 000
– 20 °C	8 500

Ambient temperature at + 30 °C (per A.T.P. procedure)

Heating capacities

6 200 W

Airflow

4 400 m³/h

Carrier TRANSICOLD

Specifications are subject to change without notice.

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500 CARRIER SERVICE STATIONS
in EUROPE, RUSSIA, MIDDLE EAST and AFRICA.

24 HOUR ASSISTANCE

A Uni logi

Carrier Transicold

Phoenix

ULTRA & ULTRA XL

The STANDARD in *temperature management* and system RELIABILITY.

Carrier

ULTRA *and* ULTRA XL.

Two *Trailer System* Options. The same SUPERIOR RELIABILITY and *Temperature Management.*

Both the Phoenix Ultra and Ultra XL are engineered for maximum performance, reliability, and temperature control with minimum service, maintenance, and operating cost. Top to bottom, inside and out, no matter which Ultra system you choose you'll find many exclusive advances not available with any competitive trailer unit.

Inside, Phoenix Ultra features Carrier-exclusive TriVortex power–the cleanest burning, low-noise engine. Or, for maximum fuel efficiency, select the Direct-Injection Ultra XL. Both systems also feature the most reliable compressor going.

Ultra and Ultra XL include UltraFresh 2,™ the most precise capacity and temperature control system, standard–to hold your most sensitive cargoes within two degrees of setpoint and deliver the highest quality products at peak freshness. And both offer state-of-the-art microprocessor controls with virtually automatic operation, user-friendly keypad, easy-to-read displays, and automatic pretrip, standard.

Outside, our DuraShell™ skins and doors are made of supertough, lightweight composite material. Only DuraShell skins and doors won't rust, dent, warp, fade, or peel.

All around, Carrier's Ultra systems are backed by the most extensive warranty available. And supported by expert service and genuine Performance Parts at all authorized Carrier Transicold dealers, around the corner and around the world.

1. Ultra XL features the most fuel-efficient 2.2-liter, direct-injection diesel engine. Carrier's performance-proven, low-friction CT4-134DI engine is highly fuel-efficient and features the longest factory-approved oil change interval in the industry. Phoenix Ultra features the cleaner-burning TriVortex engine. TriVortex technology mixes air and fuel more evenly and completely to reduce engine emissions of Nitrous Oxide, Hydro-carbons, and Carbon Monoxide by as much as 50% compared to a DI engine. And TriVortexo a DI engine. And TriVortex engines are lower-noise and lower-vibration.

2. **UltraFresh 2,™ standard.** At setpoints above 10°F (-12°C), UltraFresh 2 keeps perishables to within ±2°F (±1°C) of setpoint. No other system gives you more precise control, standard or optional.
3. **Industry-leading 40-CID 05G compressor** features refined components for even greater performance and reliability. Plus a comprehensive two-year warranty.
4. **3,350 CFM airflow** and balanced air distribution for unmatched cargo protection.
5. **Up-front service access.** The primary serviceable components–including the alternator–are positioned up front for direct service access. Accessing the main compartment is easy with Carrier's exclusive quick-release front doors. What's more, Ultra and Ultra XL have 20% fewer parts, so the main compartment is noticeably less cluttered than competitive units. These Carrier advantages facilitate faster, hassle-free maintenance to reduce service costs.
6. **Exclusive DuraShell™ composite skins and doors** won't rust, dent, warp, fade, or peel. Lighter-weight material absorbs noise and shock, retains its shape.
7. **State-of-the-art microprocessor control system.** Features proven long-life componentry and virtually automatic start-and-set operation. Protected in a separate weatherproof compartment, the Carrier microprocessor is simply the easiest to use.
8. **Fully automated diagnostic pretrip.** Carrier Ultra systems perform a functional pretrip test of all system circuits and components under actual operating conditions. Initiating the pretrip is a single-keystroke operation.

Other Important Advances:

- Your choice of HCFC Refrigerant-22 or HFC Refrigerant-404A.
- Standard Automatic Start/Stop operation cuts fuel consumption up to 75% or more.
- DuraDrive belt-drive system. One-step belt replacement takes less than half the time of conventional units. Provides up to 50% longer belt life.
- DuraDrive heavy-duty clutch and gearbox, rated at more than four times the torque requirement. Special locking pin feature overrides clutch to keep fans running.

Even our STANDARD *components* perform BETTER.

The *Industry's* MOST ADVANCED *Engines.*

Carrier offers a choice of high-efficiency, high-reliability, and highly serviceable engines. For maximum fuel efficiency, specify Ultra XL with its Direct-Injection engine (DI). Or for low noise and low emissions, specify Phoenix Ultra with TriVortex (TV) power.

No matter which system you choose, the major engine components are serviceable from the front. The offset piston design reduces engine and compressor vibration significantly, extending engine life. And oil-change intervals with synthetic oils have been extended to 3,000 hours on the Ultra TriVortex engine and 4,000 hours on the XL system's DI engine–longest in the industry. Plus, both feature Carrier's industry-leading warranty.

The Ultra XL Direct-Injection engine reduces friction to maximize fuel efficiency and minimize maintenance.

The Phoenix Ultra TriVortex engine employs a super-efficient, fuel-spray combustion system for the optimum mixture of air and fuel. This ensures complete combustion, greater power output, lower noise and vibration, and cleaner exhaust. Noise levels are low enough to meet even the most stringent standards.

No matter which engine you choose, you get proven performance, low maintenance, long life, and high reliability.

Industry-leading 05G COMPRESSOR.

Built by Carrier exclusively for transport refrigeration, 05G is the industry leader in reliability.

Thirty percent bigger than our competitor's biggest compressor, our 40-CID, 6-cylinder design delivers faster cooling capacity and pulldown for today's sensitive cargoes–perishable to deep frozen.

Our exclusive PosiLube oil-pressure protection ensures complete compressor lubrication, even in subzero temperatures. Dual-ringed pistons reduce blowby and oil circulation to improve reliability and maintain efficiency as operating hours mount up.

AUTOMATIC Start/Stop FUEL-SAVING *system.*

Automatic Start/Stop cuts reefer system fuel consumption up to 75% or more. This Carrier exclusive comes standard with our microprocessor controller. Auto Start/Stop is an energy-efficient alternative to continuous operation because the engine only operates when needed to maintain cargo temperature. Because engine running time is greatly reduced, engine life is increased.

The *most advanced* MICROPROCESSOR controller yet.

Carrier's exclusive microprocessor system features virtually automatic operation in a system that's extremely user-friendly for pretrip and service.

Fully-automated diagnostic pretrip is built into every micro. The system performs a functional pretrip test of all system circuits and components under actual operating conditions, unlike competitive systems, which don't pretrip defrost.

To improve system reliability, we seal the control box with O-rings, dip-coat all electronic boards, and use triple-sealed connections throughout the wiring harness. This makes the Carrier micro virtually impervious to water.

To enhance serviceability, we stamp-addressed all wires in the harness. We also added service plugs to make it easy to check current flow without cutting the harness or wiring.

More operating data is available, giving technicians more complete information instantly for faster troubleshooting.

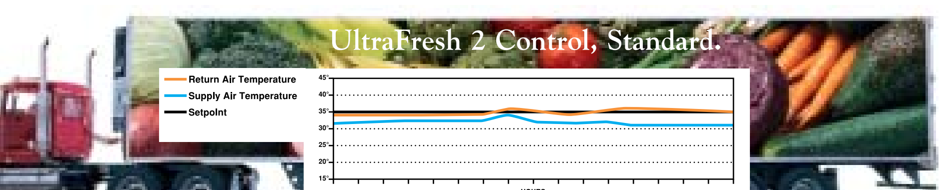
Ultra's temperature logic optimizes compressor speed and cylinder unloading for maximum pull-down speed, box temperature control, and recovery.

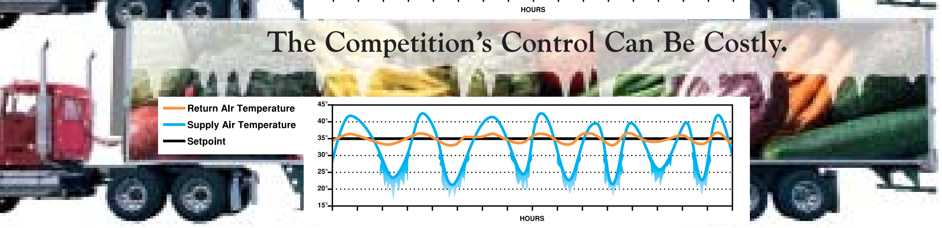
Other Carrier micro ADVANTAGES:

- Automatic start-and-set operation.
- Backlit digital displays feature a larger, more precise digital format for exceptional visibility.
- Alarm displays in English or alphanumeric code; both are built-in.
- External PC compatibility for outboard testing and diagnostics.
- Optional remote light bar.

ULTRAFRESH 2. PRECISE *temperature control* means *total cargo* PROTECTION.

Central to system performance and temperature maintenance is UltraFresh 2 control, standard. Utilizing the most advanced computer logic, UltraFresh 2 gives you pinpoint capacity control without complicating the refrigeration system–or reducing low-end capacity. The competition only offers capacity control as a cost-added option.





At setpoints above 10°F (-12°C), tests confirm UltraFresh 2 holds box temperature to within 2°F (1°C) of setpoint, with total supply-air temperature variation of ±2°F (±1°C).

With competitive units, perishable products loaded near the supply-air outlet risked top freezing. With their standard unit, supply-air temperature varied 8°F (4°C) above and 12°F (7°C) below setpoint.

Overall, Ultra and Ultra XL deliver the most precise temperature control, maximum capacity for rapid pulldown and recovery, lower fuel consumption, reduced product dehydration, less spoilage, and longer shelf life.

Carrier gives you LOTS *of extras.* For NOT *a lot* extra.

DURASHELL composite *skins* and *doors.*

Formed from the same material used in today's over-the-road tractor bumpers and body panels, Carrier's exclusive composite skins and doors won't dent, warp, fade, or peel. This super-tough, flexible material is much more forgiving than steel. It absorbs shock and pops back to its original shape–keeping your equipment looking new.

Overall, you'll probably never have to repair, repaint, or replace a door or body panel again. But if you do, you can replace a DuraShell door for a fraction of the cost of a metal door.

DuraShell doors can be removed in seconds, allowing full-width, up-front service access. Front doors are mounted using spring-loaded hinges. Simply pull the hinge bar and remove the door. Quick-release doors, and a spacious main compartment, give Ultra and Ultra XL unmatched service access.

DURADRIVE belt-drive with HEAVY-DUTY clutch and gearbox.

The DuraDrive assembly features a heavy-duty clutch and gearbox to simplify the entire drive mechanism. Overall, the DuraDrive system is more reliable, easier to service, and maximizes belt life.

New thicker, wider, stronger belt design delivers heavy-duty service, and improves belt life by up to 50%. All belts can be replaced in one step, in less than half the time required with conventional high-capacity units. Faster belt change not only saves time, it cuts labor costs.

DuraDrive eliminates defrost dampers, damper solenoids, bushings, and sensors–and the possibility of damper failure. Also part of the Ultra belt-drive assembly, the alternator is positioned right up front, for quick and easy access. DuraDrive's clutch and gearbox are rated for heavy-duty applications. More than four times the required torque capacity ensures lasting reliability. It's the same design used in rugged off-road and military vehicles and by leading over-the-road tractor builders, including Peterbilt and Mack. This assembly has been used for years and proven in millions of hours of service-free operation.

Special locking pin feature keeps the fans running should the clutch ever fail. And the gearbox is maintenance-free for life.

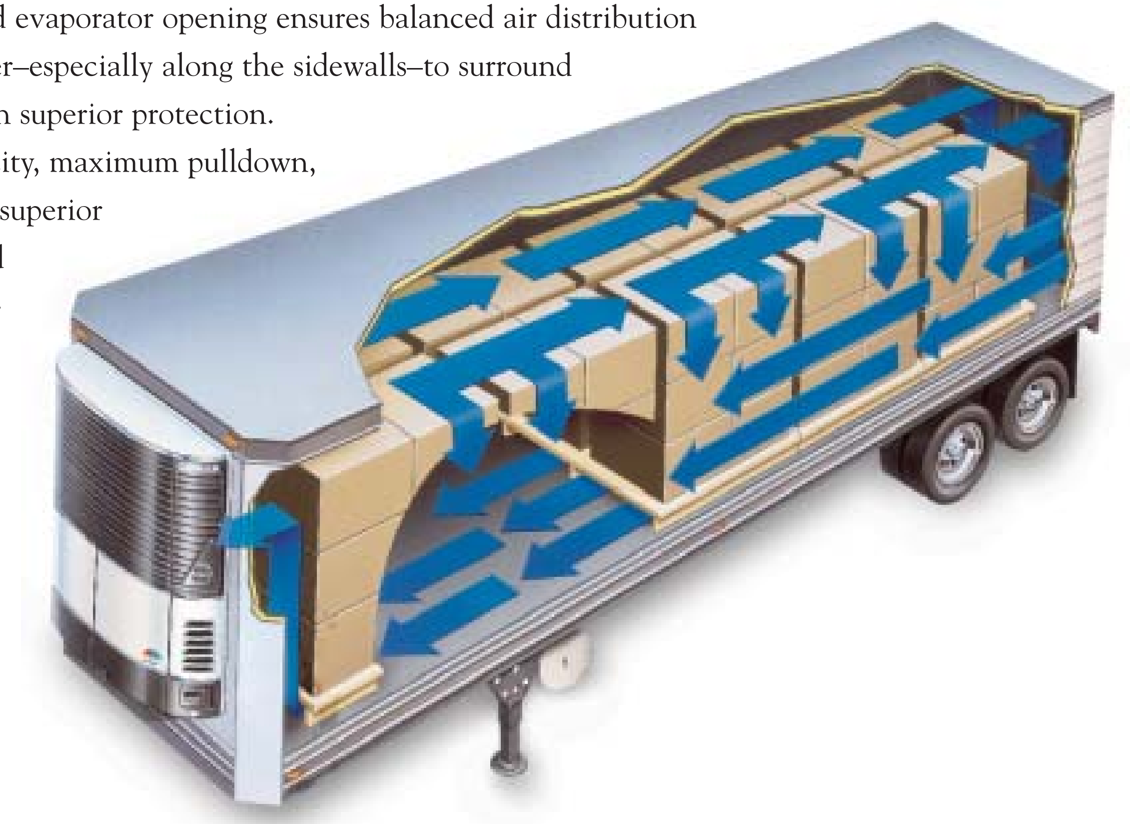
SUPERIOR *airflow*, BALANCED *air distribution* for THINWALL trailers.

Carrier's belt-and-fan drive system generates superior airflow–the optimum mix of air discharge configuration, velocity, and volume. Airflow is 3,350 CFM, unmatched in the industry.

Because we've eliminated defrost dampers, airflow is unrestricted and considerably more efficient.

And the advanced evaporator opening ensures balanced air distribution throughout the trailer–especially along the sidewalls–to surround sensitive cargoes with superior protection.

Exceptional capacity, maximum pulldown, shorter defrost time, superior airflow, and balanced temperature distribution. They're yours with Ultra and Ultra XL.



RoadCare *Extended MAJOR Component Coverage.*

Carrier's exclusive RoadCare™ Extended Major Component Coverage (EMCC) is available on every new Ultra system for up to eight years/16,000 hours, whichever comes first. What's more, coverage can be customized to your specific needs. You can specify virtually any combination of years, hours, or deductibles (up to $500). Best of all, EMCC travels with your Ultra systems, so you can expect prompt, attentive service at any authorized Carrier Transicold dealer in the U.S., Canada, and Mexico–without prior approval. And you may purchase EMCC up to six months after your Ultra systems are delivered.

PERFORMANCE *Specifications*

Phoenix

ULTRA & ULTRA XL

Dimensions:
Parenthetical dimensions are metric (mm).

Carrier Transicold participates in the ARI rating certification program.

Warranty:
See form 62-02481 for warranty terms and conditions.

This warranty applicable only in North America. Consult your Carrier Transicold representative for warranty coverage elsewhere.

Standard Features Include:
05G 40-CID compressor
CT4-134TV TriVortex engine
  (Phoenix Ultra)
CT4-134DI Direct-Injection engine
  (Ultra XL)
UltraFresh 2™ temperature control
DuraShell™ damage-resistant
  composite skins
Refrigerant-404A or Refrigerant-22
Advanced microprocessor control system
  Automatic Start/Stop
    Self diagnostics
    ClickSet tactile-feedback keypad
    Automatic pretrip
    Timed defrost interval
    Battery voltage monitor
    On-Time interval selection
    Off-Time interval selection
    High airflow selection
  Display indicators:
    Cool - Heat - Defrost - Auto-Start -
    In-Range - Hi-Air
  Digital displays:
    Setpoint temperature (˚F or ˚C)
    Return-air temperature (˚F or ˚C)
    Ambient temperature (˚F or ˚C)
    Engine coolant temperature (˚F or ˚C)
    Optional discharge air temperature
      (˚F or ˚C)
    Suction pressure
    Battery voltage
    Engine hours
    Standby hours
    On Time hours
    Programmable maintenance
      hourmeters (2)
  Control panel:
    Stop/Run switch
    Ammeter
  Manual glow/manual start switch
DuraDrive heavy-duty belt-drive system
Taper roller bearing fan shaft
Fan drive clutch locking feature
Built-in battery box
High-power 65-amp alternator
Auto low-speed unloaded start
Heavy-duty dry-type air cleaner
Bypass oil filter
Constant fuel-filter bleed system
Spin-on fuel and lube oil filters
Mechanical fuel pump
High-capacity lube oil system
50-gal. aluminum fuel tank
Super-quiet muffler
Screw-post battery terminals
Battery mounting provisions and cables
Low coolant level indicator
Defrost termination switches
Stainless steel refrigerant hoses
High refrigerant pressure protection
Control circuit overload protection
Low oil pressure protection
High coolant temperature protection
Drain-pan heater
Antifreeze
Installation package
Industry-leading warranty

Accessories and Options:
DataLink™ data recorder
Diagnostic monitor program
DataTrak™ satellite communications
Door open shut-off switch
Low fuel shutdown
Fuel tanks
  Remote (aluminum):
    30 gal.
    75 gal.
    100 gal.
    120 gal.
Antisiphon fuel fill
Fuel heater
Post-style battery terminals
Silicone hoses
Custom color paint
Remote light bar
Remote temperature probes (2)
Electric standby
Noise reduction kit
Impact protection bumper
Microprocessor protection bumper

Approximate Weights:
NDA94A 1,610 lb. (730 kg)
50-gal. aluminum fuel tank 65 lb. (29 kg)
30-gal. aluminum fuel tank 56 lb. (25 kg)
Battery 50 lb. (23 kg)

Cooling Temperature/Capacity:
Ambient at 100˚F (38˚C). Speed: 1,900 rpm diesel.

	Evaporator Return Air Temperature	Btuh	Kcal/hr	Watts
Refrigerant-22	-20˚F (-29˚C)	20,500	5,166	6,008
	0˚F (-18˚C)	35,000	8,820	10,257
	35˚F (2˚C)	54,000	13,608	15,826
Refrigerant-404A	-20˚F (-29˚C)	21,000	5,292	6,154
	0˚F (-18˚C)	34,500	8,694	10,111
	35˚F (2˚C)	46,000	11,592	13,481

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A United Technologies Company

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www.trucktrailer.carrier.com

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Specifications are subject to change without notice.

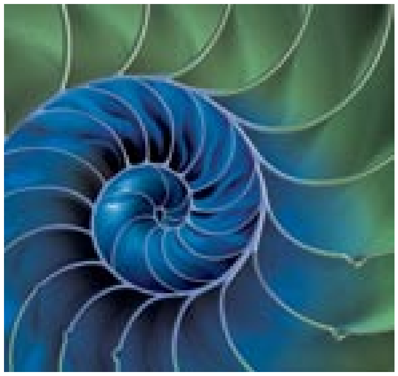
EliteLINE

Premium cargo protection. Premium environmental responsibility.

The inspiration for a system that's safer for nature came from nature.

Chambered Nautilus
Nautilus Pompilius

The chambered nautilus is a unique shellfish. With a unique shell. Its design symmetry is found nowhere else in nature. The curvature of the interior chamber walls gives the shell tremendous strength. As a result, it can withstand extreme pressure at tremendous depth.

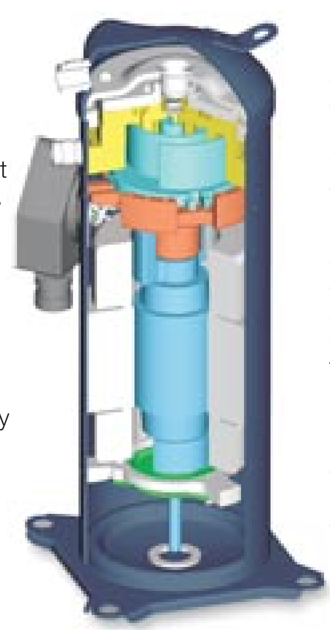


Like the nautilus, our EliteLINE™ scroll compressor design is unique. So unique, it is patented. It is specially built to meet the performance demands of container refrigeration under extreme conditions at sea.

The inner chamber of the EliteLINE scroll compressor features our patented wrap geometry. The walls are tapered, making them thicker than the standard air conditioning spiral. This higher-strength wall design maximizes efficiency and reliability. It also increases capacity without increasing frame size. The result: higher cooling capacity, using non-ozone-depleting HFC-134a. Ensuring industry-low GWP and TEWI ratings.

Scroll-wrap tapered inner wall is thicker and more robust.

Exclusive EliteLINE scroll compressor design patented by Carrier.



Molded, sealed electrical junction box for watertight connections.

Large-capacity oil sump and sump magnet for superior lubrication.

Scroll wrap optimized for low power draw, strength, and reliability.

Steel-backed carbon bearing specially designed for longer life.

Marine-duty powder paint coating for maximum corrosion protection.

EliteLINE. Unmatched refrigeration performance. Advanced environmental responsibility.

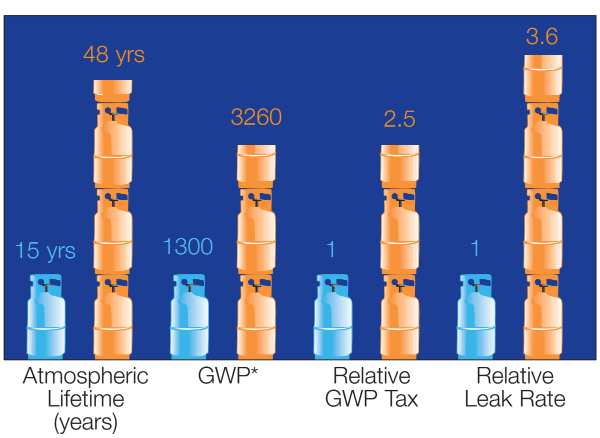
It is all here. Everything you want in container refrigeration. To meet your changing needs in an increasingly competitive world market. Innovative scroll wrap technology. Proven world-class performance. Exceptional cargo protection. And unmatched environmental responsibility. A product of Carrier's extensive experience in compressor manufacturing and industry leadership in reliable performance.

EliteLINE with purpose-built, patented scroll compressor, charged with HFC-134a. High capacity, high strength, and light weight. With industry-low GWP and TEWI ratings. Everything you need in a single-scroll platform to protect your cargoes. With minimal impact on the environment.

MicroLink 3. The user-friendly controller that thinks of everything. MicroLink™ 3 provides state-of-the-art electronic temperature control to meet even the most demanding applications. In a user-friendly platform that is fast and remarkably easy to operate, diagnose, and service. The entire DataCorder™ memory can be downloaded to the DataBank™ PC card in seconds. Incorporated into the EliteLINE system, MicroLink 3 delivers the same reliability, interchange-ability, and accuracy field-proven in our industry-leading ThinLINE™ platform.

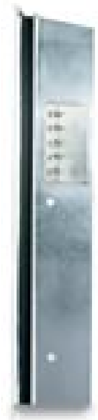
The MicroLink 3 controller.

HFC-134a proves that less is more.



*CO_2 = 1 as defined in the Intergovernmental Panel for Climate Change (IPCC)

EliteLINE. The container reefer designed to be one of the industry's elite.



- State-of-the-art electrostatically coated copper fin, tube, and tube sheet condenser coil for superior corrosion protection.
- Lightweight, corrosion-proof composite condenser fan.
- High capacity from a single HFC-134a scroll compressor. Exclusive design patented by Carrier.
- MicroLink 3 microprocessor controller. Program upgrades and DataCorder downloads in seconds with the new DataBank PC card. Backward compatibility with MicroLink 2i ensures seamless transition to MicroLink 3.
- Front panels provide quick access to evaporator fan motor, fans, and heaters. Evaporator motor mounted for quick removal of modular fan, fan stator, and motor assembly, if required.
- Addressed-wire-coding speeds service.
- Stainless steel hardware with protective coating. Mylar barrier between dissimilar metals protects against corrosion.
- Precisely aligned, high-efficiency evaporator fan motors and vane-axial fans reduce fan heat and improve cooling capacity.
- Evaporator coil with copper tubing and aluminum fins, treated for improved condensate drainage.
- Symmetrical bottom-air delivery into T-bar floor for better air distribution.
- Electric defrosting and heating.
- Slant-top return-air grille for higher load line, allowing more cargo.
- Lightweight aluminum frame and rear bulkhead exceed ISO racking and end-loading requirements.
- Peripheral seal reduces heat leakage.
- PVC-insulated spacer extends life, eliminates concern about insect infestation.
- Superior condensate collection system helps keep cargo dry.
- Auto defrost takes the guesswork out of setting defrost intervals while providing up to 40% power savings.

EliteLINE

The first scroll compressor specially built for container refrigeration.

There is no value in compromise. So our designers didn't compromise EliteLINE performance. Rather than modify existing scroll technology from less-demanding air conditioning applications, we built a scroll compressor exclusively for container refrigeration. Our innovative, exclusive EliteLINE container refrigeration system features Carrier's patented scroll wrap geometry. It is the specially built, single-scroll platform that uses non-ozone-depleting HFC-134a. As a result, EliteLINE offers industry-low GWP and TEWI. It delivers the most advanced protection for your sensitive cargoes. In the field of container refrigeration.

EliteLINE is safer for the environment while protecting your cargo.

This high-performance, single-scroll HFC-134a system generates higher cooling capacity for superior cargo protection. Low GWP combined with lighter-weight construction and high COP results in industry-low TEWI.

Holds deep frozen at high ambient temperatures.

With EliteLINE and HFC-134a, you can hold deep frozen loads, even at 50°C (122°F) ambient temperature. Competitive R-404A scroll units can't match EliteLINE's high-ambient performance.

Carrier's HFC-134a scroll compressor improves COP 15%.

EliteLINE with HFC-134a generates more cooling capacity for every unit of power consumed. This reduces operating costs. It also reduces emissions. Making it the first choice for environmental efficiency.

One scroll, over 20% increased capacity at -29°C (-20°F).

Our purpose-built, patented scroll compressor generates industry-leading deep-frozen product protection (3,960 Watts,13,500 Btu/hr) from a single-scroll compressor. Another way you succeed with Carrier.

Lower Global Warming Potential, pay less GWP tax.

Industry-accepted, non-ozone-depleting HFC-134a's GWP rating is 2.5 times lower than R-404A. Any tax based on GWP would be 2.5 times higher for R-404A. Consider your cost savings with competitively priced HFC-134a.

Carrier brings you The Complete Package.

Advanced equipment, expert assistance, and global support make Carrier the first choice for cargo quality from field to market. Carrier people, products, and protection. Complete Package, complete confidence.

PERFORMANCE SPECIFICATIONS
EliteLINE

Cooling Capacity: Ambient @ 38°C (100°F) with Purpose-Built RS-105 Scroll Compressor; HFC-134a

Temperature	Watts	Btu/hr
2°C (35°F)	10,550	36,000
-18°C (0°F)	6,160	21,000
-29°C (-20°F)	3,960	13,500

Specifications are subject to change without notice.

Standard Features Include:

Advanced Carrier purpose-built
  RS-105 scroll compressor
Zero-ODP HFC-134a
Enhanced MicroLink™ 3 modular
  controller with dual probes
DataCorder™ electronic data recorder
Energy-saving Economy Mode
  evaporator motor logic
Exclusive dual back-lit LCD displays
Time-delay motor start sequence
Current-limiting feature
Pressure-limiting feature
Exclusive stepper-modulation capacity
  control
High-efficiency evaporator and
  condenser coils
Electrostatically coated all-copper
  condenser coil
System wired for 380/460volt-3ph-
  50/60Hz power
Safe 24-volt AC control circuit with
  fuse protection
Cool, Heat, Defrost, In-Range, Alarm
  indicator lights
Bottom air discharge
Main power circuit breaker
18m (60-ft) power cable with attached
  CEE-17 plug
Electric heat
Selectable timed electric defrost
  (3-, 6-, 9-,12-, or 24-hour settings)
  or automatic defrost
Manual defrost initiation
Aluminum rear bulkhead
Removable front service panels
Single-phase dual-speed evaporator
  fan motors and vane-axial fans
ATO (Sprenger)-accepted adjustable
  fresh-air exchange
TIR
Forklift pockets
Document holder
Refrigerant receiver with dual sight glass,
  electrostatically coated copper for
  superior corrosion prevention
Low air leakage: less than 0.14 CMH
  (5 CFH) at 50.8 mm (2 in.) w.g.
Composite control box
Suction and discharge temperature
  sensors
Suction and discharge pressure
  transducers
Provisioned for:
  Dehumidification control
  USDA cold treatment
  Water-cooled condenser
  Remote monitoring
  Dual voltage (when applicable)
  Fresh-air vent position sensor

Accessories and Options:

USDA cold-treatment recording package
Rechargeable power-up battery pack
Chart recorder options
  Electronic Partlow chart recorder
  Uses 31-day 203mm (8.0 in.) chart
    recorder
  Auto calibration
  Saginomiya 31-day 203mm (8.0 in.)
    chart recorder
    Simpson lead for calibration
Dehumidification control
Quick-connect 190/230volt-50/60Hz
  dual-voltage transformer module
    Optional 230-volt plug (specify)
Optional 460-volt plug
Electronic power line communication
  module (RMU)
Water-cooled condenser system
Low-position air-exchange control,
  0-75 CMH (0-44 CFM)
Cable retainer
  Bungee cord
  Door with catch
Remote monitoring receptacle (ISO 4-wire)
Certification: ABS, BV, KRS, GL
Hinged rear bulkhead panel with
  quick-release fasteners
Thermometer insertion ports
  Supply air
  Return air
Convenience handles
  Center
  Left and Right
Rain gutters
CE marking
Fresh-air vent position sensor
Emergency Bypass System (EBS)

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Carrier TRANSICOLD

APPENDIX B

COMPREHENSIVE LIST OF NEW YORK STATE REFRIGERATED TRAILER TRANSPORTATION COMPANIES – FLEET CONTACT INFORMATION

APPENDIX B1 - COMPREHENSIVE LIST OF ALL NEW YORK STATE REFRIGERATED TRAILER TRANPORTATION COMPANIES - FLEET CONTACT INFORMATION

