A Shipper's Guide to Energy Conservation

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January 1980

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Department of Energy
Washington, D.C. 20585

"A SHIPPER'S GUIDE TO ENERGY CONSERVATION" has been developed as part of the Department of Energy's outreach activities aimed at achieving energy conservation and reducing petroleum imports through voluntary actions. To be of maximum benefit in the future, the SHIPPER'S GUIDE should reflect the experiences of its users. In the back of the SHIPPER'S GUIDE there is a self-addressed card that asks for your energy-saving ideas. It would be greatly appreciated if, in addition to new ideas for saving energy in shipping, you would add any thoughts that you might have for improving the SHIPPER'S GUIDE.

Thank you.

Office of Transportation Programs
Conservation and Solar Energy

Office of Transportation Programs
Washington, D.C. 20585

A Shipper's Guide to Energy Conservation

Prepared by:
Edward J. Marien, Ph.D.,
Management Institute
University of Wisconsin-Extension
Madison, Wisconsin
Under Contract No. DE-Aco2-79cs50067

January 1980

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INTRODUCTION

About This Guide

The transportation and distribution industry shares a national dilemma. As much as any other sector of the American economy, our field is dependent on the use of energy. We can't carry or distribute goods without using a large volume of fossil fuels; we can't store a variety of products without maintaining temperatures that will retard spoiling and deterioration; and the list of uses goes on and on.

For years the transportation and distribution industry has accepted steadily increasing fuel prices as a necessary evil of doing business. But with today's prices--and the prospect of dramatically spiraling prices--the transportation and distribution industry needs to get energy costs under control. This Guide is designed to do just that--to help you control energy costs without unnecessarily sacrificing efficiency or service.

Though none of us needs to be convinced that the cost of energy is soaring, the following charts graphically illustrate the scope of today's problem.

Chart 1 confirms what you already know, that crude oil prices
PRICE/BARREL CHART 1

COMPOSITE PRICE OF IMPORTED AND DOMESTIC CRUDE PETROLEUM

Source: U. S. Department of Energy, Energy Information Administration,
Division of Petroleum Marketing and Pricing Statistics,
Washington, D. C.

are skyrocketing--this despite the national resolve of a few short years ago to achieve "energy independence."

Chart 2 suggests that U. S. reliance on imported oil will become even greater until at least the end of this century. This does not bode well for the American economy, since increasing imports of foreign oil means an increasing imbalance of trade--which spells higher inflation. Clearly, we in the transportation and distribution industry are going to have to live with the energy dilemma--and to cope with it creatively.

Source: U. S. Department of Energy, Energy Information Administration,
Division of Petroleum Marketing and Pricing Statistics,
Washington, D. C.

If you are involved in goods procurement or distribution, or if you are a member of your company's Energy Committee, this Guide is for you. We offer a number of specific tips that are universally applicable. Because each firm is unique, we also provide aids to help you make important energy-related decisions for yourself. Included are suggestions for further reading in more specialized areas.

Some recommendations involve long-range planning; but most tips can be implemented immediately or within a short period of time. Money-saving opportunities plus more detailed, readily available references are to be found in each distribution service area included in this Guide:

1. Warehousing and Distribution Center Management.

How we process orders, handle inbound materials and finished goods in our warehouses and distribution centers can contribute major "direct" energy savings to our firms.

2. Transportation Management.

The movement of materials between facilities offers many alternative means for saving energy--often difficult to measure but significant nevertheless.

3. Materials Management for Product Packaging and Shipping.

How we package our goods and assemble shipments for distribution directly impacts fuel, shipping materials, and other distribution costs. The use of product wastes offers high energy savings potential.

4. Deployment and Management of Inventories.

The proliferation of inventories uses large amounts of energy in their production and deployment. Inventory management practices and policies must be analyzed as to their energy usage impact.

Getting Your Energy Act Together

Responsibility and review are essential if your energy-saving plan is to return significant dividends. Employees at all levels must understand your commitment to conservation. Moreover, each employee must be thoroughly familiar with his or her role in your energy-management plans. You need a continuous campaign to educate employees as both participants in your program and recipients of the benefits of their efforts (energy-awareness stickers and posters, regular round-table sessions, and tangible rewards for good ideas have all worked in various companies). Without the full cooperation of your employees, any energy-saving plan will be doomed to failure.

If yours is a larger firm, we urge your top management to name an energy manager or to form an "Energy Committee" to review this Guide and to initiate action on appropriate steps. Your lower and middle management and line personnel can then follow our specific list of recommendations; in addition, they are often the best people to analyze potential savings in areas with which they are familiar. They should be encouraged to point out these applications to top management. In the smaller firm, owner-managers will find comparable applications. Don't forget that this Guide is not exhaustive. Your firm can generate its own new energy-saving ideas for freight distribution.

Every one of your employees must realize that conservation makes more than environmental sense: Saving energy is tied directly to productivity and profitability.

Whatever the size of your firm, the key to success in this team effort is middle management. Your firm will add significantly to the profit side of its ledger if--and only if--a continual exchange occurs between the policy directives of top management and implementation by line personnel. Every suggestion in this Guide must be read in this light.

Your Energy Management Plan

Energy Conservation is a management job. In addition to motivating your employees, you as a manager want to see if your conservation measures are actually working. Are they worth the effort?

Beyond the basic maintenance steps and the development of good attitudes and habits, there are few "do's" and "don'ts" in energy conservation. To discover areas of greatest potential saving in your business, you need your own Energy Management Plan. You will learn how to chart your energy use in Appendix 1. While this plan is most useful in warehousing and plants, it will work wherever energy is consumed and can be directly measured.

You should realize that energy savings made now will be magnified later. But because of the rising cost of energy and inflation, savings will not necessarily be reflected in lower bills. The Energy Management Plan is most useful because it enables you to measure the amount of energy used for each dollar of sales, tons or number of pieces shipped, number of shipments, or by any other meaningful measure. You might still be paying more for energy; but you would otherwise be paying a whole lot more.

The recommendations in this Guide will prove their worth to you if you follow through on the Management Plan.

Share Your Ideas With Us

The freight transportation and distribution field is complex, and this Guide cannot suggest every way to save energy. You will undoubtedly come up with many of your own solutions.

The Department of Energy wants to hear about your ideas. Future editions of this Guide and possible seminars will be of much greater value if all of us in transportation and distribution pool our talents and insights.

If you have a practical energy-saving application, please fill out the self-addressed, stamped tear-away card in the back of the Guide and send it to us. Many other Americans will appreciate your effort.

Primary Author's Acknowledgements

I am very grateful to all those individuals and organizations who shared their knowledge and experience in developing this management guide. Special thanks go to the "idea generators and technical writers" on the project team. These writers and their specialties are: James L. Allen, warehousing and order processing; Glenn L. Fast, transportation; Warren R. Ross, transportation; and Walter L. Weart, transportation. Wesley T. Mott, editor for the University of Wisconsin Small Business Development Center, provided valuable assistance in editing and writing the final draft of the guide. Many other University of Wisconsin professionals aided in the guide's development. Deep gratitude goes to the many project assistants who made the guide physically come into being.

Last, but not least, I want to thank members of the Energy Committee of the National Industrial Traffic League, and of the executive committees of the National Small Shipments Traffic Conference (NASSTRAC) and the National Council of Physical Distribution Management (NCPDM). Their thoughtful suggestions aided in making the final draft of the guide readable and relevant.

Edward J. Marien, Ph.D.

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WAREHOUSING AND DISTRIBUTION CENTER MANAGEMENT

WAREHOUSING AND DISTRIBUTION CENTER MANAGEMENT

A practical energy conservation plan for warehouses must include both short-term changes in practices and procedures by employees as well as long-term policy changes relating to design and layout of facilities and equipment. You can save as much as 15% of utility costs with a minimum of capital expenditure.

First, we offer recommendations which can be implemented quickly and cheaply. Although many of those recommendations seem obvious, such as turning off the light when there is no activity in a specific area or room, many energy abuses such as this do occur in a warehouse that is not conscious of energy consumption. Next, we present some longer-term considerations for facility and equipment design which require a larger capital investment, but can result in significant energy savings.

Short-Term Operational Recommendations

Our specific recommendations fall into four functional areas plus one general area of practices that apply to the whole warehouse facility: 1) shipping and receiving, 2) stock layout, 3) order picking and packing, 4) material handling equipment, and 5) general maintenance and operational changes. Follow the checklists to discover areas applicable to your facility. We urge you when formulating your own energy plan to supplement these recommendations with steps unique to your operation.

Shipping and Receiving--The shipping and receiving area in the warehouse facility is usually the most energy-intensive and affords the greatest opportunity for energy savings. Because the receiving and shipping areas interface with the outside, tremendous amounts of energy can be wasted by poor operating practices. In addition, there is usually considerable activity in these areas which in themselves consume a great deal of energy. The following recommendations can help reduce your energy consumption and loss in the receiving and shipping areas.

1. Keep all windows and doors shut when not in use. Door closers should be inspected to insure they operate properly.
2. Check all rail and truck dock doors for a tight seal against the building when closed. Dock-door rail adjustments and weather stripping require frequent maintenance to be effective.

3. Inspect all dock doors for holes or cracks, and repair when necessary. On occasion, fork-lift drivers will lift dock doors with their forks. Discourage this practice to protect dock door seals against damage.
4. Periodically inspect dock shelters and/or dock seals and repair when necessary to insure proper sealing. Frequently check rail dock shelters to be sure they are in good repair and operate properly.
5. Be sure employees properly tie rail dock shelters against the building when not in use. If left in the extended position, dock shelters can be damaged when a rail car is put in place.
6. Inspect and repair dock plates and levelers to insure that excess heat cannot escape around sides and through holes. Some warehouses fasten a layer of insulation to the bottom of dock plates to reduce the conduction of heat through the plate itself.
7. Minimize frequent truck-dock door openings. When trucks are to leave the dock, close the overhead doors immediately.
8. Schedule loading and unloading activities to minimize dock door openings whenever possible. Unloaded trailers should be loaded for outbound shipment without their having to leave or change docks.
9. Group loading and unloading activities together so that light and heat can be concentrated in a more restricted area. On the other hand, care should be taken not to schedule activities so close that they interfere with one another and thus cause wasteful movements.
10. Post instructions at all doors to remind employees to be energy conscious and keep doors shut.
11. In colder climates, require receiving and shipping employees to dress warmer so that the temperature can be lowered.
12. Repair and replace fork-lift truck head lights. In many instances the lift truck lights are sufficient to allow safe loading and unloading of trucks and rail cars without additional dock lighting.
13. Post signs to direct employees to turn off auxiliary dock-load lighting used to light the interior of vehicles. These lights are usually high-intensity spotlights, which consume a large amount of energy.

14. Periodically inspect all heating units to insure efficient combustion. Poor maintenance of heating units is a major source of energy waste.
15. Direct space heaters so that heat is concentrated on the high-activity areas. In addition, turn the heat down or off in vestibules, hallways, unused rooms, and any other areas which have infrequent activity.
16. Caulk around all door and window frames. In addition, look for cracks in the building walls or ceilings (particularly older buildings) which should be caulked or sealed. Inspect windows in the dock areas or in the dock doors to insure they are free from cracks and properly sealed.
17. Inspect ventilating fans to insure they operate properly. This includes cleaning and checking for proper operation of air closers. In the winter, ventilation fans that are not in use should be covered with plastic or some form of insulation to improve their seal.
18. If possible, product in the receiving and shipping area should be positioned to block the flow of cold (or warm) air back into the warehouse. Often, judicious placement of product may serve as a barrier to the unwanted movement of cold air or serve as a "heat sink" whereby products hold warmth in the building.

Stock Layout--The proper layout of stock within the facility can significantly affect whether we conserve or waste energy. Of course, not all operations are able to change their warehouse layout, but as changes for other reasons are required, the energy impact of such changes should be considered. The following list of recommendations should be helpful when making any layout changes.