Company Name	Address 1	Address 2	City	State	Zip	Contact name	Title	DOT Number	Telephone	Fax
Adriaansen Trucking, Inc.	PO Box 238		Marion	NY	14505-0238	Kevin Adriaansen	President	399856	(315) 926-3471	(315) 926-1807
Awesome Transportation, Inc.	4705 Metropolitan Ave.		Flushing	NY	11385-1046	Robert C Ludlow	CFO	317404	(718) 417-3770	
B E Wright Distributing Corp.	PO Box 9		Seneca Falls	NY	13148-0009	Claude H Wright	President	34101	(315) 539-5091	(315) 539-2489
B&Q Distribution Services, Inc.	PO Box 49		Phoenix	NY	13135-0049	Betty Taylor	President	185313	(315) 695-7271	(315) 695-2837
Beechgrove Warehouse Corp.	2200 Bleecker St.		Utica	NY	13501-1739	Jason Palmer	Owner	650805	(315) 724-5042	(315) 724-5330
Bennett Distributors of Utica, Inc.	PO Box 4055		Utica	NY	13504-4055	Richard Bennett	President	838930	(315) 797-5986	(315) 793-0052
Bill Bennett Trucking, Inc.	75 Wells Rd.		Barton	NY	13734-1818	Bill Bennett	President	301443	(607) 565-7481	(607) 565-3776
Blackhorse Carriers, Inc.	PO Box 840		Tully	NY	13159-0840	Mike Murphy	Vice President	775659	(315) 696-2435	(315) 696-8145
Blue Eagle Express	8558 County Road 14		Ionia	NY	14475-9702	Gary O'Brien	Owner	512396	(585) 624-4383	(585) 624-9798
Boston-Buffalo Express, Inc.	PO Box 2818		Syracuse	NY	13220-2818	Frank J Magari	President	15046	(315) 437-6161	(315) 437-8000
Bucolo Cold Storage, Inc.	5796 Wilson Burt Rd.		Burt	NY	14028-9741	Jerome A Bucolo	Owner	460090	(716) 778-7631	716) 778-8768
C W Stuart & Co., Inc.	PO Box 155		Marion	NY	14505-0155	Karen Mohr	President	270957	(315) 926-5970	(315) 926-0718
Cicio Trucking Co., Inc.	PO Box 661	1671 Glen Wild Rd.	Woodridge	NY	12789-0661	Cicio	President	148809	(845) 434-6760	
Clancy Bros. Transportation Co., Inc.	84 Bengal Ter.		Rochester	NY	14610-2810	Harry W Clancy	President	54491	(585) 244-2565	(585) 244-2291
Cloverleaf Transportation Co., Inc.	PO Box 667		Chester	NY	10918-0667	Don Mayoras	President	675046	(845) 469-2283	(845) 469-4114
Colandrea Trucking, Inc.	5198 Route 9w		Newburgh	NY	12550-1481	Ron Colandrea	President	86653	(845) 561-2780	(845) 561-1176
D & J Hale & Son Trucking	PO Box 55		Friendship	NY	14739-0055	Richard Hale	Owner	329839	(585) 973-7912	
D G Livergood Trucking	5575 Feathers Creek Rd.		Belmont	NY	14813-9753	Donald G Livergood	Owner	355288	(585) 268-5234	(585) 268-5234
D&B Express, Inc.	PO Box 91		Nichols	NY	13812-0091	David G Moore	President	295146	(570) 247-7010	(570) 247-2745
D'Agostino Produce	2100 Park St.		Syracuse	NY	13208-1041	Anthony D'Agostino	Owner	442483	(315) 474-6000	(315) 424-7010
Doug Marchionda Trucking, Inc.	33 Champlin Ave.		Penn Yan	NY	14527-1212	Doug Marchinda	Owner	163494	(315) 536-8417	(315) 536-3769
Duggan's Trucking, Inc.	1502 Niagara St.		Buffalo	NY	14213-1104	Laurence J Duggan	President	16785	(716) 883-4421	(716) 882-1201
Edward C Lott, Inc.	2338 Slaterville Rd.		Ithaca	NY	14850-9633	Edward C Lott	President	171996	(607) 539-7247	(607) 539-7286
Elder Trucking, Inc.	14500 E. Lee Rd.		Albion	NY	14411-9545	James F Lochner	President	433194	(585) 589-7282	
Empire Beef Co., Inc.	171 Weidner Rd.		Rochester	NY	14624-5176	John Stone	Fleet Manager	356995	(585) 235-5511	(585) 527-8931
Erie Logistics, LLC	5873 Genesee St.		Lancaster	NY	14086	Rick Cohen	President	1043805	(716) 515-2399	(716) 515-3362
Escro Transport, Ltd.	275 Mayville Ave.		Buffalo	NY	14217-1894	Donald Esposito	President	26493	(716) 874-6155	(716) 874-6984
Farmington Trucking	5079 Brown Rd.		North Rose	NY	14516-9612	David Rice, Sr.	President	648957	(315) 587-9632	(315) 587-2455
Fast Food Transport, Inc.	102 Farrell Rd.		Syracuse	NY	13209-1824	Stephen Karlovitz	President	251176	(315) 451-2672	(315) 451-5882
Flatland Freight Distributors, Inc.	195 Lombardy St.		Brooklyn	NY	11222-5417	Sean McCarthy	Vice President	19751	(718) 782-9366	(718) 782-0004
Foremost Transportation, Inc.	121 Dwight Park Cir.		Syracuse	NY	13209-1057	Richard Mosley	President	421193	(315) 453-3800	(315) 453-0555
Freezer Queen Foods, Inc.	975 Fuhrmann Blvd.		Buffalo	NY	14203-3191	Matt Kwasek	President	112801	(716) 826-2500	(716) 824-0046
G & R D'Agostino Quality Produce	PO Box 11584	1415 Highland St.	Syracuse	NY	13218-1584	Guiseppe D'Agostino	Partner	372796	(315) 475-1221	
G D King Trucking	5085 1/2 Route 353		Salamanca	NY	14779-9782	Gregory D King	Owner	714757	(716) 938-9802	(716) 938-9503
G Dwyer & Sons, Inc./Dwyer Leasing	PO Box 185	457 State Hwy. 349	Mayfield	NY	12117	Paul Dwyer	President	439489	(518) 725-1231	(518) 725-8780
GSN Trucking Corp.	2060 9th Ave.		Ronkonkoma	NY	11779-6253	Glenn Nussdorf	President	58264	(361) 737-5555	(361) 737-5154
George Banks Trucking	5032 Route 11		Homer	NY	13077	George Banks	Owner	422027	(607) 749-7000	(607) 749-4050
Geri K Transport, Inc.	8405 Tuttle Rd.		Bridgeport	NY	13030-8429	Geraldine Queior	President	NA	(315) 699-4080	(315) 698-4537
Gillo Trucking Corp.	5 Nathalie Ave.		Amityville	NY	11701-1807	Stanley Gillo	President	774980	(631) 842-0087	(631) 841-2921
Greg Nellis Trucking	5300 Route 76		Ripley	NY	14775-9728	Greg Nellis	Owner	361893	(716) 736-4530	
H T Singh Trucking, Inc.	14236 130th Ave.		Jamaica	NY	11436-2007	Harry Singh	Owner	607018	(201) 955-3300	(201) 955-3332
Hauling Freight Lines, Inc.	8588 Erie Rd.		Angola	NY	14006-9618	John Lomando	President	268349	(716) 549-1213	(716) 549-1123
Independent Transport, LLC	12208 Ridge Rd.		Medina	NY	14103-9633	Roger E Plummer, Jr.	Owner	643308	(585) 798-2025	(585) 798-0853
Intercontinental Truck Brokerage Corp.	464 NYC Terminal Market		Bronx	NY	10474	Henry Hass	President	453736	(718) 378-2550	(718) 842-0509
J D Buckley & Son, Inc.	8610 Morganville Rd.		Stafford	NY	14143-9514	Richard J Buckley	President	302069	(585) 343-5960	(585) 343-5103
Jenkins Farms, Inc.	8637 Route 36 N.		Arkport	NY	14807	Keith Jenkins	Owner	316186	(607) 295-7726	(607) 295-8131
John Ferris Trucking, Inc.	PO Box 591		Bath	NY	14810-0591	Arthur J Ferris	President	270777	(607) 776-1010	(607) 776-1725
Johncox Trucking, Inc.	PO Box 189		Avon	NY	14414-0189	Dave Steer	President	40477	(585) 226-6610	(585) 226-6753
Johnnie's United Sea Transfer, Inc.	204 Titus Ave.		Staten Island	NY	10306-4708	Michael Caracappa	President	800958	(718) 987-9895	(718) 987-0294
K-C Refrigeration Transport Co., Inc.	PO Box 545		Troy	NY	12181-0545	Stephen Kowalczyk	President	19685	(518) 273-7505	(518) 273-7509
KA Transport, Inc.	270 Buell Rd.		Rochester	NY	14624-3122	John Gretzel	Dispatcher	995319	(585) 272-1150	(585) 235-3577
KJ Transportation, Inc.	PO Box 25129	6070 Collett Rd.	Farmington	NY	14425-0129	Kevin Johnson	President	40494	(716) 924-9951	(716) 924-9959
Ken Trucking, Inc.	3370 Prince St.	Suite 802	Flushing	NY	11354-2745	John Shen	President	998067	(718) 670-9945	(718) 670-9947

Leonard's Express, Inc.	PO Box 25130	6300 Collett Rd. W.	Farmington	NY	14425-0130	Patricia Johnson	President	920222	(716) 924-8140	(716) 924-0508
Loungecraft Moving & Storage Corp.	5310 46th St.		Flushing	NY	11378-1047	A Bridges	Owner	106318	(718) 784-8680	(718) 937-5324
M L Schultz Trucking	PO Box 146		Burt	NY	14028-0146	Michael Schultz	Owner	512360	(716) 778-9636	
Macy's Light Delivery, Inc.	16 Lape Rd.		Waterford	NY	12188-1101	Raymond Macy	President	316447	(518) 233-1620	(518) 233-1809
Maines Paper & Food Service, Inc.	**101 Broome Corporate Pkwy**	**PO Box 450**	**Conklin**	**NY**	**13748-0450**	**Claude Boisson**	**Vice President**	**176881**	**(607) 779-1254**	**(607) 779-1540**
Mardon Service	PO Box 2135	660 Howard St.	Buffalo	NY	14240-2135	Richard Reckenwald	CEO	482658	(716) 856-0677	(716) 847-8842
Metroplex Harriman Corp.	6 Commerce Dr. S.		Harriman	NY	10926-3101	John Doll	Fleet Manager	847132	(845) 781-5000	(845) 781-5005
Mountain Transport, Inc.	8 Hc 65		Bovina Center	NY	13740-9702	Gerald T Wright	President	521358	(607) 746-7850	(607) 746-7265
MRZ Trucking	150 Albany Ave.		Freeport	NY	11520-4702	M R Zarnegar	President	334324	(516) 377-3082	(516) 377-3084
Niagara Bulk Service, Ltd.	4286 Day Rd.		Lockport	NY	14094-9412	Duane R Murray	President	336071	(716) 433-6257	(716) 433-6274
On-Line Transport, Inc.	1766 E. New York Ave.		Brooklyn	NY	11207-2337	John Cerzerizzo	President	637883	(718) 922-2226	(718) 922-3606
Paul Marshall Produce, Inc.	PO Box 366	Maltby Rd.	Elba	NY	14058-0366	Paul A Marshall	President	298630	(585) 638-6327	(585) 638-7166
Pequa Transportation, Inc.	PO Box 398		Bethpage	NY	11714-0398	Harry Pegua	President	687683	(516) 777-7776	(516) 777-7819
Prime Time Express, Inc.	PO Box 449		Buffalo	NY	14207-0449	John A White, Jr.	President	385418	(716) 832-9783	(716) 832-9786
Productive Transportation Carrier Corp.	530 Grand Island Blvd.		Tonawanda	NY	14150-6594	Kathleen A O'Connell	President	572094	(716) 877-5542	(716) 877-6331
R & L Smith Trucking, Inc.	PO Box 301	516 Pine St.	South Dayton	NY	14138-0301	Steven Smith	President	603619	(716) 988-3241	(716) 988-3477
R & M Leto Transport	66 Chestnut St.		Johnstown	NY	12095-2721	Richard Leto	President	881196	(518) 762-7307	(518) 762-4196
R B Humphreys, Inc.	8676 Tibbitts Rd.		New Hartford	NY	13413-5224	Brian Humphreys	Vice President	143396	(315) 793-3190	(315) 793-3591
R S Maher & Son, Inc.	3200 Route 39		Bliss	NY	14024-9730	Richard Maher	President	569464	(585) 322-8878	(585) 322-7417
R&R Trucking	1620 Guyanoga Rd.		Penn Yan	NY	14527-9334	Richard D Hall	Owner	662705	(315) 531-8929	
Rizzo Trucking Co.	91 N. 5th St.		Brooklyn	NY	11211-3126	Anne Marie Maiorana	President	31479	(718) 388-6639	(718) 486-8524
RJM X-Press	PO Box 209		Pine Island	NY	10969-0209	Rodman Runnalls	President	530132	(845) 938-3185	(800) 253-4167
Ron Becker & Son	11789 Schrader Rd.		Wayland	NY	14572-9708	Ronald C Becker	Owner	365934	(585) 728-5275	(585) 728-5275
Roxbury Transport, Inc.	35 Doyle Ct.		East Northport	NY	11731-6400	Ron Rera	Owner	NA	(631) 831-4101	(631) 858-1651
Samuel A Ponto, Sr.	PO Box 373		Syracuse	NY	13209-0373	Samuel A Ponto, Sr.	President	15016	(315) 487-6982	
Sargent Transportation Lines, Inc.	119 W. Main St.		Cuba	NY	14727-1320	Jeffrey Sargent	President	275165	(585) 968-3300	(585) 968-3302
SAS Express	8501 Fort Hamilton Pkwy	Apt 4d	Brooklyn	NY	11209-4849	Stanislawa Masalski	President	735352	(718) 748-7214	
Seeco Transportation, Inc.	12823 Cedric Rd.		South Ozone Park	NY	11420-2925	Vincent Seecoomar	Owner	754860	(718) 322-6202	(718) 322-3530
Shan-Lor Trucking & Equip Lease, Inc.	2374 Mezzio Rd.		Forestville	NY	14062-9600	Larry G Perkins	President	459869	(716) 672-4800	(716) 672-4880
Sodoma Farms, Inc.	PO Box D	4490 Sweden Walker Rd.	Brockport	NY	14420	Robert A Sodoma	President	329856	(585) 637-4470	(585) 637-4824
Sodus Cold Storage Co., Inc.	PO Box 278		Sodus	NY	14551-0278	William E Bishop, Jr.	President	528447	(315) 483-6966	(315) 483-6822
Solar Express, Inc.	PO Box 283		Montgomery	NY	12549-0283	Thomas Walsifer	Vice President	424181	(845) 457-5167	(845) 457-5609
Southern Tier Provisions, Inc.	81 Geneva St.		Bath	NY	14810-9501	James D Russo, Sr.	President	534672	(607) 776-2233	(607) 776-4016
Speed Motor Express of WNY, Inc.	PO Box 738		Buffalo	NY	14217-0738	Carl Savarino	President	26364	(716) 876-2235	(716) 876-8515
Speedway Transportation, Inc.	21 Marian Dr.		Newburgh	NY	12550-1849	Clifton Green	President	513515	(845) 569-1229	
Spinella Freight Lines, Inc.	5858 E. Molloy Rd.	Ste 101	Syracuse	NY	13211-2003	Cynthia Baxter	President	326038	(315) 455-9200	(315) 455-1138
Transportes Azteca International, Inc.	PO Box 1997		Buffalo	NY	14219-0197	William Knaus	President	73898	(716) 825-3877	(716) 825-2729
Valvo Transport, Inc.	PO Box 271		Silver Creek	NY	14136-0271	Stephen M Valvo	President	265858	(716) 934-2535	(716) 934-4926
Venice Enterprise, Inc.	Long Hill Rd.		Scipio Center	NY	13147	Frederick Rejman	President	242020	(315) 364-5522	(315) 364-5630
W H Strassburg, Inc.	PO Box 59		Gansevoort	NY	12831-0059	Richard Strassburg	President	151616	(518) 793-4310	(518) 793-4310
W Peter Ronson, Jr., & Sons, Inc.	2823 Carmen Rd.		Middleport	NY	14105-9719	Ruth Ronson	Secretary	165044	(716) 735-7814	(716) 735-7371
West Island Trucking	2449 Whitehaven Rd.		Grand Island	NY	14072-1546	Diane McDonough	Secretary	387561	(716) 773-5333	
Williams Distributors, Inc.	R. D. 1, Box 436 A		Glenfield	NY	13343	Howard Williams	President	313686	(315) 376-4251	
Willow Run Foods, Inc.	PO Box 1350	1006 US Route 11	Binghamton	NY	13902-1350	Len Basso	Trans Mgr	27814	(607) 729-5221	(800) 431-3613

APPENDIX B2 - COMPREHENSIVE LIST OF ALL NEW YORK STATE REFRIGERATED TRAILER TRANPORTATION COMPANIES - FLEET OPERATIONS INFORMATION

Company Name	Number of Owned Tractors	Number of Leased Tractors	Total Number of Tractors	Number of Owned Trailers	Number of Leased Trailers	Total Number of Trailers	Trailer Type 1	Trailer Type 2	Trailer Type 3	Trailer Type 4	Commodity Transported 1	Commodity Transported 2	Commodity Transported 3	Commodity Transported 4
Adriaansen Trucking, Inc.	4	20	24	75	75	150	Van	Reefer	Flatbed	NA	General Freight	Flatbed Loads	NA	NA
Awesome Transportation, Inc.	20	0	20	29	7	36	Van	Reefer	NA	NA	Grocery Products	Produce	NA	NA
B E Wright Distributing Corp.	2	2	4	18	0	18	Van	Reefer	NA	NA	Malt Beverages	NA	NA	NA
B&Q Distribution Services, Inc.	30	0	30	48	0	48	Reefer	NA	NA	NA	Refrigerated Solids	NA	NA	NA
Beechgrove Warehouse Corp.	9	0	9	20	0	20	Van	Flatbed	Reefer	Chassis	General Freight	Metal	Fresh Produce	Intermodal Freight
Bennett Distributors of Utica, Inc.	2	0	2	7	0	7	Reefer	Van	NA	NA	Medical Supplies	Plants	Printed Matter	Furniture
Bill Bennett Trucking, Inc.	8	0	8	10	0	10	Flatbed	Reefer	Logging	NA	Flatbed Loads	Refrigerated Prods.	Logs	NA
Blackhorse Carriers, Inc.	0	20	20	0	26	26	Reefer	Van	NA	NA	Refrigerated Prods.	Produce	NA	NA
Blue Eagle Express	2	0	2	3	0	3	Reefer	NA	NA	NA	Produce	Canned Goods	Groceries	NA
Boston-Buffalo Express, Inc.	113	0	113	140	25	165	Reefer	NA	NA	NA	General Freight	Refrigerated Solids	Frozen Products	NA
Bucolo Cold Storage, Inc.	3	0	3	9	0	9	Reefer	Flatbed	NA	NA	General Freight	Produce	Refrigerated Foods	NA
C W Stuart & Co., Inc.	0	3	3	0	4	4	Reefer	NA	NA	NA	Frozen Products	Soft Drinks	NA	NA
Cicio Trucking Co., Inc.	3	0	3	6	0	6	Van	Reefer	Tank	Dump	Packing Materials	Ice	Water	Salt
Clancy Bros. Transportation Co., Inc.	2	2	4	2	6	8	Reefer	NA	NA	NA	Meat	Food Products	Produce	NA
Cloverleaf Transportation Co., Inc.	95	0	95	350	0	350	Van	Reefer	NA	NA	General Freight	Refrigerated Prods.	NA	NA
Colandrea Trucking, Inc.	8	1	9	17	0	17	Reefer	NA	NA	NA	Fruit	Produce	NA	NA
D & J Hale & Son Trucking	9	0	9	12	0	12	Reefer	Van	NA	NA	General Freight	Produce	Dry Goods	NA
D G Livergood Trucking	2	0	2	2	0	2	Reefer	NA	NA	NA	Dry Freight	Produce	Dairy Products	NA
D&B Express, Inc.	11	0	11	62	0	62	Van	Reefer	NA	NA	Cardboard	Barrels	Film	Packing Materials
D'Agostino Produce	3	0	3	4	0	4	Reefer	NA	NA	NA	Produce	Milk	Refrigerated Prods.	NA
Doug Marchionda Trucking, Inc.	10	0	10	18	0	18	Van	Reefer	Flatbed	NA	General Freight	Refrigerated Prods.	Flatbed Loads	NA
Duggan's Trucking, Inc.	6	0	6	28	0	28	Van	Reefer	NA	NA	General Freight	Appliances	Auto Parts	Refrigerated Prods.
Edward C Lott, Inc.	19	0	19	28	0	28	Reefer	NA	NA	NA	Frozen Vegetables	Refrigerated Prods.	Refrigerated Foods	NA
Elder Trucking, Inc.	3	0	3	15	0	15	Reefer	Van	NA	NA	Vegetables	Apples	Tomatoes	General Freight
Empire Beef Co., Inc.	62	0	62	100	0	100	Reefer	NA	NA	NA	Meat Products	Refrigerated Products	NA	NA
Erie Logistics, LLC	124	0	124	538	7	545	Reefer	Van	NA	NA	Produce	Meat	Refrigerated Foods	Beverages
Escro Transport, Ltd.	10	0	10	37	0	37	Reefer	NA	NA	NA	Refrigerated Solids	Dry Freight	NA	NA
Farmington Trucking	2	1	3	5	0	5	Van	Flatbed	Reefer	NA	General Freight	NA	NA	NA
Fast Food Transport, Inc.	0	8	8	0	12	12	Reefer	NA	NA	NA	Refrigerated Solids	Dry Goods	NA	NA
Flatland Freight Distributors, Inc.	0	5	5	0	6	6	Van	Reefer	NA	NA	General Freight	Refrigerated Prods.	NA	NA
Foremost Transportation, Inc.	6	26	32	47	0	47	Van	Flatbed	Reefer	NA	General Freight	Refrigerated Foods	NA	NA
Freezer Queen Foods, Inc.	0	6	6	0	10	10	Reefer	NA	NA	NA	Frozen Foods	Raw Materials	NA	NA
G & R D'Agostino Quality Produce	1	0	1	1	0	1	Reefer	NA	NA	NA	Produce	NA	NA	NA
G D King Trucking	5	0	5	8	0	8	Reefer	Van	NA	NA	General Freight	Refrigerated Prods.	NA	NA
G Dwyer & Sons, Inc./Dwyer Leasing	7	0	7	70	0	70	Van	Reefer	Flatbed	NA	Silicon Products	Rubber Products	Sawdust	Windows
GSN Trucking Corp.	100	0	100	230	0	230	Reefer	Van	NA	NA	General Freight	Groceries	Health & Beauty Aids	Pharmaceutical Drugs
George Banks Trucking	7	0	7	15	0	15	Van	Flatbed	Reefer	NA	Food	Refrigerated Prods.	Building Materials	General Freight
Geri K Transport, Inc.	2	0	2	1	0	1	Reefer	NA	NA	NA	Produce	NA	NA	NA
Gillo Trucking Corp.	1	1	2	1	1	2	Reefer	NA	NA	NA	Meat	Vegetables	Sugar	Fish
Greg Nellis Trucking	2	1	3	2	1	3	Van	Reefer	Tank	NA	Juice	Potatoes	Foodstuffs	NA
H T Singh Trucking, Inc.	10	20	30	12	20	32	Van	Reefer	NA	NA	Foodstuffs	Fresh Produce	NA	NA
Hauling Freight Lines, Inc.	26	0	26	80	0	80	Van	Flatbed	Reefer	Stepdeck	Food	Auto Parts	Building Materials	Corrugated Sheets
Independent Transport, LLC	0	9	9	0	9	9	Van	Reefer	Flatbed	NA	General Freight	Fresh Produce	Refrigerated Foods	NA
Intercontinental Truck Brokerage Corp.	4	22	26	0	0	0	Reefer	NA	NA	NA	Produce	NA	NA	NA
J D Buckley & Son, Inc.	4	0	4	12	0	12	Reefer	Tank	Flatbed	Dump	Agricultural Product	Food Products	Flatbed Loads	NA
Jenkins Farms, Inc.	2	0	2	4	0	4	Reefer	Flatbed	Van	NA	Fresh Produce	Paper Products	Canned Goods	NA
John Ferris Trucking, Inc.	14	3	17	56	0	56	Tank	Reefer	Opentop	Flatbed	Milk	Dairy Products	Stone	Heavy Equipment
Johncox Trucking, Inc.	13	3	16	31	2	33	Van	Reefer	NA	NA	General Freight	NA	NA	NA
Johnnie's United Sea Transfer, Inc.	1	2	3	2	2	4	Reefer	NA	NA	NA	Frozen Foods	Frozen Meat	Fish	Poultry
K-C Refrigeration Transport Co., Inc.	8	0	8	5	1	6	Reefer	Van	NA	NA	Perishable Products	NA	NA	NA
KA Transport, Inc.	6	6	12	12	0	12	Van	Reefer	NA	NA	General Freight	Refrigerated Prods.	NA	NA
KJ Transportation, Inc.	466	150	616	754	0	754	Van	Reefer	NA	NA	General Freight	Foodstuffs	NA	NA
Ken Trucking, Inc.	6	0	6	2	0	2	Reefer	NA	NA	NA	General Freight	Household Goods	NA	NA
Leonard's Express, Inc.	0	22	22	0	36	36	Reefer	Tank	NA	NA	Produce	Meat	Dry Bulk Commodities	Beverages
Loungecraft Moving & Storage Corp.	0	2	2	3	0	3	Van	Reefer	NA	NA	Produce	NA	NA	NA
M L Schultz Trucking	3	0	3	4	0	4	Van	Reefer	NA	NA	General Freight	Fresh Produce	NA	NA
Macy's Light Delivery, Inc.	7	1	8	13	1	14	Van	Reefer	Tank	NA	General Freight	Fresh Produce	Chemicals	Refrigerated Foods
Maines Paper & Food Service, Inc.	**84**	**9**	**93**	**125**	**0**	**125**	**Van**	**Reefer**	**NA**	**NA**	**Beverages**	**Processed Foods**	**Other**	**NA**
Mardon Service	56	0	56	78	0	78	Van	Reefer	Flatbed	NA	General Freight	NA	NA	NA
Metroplex Harriman Corp.	0	22	22	35	0	35	Reefer	Van	NA	NA	Refridgerated Foods	Paper Products	NA	NA
Mountain Transport, Inc.	6	12	18	22	0	22	Reefer	NA	NA	NA	Dairy Products	Refrigerated Prods.	NA	NA
MRZ Trucking	10	0	10	11	0	11	Van	Reefer	NA	NA	General Freight	Refrigerated Prods.	NA	NA

Niagara Bulk Service, Ltd.	2	1	3	5	0	5	Van	Tank	Flatbed	Reefer	Bark	Petroleum Products	Produce	NA
On-Line Transport, Inc.	5	1	6	5	1	6	Reefer	Flatbed	NA	NA	General Freight	NA	NA	NA
Paul Marshall Produce, Inc.	12	16	28	24	9	33	Reefer	NA	NA	NA	Produce	General Freight	Frozen Products	NA
Pequa Transportation, Inc.	1	1	2	5	1	6	Reefer	NA	NA	NA	General Freight	NA	NA	NA
Prime Time Express, Inc.	23	0	23	27	2	29	Reefer	NA	NA	NA	General Freight	Refrigerated Solids	Ink	NA
Productive Transportation Carrier Corp.	1	11	12	0	14	14	Chassis	Reefer	NA	NA	General Freight	Foodstuffs	Welding Supplies	NA
R & L Smith Trucking, Inc.	30	6	36	62	6	68	Van	Tank	Opentop	Reefer	General Freight	Liquid Bulk Freight	Grain	Refrigerated Prods.
R & M Leto Transport	2	0	2	2	0	2	Reefer	NA	NA	NA	Dairy Products	NA	NA	NA
R B Humphreys, Inc.	36	9	45	60	0	60	Reefer	NA	NA	NA	Refridgerated Solids	NA	NA	NA
R S Maher & Son, Inc.	15	0	15	25	0	25	Van	Reefer	Tank	Flatbed	Milk	Animal Feed	Lumber	Agricultural Product
R&R Trucking	3	0	3	4	0	4	Van	Opentop	Reefer	NA	Vegetables	Dry Bulk Commodities	Refrigerated Prods	NA
Rizzo Trucking Co.	2	0	2	3	0	3	Reefer	NA	NA	NA	General Freight	NA	NA	NA
RJM X-Press	4	0	4	5	0	5	Reefer	Van	NA	NA	General Freight	NA	NA	NA
Ron Becker & Son	3	0	3	5	0	5	Reefer	NA	NA	NA	Produce	Furniture	NA	NA
Roxbury Transport, Inc.	2	1	3	2	1	3	Van	Reefer	NA	NA	Machinery	Refrigerated Prods.	NA	NA
Samuel A Ponto, Sr.	4	0	4	5	0	5	Reefer	NA	NA	NA	General Freight	NA	NA	NA
Sargent Transportation Lines, Inc.	16	0	16	30	0	30	Reefer	Van	NA	NA	Dairy Products	Foodstuffs	Steel	Electronic Parts
SAS Express	4	0	4	4	0	4	Van	Reefer	NA	NA	Produce	NA	NA	NA
Seeco Transportation, Inc.	2	0	2	2	0	2	Flatbed	Reefer	NA	NA	Air Freight	NA	NA	NA
Shan-Lor Trucking & Equip Lease, Inc.	49	0	49	112	29	141	Van	Reefer	NA	NA	General Freight	Refrigerated Foods	Beverages	Paper Products
Sodoma Farms, Inc.	6	1	7	0	1	1	Reefer	NA	NA	NA	Farm Products	Foodstuffs	NA	NA
Sodus Cold Storage Co., Inc.	1	2	3	2	3	5	Van	Reefer	NA	NA	General Freight	Produce	Frozen Foods	NA
Solar Express, Inc.	68	0	68	175	46	221	Van	Reefer	NA	NA	General Freight	U.S. Mail	Chemicals	Refrigerated Prods.
Southern Tier Provisions, Inc.	4	2	6	6	0	6	Van	Reefer	NA	NA	Refrigerated Prods.	Food Products	Canned Goods	NA
Speed Motor Express of WNY, Inc.	30	0	30	150	0	150	Van	Reefer	Flatbed	NA	General Freight	NA	NA	NA
Speedway Transportation, Inc.	5	0	5	5	0	5	Van	Reefer	NA	NA	General Freight	Fresh Produce	Refrigerated Foods	NA
Spinella Freight Lines, Inc.	3	7	10	5	9	14	Van	Reefer	NA	NA	Produce	Exempt Commodities	Automobiles	NA
Transportes Azteca International, Inc.	17	0	17	80	0	80	Van	Reefer	NA	NA	Dairy Products	Film	NA	NA
Valvo Transport, Inc.	6	0	6	8	0	8	Tank	Van	Flatbed	Reefer	General Freight	Refrigerated Prods.	Lumber	Fuel
Venice Enterprise, Inc.	2	7	9	7	0	7	Van	Flatbed	Reefer	NA	Food Products	Machinery	General Freight	NA
W H Strassburg, Inc.	4	0	4	20	0	20	Van	Reefer	Flatbed	Dump	Paper	Lumber	Wood Products	Steel
W Peter Ronson, Jr., & Sons, Inc.	11	0	11	33	0	33	Van	Reefer	Flatbed	Tank	General Freight	NA	NA	NA
West Island Trucking	4	0	4	10	0	10	Reefer	Flatbed	NA	NA	Fresh Produce	Nursery Stock	NA	NA
Williams Distributors, Inc.	2	0	2	3	0	3	Van	Reefer	NA	NA	Potatoes	Watermelons	General Freight	NA
Willow Run Foods, Inc.	35	0	35	46	0	46	Opentop	Reefer	Van	NA	Dry Bulk Commodities	Refrigerated Foods	Paper products	Produce

APPENDIX C

LIST OF NEW YORK STATE REFRIGERATED TRAILER TRANSPORTATION COMPANIES WITH 10 OR MORE REFRIGERATED TRAILERS – FLEET OPERATION INFORMATION

APPENDIX C1 - LIST OF NEW YORK STATE REFRIGERATED TRAILER TRANPORTATION COMPANIES WITH 10 OR MORE REFRIGERATED TRAILERS - FLEET CONTACT INFORMATION

Company Name	Address 1	Address 2	City	State	Zip	Contact name	Title	DOT Number	Telephone	Fax
Adriaansen Trucking, Inc.	PO Box 238		Marion	NY	14505-0238	Kevin Adriaansen	President	399856	(315) 926-3471	(315) 926-1807
Awesome Transportation, Inc.	4705 Metropolitan Ave.		Flushing	NY	11385-1046	Robert C Ludlow	CFO	317404	(718) 417-3770	NA
B E Wright Distributing Corp.	PO Box 9		Seneca Falls	NY	13148-0009	Claude H Wright	President	34101	(315) 539-5091	(315) 539-2489
B&Q Distribution Services, Inc.	PO Box 49		Phoenix	NY	13135-0049	Betty Taylor	President	185313	(315) 695-7271	(315) 695-2837
Beechgrove Warehouse Corp.	2200 Bleecker St.		Utica	NY	13501-1739	Jason Palmer	Owner	650805	(315) 724-5042	(315) 724-5330
Blackhorse Carriers, Inc.	PO Box 840		Tully	NY	13159-0840	Mike Murphy	Vice President	775659	(315) 696-2435	(315) 696-8145
Boston-Buffalo Express, Inc.	PO Box 2818		Syracuse	NY	13220-2818	Frank J Magari	President	15046	(315) 437-6161	(315) 437-8000
Cloverleaf Transportation Co., Inc.	PO Box 667		Chester	NY	10918-0667	Don Mayoras	President	675046	(845) 469-2283	(845) 469-4114
Colandrea Trucking, Inc.	5198 Route 9w		Newburgh	NY	12550-1481	Ron Colandrea	President	86653	(845) 561-2780	(845) 561-1176
D & J Hale & Son Trucking	PO Box 55		Friendship	NY	14739-0055	Richard Hale	Owner	329839	(585) 973-7912	
D&B Express, Inc.	PO Box 91		Nichols	NY	13812-0091	David G Moore	President	295146	(570) 247-7010	(570) 247-2745
Doug Marchionda Trucking, Inc.	33 Champlin Ave.		Penn Yan	NY	14527-1212	Doug Marchinda	Owner	163494	(315) 536-8417	(315) 536-3769
Duggan's Trucking, Inc.	1502 Niagara St.		Buffalo	NY	14213-1104	Laurence J Duggan	President	16785	(716) 883-4421	(716) 882-1201
Edward C Lott, Inc.	2338 Slaterville Rd.		Ithaca	NY	14850-9633	Edward C Lott	President	171996	(607) 539-7247	(607) 539-7286
Elder Trucking, Inc.	14500 E. Lee Rd.		Albion	NY	14411-9545	James F Lochner	President	433194	(585) 589-7282	
Empire Beef Co., Inc.	171 Weidner Rd.		Rochester	NY	14624-5176	John Stone	Fleet Manager	356995	(585) 235-5511	(585) 527-8931
Erie Logistics, LLC	5873 Genesee St.		Lancaster	NY	14086	Rick Cohen	President	1043805	(716) 515-2399	(716) 515-3362
Escro Transport, Ltd.	275 Mayville Ave.		Buffalo	NY	14217-1894	Donald Esposito	President	26493	(716) 874-6155	(716) 874-6984
Fast Food Transport, Inc.	102 Farrell Rd.		Syracuse	NY	13209-1824	Stephen Karlovitz	President	251176	(315) 451-2672	(315) 451-5882
Foremost Transportation, Inc.	121 Dwight Park Cir.		Syracuse	NY	13209-1057	Richard Mosley	President	421193	(315) 453-3800	(315) 453-0555
Freezer Queen Foods, Inc.	975 Fuhrmann Blvd.		Buffalo	NY	14203-3191	Matt Kwasek	President	112801	(716) 826-2500	(716) 824-0046
G Dwyer & Sons, Inc./Dwyer Leasing	PO Box 185	457 State Hwy. 349	Mayfield	NY	12117	Paul Dwyer	President	439489	(518) 725-1231	(518) 725-8780
GSN Trucking Corp.	2060 9th Ave.		Ronkonkoma	NY	11779-6253	Glenn Nussdorf	President	58264	(361) 737-5555	(361) 737-5154
George Banks Trucking	5032 Route 11		Homer	NY	13077	George Banks	Owner	422027	(607) 749-7000	(607) 749-4050
H T Singh Trucking, Inc.	14236 130th Ave.		Jamaica	NY	11436-2007	Harry Singh	Owner	607018	(201) 955-3300	(201) 955-3332
Hauling Freight Lines, Inc.	8588 Erie Rd.		Angola	NY	14006-9618	John Lomando	President	268349	(716) 549-1213	(716) 549-1123
J D Buckley & Son, Inc.	8610 Morganville Rd.		Stafford	NY	14143-9514	Richard J Buckley	President	302069	(585) 343-5960	(585) 343-5103
John Ferris Trucking, Inc.	PO Box 591		Bath	NY	14810-0591	Arthur J Ferris	President	270777	(607) 776-1010	(607) 776-1725
Johncox Trucking, Inc.	PO Box 189		Avon	NY	14414-0189	Dave Steer	President	40477	(585) 226-6610	(585) 226-6753
KA Transport, Inc.	270 Buell Rd.		Rochester	NY	14624-3122	John Gretzel	Dispatcher	995319	(585) 272-1150	(585) 235-3577
KJ Transportation, Inc.	PO Box 25129	6070 Collett Rd.	Farmington	NY	14425-0129	Kevin Johnson	President	40494	(716) 924-9951	(716) 924-9959
Leonard's Express, Inc.	PO Box 25130	6300 Collett Rd. W.	Farmington	NY	14425-0130	Patricia Johnson	President	920222	(716) 924-8140	(716) 924-0508
Macy's Light Delivery, Inc.	16 Lape Rd.		Waterford	NY	12188-1101	Raymond Macy	President	316447	(518) 233-1620	(518) 233-1809
Maines Paper & Food Service, Inc.	**101 Broome Corporate Pkwy**	**PO Box 450**	**Conklin**	**NY**	**13748-0450**	**Claude Boisson**	**Vice President**	**176881**	**(607) 779-1254**	**(607) 779-1540**
Mardon Service	PO Box 2135,	660 Howard St.	Buffalo	NY	14240-2135	Richard Reckenwald	CEO	482658	(716) 856-0677	(716) 847-8842
Metroplex Harriman Corp.	6 Commerce Dr. S.		Harriman	NY	10926-3101	John Doll	Fleet Manager	847132	(845) 781-5000	(845) 781-5005
Mountain Transport, Inc.	8 Hc 65		Bovina Center	NY	13740-9702	Gerald T Wright	President	521358	(607) 746-7850	(607) 746-7265
MRZ Trucking	150 Albany Ave.		Freeport	NY	11520-4702	M R Zarnegar	President	334324	(516) 377-3082	(516) 377-3084
Paul Marshall Produce, Inc.	PO Box 366	Maltby Rd.	Elba	NY	14058-0366	Paul A Marshall	President	298630	(585) 638-6327	(585) 638-7166
Prime Time Express, Inc.	PO Box 449		Buffalo	NY	14207-0449	John A White, Jr.	President	385418	(716) 832-9783	(716) 832-9786
Productive Transportation Carrier Corp.	530 Grand Island Blvd.		Tonawanda	NY	14150-6594	Kathleen A O'Connell	President	572094	(716) 877-5542	(716) 877-6331
R & L Smith Trucking, Inc.	PO Box 301	516 Pine St.	South Dayton	NY	14138-0301	Steven Smith	President	603619	(716) 988-3241	(716) 988-3477
R B Humphreys, Inc.	8676 Tibbitts Rd.		New Hartford	NY	13413-5224	Brian Humphreys	Vice President	143396	(315) 793-3190	(315) 793-3591
R S Maher & Son, Inc.	3200 Route 39		Bliss	NY	14024-9730	Richard Maher	President	569464	(585) 322-8878	(585) 322-7417
Sargent Transportation Lines, Inc.	119 W. Main St.		Cuba	NY	14727-1320	Jeffrey Sargent	President	275165	(585) 968-3300	(585) 968-3302
Shan-Lor Trucking & Equip Lease, Inc.	2374 Mezzio Rd.		Forestville	NY	14062-9600	Larry G Perkins	President	459869	(716) 672-4800	(716) 672-4880
Solar Express, Inc.	PO Box 283		Montgomery	NY	12549-0283	Thomas Walsifer	Vice President	424181	(845) 457-5167	(845) 457-5609
Speed Motor Express of WNY, Inc.	PO Box 738		Buffalo	NY	14217-0738	Carl Savarino	President	26364	(716) 876-2235	(716) 876-8515
Spinella Freight Lines, Inc.	5858 E. Molloy Rd.	Suite 101	Syracuse	NY	13211-2003	Cynthia Baxter	President	326038	(315) 455-9200	(315) 455-1138
Transportes Azteca International, Inc.	PO Box 1997		Buffalo	NY	14219-0197	William Knaus	President	73898	(716) 825-3877	(716) 825-2729
W H Strassburg, Inc.	PO Box 59		Gansevoort	NY	12831-0059	Richard Strassburg	President	151616	(518) 793-4310	(518) 793-4310
W Peter Ronson, Jr., & Sons, Inc.	2823 Carmen Rd.		Middleport	NY	14105-9719	Ruth Ronson	Secretary	165044	(716) 735-7814	(716) 735-7371
West Island Trucking	2449 Whitehaven Rd.		Grand Island	NY	14072-1546	Diane McDonough	Secretary	387561	(716) 773-5333	
Willow Run Foods, Inc.	PO Box 1350	1006 US Route 11	Binghamton	NY	13902-1350	Len Basso	Trans Mgr	27814	(607) 729-5221	(800) 431-3613

APPENDIX C2 - LIST OF NEW YORK STATE REFRIGERATED TRAILER TRANPORTATION COMPANIES WITH 10 OR MORE REFRIGERATED TRAILERS - FLEET OPERATIONAL INFORMATION

Company Name	Number of Owned Tractors	Number of Leased Tractors	Total Number of Tractors	Number of Owned Trailers	Number of Leased Trailers	Total Number of Trailers	Trailer Type 1	Trailer Type 2	Trailer Type 3	Trailer Type 4	Commodity Transported 1	Commodity Transported 2	Commodity Transported 3	Commodity Transported 4
Adriaansen Trucking, Inc.	4	20	24	75	75	150	Van	Reefer	Flatbed	NA	General Freight	Flatbed Loads	NA	NA
Awesome Transportation, Inc.	20	0	20	29	7	36	Van	Reefer	NA	NA	Grocery Products	Produce	NA	NA
B E Wright Distributing Corp.	2	2	4	18	0	18	Van	Reefer	NA	NA	Malt Beverages	NA	NA	NA
B&Q Distribution Services, Inc.	30	0	30	48	0	48	Reefer	NA	NA	NA	Refrigerated Solids	NA	NA	NA
Beechgrove Warehouse Corp.	9	0	9	20	0	20	Van	Flatbed	Reefer	Chassis	General Freight	Metal	Fresh Produce	Intermodal Freight
Blackhorse Carriers, Inc.	0	20	20	0	26	26	Reefer	Van	NA	NA	Refrigerated Prods.	Produce	NA	NA
Boston-Buffalo Express, Inc.	113	0	113	140	25	165	Reefer	NA	NA	NA	General Freight	Refrigerated Solids	Frozen Products	NA
Cloverleaf Transportation Co., Inc.	95	0	95	350	0	350	Van	Reefer	NA	NA	General Freight	Refrigerated Prods.	NA	NA
Colandrea Trucking, Inc.	8	1	9	17	0	17	Reefer	NA	NA	NA	Fruit	Produce	NA	NA
D & J Hale & Son Trucking	9	0	9	12	0	12	Reefer	Van	NA	NA	General Freight	Produce	Dry Goods	NA
D&B Express, Inc.	11	0	11	62	0	62	Van	Reefer	NA	NA	Cardboard	Barrels	Film	Packing Materials
Doug Marchionda Trucking, Inc.	10	0	10	18	0	18	Van	Reefer	Flatbed	NA	General Freight	Refrigerated Prods.	Flatbed Loads	NA
Duggan's Trucking, Inc.	6	0	6	28	0	28	Van	Reefer	NA	NA	General Freight	Appliances	Auto Parts	Refrigerated Prods.
Edward C Lott, Inc.	19	0	19	28	0	28	Reefer	NA	NA	NA	Frozen Vegetables	Refrigerated Prods.	Refrigerated Foods	NA
Elder Trucking, Inc.	3	0	3	15	0	15	Reefer	Van	NA	NA	Vegetables	Apples	Tomatoes	General Freight
Empire Beef Co., Inc.	62	0	62	100	0	100	Reefer	NA	NA	NA	Meat Products	Refrigerated Products	NA	NA
Erie Logistics, LLC	124	0	124	538	7	545	Reefer	Van	NA	NA	Produce	Meat	Refrigerated Foods	Beverages
Escro Transport, Ltd.	10	0	10	37	0	37	Reefer	NA	NA	NA	Refrigerated Solids	Dry Freight	NA	NA
Fast Food Transport, Inc.	0	8	8	0	12	12	Reefer	NA	NA	NA	Refrigerated Solids	Dry Goods	NA	NA
Foremost Transportation, Inc.	6	26	32	47	0	47	Van	Flatbed	Reefer	NA	General Freight	Refrigerated Foods	NA	NA
Freezer Queen Foods, Inc.	0	6	6	0	10	10	Reefer	NA	NA	NA	Frozen Foods	Raw Materials	NA	NA
G Dwyer & Sons, Inc./Dwyer Leasing	7	0	7	70	0	70	Van	Reefer	Flatbed	NA	Silicon Products	Rubber Products	Sawdust	Windows
GSN Trucking Corp.	100	0	100	230	0	230	Reefer	Van	NA	NA	General Freight	Groceries	Health & Beauty Aids	Pharmaceutical Drugs
George Banks Trucking	7	0	7	15	0	15	Van	Flatbed	Reefer	NA	Food	Refrigerated Prods.	Building Materials	General Freight
H T Singh Trucking, Inc.	10	20	30	12	20	32	Van	Reefer	NA	NA	Foodstuffs	Fresh Produce	NA	NA
Hauling Freight Lines, Inc.	26	0	26	80	0	80	Van	Flatbed	Reefer	Stepdeck	Food	Auto Parts	Building Materials	Corrugated Sheets
J D Buckley & Son, Inc.	4	0	4	12	0	12	Reefer	Tank	Flatbed	Dump	Agricultural Product	Food Products	Flatbed Loads	NA
John Ferris Trucking, Inc.	14	3	17	56	0	56	Tank	Reefer	Opentop	Flatbed	Milk	Dairy Products	Stone	Heavy Equipment
Johncox Trucking, Inc.	13	3	16	31	2	33	Van	Reefer	NA	NA	General Freight	NA	NA	NA
KA Transport, Inc.	6	6	12	12	0	12	Van	Reefer	NA	NA	General Freight	Refrigerated Prods.	NA	NA
KJ Transportation, Inc.	466	150	616	754	0	754	Van	Reefer	NA	NA	General Freight	Foodstuffs	NA	NA
Leonard's Express, Inc.	0	22	22	0	36	36	Reefer	Tank	NA	NA	Produce	Meat	Dry Bulk Commodities	Beverages
Macy's Light Delivery, Inc.	7	1	8	13	1	14	Van	Reefer	Tank	NA	General Freight	Fresh Produce	Chemicals	Refrigerated Foods
Maines Paper & Food Service, Inc.	**84**	**9**	**93**	**125**	**0**	**125**	**Van**	**Reefer**	**NA**	**NA**	**Beverages**	**Processed Foods**	**Other**	**NA**
Mardon Service	56	0	56	78	0	78	Van	Reefer	Flatbed	NA	General Freight	NA	NA	NA
Metroplex Harriman Corp.	0	22	22	35	0	35	Reefer	Van	NA	NA	Refridgerated Foods	Paper Products	NA	NA
Mountain Transport, Inc.	6	12	18	22	0	22	Reefer	NA	NA	NA	Dairy Products	Refrigerated Prods.	NA	NA
MRZ Trucking	10	0	10	11	0	11	Van	Reefer	NA	NA	General Freight	Refrigerated Prods.	NA	NA
Paul Marshall Produce, Inc.	12	16	28	24	9	33	Reefer	NA	NA	NA	Produce	General Freight	Frozen Products	NA
Prime Time Express, Inc.	23	0	23	27	2	29	Reefer	NA	NA	NA	General Freight	Refrigerated Solids	Ink	NA
Productive Transportation Carrier Corp.	1	11	12	0	14	14	Chassis	Reefer	NA	NA	General Freight	Foodstuffs	Welding Supplies	NA
R & L Smith Trucking, Inc.	30	6	36	62	6	68	Van	Tank	Opentop	Reefer	General Freight	Liquid Bulk Freight	Grain	Refrigerated Prods.
R B Humphreys, Inc.	36	9	45	60	0	60	Reefer	NA	NA	NA	Refridgerated Solids	NA	NA	NA
R S Maher & Son, Inc.	15	0	15	25	0	25	Van	Reefer	Tank	Flatbed	Milk	Animal Feed	Lumber	Agricultural Product
Sargent Transportation Lines, Inc.	16	0	16	30	0	30	Reefer	Van	NA	NA	Dairy Products	Foodstuffs	Steel	Electronic Parts
Shan-Lor Trucking & Equip Lease, Inc.	49	0	49	112	29	141	Van	Reefer	NA	NA	General Freight	Refrigerated Foods	Beverages	Paper Products
Solar Express, Inc.	68	0	68	175	46	221	Van	Reefer	NA	NA	General Freight	U.S. Mail	Chemicals	Refrigerated Prods.
Speed Motor Express of WNY, Inc.	30	0	30	150	0	150	Van	Reefer	Flatbed	NA	General Freight	NA	NA	NA
Spinella Freight Lines, Inc.	3	7	10	5	9	14	Van	Reefer	NA	NA	Produce	Exempt Commodities	Automobiles	NA
Transportes Azteca International, Inc.	17	0	17	80	0	80	Van	Reefer	NA	NA	Dairy Products	Film	NA	NA
W H Strassburg, Inc.	4	0	4	20	0	20	Van	Reefer	Flatbed	Dump	Paper	Lumber	Wood Products	Steel
W Peter Ronson, Jr., & Sons, Inc.	11	0	11	33	0	33	Van	Reefer	Flatbed	Tank	General Freight	NA	NA	NA
West Island Trucking	4	0	4	10	0	10	Reefer	Flatbed	NA	NA	Fresh Produce	Nursery Stock	NA	NA
Willow Run Foods, Inc.	35	0	35	46	0	46	Opentop	Reefer	Van	NA	Dry Bulk Commodities	Refrigerated Foods	Paper products	Produce

APPENDIX D

OVERVIEW OF THE SUCCESS OF MAINES PAPER & FOOD SERVICE, INC.

2-MINUTE OVERVIEW

Maines Paper & Food Service, Inc.'s, Gets Flexible and Dramatically Increases Accuracy

Solution Profile

- Food distributor implements robust WMS
- 16,000 SKUs, 350,000-square-foot facility
- WMS functionality allows Maines to implement voice technology
- Combined solutions triple picking accuracy
- LES Provider: Manhattan Associates

In 1997, Maines Paper & Food Service, Inc., the nation's fifth largest food distributor in the country, had officially outgrown its distribution centers and was in the market for building a new, state-of-the-art facility. With items ranging from fresh, dry and frozen foods, to non-food items such as cleaning and paper products, the company knew that keeping close track of inventory was a critical component for successful operation of the more than $1 billion company.

The Need for Visibility

"Before building our new DC and implementing PkMS®, we were very limited in terms of inventory visibility," said Bill Kimler, director of systems and inventory control, Maines Paper & Foods. "With no insight into where or when product was needed, and nothing in place to track the movement of goods through the warehouse, our problems just kept growing."

> *"Without PkMS, we simply could not run our facility."*
> *Bill Kimler, director of systems and inventory control Maines Paper & Food Services, Inc.*

PKMS gives Maines more flexibility in reconfiguring picking paths and offers improved pallet building so orders can be built on a customer-by-customer basis. It also allows Maines to review "go-backs," which gives the organization the ability to streamline picking by determining if items that were out of stock when they were originally scheduled to be picked have since been replenished.

PkMS Increases Visibility, Picking Accuracy

Originally implemented in 1997, PkMS has helped Maines gain broader and more detailed visibility across the entire DC, giving it the ability to more efficiently and accurately manage inventory. With this visibility, Maines has the information necessary to expedite returns and customer recalls; meet the increasing demands of its growing employee and customer bases; and manage its diverse inventory with better control and accuracy.

In 2002, Maines upgraded to the most recent version of PkMS and implemented a voice system. This system enables DC personnel to verbally communicate with PkMS using a wireless, wearable terminal. The combined solution has enabled Maines to triple its picking accuracy, and the company expects to have further gains.

"Without PkMS, we simply could not run our facility," said Kimler. "PkMS' flexibility allows us to meet the growing demands of our business, while its open architecture enables us to add other valuable technologies to our operation."

LESA Logistics Execution Systems Association

www.mhia.org/LESA

Manhattan Associates is a proud member of the Logistics Execution Systems Association

APPENDIX E

CASE STUDY OF MAINES PAPER & FOOD SERVICE, INC.

Case Studies / Maines Paper & Food Service, Inc.

Back to Case Studies

I work for Maines Paper & Food Service based out of Binghamton NY. We sell and distribute food and other products to thousands of restaurants in the Northeast United States. We have about 1200 employees and $1.2 billion a year in sales.

I used SuperWaba to develop a scanning application for the Symbol SPT 1700. We use 18 of these devices rotated among our fleet. We download the entire contents of a delivery truck (about 1,000 cases) along with customer information. The driver then uses the SPT to scan all of the product for a customer at the point of delivery. This technology has enabled us to provide a "proof of delivery" and has cut down on lost revenue due to false claims of missing product.

I developed the Palm application using SuperWaba, the conduit using the Palm CDK (java version) and a desktop application that integrates with our host system also using java.

"In fact, we are the first in our industry to accomplish this. It's been something that we (and our competitors) have always talked about. However, the "professional" companies that sell portable scanning software are far too expensive (tens of thousands of dollars). With SuperWaba & a little Java learning curve, we developed our solution in-house. In my opinion, what we've developed is more robust, feature rich and more suited to our needs than any off-the-shelf product could ever have provided."

Without SuperWaba, I would not have been able to develop this application as I had no experience with the Palm OS (from a developer's standpoint) nor had I any experience with the C programming language.

Bill Kimler
Distribution Systems Manager

Maines Paper & Food Service, Inc
101 Broome Corp Parkway
Conklin, NY 13748

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APPENDIX F

NEW YORK GOVERNOR PATAKI AT MAINES

STATE OF NEW YORK
EXECUTIVE CHAMBER
GEORGE E. PATAKI, GOVERNOR

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FOR RELEASE: IMMEDIATE
Thursday, April 9, 1998

GOVERNOR PATAKI CHEERS MAINES SUCCESS STORY IN BROOME COUNTY
Unveils $25 Million Distribution Center that Retains 550 Jobs, Creates 150 More

Governor George E. Pataki today joined local officials and executives of Maines Paper & Food Service Inc., including its president Floyd Maines, to open its new $25 million distribution center at the Broome Corporate Park in Conklin where the company is adding 150 jobs and retaining another 550 to bring its total workforce to 800.

"Today we celebrate the renewed confidence business leaders here at Maines and across the State have shown in New York during the last three years," Governor Pataki said. "This is a celebration of Broome County's great workforce and our ability to work together to create private sector jobs and investment in the Southern Tier. We celebrate and thank Floyd Maines, and the whole Maines family, for their confidence in New York and for linking their economic future to ours.

"Maines' decision to expand here at home shows that when you have smaller, smarter, more efficient government committed to keeping New York competitive, the private sector responds positively," the Governor said. "This is a great victory for Broome County."

Maines' President Floyd Maines, Jr., said, "Four years ago, I would not have believed today's event possible. Governor Pataki kept his promise to Maines and to the State. He made the changes needed in our state government to make New York and New York businesses competitive again. Today, the business community can once again have confidence when investing in its future in New York."

Maines Paper & Food Service, Inc. was founded in 1919 as Maines Candy Company. Maines' founder and namesake, Floyd Maines, Sr., sold $30,000 of penny candy that year. In 1998, Maines projects more than $400 million in annual sales with 700 New York-based employees. Maines Paper & Food Service, Inc. is now the ninth largest food distributor in the U.S.

State Sen. Thomas W. Libous said, "When then-Senator Pataki and I stood with Floyd Maines outside his Conklin plant in 1994, we pledged to fight to keep the company and its employees in New York State. As you can see today, we've upheld that pledge to Maines Paper & Food Service, its employees, and thousands of other local employees by creating a more business-friendly climate in our State."

Assemblyman Robert J. Warner said, "With this partnership of government and private enterprise, we realize the great potential for rebuilding jobs in Broome County. I commend Floyd, Bill and David Maines for their commitment to New York State. I commend Governor Pataki and Senator Libous for their tenacity, guaranteeing Maines Paper and Food Service remains a life long resident of New York State."

In July of 1994, Floyd Maines, Jr., President of Maines wrote to former Governor Cuomo addressing his concerns over taxes, regulations, and utility rates. Maines informed Governor Cuomo that the company was considering moving its distribution operation and 550 employees to Pennsylvania. Governor Cuomo did not respond.

In August of 1994, gubernatorial candidate Pataki visited Maines and made a commitment to keep them in New York if he became Governor. In March of 1996, Maines announced an expansion plan that would involve a state of the art, $25 million distribution center and the creation of 150 new jobs and retention of 550 jobs. Another 100 jobs are not impacted by this announcement.

Charles A. Gargano, Chairman of the Empire State Development Corporation, which assisted Maines in the project, said, "Maines is the perfect example of how Governor Pataki's policies have renewed New York's business climate. We must remain on the course set by the Governor to cut taxes, cut spending and reduce burdensome regulations if we want our companies to be able to stay competitive. Maines is to be congratulated for its commitment to New York State ant the people of the Southern Tier."

# # #

ESD Contact: Maura Gallucci (212) 803-3740

APPENDIX G

THE TOP 50 BROADLINE DISTRIBUTORS

THE ID TOP 50

BROAD I

RANK '01 RANK '00	Company Name Location	Number of Distribution Centers	Sales in Millions '01 ('00)	Dollar Sales % Change '00/'01	Group Affiliation/s
1 1	SYSCO CORP. Houston, TX	125	$22,553.9 (20,645.0)	9.2%	None
2 2	U.S. FOODSERVICE Columbia, MD	100	$17,700.0** (12,000.0)	47.5%	None
3 4	PERFORMANCE FOOD GROUP Richmond, VA	25	$3,200.0 (2,605.5)	22.8%	Pocahontas
4 5	GORDON FOOD SERVICE Grand Rapids, MI	12	$2,760.0 (2,300.0)	20.0%	DMA, Markon
5 6	FOOD SERVICES OF AMERICA Seattle, WA	11	$1,325.0 (1,250.0)*	6.0%	DMA
6 7	REINHART FOODSERVICE, INC. La Crosse, WI	9	$1,281.0 (1,066.0)	20.2%	DMA, Foresight, IMA, Markon, SEFA
7 8	SHAMROCK FOODS CO. Phoenix, AZ	2	$1,040.0 (985.0)	5.6%	DMA, F.A.B., Markon
8 9	MAINES PAPER & FOOD SERVICE, INC. Conklin, NY	5	$1,020.0 (750.0)	36.0%	DMA, Markon, SEFA, UniPro
9 10	BEN E. KEITH FOODS Fort Worth, TX	6	$720.0 (618.0)	16.5%	DMA, Markon, UniPro
10 11	THE IJ COMPANY Knoxville, TN	3	$570.0 (500.0)	14.0%	DMA, Foresight, Markon
11 12	AMERICAN FOODSERVICE DISTRIBUTORS Commerce, CA	2	$420.0** (423.0)	-1.0%	UniPro
12 14	QUALITY FOODS, INC. Little Rock, AR	3	$392.5 (348.1)	12.8%	Pocahontas
13 15	CLARK NATIONAL, INC. Elk Grove Village, IL	14	$340.0 340.0	0.0%	Pocahontas, NISSCO
14 20	LABATT FOOD SERVICE San Antonio, TX	3	$339.0 (254.0)	33.5%	UniPro
15 18	CONSOLIDATED COMPANIES, INC. Metairie, LA	4	$318.0 (300.0)	6.0%	DMA, Foresight, IMA, Markon
16 13	METROPOLITAN PROVISIONS City of Industry, CA	4	$290.0*** (270.0)*	7.4%	DMA, UniPro, USA
17 21	CHENEY BROS., INC. Riviera Beach, FL	1	$275.0 (240.0)	14.6%	Pocahontas
18 19	INSTITUTION FOOD HOUSE Hickory, NC	2	$264.0 (260.0)	1.5%	Markon, UniPro
19 22	ALLEN FOODS St. Louis, MO	1	$245.0 (232.0)	5.6%	DMA, EDI, Foresight, Markon
20 23	ABBOTT FOODS, INC. Columbus, OH	1	$240.3 (215.7)	11.4%	UniPro, UniPro MUG
21 24	THOMS PROESTLER CO. Rock Island, IL	1	$233.3 (207.0)	12.7%	Markon, Premier/UniPro
22 27	NICHOLAS & CO. Salt Lake City, UT	1	$209.0 (181.0)	15.5%	DMA, Premier/UniPro, Markon
23 28	C.A. CURTZE CO. Erie, PA	3	$206.0 (173.0)	19.1%	UniPro
24 26	FEESERS, INC. Harrisburg, PA	2	$205.0 (195.0)	5.1%	UniPro
25 25	LADY BALTIMORE FOODS, INC. Kansas City, KN	2	$190.0 (197.0)	-3.6%	Premier/UniPro

The Top Tier Broadline Distributors

RANK '01 RANK '00	Company Name Location	Number of Distribution Centers	Sales in Millions '01 ('00)	Dollar Sales % Change '00/'01	Group Affiliation/s
26 30	THOMAS & HOWARD Columbia, SC	1	$151.0 (150.0)*	0.7%	Premier/UniPro
27 33	GLAZIER FOODS CO. Houston, TX	1	$150.5 (146.5)	2.7%	UniPro, UniPro MUG
28 32	VAN EERDEN DISTRIBUTION CO. Grand Rapids, MI	2	$148.0 (148.0)	0.0%	Pro*Act, UniPro
29 34	BIRITE FOODSERVICE DISTRIBUTORS Brisbane, CA	1	$147.9 (130.5)	13.3%	Premier/UniPro
30 29	HAWKEYE FOODSERVICE DISTRIBUTION, INC. Iowa City, IA	3	$147.6 (150.2)*	-1.7%	DMA, SEFA, UniPro
31 35	CASH-WA DISTRIBUTING CO. Kearney, NE	2	$145.0 (130.0)	11.5%	ProMark, UniPro
32 36	THE MERCHANTS CO. Hattiesburg, MS	2	$135.6 (123.9)	9.5%	F.A.B
33 37	MARTIN BROTHERS DIST., INC. Cedar Falls, IA	1	$131.0 (118.0)	11.0%	Premier/UniPro
34 39	WOOD-FRUITTICHER GROCERY CO., INC. Birmingham, AL	1	$123.0 (112.0)**	9.8%	UniPro
35 41	FOX RIVER FOODS INC. Montgomery, IL	1	$121.0 (106.0)*	14.2%	ProMark, UniPro, UniPro MUG
36 40	UPPER LAKES FOODS, INC. Cloquet, MN	1	$120.0** (112.0)	10.1%	ProMark, UniPro
37 38	DICARLO DISTRIBUTORS, INC. Holtsville, NY	1	$109.7 (115.4)	-4.9%	ProMark, UniPro, UniPro MUG
38 42	GOLDBERG AND SOLOVY FOODS, INC. Vernon,CA	1	$97.7 (105.9)*	-7.8%	UniPro
39 43	BUNN CAPITOL, INC. Springfield, IL	1	$95.0** (93.0)**	2.2%	F.A.B., Pro*Act
40 —	SUTHERLAND'S FOODSERVICE, INC. Forest Park, GA	6	$90.1 (80.7)	11.6%	F.A.B.
41 45	CITY LINE DISTRIBUTORS West Haven, CT	1	$89.0 (80.0)*	11.3%	UniPro
42 49	PATE DAWSON CO. Goldsboro, NC	2	$85.9 (76.3)	12.6%	Pocahontas, ProMark, Multi-Unit Solutions
43 47	J.KINGS FOODSERVICE PROFESSIONALS Holtsville, NY	1	$85.0 (78.0)*	9.0%	Pro*Act, UniPro
44 —	ZANIOS FOODS, INC. Albuquerque, NM	1	$83.5 (60.3)	38.5%	UniPro
45 46	DIERKS WAUKESHA Waukesha, WI	1	$78.5 (82.5)	-4.8%	UniPro, UniPro MUG, Promark
46 48	HFM FOODSERVICE Honolulu, HI	4	$78.0 (78.0)	0.0%	Premier/UniPro
47 50	W.S. LEE & SONS, INC. Duncansville, PA	1	$76.2 (69.4)*	9.8%	ProMark, UniPro, UniPro MUG
48 —	BANTA FOODS, INC. Springfield, MO	1	$76.0 (61.0)	24.6%	UniPro
49 —	Y.HATA & CO., LIMITED Honolulu, HI	2	$75.2 (65.9)	14.1%	NAFED, Pocahontas
50 —	JORDANO'S, INC. Santa Barbara, CA	1	$75.0 (67.3)	11.4%	Pocahontas, SEFA

*Adjusted **ID Estimate ***Adjusted to reflect elimination of $120 million in redistributor volume

APPENDIX H

THE TOP TIER BROADLINE DISTRIBUTORS

THE ID TOP 50

The Top Tier Broadline Distributors

BROAD I

10 BIGGEST PERCENT SALES INCREASES

RANK '01	Company Name Location	2001 Sales millions	2000 Sales millions	Percentage Increase
1	U.S. FOODSERVICE Columbia, MD	$17,700.0	$12,000.0	47.5%
2	ZANIOS FOODS, INC. Albuquerque, NM	83.5	60.3	38.5
3	MAINES PAPER & FOOD SERVICE, INC. Conklin, NY	1,020.0	750.0	36.0
4	LABATT FOOD SERVICE San Antonio, TX	339.0	254.0	33.5
5	BANTA FOODS Springfield, MO	76.0	61.0	24.6
6	PERFORMANCE FOOD GROUP Richmond, VA	3,200.0	2,605.5	22.8
7	REINHART FOODSERVICE, INC. La Crosse, WI	1,281.0	1,066.0	20.2
8	GORDON FOOD SERVICE Grand Rapids, MI	2,760.0	2,300.0	20.0
9	C.A. CURTZE CO. Erie, PA	206.0	173.0	19.1
10	BEN E. KEITH FOODS Fort Worth, TX	720.0	618.0	16.5

10 BIGGEST DOLLAR SALES INCREASES

RANK '01	Company Name Location	2001 Sales millions	2000 Sales millions	Increase millions
1	U.S. FOODSERVICE Columbia, MD	$17,700.0	$12,000.0	$5,700.0
2	SYSCO CORP. Houston, TX	22,553.9	20,645.0	1,908.9
3	PERFORMANCE FOOD GROUP Richmond, VA	3,200.0	2,605.5	594.5
4	GORDON FOOD SERVICE Richmond, VA	2,760.0	2,300.0	460.0
5	MAINES PAPER & FOODSERVICE, INC. Conklin, NY	1,020.0	750.0	270.0
6	REINHART FOODSERVICE, INC. La Crosse, WI	1,281.0	1,066.0	215.0
7	BEN E. KEITH FOODS Fort Worth, TX	720.0	618.0	102.0
8	LABATT FOOD SERVICE San Antonio, TX	339.0	254.0	85.0
9	FOOD SERVICES OF AMERICA Seattle, WA	1,325.0	1,250.0	75.0
10	THE IJ CO. Knoxville, TN	570.0	500.0	70.0

APPENDIX I

INITIAL STATEMENT OF REASONS FOR THE CARB AIRBORNE TOXIC CONTROL MEASURE FOR IN-USE DIESEL-FUELED TRUs

State of California
AIR RESOURCES BOARD

Staff Report: Initial Statement of Reasons for the Proposed Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities where TRUs Operate

EXECUTIVE SUMMARY

This executive summary presents the Air Resources Board (ARB or Board) staff's *Proposed Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRUs) and TRU Generator Sets, and Facilities where TRUs operate*. The proposed airborne toxic control measure (ATCM) is designed to reduce diesel particulate matter (diesel PM) emissions and resulting exposure from in-use TRUs and TRU generator sets which are powered by diesel engines and used to refrigerate temperature-sensitive products that are transported in insulated semi-trailer vans, truck vans, shipping containers, and rail cars.

The ARB, in addition to maintaining long-standing efforts to reduce emissions of ozone precursors, is now challenged to reduce emissions of diesel PM. In 1998, the Board identified diesel PM as a toxic air contaminant (TAC). Because of the amount of emissions to California's air and its potency, diesel PM is the number one contributor to the adverse health impacts of TACs known today.

Diesel exhaust is a complex mixture of thousands of gases and fine particles that contains more than 40 identified TACs. These include many known or suspected cancer-causing substances, such as benzene, arsenic and formaldehyde. In addition to increasing the risk of lung cancer, exposure to diesel exhaust can have other health effects as well. Furthermore, diesel exhaust can irritate the eyes, nose, throat and lungs, and it can cause coughs, headaches, light-headedness and nausea. Diesel exhaust is a major source of fine particulate pollution as well and numerous studies have linked elevated particle levels in the air to increased hospital admissions, emergency room visits, asthma attacks and premature deaths among those suffering from respiratory problems.

To reduce public exposure to diesel PM, the Board approved the *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (Diesel Risk Reduction Plan) in 2000. This comprehensive plan outlined steps to reduce diesel emissions from both new and existing diesel-fueled engines and vehicles. The goal of the Diesel Risk Reduction Plan is to reduce diesel PM emissions and associated potential cancer risks by 75 percent in 2010 and by 85 percent by 2020.