1. Keep freezables and heat-sensitive products segregated. Heat can be concentrated in certain areas of the warehouse and prevented from moving by either plastic partitions or stacks of product.
2. Group high-activity products together to minimize the travel distance from item to item when picking or restocking. Locate active stock near the head end of aisles or at accessible height levels in the racks to minimize energy consumption in both travel and lifting operations.
3. Use narrower aisles when possible to allow for a smaller area requiring less heat and light.
4. Where racks are used, see that they do not block existing light fixtures. Many times racks are moved and the fixtures are not. The result is that insufficient light is available for the identification and movement of product while light is wasted above the racks.

5. Periodically inspect product racking and stacking (especially bulk storage) so that space heaters are not blocked. Often product is inadvertently placed in front of heaters, restricting the flow of heat into the area.
6. Thermometers should be strategically placed around the warehouse storage area to determine if a specific area has too little or too much heat.
7. Thermostat controls should either be placed high on the wall or locked so that unauthorized employees cannot change the temperature settings.
8. Locate materials near their point of use to minimize travel distances. For instance, packing materials often are not stored close to the packing operation, thus requiring the frequent movement of the materials.
9. Keep aisles clear so that material-handling equipment can move efficiently down aisles without unnecessary detours or product rehandling.
10. Inspect the stock identification markings so that excessive light is not required in their handling. If the stock markings are bold and easy to read, it is not necessary to have as high a light level.
11. Observe good housekeeping practices, keeping the product clean and easy to identify. Soiled or disorganized product eats up unnecessary energy in its identification and handling.
12. If you have large windows and/or skylights, locate product so that natural light strikes and heats the product stacks. In this manner, the product acts as a heat sink, absorbing natural heat during daylight hours, and giving it off during the night.
13. Keep all floors clean and apply a high-gloss floor sealer. The reflection of light from the floor surface can greatly enhance artificial or natural lighting.
14. Clean all windows and skylights frequently to allow the maximum amount of natural light to enter the building. Well-positioned windows can significantly supplement artificial lighting. In addition, if a good deal of your useful lighting is natural, schedule the bulk of your activities during the daylight hours.

15. Inspect and clean all lighting fixtures and replace all burned-out lamps. Older fluorescent fixtures are particularly susceptible to high voltage usage when the lamps are defective (signaled by blinking or flickering light).
16. When old existing lamps burn out, replace them with more efficient lamps. Most suppliers of lighting fixtures have high-efficiency, energy-saving lamps which will fit your existing fixtures.
17. Limit exterior lighting to that required for building identification or security. Install photo cell switches on exterior lighting to insure its use only when required.

Order Picking and Packing--The method by which we process orders can greatly affect the amount of energy we consume. For our discussion, we shall consider order processing to include the receipt of the order, the picking of the product, the packing of product if necessary, and the movement of product to the shipping area. The following recommendations will help you save energy in these operations.

1. Group order picking and packing activities whenever possible to minimize areas requiring high heat and light levels.
2. Turn on lights only in those areas which have activity. In many warehouses, the lights covering a number of areas are controlled by one switch. It may be possible to separate the lights by area and put them on different switches. In this manner, the lights can be controlled by individual work areas.
3. Post signs instructing employees to turn lights off when leaving areas where there is no activity. It may help to have light-switch cords hung from the ceiling so that the fork-lift drivers can reach the switches.
4. Schedule picking cycles to minimize activity in areas with products that are infrequently picked. Explore batch-picking methods to move the picker from area to area, thus allowing the lights to be turned off in areas the picker is not using.
5. Locate activities requiring the largest amount of light, such as packing, near a natural light source.
6. Products that have been picked should be staged near the loading docks, and out of the aisles. It may even be possible to move products directly into trucks to minimize double handling.

7. If available, use your computer or manual systems to determine the most efficient industrial truck routes. This can minimize travel and dead-heading with empty trucks by better picking and put-away combination systems.
8. If product is occasionally mixed and needs to be sorted while picking, supply employees with supplemental lighting, either hand held or mounted on lift trucks. This can reduce the overall lighting level.
9. Be sure all material-handling equipment is equipped with lights so they may travel through unlighted areas without turning on overhead lights.
10. By batching orders, pickers may be able to pick more product on a given pick cycle, thus reducing the total number of picking cycles required, and reducing the number of energy hours required to accomplish the task.
11. Maximize loads when moving product from one area to another.

Material Handling Equipment--The cost of operating material-handling equipment is a major portion of the distribution facility's energy bill. Savings of up to 30 percent are being achieved by companies practicing proper application, operation, and maintenance of material-handling equipment.

1. Minimize travel distances by efficient layout of the product and areas of support activity.
2. Match the material-handling equipment to the job to be performed. A vehicle of excess capacity consumes unnecessary energy just to move the heavier vehicle. Conversely, a larger truck can move more product with fewer trips.
3. Train lift-truck operators on proper operating procedures.
4. Caution operators not to race the engine of their gasoline or propane truck to lift a load faster.
5. Turn off all material-handling equipment when not in use. This includes lift trucks as well as powered conveyors and transfer machines.
6. Instruct lift-truck operators not to push loads when they could carry them. Sliding friction being much greater than rolling friction, the vehicle expends more energy to push the product than to carry it.
7. Minimize the travel of material-handling equipment up ramps and steep grades.

8. Operators of electrical trucks should check battery connections and water levels daily. Damaged cables or cracked housing should be noted and repaired as soon as possible.
9. Equip all electrical trucks with a voltage indicator to determine when to recharge equipment. Many older electrics do not have this useful device and are frequently driven too long or are charged too frequently. In both cases, battery life is shortened.
10. Establish specific battery-charging procedures with the advice of your battery supplier. Over-charges or short-charges are a frequent cause of premature battery failure.
11. Obtain and affix decals to gasoline trucks warning employees against overfilling fuel tanks so as to leave room for gasoline expansion.
12. Establish a comprehensive maintenance program for all material-handling equipment. According to industry experts, the fuel consumption, or power draw, of an industrial truck can be cut up to 30 percent by a systematic approach to lift-truck maintenance.
13. Make sure that all pneumatic tires are properly inflated, and properly lubricate all wheel axles and bearings. By minimizing rolling resistance, material-handling equipment will operate more efficiently.
14. Periodically check all the circuitry in electrical material-handling equipment for overheating, corrosion, or short circuits. Defective wiring can consume excessive energy and turn it into worthless heat.
15. Where practical, consider using gravity conveyors to move product rather than powered lift equipment. Often, powered conveyors can be used as gravity conveyors with a slight modification. Many powered systems were implemented before 1972 when our industry was not as energy conscious as today. Gravity systems may be sufficient to move the products.
16. Use electric material-handling equipment in close quarters if possible. Gas trucks emit noxious fumes, which, in a closed environment, may require a powered ventilation system.

General Maintenance and Operational Changes--The following recommendations apply to the maintenance of the total facility. A thorough maintenance program can conserve a substantial amount of energy by keeping the building at its optimum designed condition.

1. Involve the employees in the goals of energy conservation.

2. Lower thermostats during the heating season and raise them during the cooling season. You can save about 8 percent of your heating bill by lowering the thermostats a mere five degrees.
3. Examine the entire building for air leaks around windows, doors, and any place that they might occur. Seal up the leaks.
4. If hot water is used for space heating, reduce the temperature to the minimum.
5. Lower employee hot water temperature to 110°F. If agreeable to employees, supply only cold water to wash rooms.
6. Reduce the use of heating and cooling systems in spaces which are used infrequently or only for short periods of time.
7. Provide a temperature-control training program for maintenance personnel to give them a thorough understanding of how the heating and ventilating systems were designed to operate. Include optimization of energy via temperature control.
8. Conduct a survey of the total building on a space-by-space basis to determine actual energy needs.
9. Disconnect all refrigerated water fountains if acceptable to employees.
10. Inspect electrical contacts and working parts of relays and maintain in good working order.
11. Change the spring, fall, and winter day-night time-clock settings to operate heating, ventilation, and cooling equipment fewer hours on the day cycle.
12. Level your electrical use to avoid excessive peak load "demand charges." Local utility company representatives can often help.
13. Seal ducts and access doors in equipment rooms to minimize bypassing of hot and cold air.
14. Schedule operations, maintenance, and cleaning to overlap more with normal working hours or when sufficient daylight is available for the task.
15. Assign responsibilities for energy conservation to the entire building staff.

16. Turn heating systems back and cooling systems off during the last hour of occupancy, on off-shift hours, and on weekends.

Longer-Term Facility and Equipment Design Considerations

Within the warehouse, energy is consumed by two major operational elements: 1) The warehouse facility itself, and 2) material-handling equipment.

The facility itself consumes the most energy and, therefore, offers the greatest chance to save energy. We use energy in the warehouse primarily for heat and light. We may realize savings not only by changing procedures, but also by switching from one or another form of energy to obtain heat and light. Therefore, it is important for you to investigate how and why you use heat and light in your facility.

There are three main reasons why most operations use heat. First, building protection. This requires that sufficient heat be maintained in the building to keep water pipes from freezing and all mechanical devices attached to the building working properly.

Second, product protection. We should identify those products in our facility really sensitive to temperature. Many products we warehouse are subject to freeze damage. Other goods--including various food products and flammable products--are sensitive to excessive heat.

Third, personnel comfort. The level of heat needed by your employees varies significantly depending on the tasks performed. Packing operations generally require more heat than picking operations. And of course individuals have different and conflicting preferences. Be careful when changing temperature levels that employees realize the need for energy conservation and have made a commitment to that end. Requiring employees to dress warmer to allow lower temperature can be taken negatively as an imposition on one's personal rights or positively as a small sacrifice in personal comfort for a common cause, depending on how the program is presented.

We can conserve energy by better matching lighting to the requirements of specific tasks. With windows and skylights, we can use natural light better to supplement our artificial light. Thoroughly review lighting needs so that effective lighting changes can be implemented to save energy without hampering work performance.

Material-handling equipment, with the exceptions of gravity-flow conveyors and the like, is energy intensive. Proper operating practices and maintenance procedures can cut energy use significantly. In addition, manufacturers of all material-handling equipment are continually designing new equipment or attachments that are energy efficient in themselves or improve the energy consumption of existing equipment.

Following are energy recommendations that require an initial capital investment. In most cases they will yield a greater return in energy and cost savings than the no-cost maintenance and operational changes listed in the previous section. However, before investing any money make sure you have implemented as many of the no-cost items as practical.

1. Add insulation to the existing building's exterior walls, to floors, and especially to ceilings to minimize heat loss.
2. Replace old inefficient heating units with new efficient ones.
3. Install door and window closers on all outside openings.
4. Install loading-dock shelters and seals to prevent the escape of heat.
5. Install large-blade ceiling fans or blowers to move the warm air in the ceiling down to floor-level work areas.
6. Replace old inefficient lighting (incandescent) with more efficient fixtures such as mercury or sodium vapor.
7. Install air curtains or vinylstrip barriers at openings to prevent the movement of heat into unwanted areas.
8. Install skylights to increase the natural light available to work areas, thus reducing the amount of artificial light required. But be careful in cooler climates that the skylights don't significantly increase the heat loss. Consult an engineer when making these changes.
9. Convert wet sprinkler systems to dry systems. This allows you to keep a lower overall heat in the building.
10. When purchasing material-handling equipment, investigate the energy-conservation features. Many of these can significantly improve the efficiency of the equipment.
11. Place guards around dock door rails to prevent their damage by lift-truck equipment. Damaged rails are a source of considerable heat leakage from a building.
12. Investigate installing a tow line to replace some of the repetitive trips required of power material-handling equipment. The net saving in power can reduce overall energy consumption.
13. Have a technician check the efficiency of boilers on a regular basis. A percent loss of boiler efficiency is a percent loss of energy and cost. It is generally worth any cost incurred to optimize the boiler operation.