ARB staff is proposing this ATCM to reduce diesel PM emissions from TRU and TRU generator set diesel-fueled compression ignition engines. The proposed ATCM is one of many ATCMs that are being considered by the ARB to fulfill the goals of the Diesel Risk Reduction Plan. The ATCMs scheduled for Board consideration in the last quarter of 2003 and the first quarter of 2004 include measures to reduce emissions from residential and commercial solid waste collection vehicles, fuel cargo delivery trucks, stationary diesel-fueled engines, and portable engines.

Presented below is an overview which briefly discusses the emissions from new and existing TRU and TRU generator set engines, the proposed ATCM and its potential impacts from implementation, as well as plans for future activities. For simplicity, the discussion is presented in question-and-answer format using commonly asked questions about the ATCM. It should be noted that this summary provides only a brief discussion on these topics. The reader is directed to subsequent chapters in the main body of the report for more detailed information. Also, unless otherwise noted herein, all references to TRUs include TRU generator sets.

1. What are Transport Refrigeration Units and Generator sets?

A Transport Refrigeration Unit (TRU) is a refrigeration system powered by a diesel engine designed to refrigerate temperature-sensitive products that are transported in insulated semi-trailer vans, truck vans, shipping containers, and rail cars. The diesel engine is generally between 7 and 36 horsepower (hp) with the most common size being about 35 hp. TRUs include refrigeration systems where the diesel engine is directly connected to the refrigeration unit and refrigeration systems where a generator is powered by a diesel engine to provide electrical power to the refrigeration unit (TRU generator set).

2. What are the emissions, exposure, and risk due to TRU diesel engines?

There are currently about 31,000 TRUs and TRU generator sets based in California, another 7,500 out-of-state refrigerated trailers, and 1,700 railcar TRUs operating in California at any given time. The estimated emissions from TRU engines and TRU generator sets operating in California are shown in Table E-1. As shown, we estimate diesel PM emissions from TRUs and TRU generator sets to be almost two tons per day or 2.6 percent of the total statewide diesel PM emissions (base year 2000). Estimated oxides of nitrogen (NOx) emissions are higher at about 20 tons per day (less than one percent of the statewide inventory). Without additional regulations to reduce emissions, we anticipate that both diesel PM and NOx emissions from TRUs will grow in future years. Based on our emissions projections, the diesel PM emissions from TRUs will increase to almost 2.5 tons per day in 2010 and increase again to over three tons per day in 2020. The projected 2010 and 2020 emission estimates do not include projected emission reductions from the proposed United States Environmental Protection Agency (U.S. EPA) Tier 4 engine standards, and do not include emission reductions due to the proposed ATCM.

Table E-1: Estimated Statewide Emissions from TRUs and TRU Generator Sets

Emission Year	Total Emissions in Tons per Day (Percent of Total Statewide Diesel Emissions)*	
	PM	NOx
2000	2.0 (2.6%)	19.6
2010	2.5 (4.0%)	24.9
2020	3.1 (6.0%)	38.2

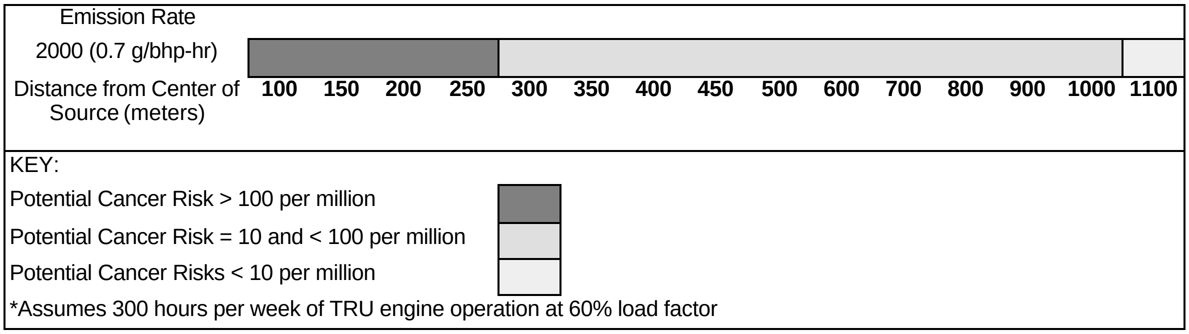
* The number in the parenthesis is the percent of the total statewide diesel PM emissions attributed to TRUs based on the October 2000 Diesel Risk Reduction Plan

The highest concentrations of diesel PM from TRUs are expected to occur at locations where numerous TRUs operate (i.e. distribution facilities, ports, and intermodal facilities). The diesel PM concentrations are dependent on the size (hp) of the engine, the age of the engine (emission rate depends on model year of engine), the number of hours of operation (run time) of the TRU engine at a facility, the distance to the nearest receptor, and meteorological conditions at the site.

Because a diesel PM monitoring technique is not currently available, diesel PM concentrations at locations where numerous TRUs operate were estimated using computer modeling techniques. To estimate exposure and the associated cancer risk near facilities where TRUs operate, staff used reasonable assumptions encompassing a fairly broad range of possible operating conditions for TRU engines. Based upon the assumptions and conditions evaluated, the results showed that facilities where numerous TRUs operate could potentially result in significant health risk to individuals living near the facilities.

To illustrate the potential near-source cancer risk, staff performed a risk assessment analysis on a generic (i.e., example) facility assuming a total on-site operating time for all TRUs of 300 hours per week. As shown in Figure E-1 below, at this estimated level of activity and assuming a current fleet diesel PM emission rate of 0.7 g/bhp-hr, staff estimates the potential cancer risk would be over 100 in a million at 250 meters (800 feet) from the center of the TRU activity. The estimated potential cancer risk would be in the 10 to 100 per million range between 250 and 1,000 meters (800 to 3,300 feet) and fall off to less than 10 per million at approximately 1,100 meters (3,600 feet). These risk values assume an exposure duration of 70 years for a nearby resident and uses the methodology specified in the latest (2003) OEHHA health risk assessment guidelines.

Figure E-1
Estimated Risk Range Versus Distance from Center of TRU Activity Area – Year 2000



3. What does the proposed TRU ATCM require?

The proposed ATCM would require in-use TRU engines that operate in California, including out-of-state TRUs while they are operating in California, to meet specific performance standards that vary by horsepower range. The in-use performance standards have two levels of stringency that would be phased-in over time. The first phase, beginning in 2008, is referred to as the low emission TRU performance standards. The second phase, beginning in 2010, is referred to as the ultra-low emission TRU performance standards. The proposed TRU performance standards are shown in Table E-2 below.

Table E-2
Proposed TRU and TRU Generator Set Performance Standards

Horsepower Category	PM Emissions Standard (grams/horsepower-hour)	Options for Meeting Performance Standard
Low Emission Performance Standards		
<25	0.30 g/hp-hr	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
= 25	0.22 g/hp-hr	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
Ultra-Low Emission Performance Standard		
<25	N/A	▪ Level 2 or better verified control strategy (51 to 85% PM reduction) ▪ Alternative technologies
= 25	0.02 g/hp-hr	▪ Level 3 verified control strategy (at least 85% PM reduction) ▪ Alternative technologies

The proposed ATCM would require owners of TRUs to meet more stringent performance standards at seven-year intervals until the TRU meets the ultra-low emission TRU performance standards. The phased in compliance schedule for various model engine years is shown below in Table E-3. For example, by December 31, 2008, all TRUs operating in the state with model year 2001 and older diesel engines will have to meet the low emission TRU performance standards. Any TRUs equipped with 2001 or older engines that are still in use in 2015 (2008 plus seven years) will have to meet the ultra-low TRU performance standards by December 31, 2015. TRUs equipped with 2002 model year diesel engines will have to meet the low emission TRU performance standard by December 31, 2009. Any TRUs equipped with a 2002 model year engine that is still in use in 2016 (2009 plus seven years) will have to meet the ultra-low TRU performance standards by December 31, 2016. TRUs equipped with 2003 model year diesel engines will have to meet the ultra-low emission performance standards by December 31, 2010. As shown in Table E-2 above, the low emission TRU performance standards can be met by either buying a new engine that meets the PM emission standard, retrofitting the existing engine with a level 2 (PM reduction of 51 to 85%) or better control system, or switching to an alternative technology.

Table E-3
Proposed TRU and TRU Generator Set Compliance Schedule

Model Year of Engine	Compliance Date for Low Emission Standard	Compliance Date for Ultra-Low Emission Standard
2001 or older	2008	2015*
2002	2009	2016*
2003	N/A	2010
Future years	N/A	Model year + 7

* Early compliance of low emission standard for model year 2002 or older may extend compliance date for ultra-low emission standard by up to three years

The average useful life of a TRU is 10 years. The proposed ATCM in effect reduces the useful life of in-use TRUs to seven years. This accelerated upgrade or replacement of TRUs will ensure that the majority of the TRU fleet will be comprised of ultra-low emission TRUs by 2020.

The proposed ATCM also contains two reporting provisions. Owners of TRUs operating in California would be required to submit an initial report to ARB that provides information about the TRUs they operate in California. Updates would need to be provided as TRUs are leased, purchased, or sold. The information is needed to assist in the implementation of the ATCM. The second reporting provision applies to large facilities where TRUs operate. Facilities with 20 or more doors serving a refrigerated storage area would be required to submit a one-time report to ARB. This information is needed to evaluate the overall effectiveness of the regulation in reducing diesel PM concentrations near facilities where numerous TRUs operate.

4. What businesses will be affected by the proposed ATCM?

The "in-use" requirements of the proposed ATCM would affect owners and operators of diesel-fueled TRUs that operate in California whether the TRUs are registered in the State or outside the State. This would include all carriers that transport perishable goods using refrigerated trucks, trailers, shipping containers, and railcars that come into California. There are a few local municipalities, school districts, and correctional institutions that operate TRUs that may be affected. Larger facilities where TRUs operate would also be affected.

5. What early reduction incentives are built into the ATCM?

The proposed ATCM includes provisions that encourage operators of 2002 and older model year TRU engines and TRU generator set engines to comply early with the low emission TRU performance standards by offering a delay in the ultra-low emission TRU compliance date. Staff is proposing that for each year of early compliance with the low emission TRU performance standards, a company can extend the compliance date with the ultra-low emissions TRU by one year, up to a maximum of three years. For example, if a 2002 model year TRU engine complies with the low emission TRU performance standards in 2006 (2006 is three years early since December 31, 2009 would be the actual compliance date for a model year 2002 engine), by using a verified control system, an operator does not have to comply with the ultra-low TRU performance standards until 2019. This provision is only available for 2002 and older engines. This early reduction incentive should provide a significant reduction in diesel PM sooner than the 2008 implementation date, thus greatly reducing the total statewide PM and the health risks at facilities.

6. What emission control strategies potentially could be used on TRU engines?

A variety of diesel emission control strategies could potentially be used for controlling emissions from these diesel engines, including "add-on" exhaust aftertreatment systems, fuel strategies, fuel additives, and engine modifications. Aftertreatment systems could be add-on technologies such as diesel particulate filters (DPF), flow-through-filters (FTF) and diesel oxidation catalysts (DOC). Fuel strategies include alternative fuels, alternative diesel fuels, and fuel additives. Alternative fuels include, but are not limited to, compressed natural gas (CNG), and liquefied petroleum gas (LPG). Dual-fuel pilot-ignition CNG or LPG fumigation engines are promising alternative fuel engine approaches. Alternative diesel fuels include, but are not limited to, water emulsion diesel fuels, biodiesel, and Fischer-Tropsch fuels. An example of a fuel additive is a fuel borne catalyst. These technologies can be combined to form additional diesel emission control strategies. In addition, repowering with a new, cleaner diesel engine is a possible strategy. Electric standby, cryogenic temperature control systems, and fuel cells are also possible diesel emission control strategies that could eliminate diesel emissions at facilities where TRUs operate.

Currently, there are no “verified” diesel emissions control strategies for TRU engines. A “verified” diesel emissions control strategy refers to an emission control system that has been evaluated by ARB for its emissions reduction capabilities and durability under the ARB’s *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emission from Diesel Engines*[1] (Verification Procedure). Staff believes that verified retrofit control systems for TRUs will become available over the next few years. Emission control technology manufacturers have indicated they are close to applying for verification of several diesel emissions control strategies under the Verification Procedure. These include fuel borne catalysts (FBC), FBC with ultra-low sulfur diesel fuel and a catalyzed wire mesh filter, and PuriNox™. In addition, staff believes that new TRUs equipped with engines that meet the more stringent off-road standards will likely replace many older TRUs. ARB staff anticipates that new engines meeting the Tier 4 nonroad standard should be available sooner than 2008.

Alternative technologies such as electric standby, cryogenic refrigeration, CNG, LPG, LNG, and gasoline-powered engines are currently feasible and would not require verification[2].

7. Is staff proposing any review to ensure that the engine and retrofit technologies for requirements with future effective dates are achievable?

Yes. Staff is proposing that two technology reviews be conducted to assure reliable, cost-effective compliance options are available in time for implementation. The first technology review would be in late 2007, a year prior to the first in-use compliance date for the first level of in-use performance standard compliance. At this time, staff would thoroughly evaluate progress made toward applying advanced technologies to meet the in-use performance standards required by the end of 2008 for TRU engines in the proposed TRU ATCM. The second technology review would be in 2009 and would evaluate whether verified emission control technology is available and cost-effective for a broad spectrum of TRUs to meet the more stringent level of in-use performance standards that would go into effect by the end of 2010 and beyond.

8. How will compliance be verified and control measure effectiveness be monitored?

Staff is proposing a registration program that uses an ARB identification (I.D.) numbering system. The I.D. numbers would include codes that indicate key compliance information such as model year of engine. California-based TRUs would be required to have I.D. numbers. For out-of-state operators, obtaining an ARB I.D. number would be voluntary. However, without such a coding system, an inspector would have to physically open up the TRU compartment to verify that the unit contains a complying engine or retrofit system. This could result in significant downtime for the truck. The

[1] Approved by the Board in May 2002. Sections 2700 through 2710, Title 13, California Code of Regulations.

[2] Spark-ignited engines are regulated under the Off-road Large Spark-Ignition Engines 25 Horsepower and Greater regulation.

coding allows a quick inspection so that trucks can get back on the road as quickly as possible. Given this situation, we anticipate that most owners of out-of-state TRUs will obtain ARB I.D. numbers for their TRUs that operate in California.

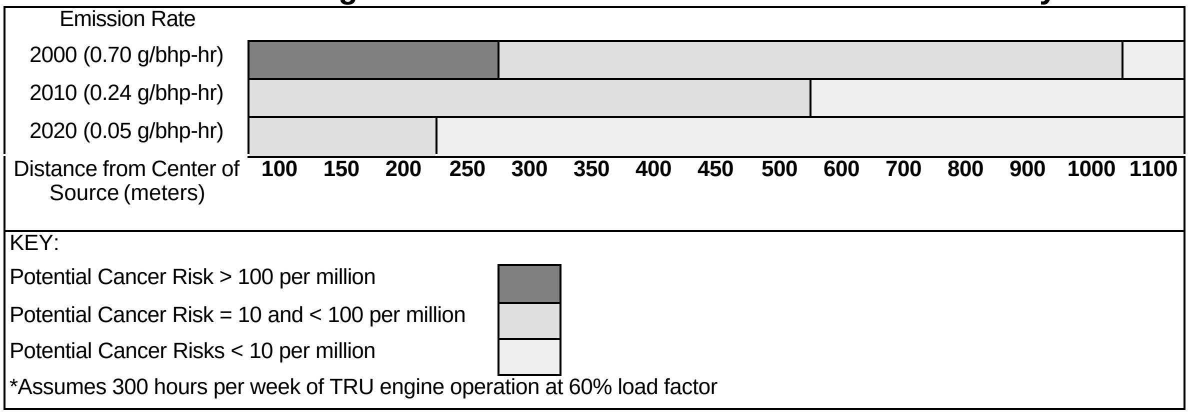
The proposed control measure would be enforced by ARB's Enforcement Division through roadside inspections conducted in conjunction with the Heavy Duty Vehicle Inspection Program. In addition, ARB inspectors would conduct audits at TRU operator terminals. As mentioned in question and answer number three, the proposed ATCM has reporting provisions that will assist ARB staff in monitoring the implementation of the ATCM and provide more accurate estimates of emission reductions.

9. What are the environmental impacts of the proposed ATCM?

The proposed ATCM will reduce diesel PM emissions and resulting exposures from TRUs operating throughout California. Staff estimated that the proposed ATCM, in conjunction with the proposed U.S. EPA Tier 4 nonroad engine standards for new engines, will reduce diesel PM emission factors by about 65 percent in 2010 and by about 92 percent in 2020. The potential total tons of diesel PM reduced by the implementation of the proposed ATCM and the U.S. EPA Tier 4 new nonroad engine standards are estimated to be approximately 3,000 tons by 2020, counting all implementation years. We also expect non-methane hydrocarbon emissions to be reduced by about 30 percent. Staff does not anticipate significant NOx reductions from this ATCM. However, some NOx reductions will result from accelerated turnover of the older fleet, or if diesel/LPG (dual fuel) TRU engines become a significant portion of the fleet. The dual fuel system can offer NOx reductions of up to 50 percent compared to a conventional diesel engine.

Reduction of potential cancer risk levels at locations where TRUs operate will result from the reduction in diesel PM emissions. Figure E-2, below, compares the cancer risk range at various distances assuming 300 hours of TRU engine run time per week. For year 2000, the current fleet average emission rate of 0.7 g/bhp-hr was used. The average fleet emission rate is assumed to be 0.24 g/bhp-hr in 2010 and 0.05 g/bhp-hr in 2020. These emission rates assume compliance with the ATCM and the proposed U.S. EPA Tier 4. Figure E-2 below also shows that the estimated near source risk is significantly reduced (by approximately 92 percent) as the diesel PM emission rate is reduced from the current fleet emission rate to the much lower emission rate in 2020.

Figure E-2
Estimated Risk Range versus Distance from Center of TRU Activity Area*



We anticipate significant health cost savings due to reduced mortality, incidences of cancer, PM related cardiovascular effects, chronic bronchitis, asthma, and hospital admissions for pneumonia and asthma-related conditions. These directly emitted diesel PM reductions are expected to reduce the number of premature deaths in California. ARB staff estimates that 211 premature deaths will be avoided by year 2020. Prior to 2020, cumulatively, it is estimated that 31 premature deaths would be avoided by 2010 and 129 by 2015. Additional health benefits are expected from the reduction of NOx emissions, which give rise to secondary PM from the conversion of NOx to PM2.5 nitrate. ARB staff has concluded that no significant adverse environmental impacts should occur under the proposed ATCM.

10 What are the estimated economic impacts of the proposed ATCM?

The economic impact of the TRU ATCM will vary depending on the compliance approach selected. Assuming that verified retrofit control devices are available to meet both the low emission and ultra-low emission performance standards in the ATCM, the estimated annual cost of the ATCM would range from $4.8 to $9 million per year between 2008 and to 2020. The estimated total cost for the retrofit compliance approach would be $87 million to $156 million (in 2002 dollars) for the 13-year compliance period. The cost to an individual choosing the retrofit control option is estimated to be between $2,000 and $2,300 per TRU. Operation and maintenance costs would add an additional $100 to $300 per year.

In the event that verified retrofit devices are not available, staff estimates that a strategy relying on new engine replacement or TRU replacement will result in annual costs of $4 to $9 million per year, and total cost ranging from $89 million to $156 million for the 13 year compliance period. These costs do not represent the total cost of engine/TRU replacement, but have been adjusted to take into consideration that many of the engines are approaching the end of their useful life of 10 years. Staff assumed that the ATCM was responsible for 40 percent of the engine replacement cost for TRUs 10 years old and newer, and 15 percent of the TRU replacement cost for TRUs that are 11 years and older. The cost to an individual purchasing a new engine for compliance is estimated to be $4,000 to $5,000 per unit. The cost to an individual purchasing a new TRU is estimated to be $10,000 to $20,000 depending on whether the TRU unit is for a straight truck or trailer. Both the new engine and TRU replacement option costs do not have any associated increase in operating costs.

We estimate the overall cost effectiveness of the proposed ATCM to be between $10 and $20 per pound ($/lb) of diesel PM reduced, considering only the benefits of reducing diesel PM. Additional benefits are likely to occur due to the reduction in reactive organic gases (ROG) and NOx emissions.

With regard to mortality benefits, we estimate the cost of avoiding one premature death to range between $282,000 to $564,000 (in 2002 dollars) based on attributing the cost of controls to reduce diesel PM. Compared to the U.S. EPA's established $6.3 million (in year 2000 dollars) for a 1990 income level as the mean value of avoiding one death (U.S. EPA 2003), this proposed ATCM is a very cost-effective mechanism to reduce premature deaths that would otherwise be caused by diesel PM emissions without this regulation. The cost range per death avoided because of this proposed regulation is 8 to 22 times lower than the U.S. EPA's benchmark for value of avoided death.

No significant economic impacts to school districts, local public agencies, state agencies, and federal agencies are expected, due to the low number of TRUs operated by them and their relatively few number of facilities that would be subject to this ATCM. Costs to ARB for initial outreach, educational efforts, and enforcement would be absorbed within existing budgets.

This regulation may lead to creation or elimination of businesses. Due to the long lead time for compliance, wide range of compliance options, and small business facility reporting exemption (facilities with less than 20 refrigerated doors), we believe that most businesses will be able to meet the compliance costs. However, it is possible that a small number of businesses (those with marginal profitability) may experience financial difficulty in complying with the regulation. Businesses that may be created include those that furnish, install, and maintain diesel emission control systems, as well as those that provide alternative compliance strategies. Engine manufacturers, TRU manufacturers, and TRU sales and service dealers are likely to see an increase in business due to accelerated attrition and other options to meet the in-use requirements of the regulation.

11. How will the proposed ATCM affect the State Implementation Plan (SIP)?

The ARB's *Proposed 2003 State and Federal Strategy for the California State Implementation Plan* (Proposed Strategy) describes defined state and federal measures that will reduce emissions and improve air quality statewide. Because this ATCM was still under development when the Proposed Strategy was released, it was not possible to project the expected ancillary reactive organic gas (ROG) emission reductions that would result from its implementation. However, once the TRU ATCM is adopted and the emission reductions are enforceable, ARB may claim any associated ROG benefits against our SIP commitments. The proposed TRU ATCM would reduce ROG emissions, which in turn would help decrease ambient ozone levels, thereby helping the South Coast air basin attain the federal ozone standard. In addition, reductions of direct diesel particulate will help decrease ambient particulate levels and make progress toward attainment of federal particulate matter standards in the South Coast and the San Joaquin Valley.

12. What actions did staff take to consult with interested parties?

Staff made extensive efforts to ensure that the public and affected parties were aware of, and had opportunity to participate in, the rule development process. Staff contacted major TRU and TRU generator set manufacturers, engine manufacturers, emission control system manufacturers, operators, and operator organizations both to alert affected industry and to gather information about the technology and operation of the equipment. The data and information collected from these sources was supplemented by approximately 25 facility tours and facility operator interviews. Staff also contacted State and local agencies that have involvement with TRU operators and the facilities where TRUs operate, informed them of the development of the ATCM, and requested information and data.

Staff discussed numerous regulatory approaches for controlling TRU and TRU generator set emissions with affected industry and the public during a public consultation meeting, nine workgroup meetings/conference calls, five public workshops, and a large number of stakeholder meetings, e-mails, and telephone conversations. Staff also conducted outreach with the agricultural community, grocers associations, trucking associations, cold storage warehouse associations, port terminal associations, and railroad associations. In addition, ARB's efforts to reduce diesel PM emissions, including TRU's, has also been discussed at several communities meetings as part of our Community Health Program. Information on our efforts was provided on April 1, 2003, at the Boyle Heights community meeting on air pollution, and on April 30, 2003 at the Wilmington community meeting.

Staff tracked available and emerging emission control methods and facilitated communication among control system manufacturers and TRU and TRU generator set manufacturers, engine manufacturers, and operators. This continuing effort has resulted in a number of demonstration projects and studies that have provided important information regarding the feasibility and efficacy of various PM control devices, retrofit technology, electrification, and alternative fuel use.

13. How does the proposed ATCM relate to ARB's goals on Environmental Justice?

The proposed ATCM is consistent with the ARB's Environmental Justice (EJ) Policy to reduce health risks from TACs in all communities, including low-income and minority communities. Many communities are located near where TRUs operate, such as heavily traveled freeways, storage and distribution facilities, railyards, and ports. By reducing emissions of diesel PM, other known TACs, and other air pollutants from TRUs and TRU gen sets, the proposed ATCM will provide air quality benefits by reducing exposure to and associated health risk from these pollutants near facilities where TRUs and TRU generator sets operate.

14. What other laws establish requirements for TRU engine emissions in California?

The U.S. EPA and ARB regulate TRU engines as mobile nonroad (off-road) engines. TRU engines less than 25 horsepower (<25 hp) became subject to U.S. EPA and ARB emission standards in 1995. Engines in the greater than or equal to 25 horsepower (=25 hp) to less than 50 horsepower (< 50 hp) became subject to U.S. EPA and ARB emission standards in 1999. In April of 2003, U.S. EPA proposed new emission standards for engines in both of these horsepower categories. These new standards are referred to as the Tier 4 nonroad standards. The proposed effective date for the Tier 4 standards for <25 hp engines is 2008.

The proposed effective dates for the Tier 4 standards for engines in the =25 hp to <75 hp category are an “interim” standard in 2008 and a “long term” standard in 2013. The “long term” standard must be implemented in 2012 if the engine manufacturer elected not to meet the “interim” standard. Staff expects that the manufacturers of TRU engines will meet the “interim” 2008 standards. As soon as the U.S. EPA Tier 4 standards are adopted, ARB plans to adopt new engine standards that harmonize with the federal standards. Below are the existing and proposed PM emission standards (Figures E-3 and E-4) for the TRU engine horsepower categories based on the model year of the engine.

Figure E-3: PM Emission Standards for TRUs < 25 hp

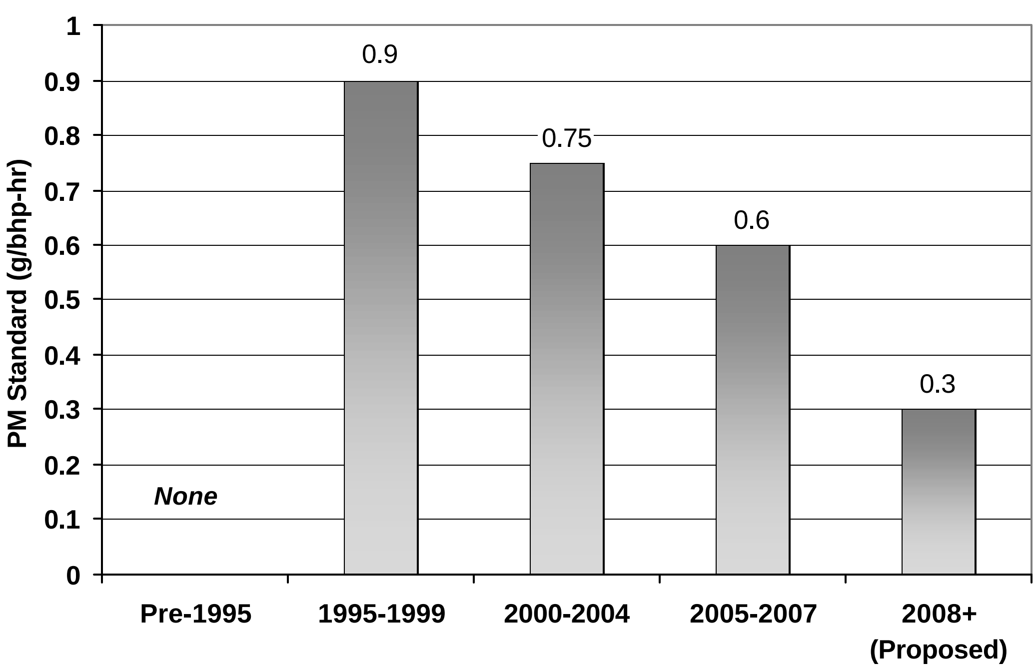
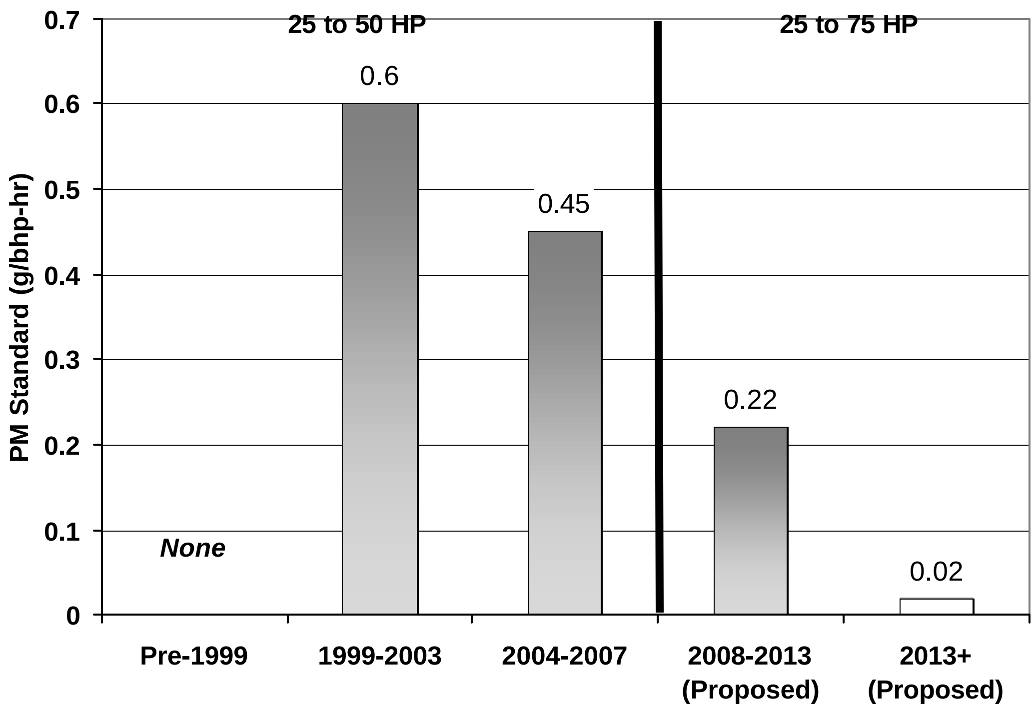


Figure E-4: PM Emission Standards for TRUs ≥ 25 HP



15. What future activities are planned?

In addition to activities associated with monitoring and implementing the proposed regulation, staff has recognized the need to continue collecting information about TRU operations, facility operations, and evaluating residual risk at facilities. Some of these activities include:

- Seek a Title I section 209(e) waiver from U.S. EPA.
- Work with affected business to develop outreach and training opportunities to assist operators and facilities in complying with the ATCM
- Development of TRU identification number issuing systems and database
- Conduct emission control technology reviews in 2007 and 2009
- Work with the U.S. EPA to propose long-term PM emission standard for less than 25 hp engines
- Conduct an analysis of the large facility data submitted in 2005.

16. What is staff's recommendation?

ARB staff recommends the Board adopt section 2022, Title 13, chapter 3, article 4, CCR, in its entirety. The regulation is set forth in the proposed regulation order in Appendix A.

In addition, staff recommends that the Board direct staff to conduct two technology reviews. The first, in 2007, would evaluate technology readiness for the in-use requirements that would begin to be phased in by the end of 2008 and continue phase-in over the next 12 years. Part of that technology evaluation would be to determine if more stringent standards for these pollutants would be feasible for <25 hp TRU engines in the 2010 to 2013 time-frame. In addition, ARB proposes a second technology review to be conducted in 2009 to evaluate whether technologies that would meet the ultra-low emission TRU performance standards would be available and cost-effective for a broad spectrum of the model year 2003 through 2005 TRU and TRU gen set engines that would need to come into compliance by the end of 2010 through 2012, respectively.

REFERENCES:

U.S. EPA, 2003. Control of Emissions of Air Pollutants from Nonroad Diesel Engines and Fuel, Proposed Rule Making Notice of Proposed Rule Making, Federal Register. Vol. 68 No. 100, May 23, 2003, pp. 28327-28603. U.S. Environmental Protection Agency.

APPENDIX J

ATRI COMPENDIUM OF IDLING REGULATIONS

COMPENDIUM OF IDLING REGULATIONS

The information in this table is for reference purposes only and should not be relied upon for regulatory compliance. This information may contain errors and omissions and is subject to change. Actual state, county or city codes should be referenced for specific requirements. On-line users may access these codes by clicking on the individual regulations.

State	Maximum Idling Time	Exemptions
Arizona, Maricopa County	**5 minutes** (30 min. for bus passenger comfort or 60 min/90 min if greater than 75° F) Fines: $100 – 1st violation $300 – 2nd+ violations	- Traffic or adverse weather conditions - Emergency or law enforcement purposes - Power takeoff involving cargo or work functions - Conform to manufacturer's specifications - Maintenance or diagnostics - Hours of service compliance
Maricopa County Vehicle Idling Restriction Ordinance. Maricopa County Air Quality Department (602) 506-6010, www.maricopa.gov/aq		
California	**5 minutes** Fines: Minimum $100	- Bus passengers are onboard or 10 minutes prior to boarding - Resting in sleeper berth beyond 100' of residential units - Traffic conditions - Queuing beyond 100' of residential - Adverse weather conditions or mechanical difficulties - Vehicle safety inspection - Service or repair - Power takeoff involving cargo or work functions - Prevent safety or health emergency - Emergency vehicles
CA Code of Regs, Title 13, Div. 3, Art. 1, Ch. 10, §2485. California Air Resources Board (800) 242-4450, www.arb.ca.gov		
California, City of Sacramento **<<NEW>>**	**5 minutes** (prohibits refrigeration unit operation within 100' of residential or school unless loading/unloading) Fines: Not <$100 nor >$25,000 per violation *(Title 1, Ch. 1.28.010)*	- Traffic conditions/control - Traffic conditions - Vehicle safety inspection - Service or repair - Conform to manufacturer's specifications - Power takeoffs involving cargo or work functions - Prevent safety or health emergency - Hours of service compliance @ truck/rest stop - To recharge hybrid electric vehicles
Sacramento City Code, Title 8, Ch. 8.116. City of Sacramento Department of Transportation (916) 264-5011, http://www.pwsacramento.com/dot/parking/onstreet.html		

COMPENDIUM OF IDLING REGULATIONS

California, Placer County	**5 minutes** (prohibits refrigeration unit operation within 1000' of residential or school unless loading/unloading) Fines: $50 Minimum	- Traffic conditions/control - Traffic conditions - Vehicle safety inspection - Service or repair - Conform to manufacturer's specifications - Power takeoffs involving cargo or work functions - Prevent safety or health emergency - Hours of service compliance @ truck/rest stop - To recharge hybrid electric vehicles - Operate intermittent equipment - Alternatively fueled vehicles - Attainment areas
Placer County Code, Article 10.14 Placer County Air Pollution Control District (530) 889-7130 www.placer.ca.gov/airpollution/airpolut.htm		
Colorado, City of Aspen	**5 minutes within any 1 hour** Fines: $1,000 maximum and/or 1 year imprisonment *(§1.04.080)*	- Safety reasons - To achieve an engine temperature of 120° F and an air pressure of 100 lbs/square inch
City of Aspen Municipal Code §13.08.110 Aspen Environmental Health Department (970) 920-5039, http://www.aspenpitkin.com/depts/44/		
Colorado, City & County of Denver	**10 minutes in any 1-hour period** Fines: Not >$999 and/or 1-year imprisonment *(DMC §1-13)*	- Less than 20° F for previous 24-hour period - Less than 10° F - Emergency vehicles - Traffic conditions - Being serviced - Auxiliary equipment
Denver Municipal Code §4-43. City & County of Denver, Division of Environmental Protection, Mobile Sources Program (720) 865-5452, www.denvergov.org/environmental_protection		
Connecticut	**3 minutes** Fines: Not >$5,000 per week *(RCSA Title 22a §174-12(c))*	- Traffic conditions or mechanical difficulties - Ensure safety or health of driver/passengers - Auxiliary equipment - Conform to manufacturer's specifications - Less than 20° F - Maintenance - Queuing to access military installation
Regulations of Connecticut State Agencies Title 22a, §174-18(b)(3). State of Connecticut Department of Environmental Protection; Bureau of Air Management (860) 424-3027, www.dep.state.ct.us		
Delaware **<<NEW>>**	**3 minutes** (15 minutes: 32° to -10° F; No limit: Less than -10° F) Fines: $50 - $500 per offense *(Title 7, Ch. 60, §6005 & §6013)*	- Traffic conditions or mechanical difficulties - Conform to manufacturers specifications - Repair - Emergency vehicles - Using auxiliary equipment/power take off - Power during sleeping or resting beyond 25 miles of truck stop with available electrified equipment - Vehicle safety inspections
Regulation 45, Excessive Idling of Heavy Duty Vehicles. Delaware Division of Air & Waste Management (302) 739-9402, www.dnrec.state.de.us/DNREC2000/Divisions/AWM/AWM.htm		

COMPENDIUM OF IDLING REGULATIONS

District of Columbia	**3 minutes** (5 minutes if less than 32° F) Fines: $500, doubles for each subsequent violation	- Power takeoff
District of Columbia Municipal Regulations Title 20, §900.1. District of Columbia Department of Health Environmental Health Administration Air Quality Division (202) 535-2257, www.dchealth.dc.gov		
Georgia, City of Atlanta	**15 minutes** (25 minutes if less than 32° F for passenger comfort/safety) Fines: $500 minimum	- To perform needed work - Traffic conditions - Natural gas or electric vehicles
Code of Ordinances §150-97(c)City of Atlanta Dept. of Public Works. City of Atlanta, Office of Transportation (404) 330-6501, www.atlantaga.gov/Government/PublicWorks		
Hawaii	"No person shall cause, suffer, or allow any engine to be in operation while the motor vehicle is stationary at a loading zone, parking or servicing area, route terminal or other off street areas…" (3 minutes for start up/cool down or passenger loading/unloading) Fines: Not <$25 nor >$2,500 per day *(106 HRS §342B-47)*	- Adjustment or repair - Auxiliary equipment or power takeoff - Passenger loading/unloading = 3 min. - At start-up and cool down for more than 3 min.
Hawaii Administrative Rules §11-60.1-34. Hawaii State Department of Health; Office of Environmental Quality Control (808) 586-4185, www.hawaii.gov/health/environmental/air		
Illinois	"No person driving or in charge of a motor vehicle shall permit it to stand unattended without first stopping the engine…" Fines: Not >$500 *(625 ILCS 5/6-601(b))*	None
625 Illinois Combined Statute 5/11-1401. Illinois Department of Transportation (217) 782-7820, www.dot.state.il.us		
Maryland	**5 minutes** Fines: Not <$500 (MC § 27-101(b))	- Traffic conditions or mechanical difficulties - Heating, cooling or auxiliary equipment - Conform to manufacturer's specifications - Accomplish intended use
Maryland Transportation Code §22-402(c)(3). Maryland Department of the Environment (410) 537-3000, www.mde.state.md.us		
Massachusetts	**5 minutes** Fines: Not <$100 - 1st offense Not <$500 for each succeeding offense	- Being serviced - Delivery for which power is needed & alternatives unavailable - Associate power needed & alternatives unavailable
General Laws of Massachusetts Ch. 90: § 16 A. Massachusetts Department of Environmental Protection (617) 292-5500, www.mass.gov/dep		

COMPENDIUM OF IDLING REGULATIONS

Minnesota, Minneapolis <<NEW>>	**0 minutes in residential areas between 10 p.m. and 6 a.m.** (including refrigeration units) Fines: $700 maximum and/or 90 days imprisonment *(Title 1, Ch. 1)*	- Permitted construction equipment - Compliance with traffic signals or signs - Emergency or law enforcement purposes
Code of Ordinances, City of Minneapolis, Minnesota, Title 15, Ch. 389.100(7) & (8). Minneapolis Environmental Management (612) 673-5897, www.ci.minneapolis.mn.us/environment/		
Minnesota, City of Owatonna	**15 minutes each 5 hours in residential areas** Fines: $1,000 maximum and/or 90 days imprisonment *(Chapter XI, Section 1100:00)*	None
Owatonna City Code, Chapter IX, Section 900:10. City of Owatonna (507) 444-4300, www.ci.owatonna.mn.us		
Minnesota, City of St. Cloud	**5 minutes, West St. Germain Street from 8th to 10th Avenue** Fines: Not <$200 *(SCOO §706:35)*	None
St. Cloud City Ordinance §706:10. City of St. Cloud, Parking Violations (320)255-7209, www.ci.stcloud.mn.us		
Missouri, City of St. Louis	**10 minutes** Fines: Not <$1 nor >$500 and/or imprisonment for not >90 days *(SLCO 64645 §26)*	- Emergency vehicles
St. Louis City Ordinance 64645 §14(D). City of St. Louis, Department of Air Pollution Control (314) 613-7300, www.stlouis.missouri.org/citygov/airpollution		
Nevada	**15 minutes** Fines: Not <$100 nor >$500 – 1st; Not <$500 nor >$1,000 – 2nd; Not <$1,000 nor >$1,500 – 3rd; Not <$1,500 nor >$2,500 – 4th and subsequent; offense(s) over a 3-year period *(NAC445B.727)*	- Variance has been issued - Emergency vehicles - Snow removal equipment - Repair or maintain other vehicles - Traffic congestion - Maintenance at repair facility - Emission contained & treated per Commission - To perform specific task
NV Administrative Code Ch. 445B.576. Nevada Division of Environmental Protection; Bureau of Air Pollution Control (775) 687-9350, www.ndep.nv.gov/bapc		
Nevada, Clark County, (including Las Vegas)	**15 minutes** Fines: Not >$10,000 *(CCAQR §09)*	- Variance has been issued - Emergency vehicles - Repair or maintain other vehicles - Traffic congestion - Emission contained & treated per Control Officer - To perform a specific task - Maintenance at repair facility
Clark Co. Air Quality Regs. §45. Clark County Department of Air Quality Management (702) 455-5942, www.co.clark.nv.us/air_quality		

COMPENDIUM OF IDLING REGULATIONS

Nevada, Washoe County (including Reno)	**15 minutes** Fines: Not >$250 – 1st offense Not <$250 nor >$500 – 2nd and subsequent offenses *(WCDBHR §020.040(E))*	- Emergency vehicles - Snow removal equipment - Repair or maintain other vehicles - Traveling on public right-of-way - To perform specific task - Maintenance at repair facility
Washoe Co. District Board of Health Regs. §040.200. Washoe County District Health Department, Air Quality Management (775) 784-7200, www.co.washoe.nv.us/health		
New Hampshire	**5 minutes if greater than 32° F** (15 minutes: 32° F to -10° F) Fines: TBD	- Traffic conditions - Emergency vehicles - Power takeoff or heat/cool passengers - Maintenance or diagnostics - Defrost windshield - Less than -10° F
Air Resources Division Admin. Rules Env-A 1101.05. New Hampshire Department of Environmental Services, Air Resources Division (603) 271-1370, www.des.state.nh.us		
New Jersey	**3 minutes** (15 min. if stopped for more than 3 hrs) (30 min. if permanently assigned) Fines: $200 for 1st offense; $400 for 2nd offense; $1,000 for 3rd offense; $3,000 for 4th and subsequent. *(NJAC 7:27A3.10)*	- Bus picking up/discharging passengers - Traffic conditions - To perform needed work - Waiting or being inspected - Emergency vehicles - Being repaired - Connecting, detaching or exchanging trailers - Sleeping or resting in a sleeper berth in non-residential zone unless equipped with auxiliary heating/cooling
New Jersey Administrative Code Title 7, Ch. 27-14.3. New Jersey State Department of Environmental Protection; Air Quality Management, Regulatory Development (609) 292-2795, www.state.nj.us/dep/aqm		
New York	**5 minutes** Fines: Not <$375 nor >$15,000 – 1st offense; Not >$22,500 – 2nd offense & subsequent offenses *(NYSCL Ch. 43-B, §71,2103(1))*	- Traffic conditions - Comply with passenger comfort laws - Auxiliary power or maintenance - Emergency vehicles - Within mines or quarries - Parked for more than 2 hrs & less than 25° F - State Inspections - Recharging hybrid electric vehicles - Farm vehicles - Electric vehicles
New York Code of Rules & Regulations Title 6, Ch. 3 Part 217-3.2. New York State Department of Environmental Conservation; Division of Air Resources (518)402-8292, www.dec.state.ny.us		
New York City	**3 minutes** Fines: Not <$50 nor >$500 and/or imprisonment for 20 days – 1st; Not <$100 nor >$1,000 and/or imprisonment for not >30 days – 2nd offense; Not <$400 nor >$5,000 and/or imprisonment for not >4 months – 3rd & subsequent offenses. *(NYCAC 24-190(g))*	- Emergency vehicles - Operate loading, unloading or processing device
New York City Administrative Code Title 24-163. New York City Department of Environmental Protection (212) 639-9675, www.nyc.gov/dep		

COMPENDIUM OF IDLING REGULATIONS

Pennsylvania, Alleghany County <<NEW>>	**5 minutes** (20 min./hour if less than 40° F or more than 75° F) Fines: Warning – 1st offense; $100 – 2nd offense $500 – 3rd & subsequent offenses	- Traffic conditions - Boarding & discharging passengers - Queuing - Cool down/warm up per manufacturer's recommendations - Sleeping/resting in truck - Safety inspections - Ensure safe operation - Emergency vehicles - Power accessory or service equipment - Repair or diagnostics
County of Allegheny Ordinance No. 16782, §2105.92. Allegheny County Health Department, Air Pollution Control (412) 687-2243, www.achd.net		
Pennsylvania, City of Philadelphia	**2 minutes or 0 minutes for layovers** (5 minutes if less than 32° F) (20 minutes if less than 20° F) Fine: $300	None
Air Management Reg. IX §3(A). Philadelphia Department of Public Health, Air Management Services (215) 685-7578, www.phila.gov/health/		
Texas <<NEW>> Cities: Austin, Bastrop, Elgin, Lockhart, Round Rock, San Marcos Counties: Bastrop, Caldwell, Hays, Travis, Williamson	5 minutes, April – October (30 minutes for bus passenger comfort or transit operations) Fine: Varies by jurisdiction	- 14,000 lbs GVW or less - Traffic conditions - Emergency or law enforcement - To perform needed work - Maintenance or diagnostics - Defrost windshield - Airport ground support - Rented/leased vehicles - Hours of service compliance
Texas Administrative Code Title 30 § 114.512. Texas Commission on Environmental Quality (512) 239-0774, www.tceq.state.tx.us		
Utah	"A person operating or in charge of a motor vehicle may not permit the vehicle to stand unattended without: (a) stopping the engine…" Fines: Not >$750 and/or not >90 days imprisonment *(UC 76-3-204; 301)*	None
Utah Code Title 41-6a-1403. Utah Department of Public Safety (801) 965-4461, www.publicsafety.utah.gov		
Utah, Salt Lake County	**15 minutes** Fines: Not >$1,000 and/or not >6 months imprisonment – 1st; Not >$2,500 and/or not >1 year imprisonment – 2nd & following; offense(s) within 2 years *(UC 76-3-204; 301)*	- Power refrigeration unit if greater than 500 ft from any residence - Heat/cool sleeper berth if greater than 500 ft from any residence - Emergency vehicles
Salt Lake City-County Health Dept. Regulation #28 6.8. Salt Lake Valley Health Department, Environmental Health Services, Air Pollution Control (801) 313-6720, www.slvhealth.org/eh/html/airpol.html		

Virginia	**10 minutes in commercial or residential urban areas** Fines: Not >$25,000 *(CV 10.1-1316)*	- Auxiliary power
Virginia Administrative Code, Title 9, 5-40-5670(B). Virginia Dept. of Environmental Quality (804) 698-4000, www.deq.state.va.us/air		

FOR MORE INFORMATION ABOUT ATRI, VISIT WWW.ATRI-ONLINE.ORG

APPENDIX K

EPRI REPORT ON TRANSPORTATION REFRIGERATION EQUIPMENT

EPRI

fact sheet

Transport Refrigeration Equipment: Cost-Effective Emissions Reduction

Electric Transportation Program

Shippers use refrigerated trucks, trailers, and oceangoing containers to transport foods and other perishable items. These vehicles and containers are essentially refrigerators on wheels. Known as transport refrigeration units (TRUs), they sometimes remain stationary for hours or even days while awaiting transport or unloading. During these periods, an auxiliary diesel engine typically powers the refrigeration compression unit.

The problem is that these TRUs contribute to high concentrations of pollutants and particulates at large distribution centers. Because the nearby communities that suffer the impact of these pollutants are typically low-income neighborhoods and communities of color, use of these engines raises environmental justice issues.

One way that air pollution at and around distribution centers can be significantly reduced is through the use of grid-connected electric standby (E/S) transport refrigeration units, or e-TRUs. Electric standby can be used while a TRU is stationary, although an auxiliary engine is still required during transport. The use of e-TRUs can improve local air quality and at the same time generate a market opportunity for utilities.

Before E/S can be widely adopted, though, questions about the costs and benefits of e-TRUs must be answered. EPRI launched a study to explore the projected emission reductions, capital costs, and feasibility of adding E/S auxiliary motors—powered by a dockside electric supply infrastructure—to operate TRUs while stationary at warehouse or terminal locations.

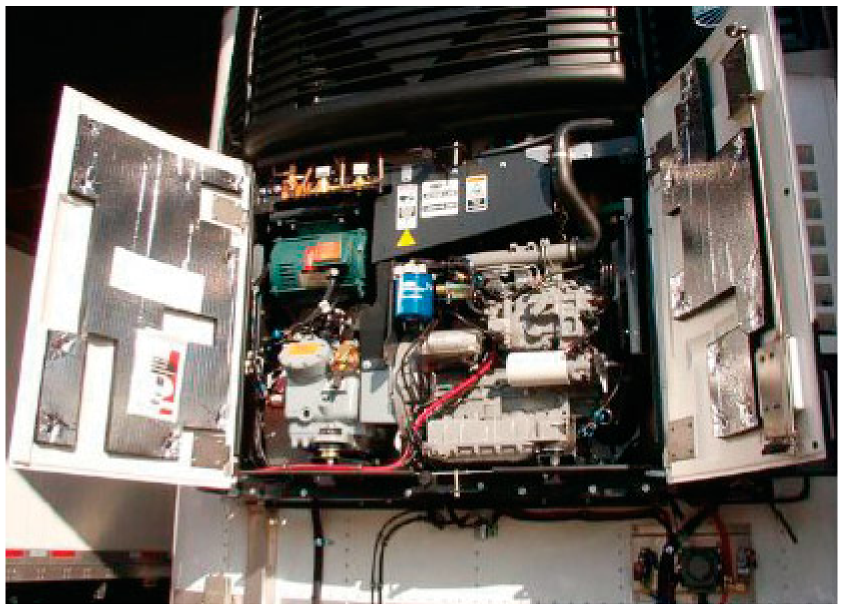


Figure 1. e-TRU in Trailer at LA Unified School District

Background

The EPRI study, *Transport Refrigeration Equipment Analysis of Emissions and Economics of Electrification,* Product ID 1008783, builds on an emissions analysis of TRUs prepared by the California Air Resources Board (ARB). The study's impetus was the Air Toxic Control Measure (ATCM) recently adopted by ARB as well as new non-road engine standards announced by the Environmental Protection Agency (EPA) in May 2004.

Before 1995, TRU engines were not regulated by either the federal or state governments. However, the new federal non-road regulations impose increasingly stringent new-engine standards on manufacturers. These regulations are expected to reduce PM emissions by about 95% and NO_x and ROG emissions by about 65% between 2004 and 2014. The use of e-TRUs could help truckers meet the new standards.

Emissions Benefits of e-TRUs

A semi-trailer diesel TRU engine can emit more oxides of nitrogen (NO_x) than the truck's main engine when idling, even though both use a similar amount of diesel fuel. This means that providing a cleaner source of power for the TRU can potentially reduce emissions more than cleaning up the vehicle's main engine. For example, for a 34-hp TRU, replacing the diesel engine with an electric motor powered by grid electricity just for one hour of operation reduces toxic particulate matter (PM), NO_x, and reactive organic gases (ROG) by more than 209 grams, which is 30% better than emission reductions achieved by eliminating idling of the main truck engine. These benefits are tempered by the fact that the TRU may run more or less than an idling truck over the course of a year, and trucks and trailers with E/S will still need to use the auxiliary diesel engine when away from the grid.

Market Opportunity

Extrapolating ARB's estimate of the number of TRUs in California, researchers determined that there were approximately 300,000 trailer-mounted TRUs of all sizes in the U.S. in 2000. The electrical load created by these trailer-mounted e-TRUs provides a significant market opportunity for electric utilities.

For example, the energy load of a semi-trailer e-TRU varies from 5 kW to 19 kW, depending on the evaporator return-air temperature. With a projected average energy use of 8 kWh per hour, annual usage would be between 8,000 kWh and 24,000 kWh. The projected average energy use for a box van e-TRU is 2.5 kWh per hour (roughly 2,500 to 7,500 kWh per year). Peak loads might be as high as 15 kW for a semi-trailer e-TRU and 6 kW for a box van e-TRU. These are larger peak loads than expected with truck stop (idle reduction) electrification and are similar to the load from a battery electric vehicle.

Study Approach

EPRI's analysis examined four strategies for shifting diesel TRUs to e-TRUs.

- Strategy 1 focuses on scrapping an existing diesel early and buying a new TRU with a cleaner diesel engine and E/S.
- Strategy 2 suggests retaining the normal TRU replacement schedule and adding the E/S option when buying a new TRU.
- Strategy 3 involves retrofitting an existing diesel TRU to add E/S.
- Strategy 4 proposes that if the TRU already has E/S, an infrastructure be added at additional locations to increase the amount of zero-emission run time.

The study examined all four strategies using a 20-year life cycle for a refrigerated trailer or box van.

Investigators developed spreadsheets to compare three cases with varying assumptions (vehicle type, operating profile, equipment age, and so on) in order to assess emission reductions and cost-effectiveness of E/S compared to natural retirement cycles and installation of exhaust after-treatment systems.

- Case Study 1 assumed a 34-hp semi-trailer TRU operating 3,000 hours per year, a high-use scenario, 50% of that time in E/S mode.
- Case Study 2 assumed a 34-hp semi trailer TRU operating 1,200 hours per year, a low-use scenario, 50% of that time in E/S mode.
- Case Study 3 assumed a 10-hp van TRU operating 1,038 hours per year, and 50% of that time in E/S mode.

Table 1. Results of Applying Strategy 1: Retiring a MY 2001 TRU in 2008 and Replacing With a New e-TRU

Description	Semi-Trailer (34 hp) With 3,000 hrs/yr and 50% E/S Operation	Semi-Trailer (34 hp) With 1,200 hrs/yr and 50% E/S Operation	Van (10 hp) With 1,038 hrs/yr and 50% E/S Operation
Number of years diesel engine was retired early	3	13	13
Incremental NO_x, ROG, and PM PM emission reductions 2008–2020 compared to federal scenario (lifetime tons)	3.3 tons	2.7 tons	0.71 tons
Incremental cost per pound of NO_x, ROG, and PM reduced versus EPA	$0.43	–$0.24	$4.92
Incremental NO_x, ROG, and PM emission reductions 2008–2020 compared to CA-ATCM scenario (lifetime tons)	3.1 tons	2.42 tons	0.66 tons
Incremental cost per pound of NO_x, ROG, and PM reduced versus CA-ATCM	–$0.07	$0.98	$2.68

Note: Negative cost-effectiveness indicates a cost savings to achieve the additional emission reductions.

The research team developed the TRU Spreadsheet Analysis Tool (TRUSAT), a model to aid in the analysis of costs, emissions, and petroleum consumption reduction benefits. The TRUSAT model enables analysts to draw conclusions about the impact of regulatory decisions and potential market niches for E/S. Using the TRUSAT model, researchers compared the incremental results of the E/S strategy to two other scenarios: one that assumes compliance with the federal non-road engine standards only, and one that assumes compliance with the federal non-road engine standards, as well as the California ATCM.

Study Results

The analysis concludes that the incremental cost-effectiveness of the two semi-trailer e-TRU cases is far better than that of many on-road vehicle emission reduction approaches. The E/S van case also reduces emissions at a reasonable cost-effectiveness. One reason is that these scenarios involve replacing a diesel TRU three to thirteen years earlier than otherwise expected.

Table 1 summarizes the results of implementing Strategy 1, starting with a MY 2001 TRU and assuming early retirement of the TRU in 2008, and replacing a new TRU with E/S that is retired in 2021.

Table 2 summarizes the results of implementing Strategy 2, and illustrates a normal replacement cycle where a new 2008 TRU meeting interim federal Tier 4 standards is purchased with an E/S option. The sensitivity of the analysis to model year is illustrated by the results in Table 2 compared to Table 1. Table 2 contrasts the emissions reductions when all scenarios start with the purchase of a new TRU in 2008, rather than 2001 as shown in Table 1. Table 2 also provides the range of lifetime tons reduced and associated cost-effectiveness for a non-electric TRU scenario.

Strategy 3, which retrofits an existing diesel TRU with E/S, can also result in very large emissions reductions, similar to Strategy 1. Both strategies remove or reduce the use of a relatively dirty diesel engine. Retrofitting also can be a cost-effective use of grant incentives to reduce NO_x, ROG, and PM. However, there are several issues related to e-TRU retrofitting which are discussed further below.

Strategy 4 is based on installing additional electric infrastructure with an existing e-TRU and is a variation on Strategies 1, 2, and 3. It can also be more cost-effective than these other strategies, if targeted at locations where TRUs can plug in for a significant number of hours. To the extent that emissions could be reduced simply by adding infrastructure at additional locations, this would be a cost-effective strategy.

Overall, the analysis concludes that the cost-effectiveness of emissions reductions is sensitive to changes in cost and model-year assumptions rather than changes in engine emissions. In addition, total emissions reductions achieved in a given scenario are very sensitive to percentage of E/S hours versus diesel operation.

Recommendations

The analysis points to several areas where additional study and market strategy development are needed:

1. The efficient use of public funds to maximize public benefits is critically important to ensure long-term success in meeting air quality and energy security enhancement goals. This can be accomplished by considering overall cost-effectiveness based on the total benefits of a project, as opposed to PM reductions only. When public benefits are considered holistically, the case for e-TRUs is more compelling.
2. Public agencies should encourage technologies that exceed the minimum standards (if any) for reducing NO_x, ROG, PM, CO_2, and petroleum consumption, either by revising existing regulations or by using non-regulatory tools, such as incentives.
3. Another type of incentive option is trading of mobile source emission reduction credits (MSERC). Proceeds from the sale of credits can help offset the additional cost of generating the extra emissions reductions. The

Table 2. Results of Applying Strategy 2: Purchasing a New TRU With E/S Option in 2008

Description	Semi-Trailer (34 hp) With 3,000 hrs/yr	Semi-Trailer (34 hp) With 1,200 hrs/yr	Van (10 hp) With 1,038 hrs/yr
E/S Operation = 50%: NO_x, ROG, and PM reductions (lifetime tons)	2.25 tons	0.9 tons	0.28 tons
E/S Operation = 50%: Cost per pound of NO_x, ROG, and PM reduced	$1.68	$4.21	$3.68
CA-ATCM: NO_x, ROG, and PM reductions (lifetime tons)	0.07 to 0.29	0.03 to 0.12	0.01 to 0.04
ICA-ATCM: Cost per pound of NO_x, ROG, and PM reduced	$19.03 to $4.64	$47.56 to $11.60	$121.43 to $35.39

TRUSAT model can be used to evaluate grant incentives or MSERC incentives by testing many key assumptions. It also provides a foundation for creating new scenarios based on the existing spreadsheets.

4. The electro-drive industry and the TRU industry should team with ARB and others to develop one or more E/S demonstration projects. A demonstration project would provide the opportunity to test the assumptions in both the ARB staff report and the TRUSAT model.
5. The analysis did not consider operating costs. A demonstration project that included these costs would determine whether there are offsetting maintenance and fuel savings associated with E/S. In addition, the impact of utility rates on various on-peak and off-peak duty cycles needs to be evaluated.
6. The need for standardization of e-TRU infrastructure must be evaluated. For example, dockside connectors and cabling are not standardized, and dozens of plug, socket and cable combinations are available. Lack of an infrastructure standard creates confusion and slows down the development of the market.
7. Similarly, the power requirements for oceangoing TRUs should be standardized and coordinated with land-based E/S systems. Currently, 460-V 3-phase power is the most typical configuration used in large modern distribution centers. Standardizing on 208/230-V 3-phase power is another possibility and is typical of TRUs in the 10-hp to 17-hp range.
8. The study did not consider potential greenhouse gas emission reductions. It would be useful to quantify these emission reductions for the existing fleet and the potential reductions from various e-TRU usage scenarios.
9. The E/S compliance option under the current ARB regulation requires that there be no diesel operation at any facility, whether home base or a brief delivery stop. Such a strict requirement will place an undue burden on TRU operators who might wish to use E/S for compliance. More work is needed to determine whether this requirement is necessary to achieve the projected emission reductions.
10. EPA and ARB should consider adding e-TRUs to the emissions inventory.

For More Information

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Contractors

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APPENDIX L

EPRI TRU CASE STUDY OVERVIEW

case study

Transport Refrigeration Units

Electric Transportation Program

Transport refrigeration units (TRUs) are used to control temperature in truck containers that carry perishable food, medications, and other commodities. Most TRUs are powered by small diesel engines whose emissions contribute to air pollution and local health concerns especially in and near distribution centers and warehouse parking lots where exhaust accumulates. Concern about these concentrated emissions has prompted the California Air Resources Board (ARB) to pursue air toxics control measures targeting TRUs. Federal regulators, also, are reviewing options for controlling emissions.

One way to significantly reduce emissions is to power TRUs with grid-powered electric motors when they are stationary – or in standby mode – for extended periods. The Sacramento Municipal Utility District (SMUD) evaluated existing technology and potential improvements to electrically powered TRUs (e-TRUs), analyzed capital and operating costs, and examined operational barriers to widespread use of e-TRUs. This full report is entitled *Transport Refrigeration Units: A Technical Assessment* [EPRI Product ID 1009992].

State of Technology

Truck-trailer TRUs are vapor compression cycle refrigeration systems, typically diesel driven. They are made by outside manufacturers and installed in trailers by trailer manufacturers. These refrigeration systems have four main components: evaporator, compressor, condenser, and control valve.

Today's trailer-mounted TRUs typically are powered by 2-liter, 1,800 to 2,200 RPM diesel engines that produce 30–40 peak horsepower. Low engine speed and low combustion temperatures result in long life and low cost. The engine drives the compressor directly and, through v-belts, also drives condenser and evaporator fans and a 12-V alternator. The engine operates in high speed mode when temperature falls below a certain set point, and in standby mode for temperature maintenance.

In today's e-TRUs, a clutch disengages the engine and a 10- to 15-horsepower industrial induction electric motor drives the compressor and fans through v-belts. One drawback is that the motor is too low-powered to lower the trailer interior from hot ambient temperature to operating temperature (a process known as pull-down) in the industry-required 20- to 30-minute period. Additionally, retrofit of electric standby on TRUs has proven to be an expensive proposition; it is much cheaper to install the electric motor capability when the system is first manufactured.

All TRUs have the ability to operate as heat pumps either to defrost the evaporator coil or to warm up the refrigerated space for loads that require a higher set point in cold weather. Certain kinds of fresh produce frequently require this

Figure 1. Front View of Refrigerated Highway Trailers With Transport Refrigeration Units (TRUs) Installed.

treatment, and may require fans to run regardless of ambient temperature because of product out-gassing, which can lead to spoilage.

The operational need for fast pull-down, the capability to cope with door openings during deliveries, and the trend towards lighter, less insulated trailers to maximize internal volume, have led industry to compensate with higher capacity, higher power refrigeration systems.

Possibilities for improving transport refrigeration technology could include introduction of efficiency standards for transport refrigeration systems. This approach has been effective in other refrigeration equipment sectors. Testing to enforce the standards should include both the refrigeration unit and the insulated trailer. Most transport refrigeration systems appear to be much less energy efficient than other refrigeration equipment – primarily because of engineering tradeoffs between efficiency and the ability to adapt to temperature extremes, to cool as well as heat, to control humidity, to ventilate cargo gas buildup, and to provide fast pull-down.

One way to improve energy efficiency is to increase the insulation in the TRU. However, better insulation usually means thicker container walls. Because the external dimensions of trailers are fixed by the Department of Transportation, any increase in wall thickness due to insulation results in a decrease in internal volume and less cargo capacity. Because the payloads are typically not high density, TRUs usually fill completely before their weight limits are reached, making any decrease in internal volume a decrease in cargo capacity.

The grocery industry typically uses standard pallet sizes, which fit exactly inside existing trailers with 2.5 inch wall thickness

Equipment Capital and Operating Cost

A detailed analysis of first cost, infrastructure cost, and fuel and maintenance costs of e-TRUs concludes that overall costs would increase 10% when compared to diesel, assuming the use of presently available technology. The analysis found that e-TRU technology does not appear viable on a purely economic basis when all costs are included, unless diesel costs reach about $2.50 per gallon at the pump.

Profit margins are narrow in the food handling business. As a result, there is little capital investment in new technology unless government mandates require it. Because of the narrow profit margins, purchase decisions for equipment are often based on small differences in equipment cost, and infrequently take into account future energy costs. The level of system integration is relatively low, and the study could identify no industry standards for testing complete refrigerated trailers.

If public funds were used to partly finance infrastructure costs or electric energy costs, the analysis would change, and electric standby could offer a better economic package for the refrigerated transport industry. Mechanisms to finance infrastructure or energy may also be available based on the emissions reductions realized with electric standby. Such mechanisms are described in the ARB's report on TRUs.

Barriers to User Acceptance

Replacing today's conventional TRUs with e-TRUs is technically feasible, however barriers to widespread acceptance remain, chief among them user objections on economic grounds.

To understand the barriers, SMUD interviewed decision makers from representative TRU users in the food supply industry, including two major grocery warehouse operations, one distributor of restaurant specialty foods and supplies, one dairy products company, and one frozen food warehouse. The interviews revealed perceptions and operational constraints that prevented users from adopting e-TRUs.

Perceptual Barriers

Many fleets based outside of California do not understand or recognize the state's high population density and climate conditions or its need to reduce emissions. For them, emissions mandates represent unwarranted regulatory intrusion.

Operational Barriers

Users also voiced several operational concerns. Three factors dominate the economics of transporting food and other perishables: the ability to maximize the amount of cargo in each vehicle, the ability to minimize the time that each vehicle is idle and empty, and the reliability of systems that can minimize waste and down time. Of lesser concern is the cost of fuel.

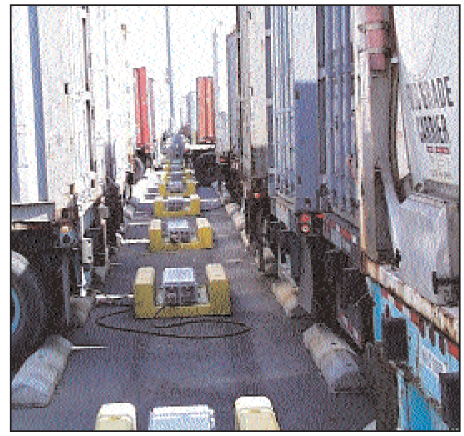

Figure 2. Container Refrigeration Systems Plugged in at Port.