14. Add controls to permit up to 100 percent shut-down of air and water supplied to unoccupied areas.
15. Install timers to cut off lights and equipment automatically.
16. Consider replacing free-running drinking fountains with spigot types which require a paper cup. Up to half the water drawn by free-running fountains is wasted.
17. Consider using an expandable enclosure for delivery ports. Because it can be adjusted to meet the back of a truck, it substantially reduces air infiltration.
18. Consider computerizing the heating and cooling systems in large applications.
19. Install thermostats for control of all heating equipment where only on-off switches exist.
20. Install key-lock covers over the thermostats to prevent building employees from adjusting settings in offices, lobbies, and production areas.
21. Connect all of the manual day-night control switches to time clocks so that night setback temperatures can be achieved even if switches are accidentally left on "day".
22. Heating equipment should be clustered together and located away from cooling equipment.

For your further reading, we recommend the following sources, which were helpful in developing this Guide. Especially valuable is Energy Audit Workbook for Warehouses (U. S. Department of Energy, September 1978).

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TRANSPORTATION MANAGEMENT

TRANSPORTATION MANAGEMENT

Let's explore how shippers can make some positive contributions to relieving the energy crisis through better transportation management. Our study has convinced us of the over-riding need for awareness of energy-saving opportunities in transportation. In this section we identify four major areas for saving energy in freight transportation:

Better Use of Our Means of Transportation

-- How can we better use our five basic modes of transportation-- rail, truck, water, air, and pipeline--and our legal forms of transportation?

Improvements in Traffic Management Operations

-- What can shippers do, sometimes quickly and at little cost, to be more productive and save energy in freight transportation?

LTL Shipments and Freight Consolidation

-- What opportunities exist for shippers to consolidate the large number of Less-Than-Truckload (LTL) shipments into larger loads for saving energy?

Private Fleet Design and Management Control

-- With the large amount of private transportation using all modes, what can shippers do when considering the design of transportation equipment and their control of this equipment to save energy?

Better Use of Our Means of Transportation

No one can question the need to reduce energy consumption in transportation. Nearly half of all U. S. energy is derived from petroleum and about one-quarter of all energy is consumed for transportation (20). Chart 1 indicates how energy for transportation was consumed by the various modes of transportation in 1977 (20: pp. 2-13). These statistics apply to both personal and freight transportation and to domestic and international transportation.

CHART 1 TRANSPORTATION ENERGY CONSUMPTION

Source: U. S. Department of Energy, Transportation Energy Conservation Data Book, ORNL-5493 Special, February 1979, pp. 2-13.

A. Relative Efficiencies and Selection of Our Transport Modes

When we consider freight transportation only, which is the main thrust of this guide, we find that it is not easy to determine which mode is the most efficient. There is a tendency to compare air, rail, marine, pipeline and highway modes on an aggregated basis--by dividing estimates of total energy consumed by a mode by the total ton-miles for that mode in a given period of time. Thus, in 1976, the aggregated energy intensities for the several modes were as shown in Table 1.

TABLE 1: MODAL BTU EFFICIENCIES (1976)

MODE	TON-MILE PERCENTAGE	BTU PER TON-MILE
Domestic Air Cargo	0.18	14,070
Class I Railroads	35.9	890
Domestic Waterborne Commerce	17.0	470
Pipeline*	23.8	200-800
Highway	23.2	2,470

* Oil moved in a 36" diameter pipeline, low to high flow

Source: Transportation Energy Conservation Data Book ORNL-5493 Special, Oak Ridge National Laboratory, Oak Ridge, Tennessee, February 1979.

Aggregated energy intensities can be misleading since the railroads, waterways and pipelines transport significantly greater quantities of bulk commodities (coal, iron ore, sand and gravel, etc.) over longer distances than do the trucks. These dense cargoes contribute to higher aggregated energy efficiencies than do the less dense commodities that constitute a large share of highway vehicle cargoes. Route circuitry can also alter the relative energy efficiencies of two modes. For instance, waterway distances between U. S. cities that are between 500 and 999 miles apart are on the average twice the highway distances (16: p. B-3).

Depending upon a number of factors, such as fleet mix, the amount of empty backhaul, operating practices, cargo densities, pipeline diameters and pumping pressures, etc., energy intensities within modes can vary widely. Chart 2 contains representative variations in energy intensities for the several freight modes.

CHART 2 MODAL VARIATIONS IN ENERGY INTENSITY ESTIMATES
FOR FREIGHT TRANSPORT. (10^3 BTU/ROUTE-TON-MILE).

Source: A. B. Rose, "The Role of Air Freight in View of Energy Intensity and Related Parameters--An Intermodal Comparison," presentation at the 1978 SAE International Air Transportation Meeting, Boston, MA, May 2-4, 1978.

However, energy efficiency is but one factor influencing the means of shipping freight. In fact, it is extremely doubtful if energy efficiency will ever become the controlling factor unless the competitive advantage of the more fuel-efficient modes is reflected favorably in the rate structure.

In addition to rates and the underlying energy efficiencies of the modes, factors influencing how shipments move include:

1. Number of plants
2. Location and size of markets
3. Length of haul from origin to destination
4. Number and types of customers
5. Shipment volume and frequency
6. Nature of products or commodities
7. Packaging and unit load characteristics
8. Freight expense as a percent of sales
9. Freedom of shipper to route the freight

10. Legal forms of carriage--for-hire or private
11. Customer service constraints--required speed and reliability of service
12. Other-than freight costs involved in: the cleaning and preparation of transport vehicles; loading and/or unloading of vehicles; bracing and securing of the load in the vehicles; inventory carrying costs for goods in transit or at sites.

All of these factors influence how merchandise moves. Yet, fuel is becoming a more important factor in selecting the means for shipping our freight. When considering other materials and supplies derived from petroleum, such as tires or other synthetic products, the effects are even more dramatic.

B. Impact of Legal Forms of Carriage on Fuel Consumption

Referring back to our list of factors influencing shipping methods, the influence of various legal forms of carriage on fuel consumption should be considered. As noted above, specialized carriers have been heavily impacted by rising petroleum and fuel prices. Because private transportation plays such a large role in our present transportation system, shippers must consider the impact of fuel consumption on their private operations.

In the area of motor truck operations where over 50% of the registrations for tractor-trailer combinations are private, more firms continue to get into private carriage or enlarge their fleets. Is this a wasteful use of energy when an Interstate Commerce Commission survey showed that private trucks generated the highest percentage of entirely empty miles (27.3%) for 3-or-more-axle truck miles? This 27.3%, however, compares relatively well to 20.4% for all motor truck carriers in the same survey (2).

In the past few years, motor truck carriers have made great strides in becoming more fuel efficient. Good data on fuel-efficiency programs have been published by shippers, motor carriers, equipment manufacturers, and independent testing agencies. Since a large volume of traffic moves by private motor fleets, a later section in this guide is devoted to "Private Fleet Design and Management Control."

Private carriage plays a dominant role in our transportation system. Shippers gain flexibility in operations and shipping schedules, door-to-door control of operations, and routing efficiencies that heavily benefit the shipper. What the shipper must do is to critically analyze, where imbalances of traffic exist, if other legal forms of carriage offer opportunities for more efficient shipping of goods.

One area for motor truck carriers to further pursue is the use of intermodal Trailer-On-Flat-Car (TOFC) services offered by the railroads. Considering the railroads' long-haul relative energy efficiencies, TOFC plans offer the energy efficiencies of railroads and the flexibility of door-to-door control in motor truck operations. There is evidence that the railroads are gearing up operations with dedicated trains, new types of cars, and improved ramping facilities to take advantage of TOFC potential.

C. An Approach to Comparing Modal Efficiencies

Water transportation has limited interest to most shippers because usage is confined basically to shippers of bulk commodities strategically located on waterways. Pipelines, often overlooked as a basic transportation mode, are in a sense comparable to a railroad buried underground, assembling large shipments over main lines, and possessing the capability of being "switched" to "branch lines." They are severely restricted as to commodities that can be carried, thus placing them beyond the reach of most shippers. Air cargo provides speedy delivery to much of the world, but for the most part it is limited to transporting high-valued small shipments. These constraints cause us to focus attention on the railroad and trucking industries, which together account for more than 60% of all intercity revenue freight and in excess of 90% of all freight revenue generated by regulated freight carriers.

If your firm were to look into the line-haul energy efficiencies for transporting goods, consider this approach. Let's compare the fuel used by two 2500-horsepower diesel locomotives against the equivalent number of trucks required to move a given number of tons between Chicago, Illinois, and New York City, New York. In this analysis these are our assumptions:

- . The highway mileage between Chicago and New York City is 811 miles.
- . The railroad mileage between Chicago and New York City is 890.
- . In 1970, the average truck load for a trip of 811 highway miles by motor carriers of general property operating within Eastern Central rate territory was 15.203 tons (Source: ICC Bureau of Accounts, Statement No. 2C1-70, p. 44, Table 6, line 17, column 6).
- . The average Eastern District freight train in 1970 carried 1981 tons (Source: Yearbook of Railroad Facts, 1972 edition. Association of American Railroads).

Under the above circumstances, it will take 130.3 trucks to carry the 1981 tons representative of the average Eastern District freight train (1981 tons divided by 15.203 tons per truck equals 130.3 trucks). Studies made by the General Electric Company estimate that a 2500-horsepower locomotive traveling over what is known as the "water level route" from Chicago to New York City will consume approximately 2 1/2 gallons of diesel fuel per locomotive mile. Two locomotives should more than adequately power a trainload of 1981 net tons. Thus we arrive at an estimated figure of 5 gallons per mile for two locomotives or a total consumption of 4450 gallons of diesel fuel. Therefore, the diesel locomotive team in our hypothesis produces an estimated 396.2 ton-miles for every gallon of fuel used. The calculations are: 1981 tons x 890 miles divided by 4450 gallons equals 396.2 ton-miles per gallon.

We next turn our attention to the comparable gallons of diesel fuel expended by the 130.3 truckloads required to move a quantity of 1981 tons between Chicago and New York City. We can reasonably expect diesel tractors to achieve about 5 miles per gallon (MPG) on turnpike driving. Thus it follows that 130.3 trucks carrying a load of 15,203 tons a distance of 811 highway miles will consume approximately 21,135 gallons of diesel fuel. The calculations are: $130.3 \text{ truckloads} \times (811 \text{ miles divided by } 5 \text{ MPG})$ equals 21,135 gallons. This in turn equates to an estimated 76 ton-miles per gallon and only 19% of the fuel efficiency realized by the railroad. The upshot is a savings of 16,685 gallons of diesel fuel.

Admittedly, this projection of fuel remains an imprecise exercise, relying on estimates and arguable choices of specific commodity movements and selected traffic lanes. Notwithstanding such shortcomings and other factors noted earlier on the selection of shipping methods, it seems clear that the railroads offer a great opportunity for saving transportation energy. However, we do not see a dramatic shift of tonnage to the railroads merely because they appear on the surface to be more energy efficient. Shippers should consider all related distribution costs in selecting the best means of shipping goods.

D. Influence of Truck Payloads

It is not unduly optimistic to suggest that an average payload of at least 15 tons per truck should be readily obtainable. Today's 45-foot trailers offer approximately 2315 cubic feet of usable stowage space. Consequently, any product exceeding a density of 13 pounds per cubic foot will cube out in excess of 15 tons. Greater payload plus an improved mileage factor would go far to improve the motor carrier's unfavorable image of being an extravagant consumer of energy. To advance our hypothetical situation a step further, let's consider the effects of a modest improvement in the average truckload to 15 tons from an assumed but fairly typical average of 12.5 tons. Let's also assume an increase in fuel economy to 5.5 MPG from a typical average for general commodity carriers of 4.6 MPG. The result of these adjustments would generate 82.5 ton-miles per gallon versus 57.5 ton-miles per gallon. Using general freight carriers as a guideline, this means a 43.5 percent improvement in ton-miles per gallon. If payloads can be increased, significant reductions in energy consumption can be achieved.

Improvements in Traffic Management Operations

Once shippers have selected the means of transporting their freight, they should check the considerations below for improving the productivity of traffic management operations--ways that can have operational impact on energy savings.

A. First of all, shippers can help improve the productivity of carrier equipment by quicker loading and/or unloading. Regulated motor carriers in 1977 required 2.4 trailers per tractor operated; and the average serviceable railroad car spent only about 13% of its time in road trains, loaded or empty. The remainder of freight car time is consumed mainly in loading and unloading at shippers' plants, moving from place to place within terminals, being classified and assembled into trains, or standing idle during seasonal lulls in car demand.

B. Reduce the number of empty miles associated with equipment movement. Table II illustrates the extent of the problem by identifying the ratio of "empty" car-miles to loaded car-miles for a general service, unequipped box car.

Table II

<u>District</u>	<u>Loaded Car-Miles*</u>	<u>Empty Car-Miles*</u>	<u>Ratio (%) Empty Miles To Loaded Miles</u>
Eastern	995,648	584,252	59
Southern	621,212	397,629	64
Western	2,672,309	1,684,544	63
United States	4,289,169	2,666,425	62

*Note - (000 Omitted)

Source: ICC Statement No. 1S2-72

The percentage of empty miles for motor truck carriers was referred to earlier. Ways for private carriers to reduce empty miles are discussed in the section on "Private Fleet Design and Management Control."

These are general ways for shippers to aid for-hire carriers in reducing empty miles. Consider these:

Short Term Actions

- . Try to route inbound and outbound shipments by the same carrier. By this method, carriers can avoid extra trips by picking up shipments when making deliveries.
- . The traffic department should review purchase orders and customer orders to select carriers whose routes are more fuel efficient and to develop fewer and larger shipments.

- . Assist carrier balance by working with them to load shipments where they can operate most efficiently. Forcing a carrier to take a shipment into an area where insufficient outbound traffic exists wastes fuel and results in poor service.
- . Gather shipments to the same general area and select a carrier for pick-up instead of calling in many carriers or one carrier several times. This will also allow you to use fewer carriers to do the same amount of work. The use of local draymen can help to achieve further benefits of this approach by allowing the draymen to distribute shipments to selected carriers' terminals.
- . Route shipments by more fuel-efficient carriers considering geographical obstacles such as grade levels, bridges, etc., which sometimes require greater motive power or limit the size of a load.
- . On interline shipments do not route connecting carriers, since the location of the connecting carrier's terminal may not be favorably located for the origin carrier, thereby slowing service and wasting fuel. This is especially important since many motor carriers are now participating in computerized cargo-interchange or substituted service systems to balance loads.
- . Load carriers' vehicles to minimize handling and loss of capacity. Sequential loading based on the carrier's routes and delivery points will save fuel and energy. If you have stop-offs in transit, load the shipments in the sequence of carrier deliveries.
- . In exchange for an allowance in freight charges, review the possibility of concentrating shipments with a few carriers, thereby allowing the carrier to pick up a large number of shipments at one time.
- . Don't force carriers to perform unnecessarily. This only wastes fuel and adds to costs which will show up in your freight bill somewhere along the way. The carriers will have to recoup their fuel costs through higher rates and surcharges.
- . Shippers should restrict the number of carriers serving their facility to the minimum required to provide a competitive and adequate level of service. Refrain from sharing a portion of your traffic with every carrier authorized to serve your location. By limiting your business to those carriers meeting your service goals, the value of your freight

takes on added significance to the carrier. The carrier's number of stops will be reduced; less time will be consumed in waiting at the dock to load and/or unload; and the carrier's average truckload volume will be improved.

Longer Term Actions

C. The above traffic operations are short-term, quick things shippers can do to save energy. Even more dramatic savings are in the offing if we are willing to make a commitment to changes in policy of long standing. Naturally, this will take time and involve a possible disruption of processes that have become solidly entrenched in our way of doing business.

- . Much of today's marketing philosophy is predicated on 'impulse buying.' As such, 'balloon packaging' provides shelf appeal without affecting the utility or equality of the product. We must ask ourselves if it is worth the price we are paying for space-consuming (and sometimes misleading) packaging of all kinds.
- . Considering customer services, untold amounts of energy could be saved if we would discard the notion that 'what is ordered today must be delivered tomorrow.' Relegating delivery time to a reasonable level would enable freight consolidation, reduce pick-ups and deliveries, and all-in-all make an important contribution to a more efficient use of energy.
- . Cooperation between company departments or divisions can have substantial energy impacts. Co-loading of shipments by nearby divisions can yield better use of carrier equipment. Review by purchasing and traffic can locate vendors which are well suited from an energy conservation standpoint.
- . Joint cooperation between sales and/or marketing and traffic can lead to a shipping program which will move goods to a customer on a timely basis yet not 1) require use of inefficient carriers; or 2) demand a service level which is inconsistent with the customer's real need.
- . Don't use inefficient shipping methods to make up for internal company problems that, if corrected, would make your operation more productive and eliminate the unnecessary use of fuel.
- . Keep shipping and receiving departments open the full business day and week to eliminate 'second calls.'
- . Encourage the use of night-time hours for the delivery of freight to heavily congested urban areas. Truck terminals are busy during night-time hours anyway, so why not deliver the freight as soon as it is sorted, thus lessening congestion on busy streets during day-light hours.

- Possibly relocate converting operations nearer key markets. Use railroad service for the long-haul, heavy-loading in-bound materials, and trucks to peddle the short-haul, urban delivery market.

D. In warehousing and shipping your products, conserve space and energy by using corrugated boxes designed to minimize wasted space inside the box. So often, we see on shipping platforms broken-down corrugated containers resulting from stacking boxes that contain empty space. Consider some shippers use a corrugated container measuring 12 inches wide by 12 inches long by 14 inches high, or 1.1667 cubic feet. However, the contents allow for two inches of empty space at the top. Some form of wadding may or may not have been used to fill the void. Nonetheless, the product could have been more efficiently packaged in a container measuring 12 inches by 12 inches by 12 inches, which equals 1 cubic foot.

Assume the package as prepared for shipment weighs 17 pounds. A truckload of the product is given to a carrier who supplies a 45-foot trailer. Assume this trailer contains 2,315 cubic feet of usable stowage space. Assume the distance from the shipper to the customer is 280 miles. Under present circumstances, the shipper is able to load 1,984 of the 12" x 12" x 14" containers which will provide a payload of 33,728 pounds. Conversely, the shipper could have loaded 2,315 of the 12" x 12" x 12" containers, which in turn would have weighed 39,355 pounds. Considering these two alternatives, we can anticipate the energy conservation indicated in Table III.

Table III

Container Size (inches)	Projected Payload (Tons)	Estimated MPG	Ton Miles Per Gallon
	[1]	[2]	[1x2]
12 x 12 x 14	16.864	5.0	84.32
12 x 12 x 12	19.678	5.0	98.39

As we can see, a 14.3% reduction in the size of the container extends to a 16.7% improvement in the energy-efficiency rating.

In addition, the shipper should enjoy over the long run a reduction in his transportation expense because the improved packaging will permit his shipping on six 45-foot trailers that which would have required seven 45-foot trailers of the less-dense package.

Besides the savings cited above, packaging to fit the contents can:

- Improve use of warehouse space
- Reduce the number of pieces to be handled in the distribution process (note in the above example, six of the redesigned containers did the work formerly required of seven)

- . Lessen damage in transit, thus largely eliminating the expense of returning and repairing damaged merchandise for eventual reshipment

There is a common thread running through this example of cost savings readily available to shippers. In every instance, the cause of energy conservation is being promoted, while at the same time, physical distribution costs are lowered.

This by no means exhausts the list of energy-conservation-related ideas that innovative shippers can do. These ideas do emphasize, however, that shippers can save a great deal of energy and, while doing so, reap the advantage of improved productivity.

LTL SHIPMENTS AND FREIGHT CONSOLIDATION

When vehicles are partially loaded or poorly utilized, when many vehicles from many carriers, common and private, operate in the same area, fuel is wasted. This is costly to all of us--shippers and receivers--in the form of higher shipping charges. Combining Less-Than-Truckload (LTL) shipments, generally defined as those under 10,000 pounds, offers a number of areas for energy conservation and cost reduction.

A. Freight Consolidation Opportunities

Freight consolidation basically involves collecting several small shipments into a larger shipment at an origin and then moving this larger shipment to a central point for breakdown and delivery (distribution). Cost reduction results from the savings made available by using different carrier operations and alternative rate structures. From origin to final destination, the combined volume and local delivery charges are lower than the charges on small LTL shipments.

This distribution process can also be reversed by combining several smaller inbound shipments at one area and forwarding them in condensed form to a receiver at a distant point (assembly). Figure 1 is an illustration of "assembly" operations.

Figure 1

CONSOLIDATION VIA WAREHOUSE - \$1.50/cwt

DIRECT TO CUSTOMER'S PLANT - \$2.00 to \$1.75/cwt

Figure 2 illustrates how "distribution" consolidation can be integrated with a TOFC operation. In relation to Figure 2, Exhibit 1 is an example of how charges can be compared. The net savings for this example in transportation charges is \$1,421.92 (\$3813.27 - \$2391.35).

Figure 2

Exhibit 1

Dollar Savings from Outbound Consolidation

Customer Location	Shipment Weight (lbs)	Direct LTL		Pool Truck Charges(\$)			
		Rate(\$)	Total Charges	TOFC*	Handling**	Local***	Total
Sacramento	3,750	1342	\$ 503.25	135.00	11.25	276.00	422.25
San Francisco	6,500	1229	798.85	234.00	19.50	231.40	484.90
San Jose	560	1728	96.78	20.16	1.68	40.65	62.49
Fresno	2,850	1342	382.47	102.60	8.55	188.96	300.11
Stockton	2,100	1342	281.82	75.60	6.30	150.57	232.47
Bakersfield	5,100	1229	626.79	183.60	15.30	129.03	327.93
Los Angeles	9,140	1229	1,123.31	329.04	27.42	204.74	56.12
Total	30,000		\$3,813.27	1,080.00	90.00	1,221.35	2,391.35

All shipments assumed to be Class 70 LTL

* TOFC charges prorated against each shipper's weight at \$3.60/cwt (\$1,080/30,000 lbs.)

** Handling at distributor assumed to be \$.30/cwt

*** Rates from distribution point to final delivery

An extension of this distribution approach for single shippers is the co-loading by shippers of shipments to similar destinations. This alternative allows two or more shippers the opportunity to capitalize under a common bill-of-lading, treating more efficient volume-load shipments.

Another more sophisticated way to consolidate LTL shipments is to use carrier stop-off, split delivery services. Suppose a firm has several LTL shipments, as illustrated in Figure 3, going from Newark, New Jersey to several towns in Florida. One order of 14,500 pounds is destined for Tampa. The other smaller LTL shipments are destined for various other points in Florida.

What can the firm do to take advantage of the larger LTL shipment? Exhibit 2 illustrates how charges for direct LTL versus consolidated transportation services can be calculated. The 14,500 pound shipment is loaded in the nose of the carrier's trailer and is the final destination or stop for the consolidated shipment. The other four shipments are dropped off at a local distribution carrier's terminal in Orlando. The line-haul carrier assesses a \$40.00 stop-off (S/O) charge for the four shipments dropped off. The rest of the charges are calculated similar to those in Exhibit 1. The net savings in transportation charges is \$174.04 (\$1725.80 - \$1551.76).