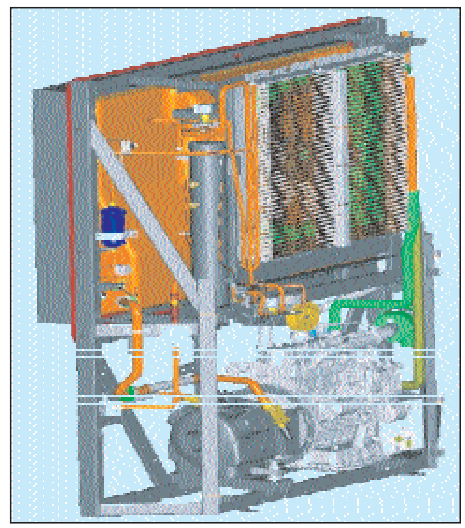

Figure 3. Trailer Mounted Truck Refrigeration Unit.

Equipment Capital and Operating Cost

Because profit margins are slim across the industry, an upgrade to e-TRUs must provide economic payback. An equipment capital expense must be offset by decreased operating costs, with as short a payback time as possible.

Reliability
High reliability is an imperative for protecting cargo, which in the case of pharmaceuticals and certain food products is high-value. Interviewees expressed concern about reliability of the equipment and of electric power.

High Performance
In the industry, high performance translates to the ability to minimize the time required to bring a TRU's temperature down to the value required for loading with perishable cargo. High performance does not necessarily equate to high efficiency because time to market and cargo capacity often outweigh efficiency in the overall cost equation.

TRU users interviewed expressed concern that e-TRUs in standby mode would not be able to provide enough power to accomplish pull-down in 30 minutes or less. Indeed, present TRU design appears to be dominated by the requirement for fast pull-down to keep pace with just-in-time deliveries and minimum waiting time.

Low Maintenance
Frequency of maintenance is a factor in overall cost of ownership. Longer maintenance intervals mean less down-time and lower cost of operation. Electric drive holds an advantage in this area because electric motors have fewer moving parts and lubrication requirements, and do not leak fuel or lubricant. Also, electric drives on the evaporator and condenser fans would eliminate the belts, and thereby reduce maintenance intervals and improve efficiency.

Low Weight
Lighter refrigeration equipment translates to lower transportation costs. To the extent that e-TRUs require electric motors in addition to the diesel engines required for use during transport, they increase weight.

Safety Issues
Interviewees were concerned about the safety of dismounting from the vehicle cabin to connect high-voltage cables to e-TRUs. Special training to use the equipment would represent an additional expense. Without a safety interlock between the electrical system and the vehicle's motive engine, the potential exists for driving away without disconnecting the power cable. Such drive-offs could result in damaged equipment and dangerous contact with ruptured high-voltage lines.

Cost and Reliability of Fuel
Although the cost of diesel fuel is borne by the carrier, the cost of electricity is generally borne by the owner of the warehouse or distribution center. These two entities are often not the same, so the warehouse or distribution center owner expects increased expense associated with e-TRU operation unless an arrangement is made to share the cost of electricity with shippers. In addition, scheduling constraints could keep customers from taking advantage of off-peak power discounts.

Interviewees also worried that unforeseen demands for additional power may not be met. They perceived that the electric utility industry is near its limit of generating capacity, and that the distribution system was vulnerable to choke points in the distribution grid.

Economic forces in the industry demand that participants show more concern for maximizing the amount of cargo in a trailer and protecting it from spoilage than for minimizing operating costs. These forces suggest that TRU operators are not likely to lower their electricity usage to accommodate electric utility peak demand constraints. In fact, they are more likely to demand more power during summer peak usage times. Diesel usage would be seen as a backup during such times, even though air quality concerns during these periods are typically high also.

Emissions Considerations
The daily duty cycle of TRU refrigeration units is an important factor in considering the emissions reductions possible with e-TRUs.

One interviewee reported that its TRUs are turned on about one half-hour before being loaded, and remain running until the load is delivered. Analysis of data provided by the interviewee showed that the switched-on time for a TRU was approximately half of the clock time. Dividing the remaining 12 hours into stage-and-load, transport-cargo, and return-to-base times, it is reasonable to believe that grocery operations TRUs are switched on 8–12 hours per day, and actually operate on the order of 4–6 hours per day. Industry users typically track only total engine time; they do not distinguish between time spent in transport or while stationary at the home facility. ARB estimates, however, that TRUs spend most of their operating time while stationary. Therefore, use of e-TRUs would eliminate half of the total emissions and all of the emissions concentrated at the facility.

Future Research Need: Evaluate Real-World Operation
Future research projects should seek to identify actual operating habits and the location of systems during operation. For example, some TRUs, often the older and least insulated, are sometimes used for extra food storage at warehouses and distribution centers. This practice might be well served with electric power, particularly if thermal insulating blankets were used to better insulate stationary trailers to decrease overall energy use.

For More Information

M. Duvall, EPRI Project Manager, phone: 650.855.2591, email: mduvall@epri.com

Contractors

Sacramento Municipal Utility District SMUD), Principal Investigator: W. Warf

J Knapp Communications, Principal Investigator: J. Knapp

About EPRI

EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

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APPENDIX M

NEW YORK REFRIGERATED TRANSPORT COMPANY PROFILES

Company Name, Address		**Last Update:**	08/16/02
KJ Transportation, Inc. PO Box 25129, 6070 Collett Rd. Farmington, NY 14425-0129		**Web:**	www.transic.com
		E-mail:	
		Telephone:	(716) 924-9951
		Toll-free:	(800) 828-9640
Principal:	Kevin Johnson	**Fax:**	(716) 924-9959
Title:	President	**Revenue:**	
Motor carrier number:	189474	**Carrier type:**	FOR-HIRE
Dot Number:	0	**Carrier/Fleet Type:**	General Freight

Number of tractors:	616	**Number of straight trucks:**	0
Owned tractors:	466	Owned straight trucks:	0
Tractors leased from O-O 's or others:	150	Trucks leased from O-O 's or others:	0
Number of trailers:	754		
Owned trailers:	754		
Trailers leased from O-O 's or others:	0		

Trailer type 1:	Van	**GVW Class 1&2:**	
Trailer type 2:	Reefer	**GVW Class 3,4&5:**	
Trailer type 3:		**GVW Class 6:**	
Trailer type 4:		**GVW Class 7:**	Y
		GVW Class 8:	Y
Commodity transported 1:	General Freight	**SIC classification**	For-hire trucking, general freight
Commodity transported 2:	Foodstuffs	**TL/LTL designation:**	TL
Commodity transported 3:		**Year established**	1973
Commodity transported 4:		**Maintenance at Facility:**	Y
SIC Code:	4207		

Company Name, Address		**Last Update:**	07/23/03
Erie Logistics, LLC 5873 Genesee St. Lancaster, NY 14086		**Web:**	
		E-mail:	
		Telephone:	(716) 515-2399
		Toll-free:	
Principal:	Rick Cohen	**Fax:**	(716) 515-3362
Title:	President	**Revenue:**	
Motor carrier number:	0	**Carrier type:**	FOR-HIRE
Dot Number:	1043805	**Carrier/Fleet Type:**	Refrigerated Solids

Number of tractors:	124	**Number of straight trucks:**	0
Owned tractors:	124	Owned straight trucks:	0
Tractors leased from O-O 's or others:	0	Trucks leased from O-O 's or others:	0
Number of trailers:	545		
Owned trailers:	538		
Trailers leased from O-O 's or others:	7		

Trailer type 1:	Reefer	**GVW Class 1&2:**	
Trailer type 2:	Van	**GVW Class 3,4&5:**	
Trailer type 3:		**GVW Class 6:**	
Trailer type 4:		**GVW Class 7:**	Y
		GVW Class 8:	Y
Commodity transported 1:	Produce	**SIC classification**	For-hire trucking, refrig. solids
Commodity transported 2:	Meat	**TL/LTL designation:**	TL
Commodity transported 3:	Refrigerated Foods	**Year established**	0
Commodity transported 4:	Beverages	**Maintenance at Facility:**	
SIC Code:	4216		

Company Name, Address		**Last Update:**	09/13/02
Boston-Buffalo Express, Inc. PO Box 2818 Syracuse, NY 13220-2818		**Web:**	
		E-mail:	
		Telephone:	(315) 437-6161
		Toll-free:	
Principal:	Frank J Magari	**Fax:**	(315) 437-8000
Title:	President	**Revenue:**	$8,406,976
Motor carrier number:	46518	**Carrier type:**	FOR-HIRE
Dot Number:	15046	**Carrier/Fleet Type:**	Refrigerated Solids
Number of tractors:	113	**Number of straight trucks:**	9
Owned tractors:	113	Owned straight trucks:	9
Tractors leased from O-O 's or others:	0	Trucks leased from O-O 's or others:	0
Number of trailers:	165		
Owned trailers:	140		
Trailers leased from O-O 's or others:	25		
Trailer type 1:	Reefer	**GVW Class 1&2:**	Y
Trailer type 2:		**GVW Class 3,4&5:**	
Trailer type 3:		**GVW Class 6:**	
Trailer type 4:		**GVW Class 7:**	Y
		GVW Class 8:	Y
Commodity transported 1:	General Freight	**SIC classification**	For-hire trucking, refrig. solids
Commodity transported 2:	Refrigerated Solids	**TL/LTL designation:**	TL
Commodity transported 3:	Frozen Products	**Year established**	1969
Commodity transported 4:		**Maintenance at Facility:**	Y
SIC Code:	4216		

Company Name, Address		**Last Update:**	07/23/03
GSN Trucking Corp. 2060 9th Ave. Ronkonkoma, NY 11779-6253		**Web:**	www.gkd.com
		E-mail:	
		Telephone:	(361) 737-5555
		Toll-free:	(800) 669-1828
Principal:	Glenn Nussdorf	**Fax:**	(361) 737-5154
Title:	President	**Revenue:**	
Motor carrier number:	189415	**Carrier type:**	FOR-HIRE
Dot Number:	58264	**Carrier/Fleet Type:**	General Freight

Number of tractors:	100	**Number of straight trucks:**	15
Owned tractors:	100	Owned straight trucks:	15
Tractors leased from O-O 's or others:	0	Trucks leased from O-O 's or others:	0
Number of trailers:	230		
Owned trailers:	230		
Trailers leased from O-O 's or others:	0		

Trailer type 1:	Reefer	**GVW Class 1&2:**	Y
Trailer type 2:	Van	**GVW Class 3,4&5:**	Y
Trailer type 3:		**GVW Class 6:**	Y
Trailer type 4:		**GVW Class 7:**	Y
		GVW Class 8:	Y
Commodity transported 1:	General Freight	**SIC classification**	For-hire trucking, general freight
Commodity transported 2:	Groceries	**TL/LTL designation:**	TL
Commodity transported 3:	Health & Beauty Aids	**Year established**	1986
Commodity transported 4:	Pharmaceutical Drugs	**Maintenance at Facility:**	Y
SIC Code:	4207		

APPENDIX N

TEMPERATURE CONTROLLED LOGISTICS REPORT

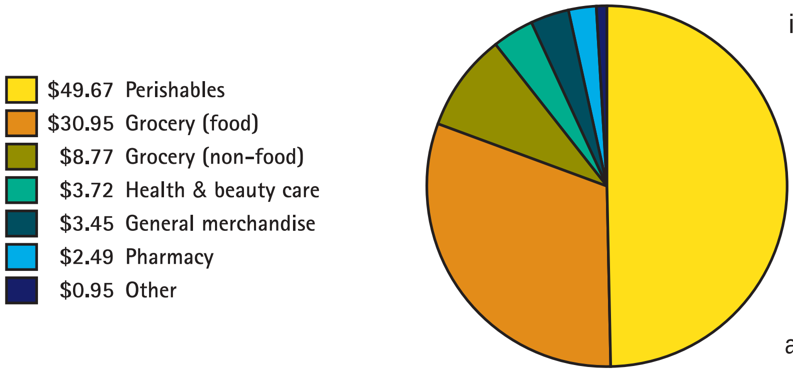
[2 0 0 2 - 2 0 0 3]

TEMPERATURE CONTROLLED LOGISTICS REPORT
SHIPPER AND CARRIER PERSPECTIVES

C.H. RO

IOWA STATE UNIVERSITY

[1] How $100 is spent in the supermarket



Source: *Progressive Grocer*, used by permission

Temperature controlled products represent a relatively small percentage (approximately 4%, as estimated by *Refrigerated Transporter* magazine) of the total U.S. freight volume, but they include products purchased by virtually all consumers. A look at how $100 is spent at the supermarket underscores the pervasiveness of temperature controlled products in the life of the average consumer. In 2001, *Progressive Grocer* reported that more than 50% is spent on perishable goods—dairy products, deli items, florals, frozen foods, meats, seafood, packaged bakery foods, and produce. Additionally, some products in the other supermarket categories also require temperature control. [1]

Temperature controlled products face substantial logistics challenges because they often have a short shelf-life; they require specialized transportation equipment and storage facilities and close monitoring of product integrity in transit; and frequently, their demand is seasonal. This latter characteristic creates operating challenges for carriers. As noted by several refrigerated carriers interviewed by *Transport Topics*, wide swings in volume and the time pressures associated with perishable goods make it more difficult to schedule drivers and have equipment positioned where it is needed; in addition, extended waiting time at shippers' and receivers' facilities is a major problem.

Shippers and carriers of temperature controlled products have been responsible for many of the key logistics management initiatives and programs that have taken place in the U.S. during the last two decades. And they continue to develop innovative approaches to improving supply chain management.

In *TrafficWORLD*, a recent survey by McHugh Software International and Tompkins Associates identified a strategic initiative in a key temperature controlled market that will greatly affect logistics service providers. The survey discovered that suppliers in the food and beverage industry are investing heavily in a pull-based production planning and inventory management approach (referred to as available-to-promise logistics systems) to support the leaner supply chains of their powerful retailer customers. Pursuing available-to-promise capabilities will put even greater pressure on transportation and handling systems to provide speed, dependability, and inventory visibility on a real-time basis.

In a similar vein, *Inbound Logistics* reported that leading food companies are employing various methods and tools to improve their logistics performance. Among them are outsourcing, more formal collaboration among supply chain partners, information technology (including e-commerce), and reorganization/integration of logistics within the shipper organizations.

In short, shippers of temperature controlled products face the same logistics challenges as shippers of other products and then some, due to the nature of their freight. They are constantly implementing new strategic and operational initiatives to lower costs and improve customer service. In addition, carriers of temperature controlled products confront unique requirements (e.g., equipment cleaning, temperature probes, product inspection) and incur greater costs (e.g., equipment capital costs and equipment operating costs) than carriers of dry goods.

The *Temperature Controlled Logistics Report 2002-2003* chronicles the efforts of shippers to meet rigorous demands and provides insights on emerging logistics management issues and developments. Because successful logistics performance is a team effort, motor carrier efforts and perspectives on a key issue identified in previous years' reports—waiting time at shipper and receiver facilities—are also included in this year's study.

This report is the latest in a series dedicated to tracking the temperature controlled logistics industry. It highlights today's best practices but also tries to identify what will become tomorrow's best practice, based on findings derived from the participants in the survey. The report is a reference for those already involved in the temperature controlled supply chain, and can educate and inform those not currently participating in this market.

HISTORY OF THE TEMPERATURE CONTROLLED LOGISTICS REPORT

About the Survey

C.H. Robinson Worldwide, Inc. (CHRW), one of the largest third-party transportation and logistics companies in North America, has conducted surveys since 1997 to learn more about logistics practices, needs, and trends in the temperature controlled market. The goal is to share relevant information and data to facilitate improvements in temperature controlled logistics performance and to assist firms in benchmarking.

This yearís report marks the third year of CHRW's collaboration with Iowa State University (ISU). Professor Michael Crum, ISU, and Professor Thomas Goldsby, formerly with ISU and now at The Ohio State University, revised the surveys and supervised collection and interpretation of the survey data. Some 125 shippers and 125 motor carriers participated in this year's telephone surveys.

What You Will Find In This Report

In addition to the key issues confronting shippers and carriers of temperature controlled products, this year's report, the sixth in the series, offers two additional features.

The latest information on waiting time is highlighted on pages 16 to 21. Shippers and carriers both offer their views of how long drivers wait at the dock to load and unload refrigerated, frozen, and temperature protected products, and what they are doing to minimize the wait. Carriers offer additional perspectives on the magnitude of waiting time costs and the most problematic sectors of the temperature controlled market.

Two mini-case studies, which discuss aspects of temperature controlled shipping, appear on pages 4 and 5. Ellison Meats discusses various initiatives to minimize waiting time. Ghirardelli Chocolate Co. presents how and why it outsources transportation and logistics activities.

Waiting Time Case Study:

Ellison Meats

Ellison Meats, a processor and distributor of frozen meat products, receives boxed meat at its plant in Pipestone, Minnesota, and cuts the meat into the chops, steaks, and patties that we buy at our local grocery store. Ellison ships the equivalent of 5 to 6 full vehicle loads per week from its portion control plant. Ninety percent of its volume moves by LTL, and its truckload movements typically involve multiple drops.

When Ellison product is detained during distribution, the primary costs derive from failure to maintain product integrity. The longer the loads sit, the greater the likelihood of temperature variations that can affect the product's shelf-life and can potentially discolor the product—a serious problem, since appearance is one of the biggest selling points of frozen meat products. Thus, maintaining appropriate temperature control is essential.

Fortunately, excessive waiting time at their own and receiver facilities has not been a problem for Ellison to date, although it is aware of the problem at other firms. Tom Krakow, traffic manager for Ellison, believes that shippers, receivers, and carriers all have responsibilities in the effort to minimize waiting time. Based on his own experience, he suggests that shippers and receivers establish appointment times for their carriers that are attainable. That is, the carriers must be given a reasonable amount of time to provide the pickup and delivery service.

At Ellison Meats, carriers are obligated to meet their scheduled appointment times. This means that carriers must schedule their vehicles and drivers so that they can reasonably meet their appointments. Hitting the pickup and delivery windows is particularly important for LTL freight, since one late shipment has a domino effect, delaying later pick-ups and deliveries. Carriers also should stay in constant communication with their shippers and receivers. Although the receiver may be more directly affected by changes in delivery times, it is equally important to keep the shipper in the loop. If a driver will be late, the carrier must inform both the shipper and receiver as soon as possible so that alternative plans can be put into action.

Ellison evaluates its carriers on their on-time pickup and delivery performance. However, because waiting time is not a major issue now, Ellison currently does not measure the costs of excessive waiting time. This is likely to change in the near future as the company adds new product lines and begins to distribute more fresh meat products, which have a shorter shelf-life and are more susceptible to spoilage and damage. Maintaining product integrity throughout the supply chain process, and especially during transport, will become even more critical.

Krakow thinks that the waiting time issue will become even more significant for his industry in the future. The biggest factor is the effort to streamline inventories by both buyers and suppliers, leading to an increase in smaller orders. The increased frequency of transportation loads and unloads that accompany this reduction in shipment size creates challenges for dock managers. He is concerned that many receiver facilities are not prepared to handle the expected increase in delivery volumes.

Outsourcing Case Study:

Ghirardelli Chocolate Company

As noted in this year's report, interest in logistics outsourcing continues to grow in the U.S. and particularly among temperature controlled shippers. The Ghirardelli Chocolate Company, based in San Leandro, California, manufactures and markets premium chocolates, and ships approximately 80% of its products in a temperature controlled environment. Mark Greenhall, vice president of sales and services, explains that sensitive Ghirardelli products must be stored and shipped between 55°F and 65°F throughout the supply chain, year-round—no small task for a manufacturer that can literally see its profits melt with poor supply chain execution.

Ghirardelli had used a third-party service provider (3PL) on a limited basis, but in mid-year 2002, the company outsourced 100% of its intercompany transportation (manufacturing to regional warehouses) to a 3PL, along with virtually all outbound transportation to customers. Their primary outsourcing goals: to improve customer service to retail customers, and to take control of rising, unpredictable costs, which can swing by as much as 20%, month over month. As Greenhall explains, "We're a relatively small company with significant variance in our business volumes. One huge order can create a variance that can have massive influences on transportation." Outsourcing to a 3PL provides flexibility to better manage these dramatic swings without incurring the fixed and variable costs that accompany the peaks and valleys in demand.

Ghirardelli also expected its outsourcer to lend expertise as the company consolidated its distribution facilities. In addition, the 3PL could better accommodate the company's reliance on refrigerated less-than-truckload transportation, which is typically more difficult to manage than truckload shipping.

When Ghirardelli began searching for a 3PL, they looked for a provider of sufficient size to ensure coverage when capacity tightens and as needs change. They also sought access to valued information technologies. Greenhall says, "Improved communications, such as Web-based order tracking, was extremely important for keeping our customers informed, letting them know what's coming, whether there are any cuts or disruptions in the order." Experience with refrigerated LTL shipping was also a prerequisite. "In total," Greenhall says, "we were seeking best practice implementation from our service provider."

Since outsourcing, Ghirardelli has experienced improved service and higher on-time delivery performance. Communications have improved, providing retail customers with higher levels of reassurance and satisfaction. Transportation costs have decreased by 10%. At the end of the day, these are also the key areas in which Ghirardelli evaluates the 3PL during regularly-scheduled conference calls. "We assess on-time delivery, whether our costs are consistent with our expectations based on the contract, and the working relationship," explains Greenhall. "Once each quarter, we compile a full report in the form of a comprehensive scorecard to summarize performance for the period."

For the industry, Greenhall foresees greater use of intermodal to cut costs, and sees tremendous opportunities among small- and medium-sized companies to embrace logistics outsourcing. "Larger companies will continue to do their own thing, but the 'B' and 'C' companies stand to gain a great deal from working together and sharing costs." An industry push will be necessary to make these efforts and results happen, he says. "We should work together [through third parties] to deliver better value to the customer."

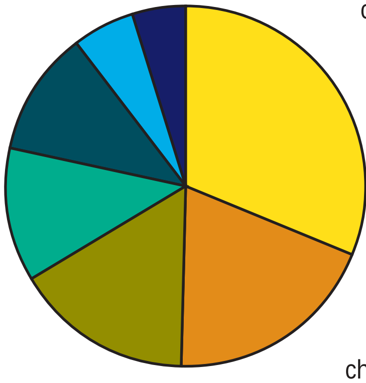
Profile of Survey Resondents

The information for this report was gathered through telephone interviews with 125 shippers and 125 carriers in the temperature controlled logistics industry. While it is impossible to precisely determine the true composition of shippers and carriers of temperature controlled products in the U.S., it is believed that the report represents an appropriate cross-section of firms in the temperature controlled logistics industry. Among the shipper respondents, 79% are manufacturers, processors, or growers in the supply chain; 14% are wholesalers or distributors; 4% are retailers; and 3% are temperature controlled warehouse operators who ship products on behalf of their customers.

Shippers of frozen food represented the single largest segment of respondents (31%), followed by other food and beverage classifications. Shippers of pharmaceuticals and chemicals are also represented in the findings. These non-food shippers represent a small yet important segment of the temperature controlled logistics market. [2]

[2] Shipper Industries

- 31.2% Frozen food
- 19.2% Meat/Poultry/Fish
- 16.0% General Refrigerated Food *
- 12.0% Dairy
- 11.2% Pharmaceuticals
- 5.6% Beverages
- 4.8% Chemicals

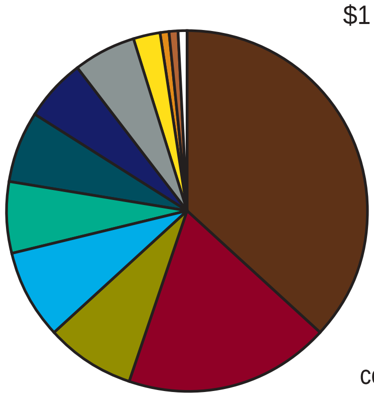


* All food types not included in the other food categories

Of the respondents, 18% reported sales of less than $100 million, 20% reported sales of $100 million to $1 billion, and almost 26% reported sales of $1 billion or more. Revenues ranged from $1.0 million to $50 billion. On average, 75% of each respondent's business is shipped in a temperature controlled environment. Shipping points ranged from a single location to as many as 120 facilities, with the average respondent shipping from just over 11 facilities. [3]

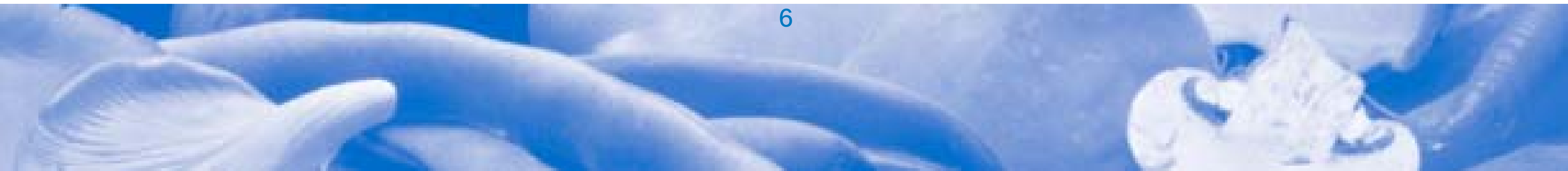
[3] Annual Sales Volume

- 2.4% $1-$4.9 million
- 0.8% $5-$9.9 million
- 8.0% $10-$49.9 million
- 6.4% $50-$99.9 million
- 6.4% $100-$199.9 million
- 8.0% $200-$499.9 million
- 5.6% $500-$999.9 million
- 18.4% $1-$4.9 billion
- 0.8% $5-$9.9 billion
- 5.6% $10-$49.9 billion
- 0.8% More than $50 billion
- 36.8% Don't know/Refused



Logistics Costs

Logistics costs (transportation, inventory, and warehouse costs) account for 11.7% of the delivered price of temperature controlled products for the surveyed shippers—up from 10.6% last year. The 11.7% figure is considerably above the national average for all shippers [as determined by the total U.S. logistics expenditure as a percentage of Gross Domestic Product (GDP)]. According to the *13th Annual State of Logistics Report*, logistics consumed 9.5% of GDP in 2001, down from 10.1% in 2000. This suggests that total logistics costs are declining for U.S. shippers, on average, but



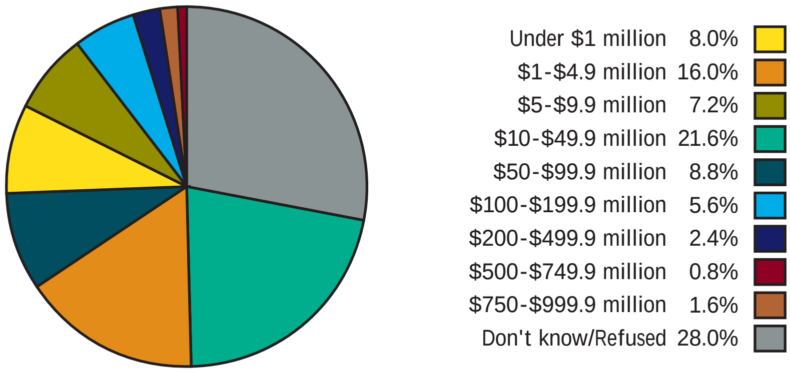
are rising for shippers in temperature controlled industries. As in last year's report, there is a disparate range of relative costs among our shipper sample. For one shipper, logistics represents only 1% of the product's delivered price, while another firm indicated that logistics consumed 50% of the price for goods. Not surprisingly, companies that shipped commodity-like goods and materials incurred higher logistics costs as a share of revenues. Shippers of more valuable goods (such as pharmaceuticals, meats, and beverages) enjoyed lower relative logistics costs than the sample average.

There were notable differences in the relative cost of logistics depending upon the level of the supply chain (manufacturer vs. wholesaler vs. retailer). Logistics represented 11.1% of total delivered price of manufacturers' temperature controlled products; logistics represented 7.3% and 16.5%, respectively, for retailers and wholesalers. The manufacturers in this year's sample indicated higher relative costs than last year's sample (7.9% of total delivered price), while the relative cost for retailers and wholesalers is considerably lower.

Like company sales, the transportation budget for this year's sample was somewhat larger than in years past. The average transportation budget was $56.9 million. [4]

The individuals who completed the shipper interviews average 15 years of experience in temperature controlled logistics, with almost 10 years at their current employers. Almost 75% have logistics responsibilities for multiple shipping locations within their firms. Approximately 56% of the respondents are responsible for nationwide logistics. Roughly 30% assume responsibility for regional operations, while 14% manage global logistics. A description of the carrier sample can be found in the final section of the report.

[4] Annual Transportation Budget



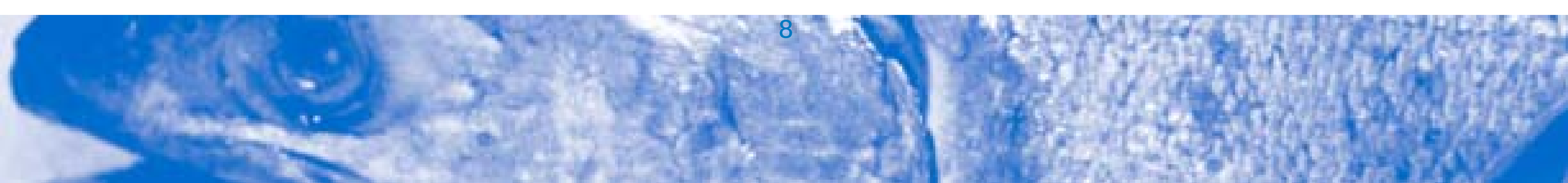
[1] Logistics costs for temperature controlled shippers rose during the last year, even as the national average for all shippers dropped. Logistics costs (transportation, inventory, and warehouse costs) comprise 11.7% of the delivered price of temperature controlled products for the surveyed shippers, up from 10.6% last year. This was higher than logistics cost for all shippers, which consumed 9.5% of GDP in 2001, down from 10.1% in 2000. Logistics costs represented 11.1% of total delivered price of temperature controlled products for manufacturers, up sharply from 7.9% last year, and represented 7.3% and 16.5% for retailers and wholesalers, respectively, down from last year.

[2] The strategic importance of logistics continues to ascend among temperature controlled shippers. More than half (54%) of our respondents strongly agree that their top management views logistics as a critical element of corporate strategy (up from 45% and 37% in 2000 and 2001, respectively). While the service aspects of logistics are becoming more important and valued, shippers have certainly not forgotten about cost. Almost half (48%) of the sample firms indicate that activity-based logistics costs are reflected in the price of their temperature controlled products.

[3] Temperature controlled shippers continue to shift freight from private fleets to for-hire carriers. This year's respondents used for-hire carriers to ship 79% of their temperature controlled freight; 56% rely exclusively on for-hire carriers for their transportation needs (up from 50% last year). In comparison, only 6% of shippers rely exclusively on private fleets. The remainder (38%) uses a combination of for-hire and private fleets. Truck transportation remains far and away the most common mode used, accounting for 58% of the respondents' temperature controlled freight. Less-than-truckload carriers increased their share from 28% last year to 32% this year, with the remainder of temperature controlled freight traveling by ocean, air, and rail.

[4] There has been virtually no change in the overall use of traditional EDI and the Internet for transactions involving temperature controlled truck shipments since last year. In total, 46% of these shippers conduct electronic transactions for the shipment of temperature controlled products. Approximately 38% use EDI and 22% use the Internet, with 15% using both methods. Shipment tracing, shipment status reports, and load tendering are widely conducted by both EDI and Internet. EDI is used more often for advanced shipment notices, bills of lading, and freight bill transmission and payments. The Internet is used more often for ordering equipment from motor carriers.

[5] Temperature controlled shippers continue to outpace the national average in transportation outsourcing. This year's respondents outsourced nearly 16% of their transportation dollars to a 3PL, compared to the national average of 10.1% for all freight. Some 28% of our sample outsourced at least some of their transportation needs to a third party; on average, 57% of the transportation business for these shippers was outsourced, compared to 43% last year. There was not much difference among manufacturers, wholesalers, and retailers with respect to the percentage of firms who outsource. However, wholesalers outsource a much larger share of their transportation business (71%) compared to



retailers (25%) and manufacturers (54%). Ten percent of the full sample relies almost completely on a 3PL to fulfill transportation management needs.

[6] Shippers say waiting time at loading docks continues to increase. Shippers report that carriers wait, on average, 86 minutes for an opportunity to load, and say the actual loading time takes 82 minutes. These figures are up from 69 minutes and 66 minutes, respectively, a year ago. Once at the receiving location, carriers wait 75 minutes for the opportunity to unload, and actual unloading consumes 66 minutes, the same as last year. More than half of the shippers acknowledge that long waits negatively affect carriers' utilization of equipment and labor and also impair the retention of drivers. Just over 40% of this year's shippers use a drop-trailer program to allow loading to take place when it is most convenient, without forcing the carrier to wait.

[7] Carrier respondents confirm that excessive waiting time is one of their top issues. Some 74% of the carriers consider it a significant problem, and 25% consider it a minor problem. Only one firm did not think it is a problem.

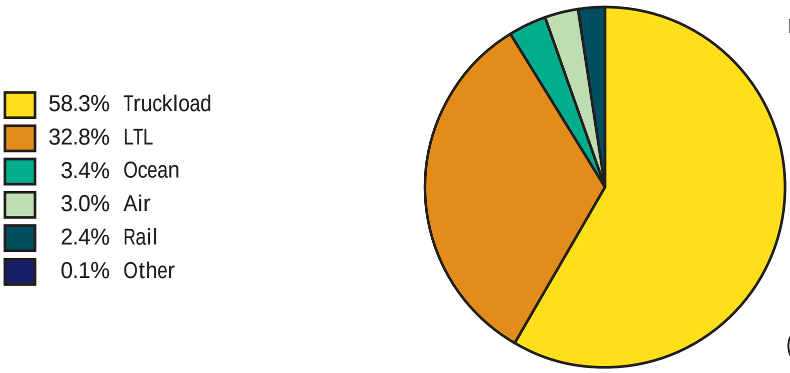
[8] Most carriers singled out the food industry as the most problematic, in terms of waiting time. This is not surprising, given that food represents the largest share of temperature controlled freight. The grocery sector was identified by 50% of the respondents; produce growers and distributors were named by more than 25%.