Figure 3

EXAMPLE OF STOP-OFF SAVINGS OPPORTUNITIES

S/O AT DISTRIBUTOR AT ORLANDO
FINAL DESTINATION TAMPA
DISTRIBUTION TO SANFORD, HOLLYWOOD,
MIAMI AND W. PALM BEACH

Exhibit 2
Dollar Savings from "Stop-Off" Consolidation

Location	Shipment Weight(lbs)	Direct LTL Charges(\$)	Pool Truck Charges(\$)				
			Line Haul	Stop-Off*	Local		Total
					Handling	Distr	
Tampa (final destination)	14,500	933.80	783.00				783.00
Miami (S/O)	1,248	117.94	67.39	6.13	3.12	56.41	133.05
Sanford (S/O)	1,320	110.22	71.28	6.48	3.30	27.72	108.78
Hollywood (S/O)	2,640	276.25	142.56	12.97	6.60	91.34	253.47
W. Palm Beach (S/O)	2,937	287.59	158.59	14.42	7.35	93.10	273.46
Total	22,645	1,725.80	1,222.82	40.00	20.37	268.57	1,551.76

*A \$40.00 stop-off at local distributor carrier was assessed

If air services or parcel delivery services are used, consolidation can offer real energy savings since it will allow greater efficiency in the use of aircraft or trucks. If many small parcel shipments are destined for delivery in a high-volume market area, meter the parcels via the local parcel shipment station in the market and ship volume loads into those remote stations. These programs have proven to generate major cost reductions and energy savings.

B. Possible Problems in Consolidation Programs

The above cases illustrate how consolidation programs can be conceptually developed. However, holding shipments to gather necessary volumes may create customer dissatisfaction, since shipments will be scheduled rather than shipped as ordered. More handlings in a pool distribution may create a damage problem. Claims may be harder to collect, since a number of different carriers may handle the same shipment. Possibly longer cycle times may require larger inventories. Cooperation of the various departments may be difficult to obtain. However, freight costs can be conservatively reduced 15-20% and deliveries can be much more consistent.

C. Setting up a LTL Consolidation Program

Before starting a major consolidation program, you should consider several steps.

1. First, analyze geographic zones for assembly and distribution opportunities. Various computer systems can give great assistance in analyzing shipment-consolidation opportunities. The computer can group orders and select the best combination of orders, as well as compute the allocated consolidation charges. If your business has a seasonal or cyclic nature, this factor must be considered in your planning. Initially, you should locate major areas of customer sales and vendor origins. If you have multiple vendors of the same product, conduct a "delivered cost" analysis to determine if you can work the most favorably located vendors into your program.
2. After you complete your study, the next step is to review the results with other affected departments to secure their cooperation and convince them of the important energy savings and cost reductions.
3. Now, what are the ways to assemble or distribute orders? You must consider these alternatives:
 - . You can use pool cars or trucks wherein a number of shipments are assembled for volume movement to a central location or assembled at a central location then forwarded to destination as a volume shipment using regular for-hire or private carriage.
 - . Consider specialized Assembly and Distribution (A&D) carriers. These carriers offer reduced rates for assembling shipments from nearby origins into volume shipments, and then forwarding them to common destinations. The same carriers can be used for outbound customer deliveries.
 - . Public and private warehousemen can be used for assembly or distribution services. They can receive consolidated shipments for break-bulk distribution or act as collection agents for assembly and forwarding. Some warehousemen offer to assemble pool shipments from their location to even more distant pool points offering their customers further cost reductions.
 - . Investigate the use of freight forwarders and bona fide shippers cooperatives or associations for the movement of shipments where you lack the volume to consolidate your own loads. Freight forwarders gather many shipments into volume lots for movement by energy-efficient methods.

Freight forwarders offer attractive rates for small shipments and some offer discounts for multiple shipments tendered at one time going to a similar geographic area. Shippers associations consolidate shipments from member companies into full volume movement to a common destination. Since bona fide associations are nonprofit, they offer substantial opportunities for savings.

- . Agricultural Cooperatives can offer service improvements and lower rates. Since their trucks often move back empty to the farm locations, the use of these carriers can avoid wasting fuel. Take care to select cooperatives that comply with the various laws and regulations.
- 4. Develop a chargeback system for allocating back to the consolidated shipments the appropriate transportation charges similar to the system illustrated in Exhibits 1 and 2.
- 5. You are now ready to implement the consolidation system. Even though consolidation programs can require much developmental time and analysis, they offer significant opportunities for savings.

PRIVATE FLEET DESIGN AND MANAGEMENT CONTROL

Many shippers now own or lease their own freight transport vehicles including the power units to move the freight. Significant reductions in fuel consumption have been realized by shippers and carriers in the design and use of transportation equipment over the past few years. This critical section is devoted to the identification of major fuel-saving approaches related to equipment design and use for primarily highway transportation. Consideration is also given to rail and waterway equipment.

A. Equipment Specifications and Sizing

1. Tractor/trailer combinations--Significant fuel savings of approximately 20-35% are possible through proper equipment design and operation. The basic ways to save fuel and reduce costs are to reduce the horsepower required to overcome resistance to truck movement and to use proper engine and tractor-trailer design. To diminish fuel consumption and costs, the vehicle operator must reduce the total power requirement. The power required to overcome resistance to truck movement is the sum of four basic parts: Rolling Resistance, Air Resistance, Grade Resistance, and Parasitic Losses.

ROLLING RESISTANCE--generated between the tires and the road. It is dependent on vehicle weight, road surface type and conditions, tire type and condition, and road speed.

- . One of the simplest methods of reducing rolling resistance without incurring any additional expense is to maintain the proper tire inflation. It has been proven by controlled tests that this factor alone can contribute a fuel improvement up to 5.8% (15). Another method of reducing rolling resistance without additional expense is to maintain proper alignment of the tractor driving axle and the trailer tandem axles. This also decreases tire wear.
- . Radial tires can contribute to fuel savings because of their construction and operating characteristics. Radials have more "sidewall flex" and always sit squarely and firmly on the road with less slippage, turning fewer revolutions per mile. Coast-down tests show that the rig will freewheel an average of about 31% more with radials than with conventional rubber. The reduced rolling resistance translates into a reduction in power required to maintain a given highway speed. Fuel savings range from about 3% to 11.6%, depending upon driver practices,

speed, mixture of radial and bias-ply tires, road surface, and gross weight. The percentage of loaded to empty miles is also a factor, since the percentage of gain in m.p.g. is greater at higher weights and at lower speeds.

AIR RESISTANCE--produced by truck movement through the air. It is dependent on wind conditions, truck frontal area and shape, road speed, and air density (determined by temperature and altitude).

- . Aerodynamic drag can account for as much as half the fuel used by a unit averaging 55 mph. A tremendous amount of drag-producing frontal area is presented by a Cab-Over-Engine (COE) tractor pulling a high, exterior-post van. We must, therefore, reduce the air resistance by streamlining the truck to achieve fuel savings.
- . One of the simplest methods is to size the equipment for the best load but the lowest profile. A reduction in the height of the trailer, for example, indicates:
 - 13-1/2 ft ht -- base height
 - 12-1/2 ft ht -- 1.7% fuel savings
 - 11-0 ft ht -- 4.6% fuel savings.
- . Wind tunnel tests at the University of Maryland indicate substantial reductions in drag between sharp-cornered trailers and other designs. For example, a few comparisons are:
 - 18" corner radius - 15% drag reduction
 - 18" roof radius - 9% drag reduction
 - Oval trailer front- 28% drag reduction.
- . The tests also indicate vertical exterior-post trailers increase drag 14% as compared to smooth-skin or horizontal-rib models.
- . Major causes of air resistance on COE tractor/trailer combinations are the abrupt difference in cab and trailer configurations and the gap or space between cab and trailer. Mounting aerodynamic "gap" devices on the cab or trailer can save significant fuel.
- . A simple method of achieving reasonable fuel savings right away--without investment--is to close the air gap between the tractor and trailer as much as possible. Operators of three-axle tractors with a sliding fifth wheel have reported a savings of as much as a half mile per gallon by sliding the trailer as far forward as axle weights and clearances permit.
- . With several of the changes noted we can easily achieve a saving of 5% to 6%. Various industry data and controlled tests indicate savings from 3.5% to 6.8%.

GRADE RESISTANCE--caused by lifting the truck against gravity. It is dependent on truck weight and the vertical distance it must be lifted.

- . The road surface affects grade resistance somewhat. For example, packed gravel or dirt would be 0.75% grade level as compared to smooth concrete, at 0%. The simplest way to achieve fuel economy in this power-loss factor is to route the equipment over the best possible roads provided other factors such as circuitry do not overrule.
- . The use of lighter-weight components should also be considered.

PARASITIC LOSSES--results from power losses through accessory operations such as the engine cooling fan, air conditioner, power steering, alternator, drive train.

- . Cooling fans eat up 15-30 hp even when cooling isn't required, which is about 95% of the time an engine is operating. Fan clutches and/or viscous fan drives partially or fully disengage the fan when not needed, generating average fuel savings of 5% to 8%.
- . Air conditioners consume about 7 hp and power steering another 3 hp. This should be considered when specing the equipment.
- . Synthetic oil and gear lubricants--Power consumed by internal friction of an engine varies greatly with lubricants used. Gear training inefficiencies also reduce the power delivered to the clutch by as much as 6% per gear box. Improved lubricants and fuel additives can reduce internal friction, which consumes extra fuel. Recent controlled tests indicate that synthetic oil and lubricants can contribute up to 3.1% improvement in mpg.
- . Fleets operating three-axle tractors with the driving power at both tandem axles should consider using tractors with only one powered axle and the other free wheeling (TAG axle). This can be accomplished by revising existing units or when acquiring new equipment. Savings are possible in fuel consumption through reduced drive-train power loss and reduction of weight; a side benefit is savings in maintenance costs.

By making the recommended modifications or additions to existing units (radial tires, aerodynamic devices, etc.)

we can promptly achieve fuel savings of 15-20%. The choice of the proper truck engine and gear train together with proper driver operation will deliver further substantial fuel savings. The greatest contribution is the new high-torque rise/lower rpm engine. This is an engine designed to operate at a lower speed range (1300 to 1900 rpm vs. 1500 to 2100 rpm) providing better torque through high-speed axle ratios. These new "economy" engines can be installed in existing vehicles where engine overhaul or replacement is considered so that savings can be generated immediately. Positive fuel savings ranging from 6 to 18% are possible depending upon operating conditions.

SUMMARY--By working toward reducing all of the factors resisting the movement of the vehicle and by using the new economy engines, we can achieve 20-30% reduction in fuel consumption; actual operating data indicates savings of up to 35.1%. Savings vary among fleets, reflecting the various types of operations, maintenance controls, and degree of driver proficiency. However, a brief summary of savings attainable based on approximate averages is indicated below:

Rolling Resistance	
radial tires, proper inflation, etc.	7.5%
Air Resistance	
aerodynamic devices, trailer design	4.3%
Grade Resistance	
weight reduction, etc.	.2%
Parasitic Losses	
temperature modulated fans,	
synthetic lubricants and additives,	
tag axles, etc.	8.0%
	<u>20.0%</u>
Sub-Total	
Economy engines	5.5%
	<u>25.5%</u>
Total fuel savings	25.5%

2. Straight Trucks- Equipment Specifications

- The basic reduction-of-power requirement factor discussed for tractor/trailer combinations should be reviewed for application. Aerodynamic devices, for example, may deliver even more dramatic savings. The reason is that, with the exception of a few specials, such as insulated freezers, all straight trucks are absolutely sharp cornered--the worst of all aerodynamic shapes.
- Carefully consider using a diesel instead of gasoline power. Much progress has been made in developing efficient mid-range and small diesels.

- . Consider using an automatic transmission for medium-duty trailers. Recent controlled tests indicate 4% better fuel economy and 5.2% better ton-mile productivity than for trucks with manual transmissions.

3. Sizing of Truck Equipment--These factors are important in sizing equipment:

- . the general operations: sleeper operation, tandems, etc.
- . the geographic area to be served, terrain conditions, general weather conditions
- . the maximum weights to be transported, the density of the product
- . the demands to be placed on the equipment and drivers - hours of service
- . possible regulatory changes over the next 5-10 years that might affect sizes and weights
- . possible modal shifts to TOFC, etc.
- . a larger trailer for the greatest payload if the axle weights permit. But remember, the smallest trailer to handle maximum loads is required to keep a low aerodynamic profile.
- . larger fuel tanks so as to extend the operating range from home base. However, the larger tanks take away payload capability, and the development of a good fuel-supply network, either through the equipment lessor (if leased equipment) or through a national fuel supply service, is the trade-off.