[9] Few carriers calculate the cost of waiting time. Of the 125 carriers interviewed, 16 (13%) had determined the cost of waiting to their firms. Two firms reported that waiting time cost represented 2% to 3% of total revenue. Fourteen firms reported hourly waiting costs ranging from $25 per hour to $100 per hour, with the average being slightly above $50 per hour. Most of these carriers included driver pay and equipment utilization in their cost calculation, and a few added mileage lost (i.e., lost revenue opportunity).

[10] Many carriers experience a sense of futility when it comes to waiting time. Nearly 45% felt their customers were doing nothing or virtually nothing to alleviate the problem. Several carriers noted the difficulty of charging shippers for excessive waiting time; costs are difficult to measure, and the carrier is not in a position to force payment. To address the problem, more than one-third of the carriers currently assess a detention fee, or will soon. The amount of "free time" carriers will allow tends to range from 2 to 4 hours, with more carriers reporting that they are moving toward the lower end of the range. Some 20% of these carriers don't serve shippers and receivers who consistently hold up drivers and equipment and/or refuse to pay their detention fees.

To be proactive, carriers establish appointments for loading and unloading, particularly with those shippers and receivers who create waiting problems, and are working to improve communications with shippers and receivers. Respondents say some shippers are taking steps to improve dock operations by scheduling enough workers for loading/unloading, staggering appointments to avoid congestion, loading last-out shipments so they are at front of trailer, establishing appointment times, using drop trailers, and participating in pallet exchanges.

[5] Percentage of temperature controlled freight transported by different modes



How Temperature Controlled Freight Is Transported

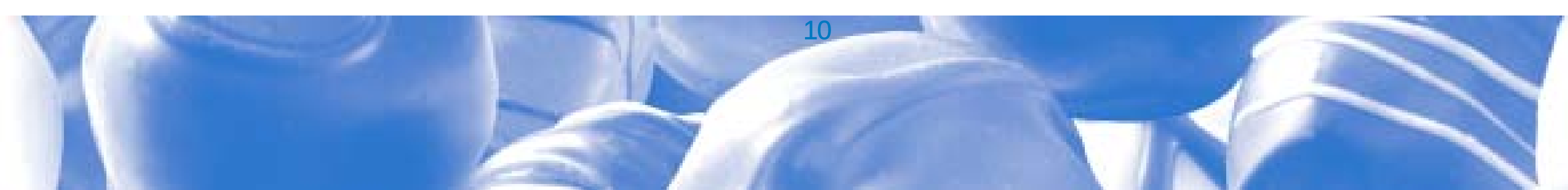
This year's respondents shipped 79% of their temperature controlled freight by for-hire carriers. This steadily rising number indicates that many shippers continue to shift freight from private fleets to for-hire carriers. In fact, 56% of this year's shippers rely exclusively on for-hire carriers for their transportation needs (up from 50% last year). In comparison, only 6% of shippers rely exclusively on private fleets. The remainder (38%) uses a combination of for-hire and private fleets.

With regard to the transportation mode of choice for temperature controlled logistics, truck remains the most common. Truckload carriers ship over half (58%) of the respondents' temperature controlled freight. Less-than-truck-load carriers demonstrated some gain in this year's report (increasing from last year's 28% to 32% this year). Ocean, air, and rail transportation follow in order, although each mode receives less than 4% of shippers' temperature controlled freight volume, on average. Truckload remains a preferred option for temperature controlled shippers, given the vast number of truckload carriers in the marketplace, plus the added advantage of not having to rehandle or transload freight before customer delivery. Rehandling and transloading exposes sensitive freight to temperature variance. [5]

Transportation Buying Practices

Shippers expressed continued concern for carrier dependability and timely service when shipping temperature controlled products. We asked shipper respondents to rate the importance of criteria by which they choose temperature controlled motor carriers. The top 4 criteria used to select carriers remain unchanged from last year: *pickup/delivery reliability; adequate equipment availability, especially during peak seasons; consistent transit times;* and *frequency of mechanical failures*.

Rising in importance are *driver professionalism*, *carrier's ability to provide shipment tracking, carrier safety record, loss and damage performance/claims ratio*, and *carrier financial stability*. In turn, *rate level* has dropped in significance. These factors appear to reflect the difficult economy and, perhaps, concerns for freight security in light of the tragic events of September 11. Shippers recognize that transportation costs will rise as service levels increase. [6]



Shippers continue to implement core carrier programs. Just over 71% of this year's respondents indicate that they use a core carrier strategy (i.e., opting to work with fewer carriers in anticipation of lower transportation costs and higher priority service). This figure is 4% higher than last year and 10% higher than 2 years ago.

E-Commerce Among Temperature Controlled Shippers

This is the third year that the *Temperature Controlled Logistics Report* has tracked both EDI and Internet usage among shippers. In total, 57 respondents, or 46% of our sample, conduct electronic transactions for the shipment of temperature controlled products. Some 29 firms use only traditional EDI, 19 use both the Internet and traditional EDI, and 9 use only the Internet.

Forty-eight respondents (38% of our sample) use traditional EDI with their temperature controlled motor carriers, compared to 32% last year. On average, these shippers use EDI in some way with about 45% of their truck shipments, compared to 52% reported last year. Nearly a quarter of the EDI adopters require their motor carriers to have EDI capabilities. More than half of the EDI-enabled shippers use EDI for shipment tracing, shipment status reports, advanced shipment notices, freight bill transmission, and freight bill payment. More than 45% also tender loads and transmit bills of lading via EDI.

There has been virtually no change in the reported level of Internet use since last year. Some 22% use the Internet to conduct business with their temperature controlled motor carriers. This year's respondents, on average, use the Internet with 32% of their temperature controlled truck shipments, compared to 31% last year. Nine firms use the Internet for 100% of their truck shipments; 4 use the Internet for 90% or more of their truck shipments.

The 9 firms that use only the Internet use it with 50.4% of their temperature controlled shipments. The 19 firms that use both EDI and the Internet use EDI for 39.3% and the Internet for 23.6% of their temperature controlled shipments.

While more than half of Internet users receive shipment status reports over the Web and use the Internet for shipment tracing and load tendering, there is much less use of the Internet (relative to EDI) for advanced shipment notices (33%),

[6] Top 15 selection criteria for a temperature controlled carrier

TOP 15 CARRIER SELECTION CRITERIA	MEAN SCORE[1]
Pickup and delivery reliability	6.63
Adequate equipment availability, especially during peak seasons	6.48
Consistent transit times	6.25
Frequency of mechanical failures	6.06
Driver professionalism	5.77
Carrier can provide shipment tracking	5.69
Carrier safety record	5.68
Loss and damage performance/claims ratio	5.65
Carrier financial stability	5.60
Carrier reputation	5.59
Consistent practices on the receiving end to measure or detect failures	5.59
Rate level	5.54
Familiarity with carrier	5.40
Carrier has formal quality programs	4.95
Carrier has ability to share information electronically	4.60

1] Scale of 1-7, where 1=Not important at all to 7=Very important

bills of lading (26%), and freight bill transmission (19%) and payments (11%). On the other hand, the Internet was used more than EDI for ordering equipment from motor carriers (56% vs. 23%). [7]

[7] Traditional EDI and Internet usage among shippers

TRANSACTION	TRADITIONAL EDI # FIRMS	(% USERS)	INTERNET # FIRMS	(% USERS)
Shipment status reports	33	(68.8%)	18	(66.7%)
Shipment tracing	30	(62.5%)	19	(70.4%)
Advanced shipment notice	29	(60.4%)	9	(33.3%)
Freight bill transmission	28	(58.3%)	5	(18.5%)
Freight bill payments	26	(54.2%)	3	(11.1%)
Tendering loads	23	(47.9%)	17	(63.0%)
Bills of lading	22	(45.8%)	7	(25.9%)
Ordering equipment	11	(22.9%)	15	(55.6%)
Loss and damage claims	10	(20.8%)	9	(33.3%)

Shippers' Use Of Logistics Outsourcing

The third-party logistics (3PL) industry grew at a rate of 7.4% during 2001, according to Armstrong & Associates, generating $60.8 billion in gross revenues. Though the growth rate was down markedly from the 20% growth achieved in 2000, it was impressive in light of the economy's health. Even more impressive was the increase in 3PL revenue from transportation (i.e., dedicated contract carriage and domestic transportation management). Their transportation business increased by 38%, from $18.7 billion in 2000 to $25.8 billion in 2001. Based upon the national freight bill (estimated at $600 billion in the *13th Annual State of Logistics Report*), this translates into outsourced management of approximately 10.1% of the nation's freight bill (up from 9.5% in 2000).

As in last year's report, temperature controlled shippers outpaced the national average in transportation outsourcing. This year's respondents outsourced nearly 16% of their transportation dollars to a 3PL. The 35 respondents who outsourced *some* transportation to a third party reported that on average, 57% of their transportation business is outsourced (compared to 43% last year).

Seven percent of the full sample (and 26% of those who outsource at all) rely completely on a 3PL to fulfill transportation management needs. Another 3% of the full sample (and 11% of outsourcers) rely on 3PLs to fulfill 98% to 99% of their transportation needs. Twenty-six percent of the companies that currently oursource expect outsourcing to continue growing over the next 3 years.

With respect to the percentage of firms that hire third parties for transportation management, there was not much difference among manufacturers (29%), wholesalers (24%), and retailers (25%). However, wholesalers outsource a much larger share of their transportation business (71%) compared to retailers (25%) and manufacturers (54%).

A case study of Ghirardelli Chocolate Company shows one shipper's experiences so far with outsourcing temperature controlled shipments to a 3PL. You will find it on page 5.

Quality Assurance For Temperature Controlled Shipments

Past reports have focused on efforts by all supply chain entities, logistics service providers included, to ensure the integrity of goods throughout distribution. Each year, respondents are asked to identify which party in the supply chain is most responsible for quality assurance.

As was the case last year, respondents believe that manufacturers bear the greatest responsibility for product quality but the percentage of respondents ranking manufacturers first is lower this year (50% vs. 69%). About one-third of the respondents believe carriers are the most responsible, followed by 15% who say that distinction belongs to warehouse operators.

These percentage figures are pretty consistent, regardless of whether the temperature controlled products being shipped are frozen, refrigerated, or protected. Of the respondents, 48% primarily ship frozen products, 32% refrigerated goods, and 20% ship mostly items that require temperature protection. [8]

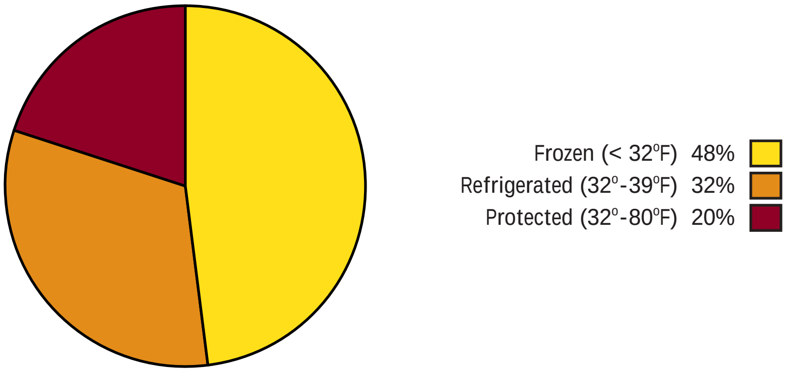
Finally, while all firms indicated some degree of tolerance for temperature variation, slightly more than two-thirds say their acceptable range for temperature variation continues to tighten.

Shippers' Views On Carrier Consolidation And Capacity

The greatest concern for shippers is the prospect of higher freight rates as competition erodes with fewer carriers vying for business in the temperature controlled market. The quality of carrier service and availability of equipment appear next among shipper concerns. Shippers are more concerned about consolidation in the truckload industry than the less-than-truckload industry—an expected outcome, given the extensive reliance on truckload service among temperature controlled shippers.

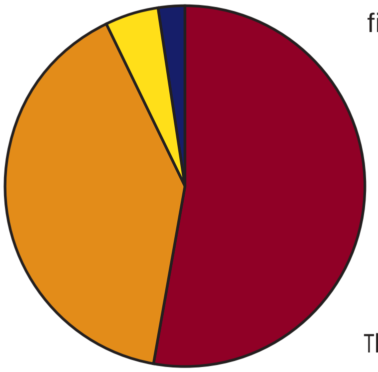
In general, shippers are not concerned about capacity, even during the peak shipping season. Some (53%) of the respondents believe that motor carrier capacity will be about equal to demand for temperature controlled trucking

[8] Temperature controlled logistics involves the movement, storage, and handling of frozen, refrigerated, or protected goods



service. However, if there is to be an imbalance, 40% believe that capacity will fall short of peak season demand. [9]

[9] Most shippers feel that there is sufficient carrier capacity to cover peak demand this year



General Trends Affecting Temperature Controlled Shippers

Some 54% of our respondents strongly agree that logistics is viewed as a critical element of corporate strategy by top management in their firms (up from 45% and 37% over 2000 and 2001, respectively). A full two-thirds of the shippers strongly agree that the strategic importance of logistics is rising in their firms—another considerable increase over the past few years. Based on these statistics, logistics continues to gain recognition as more than simply a necessary cost of doing business, but rather as a key competitive differentiator.

The strategic importance of logistics is perhaps heightened in temperature controlled shipping, given the premium placed on quality service and maintenance of product integrity throughout the supply chain. This is apparent in the very strong support found for the statement, *Consistency in handling, storage, and transportation will be a competitive advantage*. To add further to the point, shippers widely believe that *quality and consistency in meeting customers' needs is becoming more important than price*—a growing trend over the past few years. Shippers generally agree that *tolerance for temperature variation is becoming even more stringent*. In addition, shippers face demands for tightening delivery windows on their inbound and outbound shipments, suggesting ever-escalating customer expectations for improved on-time service.

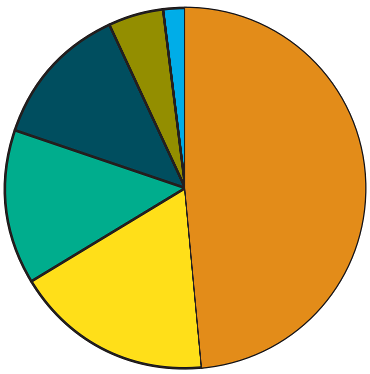
This year's survey also found strong support in the shift from "push" to "pull" strategies in the supply chain (56% strongly agreed last year compared to 65% this year). Despite interest in response-based supply chain systems, only 39% said that cycle times for order fulfillment were reduced over the past year.

Activity-based costing (ABC) has seen considerable growth in interest and application over the past year. Last year, only 7% of shippers strongly agreed that their firm used ABC to assess logistics costs associated with their temperature controlled products, and only 26% anticipated greater use in the future. Of the sample firms, 48% reflect activity-based logistics costs in the prices charged for temperature controlled products. Growing interest in cost measurement may be attributed to cost-cutting efforts, given the trying state of the economy over the past year. [10]

[10] The strategic importance of logistics is rising among shippers

STATEMENT	MEAN	% STRONGLY AGREEING
Consistency in handling, storage, and transportation will be a competitive advantage	6.1	74%
The strategic importance of logistics is rising in our firm	5.7	66%
Inventory movements in our industry are increasingly being driven by "pull" from suppliers, rather than suppliers' "push" to users	5.7	65%
Quality and consistency in meeting our customers' needs is becoming more important than price	5.5	61%
Logistics is viewed by top management in our firm as a critical element of corporate strategy	5.5	54%
Our firm's acceptable range (i.e., tolerance) for temperature variation is getting tighter	5.3	52%
Delivery windows on our outbound shipments will be even tighter in the future	5.3	52%
Activity-based logistics costs are reflected in the prices of our temperature-controlled products	5.1	48%
Delivery windows on our inbound shipments will be even tighter in the future.	5.0	44%
Our firm was able to reduce its cycle time for order fulfillment last year	4.8	39%

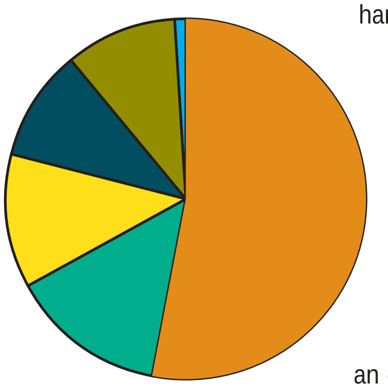
[11a] Waiting to load at shipper location*



- 18% Less than 30 minutes
- 49% 30 to 60 minutes
- 5% 61 to 90 minutes
- 14% 91 to 120 minutes
- 13% More than 120 minutes
- 2% Don't know/Do not ship

* Rounding leads to 101%

[11b] Loading time at shipper location



- 12% Less than 30 minutes
- 53% 30 to 60 minutes
- 10% 61 to 90 minutes
- 14% 91 to 120 minutes
- 10% More than 120 minutes
- 1% Don't know/Do not ship

Shipper Perspectives On Waiting Time: Loading And Unloading

Last year's report was the first to examine the issue of driver waiting time at shipping and receiving locations in the temperature controlled logistics industry. While shippers generally viewed the waiting time problem as a concern in the industry, they also agreed that the problem would get worse before it improved. That appears to be the case, judging by this year's findings.

Drivers wait in line for an available loading dock. Roughly 7% of this year's shipper respondents claim that carriers do not have to wait at all prior to loading at their facilities, and two-thirds of the sample say that carriers wait 60 minutes or less. Thirteen percent claim waits of two hours or more. Shipper respondents reported that the average wait prior to loading is 86 minutes, compared to an average of 69 minutes last year.

Once the driver reaches the loading dock, shippers estimated that it took 82 minutes, on average, to load a truck for delivery—up from 66 minutes a year ago. About 65% of the respondents believe that loading time at their facilities is 60 minutes or less. Granted, the size of the shipment and freight handling methods (e.g., mechanical vs. manual) will dictate some level of variance in loading time, but the respondents gave loading times from a few minutes to 8 hours, a wide disparity of experience. [11a] [11b]

On the receiving end, most shippers agree that carriers must wait before unloading commences. Unlike the loading situation, shippers indicate that waits prior to unloading have decreased slightly, although carriers still wait longer for an opportunity to unload than an opportunity to load. The average time that a carrier waits to unload, shippers say, is 75 minutes. Some 62% percent of respondents believe that waiting time to unload is 60 minutes or less, but 28% say that carriers usually wait more than an hour before unloading commences.

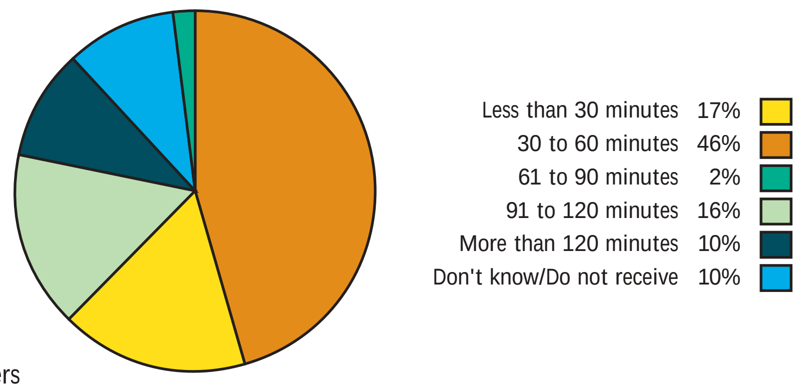
As for the unloading activity itself, the average unloading time is 66 minutes (the same as last year), although the times range from a few minutes to 8 hours. Some 72% of these shippers believe that unloading takes 60 minutes or less, but 22% say unloading takes more than an hour. [11c] [11d]

The ills experienced by carriers due to extended waiting times are not lost on shippers. In fact, 62% of shippers strongly agree that temperature controlled carriers usually experience waiting time problems, and 49% believe that waiting time is generally increasing for motor carriers. Shippers widely recognize that waiting negatively influences motor carriers' utilization of equipment and drivers. In addition, 59% of shippers acknowledge that waiting times impair the carrier's ability to retain drivers—arguably the most critical resource to any trucking company.

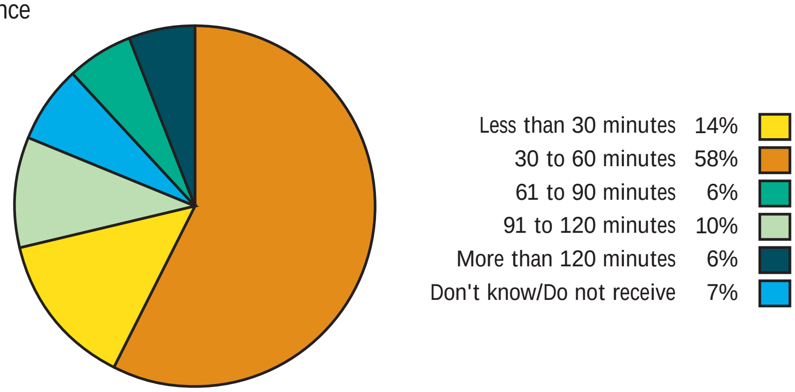
To circumvent the waiting time problem, some shippers and carriers implement a drop-trailer program, where trailers are left at shipping points so they that they may be loaded or unloaded at the shipper's convenience. More than 40% of shippers surveyed currently require carriers to drop trailers at their shipping facilities. The most common reasons cited for the drop-trailer approach are the convenience associated with preloading freight before pickup appointments, flexibility in scheduling, and greater convenience in shipping operations. While obtaining trailers in advance is valued by shippers, and although drop trailers eliminate waiting time frustrations for drivers, the process can create a strain on carriers' trailer planning and scheduling.

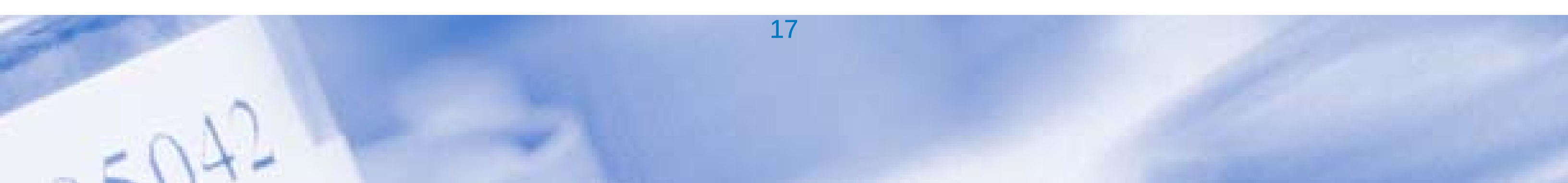
Ellison Meats presents its strategies to prevent waiting time on page 4.

[11c] Waiting to unload at shipper location*

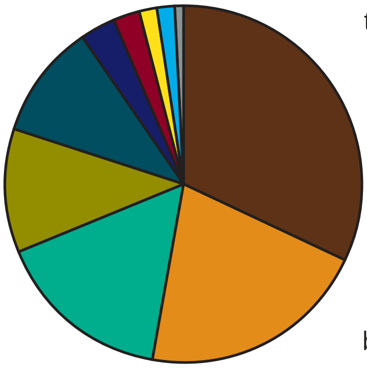


[11d] Unloading time at shipper location*





[12] Carrier profile: Firm size



Carrier Survey Demographics

Carriers both large and small participated in the research. Year 2001 revenues for carrier respondents ranged from $164,000 to $1.4 billion. The average revenue for the group was $43.4 million. The vast majority—112 of the 125 respondents—are in the truckload sector, while 9 provide primarily less-than-truckload (LTL) service. Four firms provide an even mix of truckload and LTL service. [12]

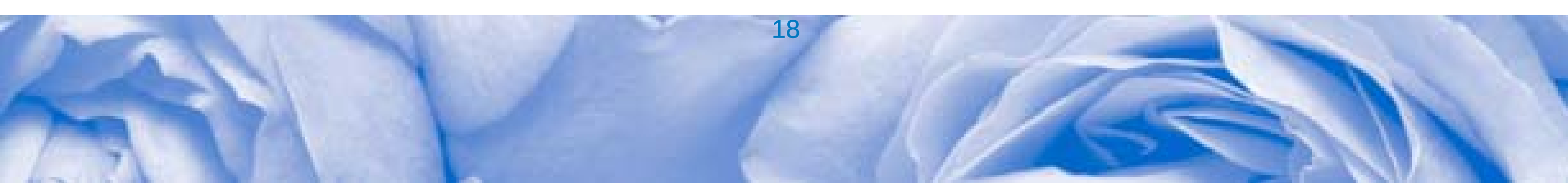
Temperature controlled shipments are clearly the primary business of the respondents. On average, the carriers said that 65.5% of their sales derive from temperature controlled products. Temperature controlled shipments comprise at least 75% of all business for 65 of the 125 respondents. Almost 15% of the respondents report that 100% of their business is temperature controlled.

Carrier Perspectives On Waiting Time

This year's report is the first to include a survey that focuses on one specific logistics issue confronting temperature controlled shippers and carriers. The problem of excessively long waiting times associated with loading and unloading was chosen because it was identified as a major challenge by respondents in previous years. Also, the trade literature includes several articles that address this problem for industry in general, but not specifically for temperature controlled product shipments.

The survey of carriers included mostly open-ended questions that sought information about which segments of the temperature control industry are most problematic, the costs associated with waiting, and strategies for reducing or eliminating the problem.

The carrier respondents confirm that excessive waiting time is one of their top issues; 92 of the 125 interviewed trucking firms (74%) consider it to be a significant problem. Only one firm did not think it is a problem.



The Most Problematic Sectors

Although most carriers noted that the waiting time problem is shipper or receiver specific (and the receiver is more often the culprit), 108 did identify one or more sectors of their temperature controlled business that tend to be more problematic.

Not surprisingly, given that it represents the largest share of temperature controlled freight, the food industry was singled out by the vast majority of carrier respondents for waiting time problems. Within the food industry, the grocery sector was identified by 50% of the respondents. Grocery warehouses have the dubious distinction of being named by the largest number (one-third) of temperature controlled trucking firms. Others in the grocery business, most notably the larger grocery retail chains, were identified by one-sixth of the respondents. Produce growers and distributors were named by more than 25% of the respondents, and meat and poultry processors and distributors were named by more than 20%. [13]

The Cost Of Waiting

Of the 125 carriers surveyed, 16 had determined how much waiting time costs their firm. Some 14 respondents reported the cost on a per hour basis, one on a per load basis, and one as an annual figure. For the latter two, it was possible to determine waiting costs as a percentage of annual revenue. One firm reported a per load waiting cost of $50, which translates to an annual cost of $390,000 on $13 million revenue, or 3% of total revenue. The other firm reported its annual waiting costs at $50,000 on $2.5 million revenue, or 2% of total revenue. For the small-margin trucking industry, these costs are substantial.

The average hourly waiting cost came to $50 per hour, with a range from $25 to $100 per hour. The carrier reporting the $100 cost figure cited driver pay, equipment utilization, and mileage lost (i.e., lost revenue opportunity) as the key costs it included. These costs were mentioned by most of the 16 respondents. Other costs mentioned by just a few included fuel to keep the refrigeration unit running and equipment maintenance costs.

[13] Most problematic sectors with respect to excessive waiting times*

SECTOR	NUMBER (%) OF CARRIERS REPORTING	
Grocery warehouses	36	(33.3%)
Produce	28	(25.9%)
Meat and poultry	23	(21.3%)
Grocery, general	18	(16.7%)
Large retail chains	3	(2.8%)
Brokers	2	(1.9%)
Food processors	2	(1.9%)
Dairy	1	(0.9%)
Nurseries	1	(0.9%)
Pharmaceutical	1	(0.9%)

* Percentages based on 108 respondents who identified a problematic sector. Percentages sum to more than 100% because some respondents identified more than one sector.

How Trucking Companies And Customers Are Addressing The Issue

The respondent carriers discussed a number of initiatives to address the excessive waiting time problem. A disturbing discovery, however, was the sense of futility felt by a large percentage of the respondents. Nearly 45% of the respondents felt their customers were doing nothing or virtually nothing to alleviate the problem because, as one carrier put it, "They know they own us." A number of factors contribute to this feeling of futility.

Several carriers noted that the shippers pay the cost, but the receivers create most of the problems. The shippers are naturally hesitant to put pressure on the receivers, their customers. Furthermore, many of the initiatives undertaken by the carriers and shippers often encounter difficulties. For instance, many carriers report difficulty charging for excessive waiting time; the costs are hard to measure, and it is hard to make the charges stick because the carrier is not in a position to force payment. One respondent gave another example of "misdirected" incentives. "Many shippers will give a reduction in the cost of goods to the buyer if it performs the unloading of the product in a timely manner," he said. "However, the credit goes to the purchasing department. The warehouse doesn't receive any credit, so it has no incentive to improve the dock operations."

The most frequently mentioned action carriers take to attack the problem is one they would rather not have to do—charge a fee for excessive waiting time. More than one-third of the respondents are currently assessing a detention fee or will soon. The amount of "free time" a carrier provides to its shippers and receivers will vary, based on load and facility characteristics. The range tends to be 2 to 4 hours, with more carriers reporting that they are moving toward the lower end of the range.

The second most frequently mentioned action is refusing to provide service to those shippers and receivers who are known to be chronic offenders. That is, 20% of the respondents said they are avoiding shippers and receivers who consistently hold up drivers and equipment and/or refuse to pay their detention fees.

Most of the respondents say they won't drop a shipper or receiver until they have attempted to resolve their problems. More than 14% of the carriers reported they are attempting to establish appointments for loading and unloading, particularly with those shippers and receivers who create waiting problems. Another 12% are focusing on improving communications with their shippers and receivers. One respondent said, “We held roundtable discussions with our customers and tried to make improvements based on the conclusions from the roundtable.” Because the shippers and receivers frequently do not coordinate with one another, the carriers need to provide this function. Constant communication with both parties is essential to avoiding problems at the docks.

Carriers stress the need to educate shippers and receivers on the costs and other implications of excessive waiting time. As one respondent explained, “We are trying to measure wait time so shippers better understand the significance of the problem.” When asked what activities or initiatives were being implemented by shippers and receivers to improve dock operations, respondents identified the following:

- ✔ Having enough workers available for loading/unloading.
- ✔ Staggering appointments and adjusting hours of operation to avoid congestion.
- ✔ Pre-planning loads so outbound freight is loaded in the order it will be delivered, which saves unloading time and eliminates additional handling later.
- ✔ Setting appointment times, rather than “first come, first served” approach.
- ✔ Using drop trailers when appropriate at an additional fee.
- ✔ Participating in pallet exchanges.

Finally, the respondents recognize that the carriers can make some adjustments to help improve the situation, as well. One respondent said, “We are trying to establish a pattern of shipping and take variation out of the system. We try to assign the same driver to the same place at the same time of the week to develop consistency in freight patterns and all elements of the load.”

Another carrier clearly and concisely articulated what carriers need to do to hold up their end of the bargain: “Make sure we show up on time. Make sure we have all paperwork in order for each shipment. The guy on the dock is generally at the bottom of the corporate ladder, and he only gets to be the boss of drivers when they show up. So our drivers need to be polite and professional. Driver training is important.” [14]

[14] Frequently-used carrier initiatives to alleviate the waiting time problem*

INITIATIVE	NUMBER	(%) OF RESPONDENTS
Charge for excessive waiting time (detention)	43	(34.4%)
Eliminate or avoid chronic problem customers	25	(20.0%)
Establish appointments for loading and unloading	18	(14.4%)
Improve communications with shippers and receivers	15	(12.0%)

* Percentages based on 125 respondents. Some respondents identified more than one approach.

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C.H. ROBINSON WORLDWIDE, INC.

IOWA STATE UNIVERSITY

APPENDIX O

USDA CAPACITY OF REFRIGERATED WAREHOUSES SUMMARY

United States Department of Agriculture

National Agricultural Statistics Service

Co St 2 (04)

Capacity of Refrigerated Warehouses

2003 Summary

January 2004

General Refrigerated Warehouse Capacity Up 4 Percent

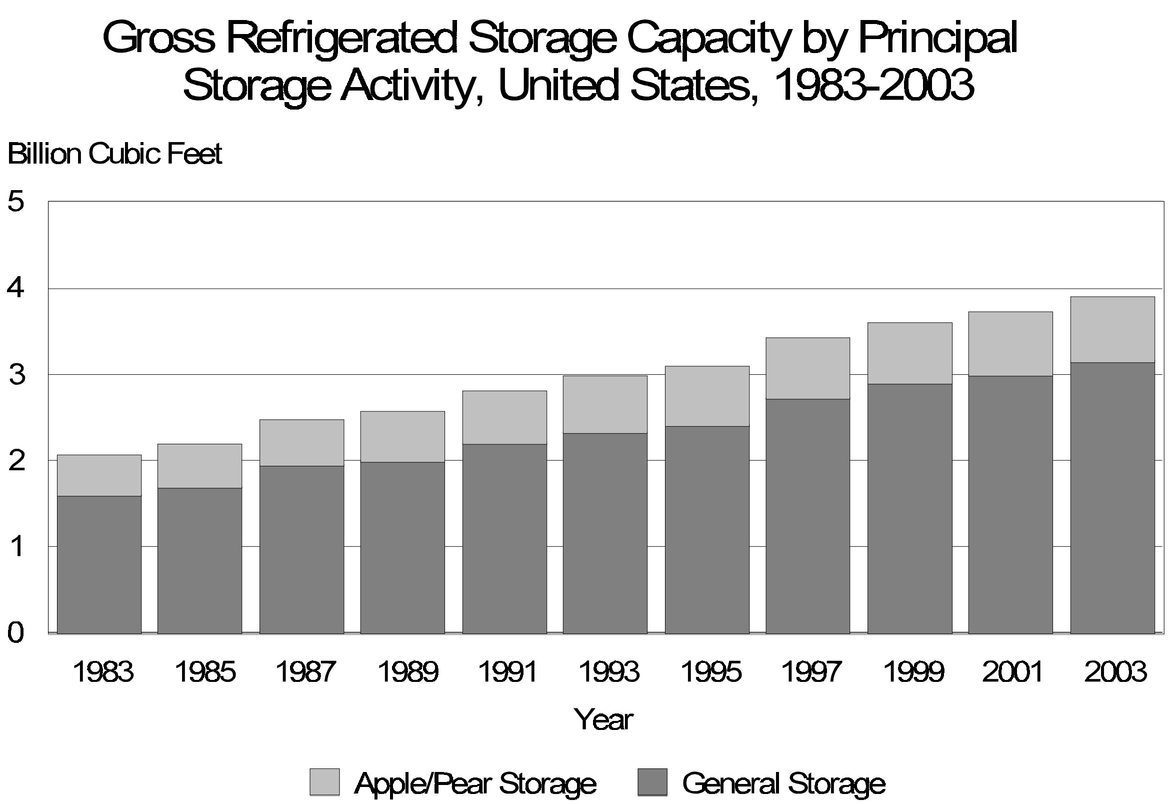
General refrigerated storage capacity in the United States totaled 3.16 billion gross cubic feet on October 1, 2003, an increase of 4 percent since the previous survey was conducted two years ago. This was the 43nd biennial survey of refrigerated warehouses. The five States with the largest gross general warehouse capacity (million cubic feet) were: California with 449; Florida, 253; Washington, 189; Wisconsin, 167 and Texas with 159.