All these considerations, coupled with the need for fuel conservation, enter into the proper sizing of the equipment. What about the use of specialized truck equipment?

Specialized truck equipment--Cargoes should be carefully reviewed to determine if specialized equipment can develop better loading/unloading capability with resultant savings in energy, increased equipment utilization, and productivity. Equipment should not be so specialized that it can become inflexible or obsolete before its time.

- . Where small parts or packages are concerned, cargo baskets or containers with rollers can be used. These baskets can be used for order picking and then rolled on and off the trailer without delay.

- Trailers have been developed with hydraulically powered roller beds that raise up for loading/unloading. The cargo can rapidly be moved into place - one shipper reports a 9-minute unloading time for its products.
- Loading racks that snap into the sides of trailers so as to make a second tier can help utilize the cube without consuming a great deal of time.
- The use of a freezer container, packed with dry ice, can be helpful in releasing a reefer for short-haul applications.
- When specing tank trailers for various liquid commodities, consider using stainless steel instead of mild steel with a liner so as to make the unit more versatile over a broader range of products. The higher capital cost can be rapidly offset by the greater use of the trailer.

4. Rail Cars - Specifications and Sizing

Use of jumbo-sized cars to haul the greatest volume can generate lower freight costs and possibly better ton miles for fuel consumed. However, it is important to carefully review the area of operations to determine if the trackage, including bridges and trestles, can carry the load. Where hazardous materials are involved, it is important to consider whether a derailment could cause public reaction enough to ban the operation of jumbo cars, or cause them to operate at less than full capacity or on a slower operating train.

Smaller cars offer flexibility for many customers who cannot handle the larger equipment because of either storage capability or clearance problems.

Shippers should consider the use of specialized rail equipment to facilitate loading and unloading.

- Consider special-purpose box cars with efficient loading racks, compartment doors, or tie-down equipment to offset energy spent in loading the car and in keeping the loading area exposed to the elements for a long period of time.
- Where the shipment of liquid commodities is involved, seriously consider using the tank train system developed by a large leasing company. This was especially developed for efficient loading, transporting, and unloading of bulk liquids and consists of a string or strings of interconnected cars with each string being loaded or unloaded through a single connection.

Long-term projections as to the future reliability of particular traffic movements and carrier operations are important in deciding if specialized rail equipment should be acquired. Shippers should also consider a possible cost tradeoff in loading and unloading efficiency versus the extra empty car-miles that might be generated from the use of specialized equipment.

5. Barges - Specifications and Sizing

There are more problems in leasing or buying marine equipment than rail or truck equipment, which operates within strict size and weight limitations. Marine equipment, except for locking limitations on the canals and rivers and draft (water depth) limitations, operates in a broader environment. Certain stock barges for the inland waterways can be ordered, but they may not be the most efficient design for your purpose. This is due to the varying diversities of the commodities, unloading characteristics, temperature requirements, protection from the weather, and special linings to protect the integrity of the product. In following the suggestions below, secure expert advice in making decisions relative to barges.

- When acquiring new equipment, consider barges on which both ends are square. Normally, the standard hopper barge will have one rake-end and one box or square-end. However, the use of a box barge increases both the carrying capacity of the barge and the speed of the fleet in which the barge is towed.
- When designing new equipment, invest in tank testing to be certain that the equipment is hydrodynamically clean.
- When designing or specing deepwater barges, consider carefully an integrated system or stern notch deep enough to develop more efficient push-towing.
- If the barge contains skegs, carefully weigh the advantages of fixed versus adjustable. If fixed, use tank testing to develop optimum placement.
- Carefully consider unloading capabilities where liquid commodities are involved. Additional pumping capacity will enable the equipment to be turned around more promptly, which may be offset by the additional energy cost of diesel fuel or electricity. The question of whether to use diesel engines or electrical motors to power the pumps should be part of your total consideration.
- When designing or specing barges for liquid commodities, carefully consider double-skin construction. Double-skin barges have an inner and outer shell, reducing the possibility of a hull puncture that might result in a cargo spill.

Carefully study all applicable regulations relating to the product; what new regulations might develop for the future; the area of operations; the hazardous nature of the product; cost of insurance; down-time; public relations in the event of a spill.

- Generally, barge sizes are limited by the locks they must traverse when in a tow. Where integrated tows are possible, consider using box barges because of their increased cargo capacity and towing efficiency.

6. Towboats - Specifications and Sizing

- When designing new equipment, be sure it is hydrodynamically clean and will deliver the performance desired by investing in adequate tank testing.
- A "Kort nozzle" is essentially a steel ring of air-foil section encircling the propeller. When it is installed on towboats, both forward push and backing power are increased measurably, as is maneuverability. Propeller protection from damage is also an advantage. Seriously consider the installation of such equipment.
- Consider the use of slow-speed diesels as energy cogeneration units for propulsion and ancillary heating.
- Towboats must be sized to do the job, and here again it is management's decision after consideration of all the factors of market demand and power requirements.

7. Deepwater Vessels - Specifications and Sizing

- Vessel design is most important; good tank testing is essential to ensure performance.
- You should consider the use of slow-speed and/or medium-speed diesels from the standpoint of fuel consumption and economy. More importantly, the ability of these engines to burn lower-quality fuels will offer flexibility and lower-cost operations.
- Carefully consider the installation of bow thrusters to reduce the need for tug assistance when docking.
- Tank configuration and/or cargo hold design should be carefully engineered to carry various products for maximum loading possibilities. Use computer assistance for maximum loading per voyage.

- For many years it was assumed that bigness was the route to the best economy of operation; so the super tankers were born. With reference to the domestic coastwise and inter-coastal fleet, you should consider a careful study of operating costs, including fuel consumption, crewing costs, capital expenses, and areas of operation. Transfer costs and transshipping costs have greatly increased. A vessel's reaching farther upstream with lower diversion costs can develop better total economies for the shipper, particularly with smaller, lower-cost vessels using the newer slow-speed diesels and with less stringent draft requirements.

B. Equipment Maintenance Versus Energy Costs

Proper maintenance will reduce fuel requirements to generate the same power.

. Trucks and Tractor/Trailer Units

- Tire pressure should be monitored continually in the shop and on the road. This alone can contribute up to about 6% in fuel improvement.
 - Reducing air-cleaning restrictions by keeping it clean of dirt, water, and other contaminants which cause restrictions, fuel savings of approximately 1.3% are possible.
 - Monitoring the condition of the exhaust system to keep the back pressure at a minimum--you can save 2.4% of your fuel.
 - Check the fuel system for correct calibration; check the fuel pump adjustment for tampering. Valves and injectors should be clean and adjusted to specs to develop the proper output.
 - Develop a good preventive maintenance program with proper lubrication intervals to keep rolling resistance at a minimum.
 - Instead of completely overhauling an older engine, carefully consider replacement with a newer economy type or the possibility of derating an existing engine.
2. Rail equipment--The rolling gear should always be maintained properly from the standpoint of both safety and proper operation. If any cars are not equipped with roller bearings, for safety reasons do so as promptly as possible.

3. Barges - Towboats - Deepwater Vessels--Keeping the bottom free from marine growth is a simple way to save energy and money. The application of friction-free types of coatings may be beneficial in this regard. The additional drag placed on a marine vessel immediately translates into power loss due to the higher friction coefficient.

C. Management Practices - Use of Equipment

Transportation equipment is only cost efficient when moving and doing what it was designed for. The use of such equipment for storage (except, in certain cases, for special products) is costly.

1. Trucks and Tractor Trailer Units

- The easiest way to save fuel and costs is to support the 55 mph speed limit. The U. S. Department of Transportation has conducted extensive tests. Their August 1974 report indicated that if a vehicle increased its speed from 55 mph to 60 mph, the percentage increase in fuel consumption ranged from 6.3% to 10.0%; an increase from 50 mph to 65 mph indicated increases from 16.6% to 32.2%.

A Fuel Economy Speed Test was conducted subsequently at Columbus, Ohio, on October 29, 1977, under controlled conditions by an independent company. (21) The test results for a loaded tractor-trailer unit indicated 7.05 mpg at 55 mph and 5.33 mpg at 65 mph - a difference of 32.2% savings.

- Consider the use of additional trailers where it is possible to improve tractor use. This can be beneficial if the road unit can drop a trailer, hook up to another, and get back on the road without delay.
- The use of double- or triple-bottom units should be considered where permitted by law. It requires little additional fuel to carry substantially more tonnage.
- Review the use of Trailer-On-Flat-Car (TOFC) applications to reduce the use of tractor equipment. Rail carriers are attempting to improve their TOFC operations and truck operators should continually review this method of shipping. The "Santa Fe" Railway Company has developed a new energy-saving train concept for this service which consists of 10 cars of 10 articulated units each. Each car carries 10 trailers with a total train capacity of 100 trailers. Each car weighs about 35% less than the same size train of conventional flat cars, and the savings in weight amounts to about six tons per trailer handled. In addition to reduced weight, the loaded car has a lower profile than

standard flat cars and trailer cars, which reduces the air resistance of the train which presently operates between Chicago and the West Coast.

- Trucking operations exist between two or more points with return to a home base. In most cases, during the tour there is either an empty leg or the truck may only be partially filled. Generally, the outbound movement is called the headhaul and the return is the backhaul. The most efficient operation results when the truck is kept loaded all the time; in actual practice this is impossible. This difference is known as the empty-mile ratio. The ratio is specifically developed by comparing total empty vehicle miles to total loaded miles.

The more proficient shippers can become in keeping the empty-mile ratio down, the more fuel economy will improve and costs will be reduced.

- 1) An effective management policy must be developed to promote interdivisional trucking and a fair method of pro-rating costs. By looking for opportunities in other divisions and the possibility of backhauling purchased materials, the empty backhaul miles can be changed, improving the ton-mile earnings considerably.
- 2) This same principle applies to inter-corporate hauling, either gratuitously for the good of the corporation, or with proper allocation of charges when permitted by a possible revision of the existing regulations presently under consideration.
- 3) To reduce empty miles, another method, which is presently being contested in the courts, is to consider hauling products for other shippers or a subsidiary, as a backhaul, under authority that can be granted under the so-called "TOTO" Case [128 MCC 873] decision. A summary of the TOTO case decision follows:

"for-hire motor carrier operating authority can be granted to an applicant who intends to use it primarily as an incident to the carriage of its own goods and its own nontransportation business, provided (1) that the standard criteria for motor carrier applications, as the case may be, are met, and (2) that the applicant is agreeable to the imposition of conditions requiring it to conduct its for-hire motor carrier activities and its other activities independently and to maintain separate records for each."

Essentially this means that the applicant must prove that he is ready, willing and able to perform the service applied

for, will file tariffs indicating the charges, and will maintain records of this part of his operations separately from the total fleet. The recordkeeping is not as extensive as that required for large common carriers (Class I and II carriers).

Review all the pros and cons of using the TOTO approach to reducing empty miles before making application.

- 4) Another effective method of reducing the empty miles is to consider the hauling of exempt commodities. This has now developed into a professional business. It is important to develop a good broker relationship, since this is an unregulated business. The shipper should work out regular schedules that the broker can depend on. The equipment should be clean and must not contaminate any exempt products that might be destined for human consumption. Rates are negotiated between the shipper and the broker and vary according to supply and demand. However, if the shipper develops a steady operation with the broker, he will receive prime loads and the best price. It is important to check existing state laws, since several states do require exempt operating authority to pass through them. A good broker or state authorities will have this information. A checklist of exempt commodities may be secured from the Interstate Commerce Commission (Administrative Ruling 119) or the broker.
- 5) Dispatching and routing control is a basic means of reducing the empty miles. The shipper should be certain that the personnel responsible for this operation are actually trained in this area and that driver personnel are not, in effect, controlling the operation.