Usable refrigerated space in general storages was 2.51 billion cubic feet, or 79 percent of the gross space. Freezer space was 78 percent of the usable refrigerated space with the remaining 22 percent used as cooler space. Convertible refrigerated space was classified as usable freezer space.

Public general warehouse capacity totaled 2.36 billion gross cubic feet in 2003, accounting for 75 percent of the general storage. Public general storage capacity increased 5 percent since 2001 and is 40 percent above the capacity of ten years ago.

Private and semiprivate general warehouse capacity totaled 802 million gross cubic feet, or 25 percent of the general gross refrigerated space.

Apple and pear storage totaled 736 million gross cubic feet, up 1 percent from October 1, 2001. Controlled atmosphere (CA) capacity totaled 169 million bushels, up 3 percent from 2001. The State of Washington had 80 percent of the Nation's CA capacity.



Refrigerated Warehouses: Number by Type, State, and United States, October 1, 2003

State	General Storages			Apple & Pear Storages			Total
	Public	Private & Semiprvt	Total	Regular	CA	All [1]	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
AL	14	9	23				23
AK	2	24	26				26
AZ	7	3	10	1	2	2	12
AR	14	8	22				22
CA	121	96	217	27	7	29	246
CO	8	4	12	6	1	6	18
CT	2	2	4	25	7	27	31
DE	4	6	10	2		2	12
FL	38	34	72				72
GA	36	33	69				69
HI	3	1	4				4
ID	6	14	20	9	6	9	29
IL	26	13	39	15		15	54
IN	15	6	21	29	4	31	52
IA	29	7	36				36
KS	10	2	12	1		1	13
KY	5	1	6	3		3	9
LA	12	8	20				20
ME	1	15	16	20	15	21	37
MD	8	4	12	5	3	6	18
MA	24	16	40	51	27	55	95
MI	25	20	45	149	99	179	224
MN	23	23	46	12	1	12	58
MS	9	4	13				13
MO	21	8	29	4		4	33
MT	4	1	5				5
NE	13	8	21	1		1	22
NV	3	2	5				5
NH	1	2	3	21	12	21	24
NJ	29	9	38	20	4	22	60
NM	1	5	6	2		2	8
NY	31	50	81	135	92	147	228
NC	18	4	22	17	3	19	41
ND	3	1	4				4
OH	20	6	26	53	13	53	79
OK	6	5	11				11
OR	15	23	38	57	18	61	99
PA	38	9	47	106	17	108	155
RI		3	3	4	2	6	9
SC	10	4	14	3		3	17
SD	2	4	6				6
TN	9	6	15				15
TX	36	27	63				63
UT	13	7	20	17	5	18	38
VT		2	2	11	5	11	13
VA	21	12	33	30	11	31	64
WA	39	34	73	217	208	263	336
WV	2	2	4	12	5	15	19
WI	49	68	117	17	3	17	134
WY	1		1				1
US	827	655	1,482	1,082	570	1,200	2,682

[1] Firms with both regular and CA storage are counted once.

General Refrigerated Warehouses: Number by Size Group, United States, October 1, 2003

Size (Cubic Feet)	Public	Private	All
	Number	*Number*	*Number*
0-499,999	115	320	435
500,000-999,999	124	116	240
1,000,000-2,499,999	243	121	364
2,500,000-4,999,999	216	70	286
5,000,000 and Over	129	28	157

Apple and Pear Refrigerated Warehouses: Number by Size Group, United States, October 1, 2003

Size (Bushels)	Regular [1]	CA [1]	All
	Number	*Number*	*Number*
0-49,999	711	191	634
50,000-99,999	133	106	172
100,000-499,999	193	180	253
500,000-999,999	33	46	72
1,000,000 and Over	12	47	69

[1] Number of operations with regular or CA storage. Many operators have both types in the same building, thus the count of regular plus CA does not equal "All".

Refrigerated Storage: Gross Capacity by Type of Warehouse, United States, October 1, 1985-03

Year	Public	Private and Semi-private	Total [1]
	Million Cubic Feet	*Million Cubic Feet*	*Million Cubic Feet*
1985	1,130	1,056	2,186
1987	1,306	1,171	2,476
1989	1,414	1,158	2,571
1991	1,600	1,208	2,808
1993	1,700	1,272	2,972
1995	1,765	1,323	3,088
1997	2,068	1,359	3,427
1999	2,168	1,437	3,606
2001	2,266	1,501	3,767
2003	2,370	1,526	3,896

[1] Totals may not add due to rounding.

Refrigerated Space: By Type of Warehouse, United States, October 1, 2003 [1]

Type	Number	Gross Space			Usable Space		
		Cooler	Freezer	Total	Cooler	Freezer	Total
		1,000 Cubic Feet	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*
General							
Public	827	384,779	1,972,301	2,357,080	301,630	1,586,106	1,887,735
Private & Semiprvt	655	311,464	490,990	802,454	239,982	382,169	622,151
Total	1,482	696,243	2,463,291	3,159,535	541,612	1,968,275	2,509,886
Apple							
Apple							
Public	13	12,092	426	12,517	9,841	301	10,141
Private & Semiprvt	1,187	718,287	5,212	723,499	579,324	3,724	583,048
Total	1,200	730,378	5,638	736,016	589,164	4,025	593,189
Total	2,682	1,426,622	2,468,929	3,895,551	1,130,776	1,972,299	3,103,075

[1] Totals may not add due to rounding.

Gross Refrigerated Space: By Type of Warehouse, United States, October 1, 1985-03 [1]

Type	1985	1987	1989	1991	1993
	1,000 Cubic Feet	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*
General					
Public	1,110,394	1,285,860	1,391,901	1,572,879	1,678,461
Private and Semiprivate	589,132	676,369	603,402	624,005	658,893
Total	1,699,526	1,962,229	1,995,303	2,196,884	2,337,354
Apple					
Public	19,383	19,750	21,945	27,227	21,645
Private and Semiprivate	466,768	494,404	554,150	584,296	613,093
Total	486,151	514,154	576,095	611,523	634,737
Total, All	2,185,677	2,476,384	2,571,397	2,808,407	2,972,092
	1995	1997	1999	2001	2003
	1,000 Cubic Feet	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*
General					
Public	1,741,585	2,043,908	2,146,643	2,251,943	2,357,080
Private and Semiprivate	674,649	683,372	756,505	788,853	802,454
Total	2,416,234	2,727,280	2,903,152	3,040,796	3,159,535
Apple					
Public	23,419	23,907	21,690	14,183	12,517
Private and Semiprivate	647,993	675,838	680,736	712,412	723,499
Total	671,412	699,745	702,426	726,595	736,016
Total, All	3,087,646	3,427,025	3,605,578	3,767,394	3,895,551

[1] Totals may not add due to rounding.

General Storages: Gross and Usable Refrigerated Space by State and United States, October 1, 2003 [1] [2]

State	Gross Space			Usable Space		
	Public	Private & Semiprvt	Total	Public	Private & Semiprvt	Total
	1,000 Cubic Feet	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*
AL	27,532	1,893	29,425	23,526	1,611	25,137
AK	*	*	4,067	*	*	3,426
AZ	14,344	2,310	16,654	11,436	1,943	13,379
AR	55,044	32,408	87,453	45,250	26,305	71,555
CA	309,960	139,311	449,271	247,679	112,125	359,804
CO	15,276	2,516	17,792	12,091	1,611	13,702
CT	*	*	4,876	*	*	3,925
DE	12,156	13,983	26,139	7,537	10,569	18,106
FL	108,730	144,410	253,140	89,033	117,198	206,231
GA	123,623	19,988	143,611	99,108	16,941	116,050
HI	*	*	*	*	*	*
ID	33,737	24,850	58,587	29,741	20,018	49,758
IL	92,732	12,661	105,393	69,256	8,602	77,858
IN	*	*	55,478	*	*	45,151
IA	68,865	5,683	74,547	57,614	3,775	61,389
KS	*	*	44,490	*	*	32,211
KY	*	*	22,337	*	*	19,487
LA	*	*	13,590	*	*	11,504
ME	*	*	12,318	*	*	8,139
MD	21,680	7,536	29,216	16,380	5,783	22,163
MA	64,578	15,149	79,727	56,071	10,523	66,594
MI	66,888	21,322	88,211	51,485	17,847	69,332
MN	48,850	23,002	71,852	37,297	16,593	53,890
MS	*	*	21,814	*	*	17,632
MO	100,511	6,053	106,564	82,137	5,172	87,309
MT	*	*	976	*	*	753
NE	*	*	40,723	*	*	32,339
NV	*	*	7,370	*	*	6,536
NH	*	*	*	*	*	*
NJ	73,258	8,280	81,538	58,545	6,413	64,959
NM	*	*	2,529	*	*	2,071
NY	59,599	39,679	99,278	49,088	33,075	82,164
NC	53,096	10,495	63,591	45,710	7,663	53,373
ND	*	*	8,926	*	*	6,862
OH	61,789	15,582	77,371	49,787	10,482	60,269
OK	10,925	4,433	15,359	8,485	3,993	12,477
OR	69,001	34,966	103,967	57,495	26,140	83,635
PA	133,637	11,955	145,592	108,756	8,872	117,628
RI		*	*		*	*
SC	22,848	1,879	24,727	18,888	1,540	20,428
SD	*	*	12,352	*	*	6,524
TN	24,803	11,502	36,305	19,955	7,989	27,944
TX	139,625	19,904	159,529	94,872	14,343	109,216
UT	25,792	4,239	30,031	21,603	3,440	25,043
VT		*	*		*	*
VA	43,446	18,729	62,175	37,426	16,215	53,641
WA	145,221	43,740	188,961	112,427	33,705	146,131
WV	*	*	2,420	*	*	1,096
WI	127,399	39,906	167,305	107,464	26,876	134,340
WY	*		*	*		*
Oth Sts	202,135	64,089	11,960	161,595	44,788	8,728
US	2,357,080	802,454	3,159,535	1,887,735	622,151	2,509,886

* Not published to avoid disclosure of individual operations. Included in "Other States" and U.S. totals.
[1] Totals may not add due to rounding.
[2] Includes frozen juice tank storage capacity.

General Storages: Gross and Usable Cooler Space by State and United States, October 1, 2003 [1] [2]

State	Gross Space			Usable Space		
	Public	Private & Semiprvt	Total	Public	Private & Semiprvt	Total
	1,000 Cubic Feet	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*
AL	*	*	5,599	*	*	5,052
AK		163	163		147	147
AZ	*	*	*	*	*	*
AR	*	*	*	*	*	*
CA	75,320	94,339	169,659	59,790	75,609	135,399
CO	*	*	5,216	*	*	3,783
CT	*	*	*	*	*	*
DE		*	*		*	*
FL	21,462	53,245	74,707	17,359	42,963	60,323
GA	34,185	11,172	45,358	26,528	9,771	36,299
HI	*	*	*	*	*	*
ID	*	*	2,293	*	*	1,798
IL	11,246	6,587	17,833	8,103	4,470	12,573
IN	5,754	517	6,271	4,896	320	5,216
IA	*	*	11,811	*	*	8,186
KS	*	*	8,362	*	*	5,408
KY	*	*	5,700	*	*	4,480
LA	*	*	1,579	*	*	1,376
ME	*	*	278	*	*	241
MD	*	*	2,295	*	*	1,842
MA	*	*	9,532	*	*	7,874
MI	7,408	6,654	14,061	5,745	5,720	11,465
MN	7,041	8,245	15,286	5,742	5,285	11,027
MS	*	*	*	*	*	*
MO	*	*	30,485	*	*	25,182
MT	*	*	*	*	*	*
NE	*	*	9,638	*	*	7,406
NV	*	*	1,491	*	*	1,340
NH	*	*	*	*	*	*
NJ	*	*	24,705	*	*	19,370
NM	*	*	*	*	*	*
NY	10,384	20,343	30,727	7,167	17,346	24,513
NC	*	*	3,938	*	*	3,373
ND	*		*	*		*
OH	8,199	1,112	9,311	6,574	911	7,485
OK	422	4,433	4,855	346	3,993	4,339
OR	2,459	2,715	5,174	2,062	1,835	3,896
PA	*	*	19,924	*	*	14,292
RI		*	*		*	*
SC	378	392	769	312	270	581
SD		*	*		*	*
TN	*	*	459	*	*	346
TX	23,148	10,584	33,733	15,829	8,085	23,914
UT	*	*	1,759	*	*	1,381
VT		*	*		*	*
VA	10,838	8,178	19,016	8,943	7,125	16,068
WA	6,056	4,159	10,215	5,054	2,390	7,444
WV	*	*	*	*	*	*
WI	39,722	29,989	69,711	32,657	19,078	51,735
WY	*		*	*		*
Oth Sts	120,757	48,639	24,328	94,523	34,663	16,455
US	384,779	311,464	696,243	301,630	239,982	541,612

* Not published to avoid disclosure of individual operations. Included in "Other States" and U.S. totals.
[1] Totals may not add due to rounding.
[2] Includes frozen juice tank storage capacity.

General Storages: Gross and Usable Freezer Space by State and United States, October 1, 2003 [1 2]

State	Gross Space			Usable Space		
	Public	Private & Semiprvt	Total	Public	Private & Semiprvt	Total
	1,000 Cubic Feet	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*	*1,000 Cubic Feet*
AL	*	*	23,826	*	*	20,086
AK	*	*	3,904	*	*	3,279
AZ	*	*	*	*	*	*
AR	*	*	*	*	*	*
CA	234,640	44,972	279,612	187,889	36,516	224,405
CO	*	*	12,576	*	*	9,919
CT	*	*	*	*	*	*
DE	*	*	*	*	*	*
FL	87,268	91,165	178,433	71,673	74,235	145,908
GA	89,438	8,815	98,253	72,580	7,170	79,750
HI	*	*	*	*	*	*
ID	*	*	56,294	*	*	47,960
IL	81,486	6,074	87,559	61,153	4,132	65,285
IN	*	*	49,206	*	*	39,935
IA	*	*	62,736	*	*	53,202
KS	*	*	36,128	*	*	26,803
KY	16,637		16,637	15,007		15,007
LA	*	*	12,011	*	*	10,128
ME	*	*	12,039	*	*	7,898
MD	*	*	26,921	*	*	20,322
MA	*	*	70,194	*	*	58,720
MI	59,481	14,669	74,149	45,740	12,127	57,867
MN	41,809	14,757	56,566	31,555	11,308	42,863
MS	*	*	*	*	*	*
MO	*	*	76,079	*	*	62,127
MT	*	*	*	*	*	*
NE	24,710	6,375	31,085	20,156	4,777	24,933
NV	*	*	5,879	*	*	5,197
NH	*	*	*	*	*	*
NJ	*	*	56,833	*	*	45,588
NM	*	*	*	*	*	*
NY	49,215	19,336	68,551	41,921	15,729	57,650
NC	*	*	59,653	*	*	50,000
ND	*	*	8,659	*	*	6,651
OH	53,590	14,470	68,059	43,213	9,571	52,784
OK	10,503		10,503	8,138		8,138
OR	66,542	32,251	98,793	55,433	24,305	79,738
PA	*	*	125,668	*	*	103,337
RI		*	*		*	*
SC	22,470	1,487	23,957	18,576	1,270	19,846
SD	*	*	*	*	*	*
TN	*	*	35,846	*	*	27,598
TX	116,476	9,320	125,796	79,043	6,258	85,302
UT	*	*	28,272	*	*	23,662
VT		*	*		*	*
VA	32,608	10,551	43,160	28,482	9,090	37,572
WA	139,165	39,581	178,746	107,373	31,315	138,688
WV	*	*	*	*	*	*
WI	87,677	9,917	97,594	74,807	7,798	82,605
WY	*		*	*		*
Oth Sts	758,587	167,249	163,112	623,366	126,571	127,523
US	1,972,301	490,990	2,463,291	1,586,106	382,169	1,968,275

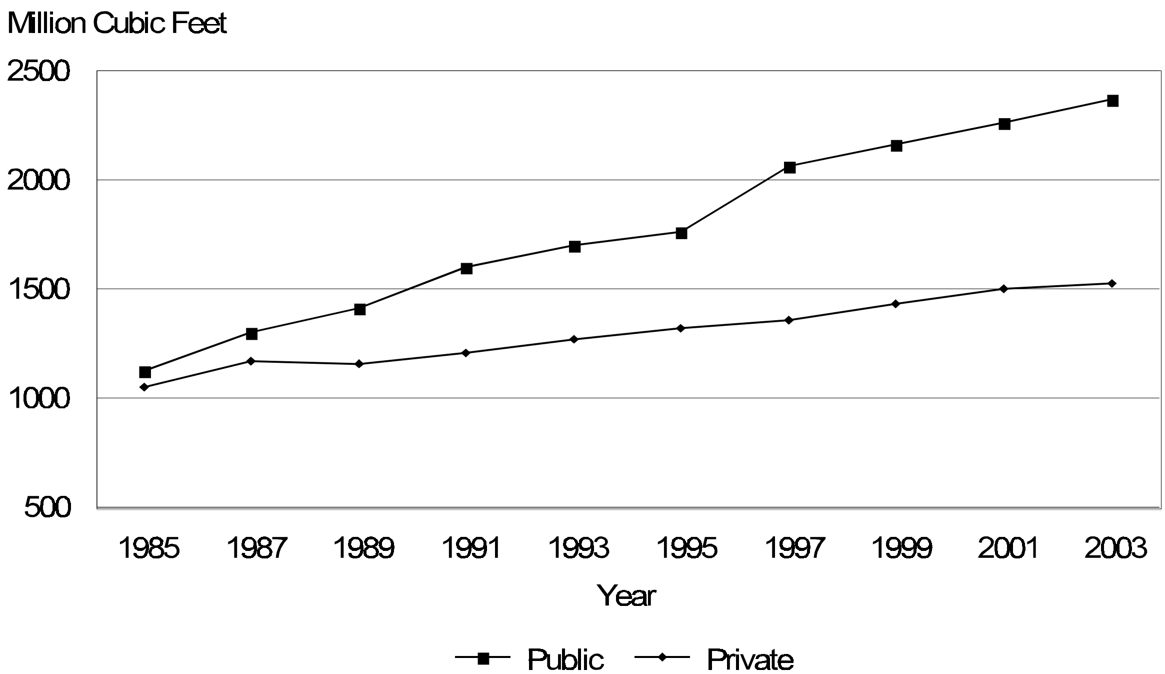
* Not published to avoid disclosure of individual operations. Included in "Other States" and U.S. totals.
[1] Totals may not add due to rounding.
[2] Includes frozen juice tank storage capacity.

Apple and Pear Storages: Gross and Usable Refrigerated Space, Regular and CA Capacity by State and United States, October 1, 2003 [1] [2]

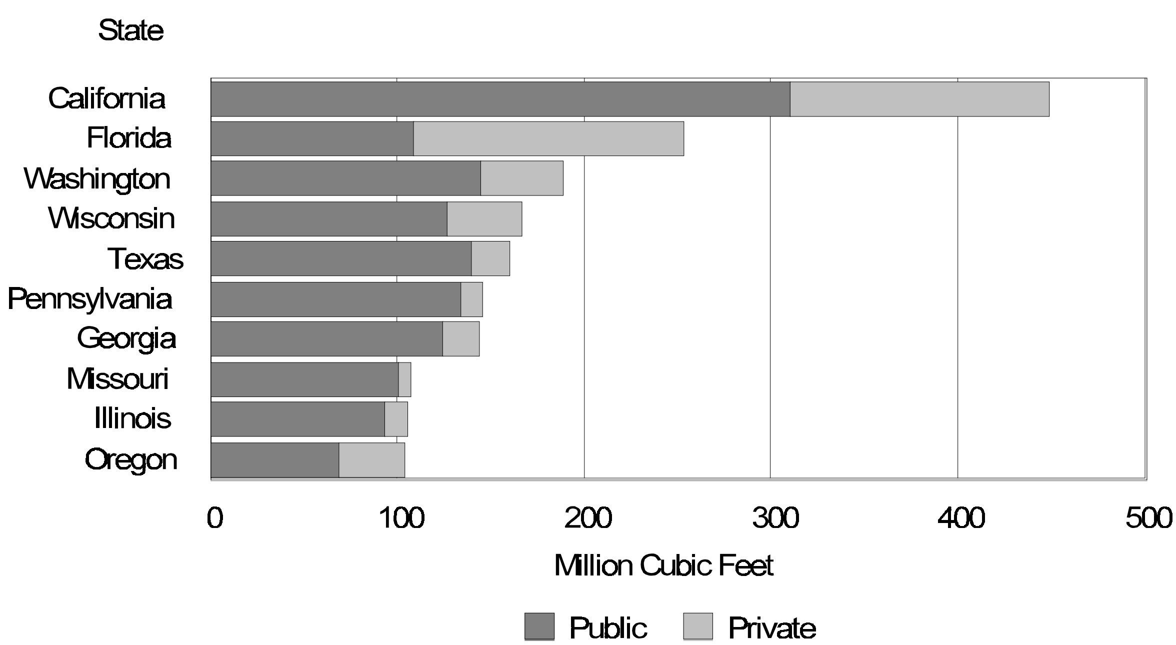
State	Refrigerated Space		Apple Storage Capacity		
	Gross	Usable	Regular	Controlled Atmosphere	Total
	1,000 Cubic Feet	*1,000 Cubic Feet*	*1,000 Bushels*	*1,000 Bushels*	*1,000 Bushels*
CA	28,502	21,415	5,933	1,757	7,690
CO	2,555	2,094	681	163	844
CT	1,490	1,195	288	174	461
ID	5,840	5,023	1,271	1,049	2,320
IL	1,326	1,141	345		345
IN	2,317	1,813	388	206	594
KY	117	97	33		33
ME	2,750	2,405	337	729	1,066
MD	1,390	1,115	173	354	527
MA	4,136	3,366	802	600	1,402
MI	35,196	30,806	4,947	7,795	12,742
MN	738	643	242	33	275
NH	1,901	1,657	311	449	760
NJ	2,312	1,925	545	173	717
NY	37,307	32,887	5,125	8,614	13,739
NC	4,413	3,972	1,106	480	1,586
OH	3,442	2,804	787	332	1,119
OR	51,642	39,016	7,965	3,926	11,891
PA	27,565	21,541	4,787	2,925	7,712
RI	151	142	38	8	46
UT	2,406	2,125	454	467	921
VT	2,275	1,928	318	507	825
VA	12,457	10,787	1,947	2,122	4,069
WA	492,326	393,968	61,177	135,792	196,969
WV	7,135	5,859	1,872	418	2,290
WI	1,084	901	297	98	395
Oth Sts	3,242	2,567	524	234	758
US	736,016	593,189	102,692	169,402	272,095

* Not published to avoid disclosure of individual operations. Included in "Other States" and U.S. totals.
[1] Totals may not add due to rounding.
[2] Firms in this table store only apples or pears. Nearly all the storages are private and nearly all the space is cooler, thus public use and freezer space breakouts are not presented at the State level. See page 4 for U.S. totals.

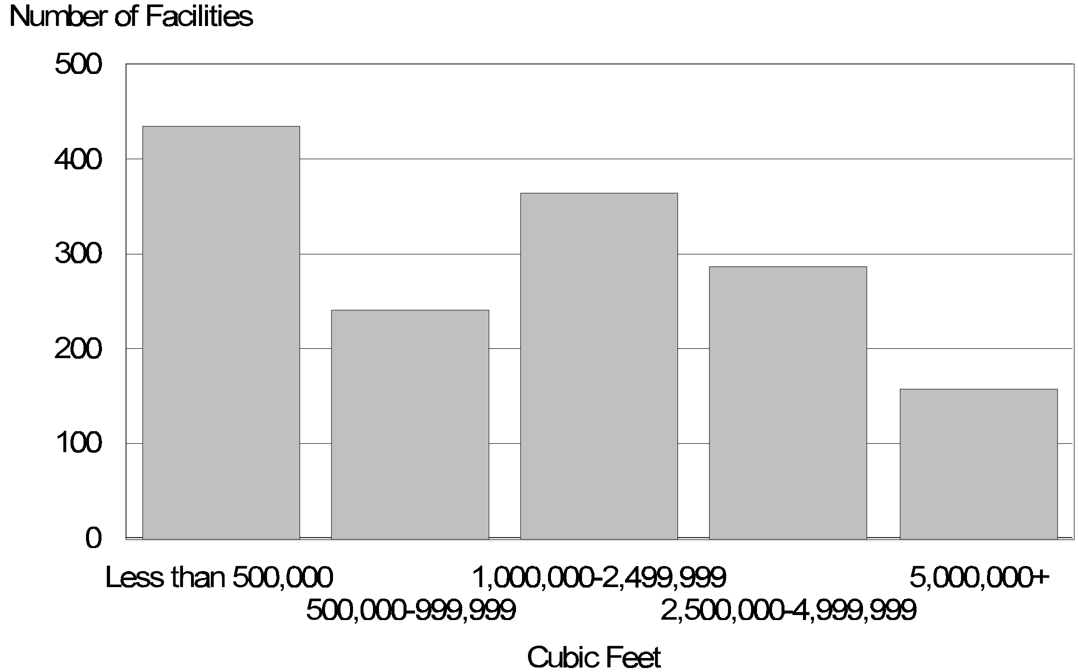
General and Apple Storages: Gross Refrigerated Space by Type, October 1, 1985-2003



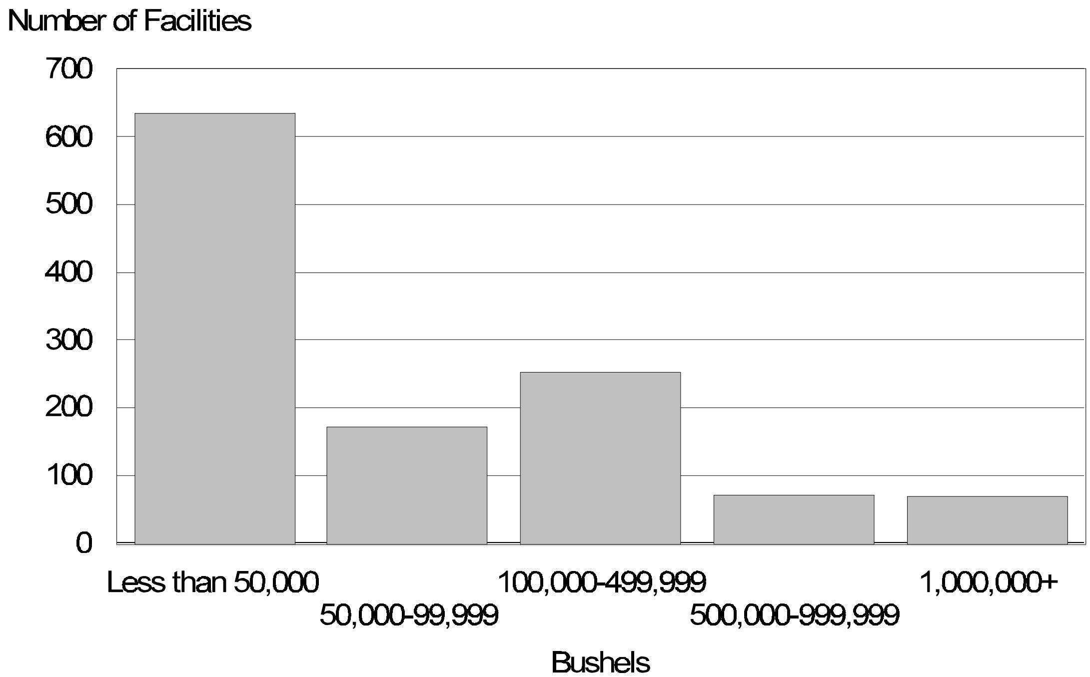
General Storages: Gross Refrigerated Space, 10 Largest States, October 1, 2003



General Refrigerated Warehouses: Number of Facilities by Size Group, United States, October 1, 2003



Apple and Pear Refrigerated Warehouses: Number of Facilities by Size Group, United States, October 1, 2003



Definitions

General storages: Includes refrigerated facilities classified as general storages, plus facilities classified as storing only cheese, meat, or citrus concentrates.

Public general storages: Refrigerated facilities maintained for storing food for others at specified rates per unit.

Private and semiprivate general storages: Refrigerated facilities maintained by an operator to facilitate his principal function as a producer, processor, or manufacturer of food products. The space is used to store the owner's products, although some space may be used by others at specified rates per unit stored. Working space, chill rooms, and curing rooms in meat storages are not included in the storage statistics.

Apple and pear storages: Refrigerated facilities maintained exclusively for storing apples or pears. Storages operated by cooperatives for use by members are included as private storages.

Cooler space: Space that maintains temperatures between 0 and 50 degrees Fahrenheit.

Freezer space: Space that maintains temperatures at 0 degrees Fahrenheit or lower.

Controlled atmosphere (CA) space: Sealed cooler space in which the oxygen and carbon dioxide content is controlled to extend the storage life of apples or pears.

Gross space: Total area under refrigeration, measured from wall to wall and from floor to ceiling.

Usable space: Actual area used for storing commodities. Gross space less an allowance for aisles, posts, coils, blowers, etc.

Number of storages: Storages at different locations are counted separately even though operated by the same management.

Survey Procedures and Reliability

Survey procedures: Questionnaires were mailed about the 20th of September to operators of over 3,000 public and private cold storage warehouses. Two thousand six hundred eighty-two firms met the qualifications that their warehouses were artificially cooled to a temperature of 50 degrees Fahrenheit or lower, and normally stored food products for 30 days or more. The other firms who received questionnaires either did not qualify or the plants had ceased being cold storage facilities during the past two years. The list included specialized storage facilities meeting the 30 day requirement, such as fruit houses, dairy manufacturing plants, frozen fruit, fruit juice, and vegetable processors, and poultry and meat packing plants. Wholesalers, jobbers, packer branch houses, and frozen food processors whose entire inventories are turned over more than once a month were excluded. Firms that did not respond were mailed a second request and/or phoned or visited.

Estimating procedures: Data for reporting firms were added to estimates for non-reporting firms to obtain State and National totals. Estimates for non-reporting firms were set based on previous reports or administrative data.

Revision policy: These data are considered to be final and will not be revised.

Reliability: Usable reports were received from about 2,189 firms which represent about 82 percent of the total capacity tabulated. The numbers published should be considered to be minimum figures as there are cold storage firms that are not known to NASS. Special care in identifying individual plants minimizes duplication. Survey data are also subject to non-sampling errors such as omissions and mistakes in reporting and processing the data. While these errors cannot be measured directly, they are minimized by carefully reviewing all reported data for consistency and reasonableness.

Index

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APPENDIX P

REFRIGERATED WAREHOUSE AND GROSS REFRIGERATED SPACE, BY TYPE, IN NEW YORK STATE, 1987-2003

Table 87. **COLD STORAGE CAPACITY:** Number of Refrigerated Warehouses and Gross Refrigerated Space, by Type, New York, October 1, 1987-2003

Category	1987	1989	1991	1993	1995	1997	1999	2001	2003
					Number				
REFRIGERATED WAREHOUSES:									
Public	36	42	41	35	34	35	37	32	31
Private and semi-private	73	66	64	62	56	51	48	51	50
Apple Storages:									
All *(Regular and CA)* 1/	186	187	169	174	172	156	156	154	147
CA *(Controlled Atmosphere)*	104	106	97	101	100	95	93	92	92
TOTAL	**295**	**295**	**274**	**271**	**262**	**242**	**241**	**237**	**228**
GROSS REFRIGERATED SPACE:					*1,000 cu. ft.*				
General Storages:									
Public	48,897	57,910	61,128	53,487	50,364	53,708	51,096	54,048	59,599
Private and Semi-Private	25,275	32,888	31,169	29,003	34,693	30,782	33,111	32,155	39,679
Apple Storages:									
All *(Regular and CA)*	31,021	32,782	29,489	31,285	32,113	34,664	35,251	36,446	37,307
TOTAL 2/	**105,193**	**123,570**	**121,786**	**113,774**	**117,170**	**119,154**	**119,458**	**122,649**	**136,585**
Apple Storages:									
CA *(Controlled Atmosphere)*	5,877	6,048	5,750	6,170	6,429	6,996	7,053	7,590	8,614

1/ Firms with both regular and CA storage are counted once.
2/ Total may not add due to rounding.

Table 88. **COLD STORAGE CAPACITY:** Refrigerated Space by Type of Warehouse and Total Capacity, New York, October 1, 2003

Type of Refrigerated Warehouse	Storages	Gross Space			Usable Space		
		Cooler	Freezer	Total	Cooler	Freezer	Total
	Number			*1,000 cu. ft.*			
GENERAL STORAGES:							
Public	31	10,384	49,215	59,599	7,167	41,921	49,088
Private and semi-private	50	20,343	19,336	39,679	17,346	15,729	33,075
APPLE STORAGES:							
All *(Regular and CA)*	147	37,307	-	37,307	32,887	-	32,887
TOTAL 1/	**228**	**68,034**	**68,551**	**136,585**	**57,400**	**57,650**	**115,050**

1/ Total may not add due to rounding.