Investigate computer systems applications to routing control. Various systems and programs are now being offered by vendors to develop the best highway routing for fuel efficiency, speed, etc. Updated records on road conditions are maintained by the vendors as changes occur and new areas are opened to service.

Most important in the dispatching and routing control is the development of the most efficient fueling locations. It is senseless to send the driver miles out of route if the tractor could have been equipped with larger fuel tanks when speced. If leasing, use should be made of the lessor's fuel network; or the use of contract fuel services with nationwide coverage should be considered.

2. Private Rail Car Fleets

- Whether the private fleet is leased or owned, it is important that it be used efficiently. Data processing systems applications can be used to track cars and assist in allocating the fleet. Where fleet data is not promptly available, it is extremely difficult to allocate cars to plants to meet shipping requirements. In addition, cars can actually be lost at plants for extended periods of time or held in storage without the knowledge of the transportation department. The use of a shipper tracking system, possibly coupled with carrier message systems, will result in:
 - smaller fleet requirements
 - improved equipment turn-around time
 - better customer service
 - less down-time due to better maintenance control.

3. Barges and Towboats

- Consider the speed of towing operations. Often, it is better to operate a faster tow for prompter equipment turn-around. At other times, it is wiser to operate a slower tow (perhaps consuming less fuel) by throttling back the towboat. If delivery is not critical, and considering whether you are going upstream or downstream, then the slower operation might be more desirable.
- The development of more fully integrated tows conserves fuel and saves money. For example, using as our base a unit tow of 15 barges, 195' x 35', all double raked, using the same towing power we can develop savings from:

semi-integrated tow

5.0% more speed - 3.2% more cargo

fully-integrated tow

10.0% more speed - 4.0% more cargo

D. Driver Training and Motivation - Truck Equipment

The most efficient transportation equipment and dispatching control system will not generate its full potential unless the driver is trained in its use and is motivated to perform.

1. Shippers must implement an effective training program to demonstrate the proper use of the equipment and all its energy-saving equipment. Unless the driver understands when to shift by paying attention to the tachometer instead of "by the seat of his pants," the economy engine will not realize its full performance. The importance of proper tire

inflation, the use of the aerodynamic devices, etc., should all be explained carefully so that drivers are fully aware of the goal of energy conservation.

2. Drivers should be taught the "Progressive Shifts" technique, which will improve both fuel economy and engine life: When using the lower gears of first through fifth, the engine should not be accelerated to the full governed speed. The lower gears should be used to get the load moving; it is important to proceed to the next gear as quickly as possible. This saves a considerable number of engine revolutions, thus saving fuel.

"Skip Shifting" should also be used when vehicle loads are far below maximum. All gear ranges are not required. "Skipping" again cuts back on engine revolutions.

3. Management must effectively support training programs - lip service cannot be tolerated, or the total investment in energy-saving equipment will be a loss. To initially train drivers, consider short ten-minute discussions on individual fuel-saving approaches at weekly driver meetings.
4. Broad training programs should be presented on a regular basis; at least quarterly. The basic themes should be: proper operation of the equipment; safety and compliance with all DOT and other state regulations; and motivation to meet these goals and objectives.
5. Shippers must implement a motivational program for the drivers for achieving proper equipment operation and performance in accordance with management objectives.

These programs to improve fuel efficiency should have sanctions for non-performance and rewards for achievement discipline versus merit. Incentive programs can award points toward prizes that a driver's entire family can work toward, such as sports equipment and home items. Time off or bonuses can be offered for achievement.

A recognition program can award uniforms, patches, trophies, plaques, commendations, participation in rodeos, include awards banquets, etc.

Recognition can be given to the driver with the best fuel economy. This is difficult to post due to varying operations, load factors, and equipment design. Each shipper will have to determine whether this program can be developed for his fleet with any standard that might be appropriate.

6. Availability of Programs - Training programs for proper equipment operation are available upon request from most engine manufacturers. Equipment leasing companies offer training programs to assist in this area, as do driver leasing companies.

Various associations, such as American Trucking Associations, Washington, D. C., offer many programs. In addition, commercial organizations offer various motivational programs.

Most moderate-size companies have excellent management training programs administered by professional personnel. Safety directors and supervisors, generally available in the plant area, should be enlisted by the shipping supervisor to help develop a training program. Senior drivers can also be trained to work with the new driver.

In summary, goals of equipment-oriented programs should be: safety, improved fleet operations, and fuel conservation. The many companies that have established good training programs report these proven results:

Improved:

- tonnage hauled
- fuel economy
- driver earnings
- delivery reliability
- equipment turn-around

These improvements result in reduced:

- operations costs
- maintenance costs.

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MATERIALS MANAGEMENT FOR PRODUCT PACKAGING AND SHIPPING

MATERIALS MANAGEMENT FOR PRODUCT PACKAGING AND SHIPPING

In making packaging and shipment assembly decisions, the shipper is presented with a wide variety of packages and techniques for aggregating several packages into larger unitized loads. In satisfying packaging requirements, many astute shippers have focused on meeting customer appeal, safety and handling aspects, and storage efficiency. Shippers continue to meet these goals, but the relative importance of these components has been changing as packaging costs have been rising rapidly. "In the near future, significant energy or free-energy savings in this area can be achieved by changing packaging techniques in terms of the materials used and the disposal of discarded packages," (1, p. 34)

The following suggestions direct your attention to areas where packaging and load unitizing energy costs can be controlled by conservation techniques. Some of the techniques are readily applicable operational points while others will require longer-term analysis tailored to your activities.

The Payback from Basic Product Packaging and the Unitizing of Loads

The results of many of the following suggestions will be noticed in direct energy savings while other results will be reflected in material purchase costs or in your freight transport bill. Overall, the techniques that fit your operations will benefit the entire distribution-supply area and in turn your firm.

1. Packaging the Product--or, do you need packaging at all?
 - . If products are adequately coated, painted, or otherwise prepared to withstand the weather, consider simply banding them to skids or pallets and then shipping them.
 - . If your customers are intermediate users (converters or assemblers), eliminate extensive packaging, possibly by bulk-shipping items.
 - . For expensive items such as computers or precision instruments, consider household movers who require less packaging and crating.
2. Unitizing Loads--Consider energy conservation opportunities from the aggregation of individual pieces or packages into larger unit loads suitable for shipping.

- . Examine opportunities to revise the unit sizes and groupings of packages in order to get more items on a tray, pallet, or skid, thus saving materials.
- . In choosing the size of your pallet loads, discard the old 48x48 idea, which has restricted you from using higher, lower, wider, or narrower pallet loads to more efficiently use the space in your trailers, cars, and storage areas.
- . Fit various sizes of individual packages into bundles for consolidated unit shipping loads.
- . Compare the costs of banding or using adhesives to the higher costs of shrinkwrapping or stretchwrapping. Costs can be reduced with no loss in effectiveness.

3. Types and Specifications of Packaging

- . Packaging materials themselves require varying amounts of energy to produce. Wood-based products generally require the least amount of energy. In increasing order, wood-based materials, steel, plastics, and finally aluminum generally use the most energy⁽¹⁾. Keeping in mind this ranking and that materials vary widely in their weight-to-density relationships, consider the use of more energy-efficient primary packages.
- . Look at the possible use of less packaging by lightening specifications or reducing your box and board requirements. Particularly in air transport, weight of containers or packages is an important factor in cutting both energy and transport costs. A good example is the development of a new 90-pound baggage container to replace the old 300-pound structural LD-3 baggage container.

4. Product Form Conversion

- . Discuss with marketing, packaging and other company people possible changes in basic product packaging and consistency. Can product packages be changed to eliminate wasted space in shipping containers and improve density? For example, can long-necked, round bottles be changed to short-necked, square bottles? Can products be shipped in a concentrate state with water being added in by the consumer or at local distribution outlets? Can the breadth of the product lines be reduced to a smaller number of items? These changes can simplify and provide more uniformity in production, packaging, storage, handling and shipping.

5. Reduction of Balloon Packaging

- . Check the volume of airspace in your packages. Are your products capable of being shipped knocked down or nested? If so, have you analyzed the volume of airspace consumed when a product is shipped set up? If you can ship your product knocked down, analyze possible benefits with traffic and consult marketing to implement this method.

- . Consider alternative outer packaging materials or procedures in order to reduce the space needed for storage and shipping. This option was discussed in detail in the operational traffic management section.

6. Packing Materials

- . Use corrugated, folded, or shredded paper (perhaps from your own office) as dividers or cushions inside cases instead of petroleum-based styrofoam or foam padding.

Opportunities in the Post-Distribution of Products and Packaging Materials

Post-distribution involves those activities associated with the disposition of the product's basic package, the outer-packaging materials used in materials handling, storage and freight distribution, and other by-products or materials used in the distribution process. Packaging and container producers have been very active in developing new resources. Packaging manufacturers have found ways of combining alternative forms of materials, recycled and virgin sources, in their manufacturing activities. They have helped to develop new equipment to package at high speeds while reducing packaging waste and thus conserving scarce energy resources. The economy of energy resources must be a joint effort of shippers, packaging and container manufacturers, and conservationists.

The following areas of potential energy savings will be discussed:

- . Returnable bottles and containers
- . Reusable freight containers
- . Recyclables and product waste management
- . Repairables and recalled items.

For the related area of customer-returned goods, see the section on "The Deployment and Management of Inventories."

1. Returnable Bottles and Basic Product Containers

Returnable bottles for products offer major opportunities for saving energy in addition to their use for beverages. Using returnables, however, does present problems. To aid our discussion and your analysis of this area, a model of the flow of returnable containers is depicted on the next page.

Look into these opportunities:

- . Investigate the impact of returnable containers on energy usage at the various stages of a model similar to the one above. Comparing energy dollars and BTU consumption for a year will identify possible savings in using returnables as opposed to non-returnables.
 - . Consider using industry "standard" size and type containers. Are industry trade associations seriously considering returnable standard-size bottles and containers? Significant energy savings are possible if firms move toward standard-size returnable containers.
 - . Multiple-use metal or fiber drums can be reconditioned for additional outbound shipments instead of using one-way drums. Energy savings result from avoided new steel and fiber drum production costs which often exceed return processing costs.
2. Reusable Freight Containers--Can "shipping" containers be reused or are reusable shipping containers more energy efficient?
- . Corrugated boxes from inbound freight can be reused for customer outbound shipments. Consider turning boxes inside out and resealing them for outbound mixed-item shipments.
 - . For particular types of products collapsible containers have been developed that not only can be reused but can alleviate back-hauls that have low productivity. These containers can be filled, delivered, and emptied. Then for their return trip they can be collapsed, thus making room inside the transport vehicle for freight on the return haul. A firm can reuse containers four or five times by measures which tightly control their use. For example, reuse these containers for company inter-facility shipments.
 - . Can you use collapsible containers for the shipment of bulk commodities? Many firms are using collapsible rubber tubes for products normally requiring drums or tank trucks. This permits the use of the same vehicle for non-compatible products.
 - . Is freight being palletized, put on skids or slip sheets, or being transported in reusable unitized shipping baskets? Unitized loads can save energy in materials production and in materials handling, particularly for items that can be shipped in bulk or strapped.

3. Recyclables and Product Waste Management--What issues are involved in recycling packaging materials? The biggest barriers to recycling paper are the economic incentives favoring the use of forest products, the lack of facilities for collecting and repulping, and the problems of separating waste paper from other wastes. Until these problems are solved, we probably will have to look to other ways of saving energy from paper packaging. Yet opportunities exist for saving energy through the use of recyclables.
 - Can liquid wastes (such as lubricants and chemicals) be recycled through a treatment center with reconditioning equipment? Efficient methods exist for recycling oils and lubricants offering good savings. Four gallons of quality lubricating oil can often be made from five gallons of used oil. Depending upon the crude oil and refinery process, four gallons of lubricating oil, along with other derived products, can be obtained from four barrels of crude oil...It takes about twice as much energy to refine lubricating oil from virgin crude oil as it does to re-refine it from waste oil.
 - If possible, recycle your own firm's wastes from converting, assembling and shipping operations back into your raw materials or recycling conversion centers.
 - What waste materials such as wood, corrugated materials, lubricants, and oils can be used as heating supplements? Install auxiliary heaters on your petroleum or gas-fired heating plants. Efficient auxiliary units are available for waste disposition and heating.
 - Following the above model on returnables, look into the impact on energy usage from the complete disposal of end products. Is it as efficient as recycling basic product and packaging materials through a solid-waste-management center? The model framework, adding energy expenditures for solid-waste recycling activities, will help you decide whether to recycle product materials or to dispose of them altogether as wastes.
4. Repairables and Recalled Items--Repairables and recalled items can be very costly to your firm. What can you do to handle them efficiently?
 - Consider better packaging--not necessarily more--to prevent loss and damage and, thus, prevent returns and the need for repairs and reshipments. Product testing services of independent laboratories and many carriers can give you assistance in analyzing possibly excessive packaging or packaging that is not adequately protecting your products.

- . Consider the use of concentration centers, possibly through an agent such as a public warehouseman, for periodically transporting aggregated repairable or recalled items to minimize energy use. This activity ties in closely with the consolidation of inbound raw materials.
- . Consider "modularizing" repair parts in order to inventory fewer stock-keeping units (SKU's). The economic tradeoff is a higher per unit cost versus the costs of inventorying many more SKU's and higher labor costs for repairs.
- . Consider the energy impact of not repairing items, i.e., making new-product "allowances" for warranty or non-warranty items and disposing of the malfunctioning item at the consumer level. Transportation energy cost savings can substantially offset new product production costs.

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DEPLOYMENT AND MANAGEMENT OF INVENTORIES

THE DEPLOYMENT AND MANAGEMENT OF INVENTORIES

U. S. Department of Commerce figures indicate that the level of U. S. inventories has increased dramatically--50 percent in the last five years. The proliferation of inventories, demanded primarily by our standard of living, consumes a great amount of energy. Proper management of inventories offers a good opportunity to conserve energy. However, little hard, quantitative data is available on energy savings from better inventory-management techniques. We suggest looking into the following eight areas for potential energy savings.

1. Policies Considering the Source of Inventories--Decide carefully which vendors should be selected for supplying materials. How should inbound supplies be shipped?
 - . Analyze vendor and plant sources as to the impact of transportation costs on delivered product prices. Using vendor pricing terms of sale, determine the delivered product price if freight charges are extra. F.O.B. origin, freight collect terms of sale offer the customer the best control in routing and controlling freight costs. If buyers will specify these terms, significant opportunities for saving energy will result.
 - . Check into the possible consolidation of inbound materials from multiple vendors for possible savings. Will consolidation impact lead times? You can achieve significant reductions in freight costs and inventory levels plus achieve more reliable service times through consolidation programs. (This area is addressed in detail in the Transportation Management section.)
 - . Develop Scheduled Delivery Systems (SDS) for the delivery of products to remote warehouses and/or customers. Planned inventory schedules and levels can lead to inventory reductions for suppliers and customers. Safety stocks due to uncertainty can be reduced. By developing distributions of order sizes for accounts and geographic market areas, your firm can determine how many orders of given sizes went to various accounts into various geographic areas. Your firm can use this analysis as the basis for a great marketing tool. When customers realize the reductions in inventories that can be realized by regularly scheduled delivery into their areas, sales potential can increase substantially.

2. Determining Vendor Requisition Order Sizes--Calculate how much should be ordered from vendors when you consider volume discounts available from vendors and considering transportation pricing weight-breaks available from carriers.
 - . Your purchasing agent should consider transportation pricing weight-breaks in setting shipment sizes. These price breaks offer your firm the opportunity to ship more at no increase in transportation costs. For example, assume that these two transportation pricing weight-breaks apply:

500-1,000 pounds	\$2.00/hundredweight (cwt)
1,001-2,000 pounds	\$1.50/cwt.

 Suppose that we have an 800-pound shipment. Using the first weight-break, the charge would be \$16.00 (8 cwts x \$2.00/cwt). However, transportation pricing rules state that the shipper does not have to pay more than the minimum costs for the next weight-break. Thus, the true charge is \$15.00 (10 cwts x \$1.50/cwt). An important point is that a firm can ship another 200 lbs. with no increase in transportation costs. By taking advantage of weight-break differences, you can reduce transportation costs by "free" larger shipments and possibly fewer shipments. What must be analyzed is the possibly negative effect on inventory investment resulting from fewer, larger shipments.
 - . In establishing order sizes consider the impact of shipment size on carrier service times. Taking into account the effect of fewer, larger shipments, you can realize possibly more reliable, shorter service times.
 - . Check for excessive expedited ordering and backordering of materials. Analysis of backorders and expedited rush orders may reveal that order sizes are out of date given today's sales patterns. How often do you reset order sizes? Are you ordering more frequently but ordering less?
 - . Consider the effect of transportation costs in setting Economic Order Quantities. In many of our inventory-stock control systems, only "ordering or set-up" costs and inventory costs are considered in calculating traditional Economic Order Quantities. Transportation costs must be included as a direct element in order-size determination. The costs of carrying inventories should equal the minimum of these cost elements:

- a. Set-up ordering cost is determined by multiplying the number of set-ups or orders by the cost per set-up or order;
 - b. Inventory holding cost results from multiplying average inventory investment per year by the inventory carrying charge (of, say, 15-40%);
 - c. Transportation cost is derived by multiplying the tons of freight shipped by transportation costs/ton.
- . Consolidate inbound purchase orders, interplant transfers, and customer orders across divisions. Too often divisions or departments individually place orders to the same source of supply without consolidating multidivisional requests into more efficient order and shipment sizes.
3. Determining Reorder Points and Safety Stocks--It is difficult to determine when to reorder and how much safety stocks a firm needs in order to guard against uncertainties involved in satisfying demand and in replenishing stocks. With tighter controls on inventories, however, you can realize substantial reductions in inventory levels and related energy costs for the supply and maintenance of inventories.
- . Adjust reorder points and levels of safety stocks to reflect seasonality and current levels of sales volume. Often these items are not changed when new conditions would dictate.
 - . Adjust average lead times to reflect new operating conditions. Reorder lead times are crucial in an inventory management system. Firms will change vendors, ordering procedures, or methods of transportation having significant effect on lead times, and yet related system reorder points and safety stocks are not adjusted.
 - . Test alternative forecasting systems as to their effectiveness in reducing inventory costs.
 - . Implement adaptive, flexible forecasting systems that reflect current operating conditions. In controlling inventories, how your firm detects and reacts to changes in sales volume is often more important than the forecasting system itself. Monitoring budgeted and actual levels of sales (preferably on the front-end at the "consumer-user" level) can allow you to quickly adjust inventory levels.
 - . Look for an increase or reduction in the number of customer order stockouts. Stockouts can be costly in both individual lost orders and in the loss of entire customers.

If stockouts become excessive, then inventory management adjustments must be made. With energy shortages, reduced service levels may become more common. Reductions in inventory levels and longer waiting times may become acceptable. Watch competitive actions in this area.

- . Assess your firm's experience with product obsolescence. Is it a high or increasing percentage of inventory value? Many firms trim slow-moving items of inventory only in an emergency. Periodic checks of the sales movement of stock items is a means of weeding out slow movers that can be very costly to maintain. Significant energy savings may be attained by reducing the number of inventory items if customers and marketing will allow it.
- 4. Full versus Partial-Line Inventory Locations--Try to place fast-moving critical inventories forward in the distribution system at perhaps many locations and retain slower-moving items only at central or regional inventory sites.
 - . Conduct an ABC analysis to study possible economic benefits of partial-line warehouses--warehouses that contain only a part of a firm's total line of products. An ABC segmentation of inventories on the basis of sales dollars or units into fast (A), medium (B), and slow (C) moving items can reveal opportunities for the split deployment of inventories. Faster, possibly more costly transportation methods can be used to get the slower movers to market. The tradeoff is the lower inventory holding costs resulting from an overall smaller inventory investment.
 - . Do partial-line inventory locations result in net benefits to your customers? Total transportation-energy costs may be lower but costs from split orders-sales processing systems are higher. Split orders can be more difficult to control and customers may not appreciate them.
 - . Consider the reduced impact of inventory obsolescence in the use of partial-line warehouses. In using partial-line warehouses, less inventories are deployed throughout the total distribution system. The risk associated with obsolete inventory can thus be minimized, saving materials and energy.
 - . Determine which shipments are to be drop-shipped direct to remote locations or which shipments should be centrally received, consolidated, and sent to remote locations. In the case of inbound movement of materials from vendors to a customer's warehouses, or plants, a shipment-size distribution analysis on drop shipments and centrally received shipments may indicate that too many small shipments

are being sent direct to warehouses or that centrally received shipments could now be shipped directly to remote warehouses. Too many small drop-shipments waste energy.

5. Trans-shipments of Inventories--The trans-shipment or redeployment of inventories to satisfy changing local market demands can be costly. Keep a close watch on how much shifting of inventories is taking place.
 - . Determine the level of trans-shipped inventories needed to satisfy market demands. How many shipments of inventories result from the need to relocate inventories? Have premium, expedited transportation costs for trans-shipments been rapidly increasing? Are you aware of changes in marketing programs or market conditions? As traffic manager, are you part of the business team that allows you to know best estimates of company sales--in terms of commodity and geography? Knowing these best estimates will enable you to minimize trans-shipments and to deploy original inventories to areas where marketing sees sales materializing.
 - . Are customers willing to tolerate longer waiting times for inventories that are not trans-shipped? This question relates to earlier discussions about how reductions in customer service levels may be necessary in order to achieve energy efficiencies. Conduct a customer service audit to determine current customer needs and competitive service levels. In the present energy situation, an audit is a must.
6. Customer Backorder Policies--Policies considering if and how your firm processes backorders for stocked-out inventories can substantially affect energy use. Extra paperwork plus premium small-shipment transportation make many backorder procedures costly. Can customers do with a little less service in this area?
 - . Have your costs for handling backorder costs been escalating? When considering backorders, monitor information systems costs for retaining backorders, possible costs for maintaining broken pallet or case stocks, additional order-processing costs, extra transportation costs, and the costs of lost sales. These are all part of the total cost of backorders. If these costs are rising under current backorder and inventory management policies, a quick review of key item and account information may aid in remedying the situation.

- See if vendors and your firm can substitute items in shipments to take advantage of transportation pricing weight breaks and deficit weight opportunities. By keeping track of item sales by account and with the approval of customers, vendors can substitute in-stock for out-of-stock items to take advantage of weight breaks, thereby cutting the costs per shipment and total costs by reducing the number of orders.
 - Look into the energy impact of alternative backorder policies. Have you considered that: no backorders will be honored; holding backorders for the next regular orders instead of expedited small shipments for backordered items; time constraints on how long backorders will be held until vendor cancellation of orders. Educate the customer on how reduced line-item fill rates and revised backorder policies can be set to minimize energy usage.
- 7. Returned Goods Policies--The return of resaleable goods is a source of much concern and cost to management. Returned goods require management control that often goes beyond benefits to the customer. Because of marketing and product-warranty factors, returned goods will always be with us. The problem is to process them efficiently.
 - Consider all the costs associated with handling returned goods and putting them back into stock. Don't overlook costs for: repackaging to transport items back; reversing transportation (often including misdescriptions on carrier bills of lading); checking item condition before it is put back into stock; lot-control procedures to get items back into stock under the correct lot-control numbers; stock selection procedures to make sure these items go out first; and costs for lost customer goodwill if a returnable item is not accepted or if a previously returned item is unsatisfactory to the next customer.
 - It may be cheaper to handle a returned good remotely instead of bringing it back to a plant or home office. Some firms bring all returned goods back to plant locations or the home office before putting them back into inventory. The closer to the customer you can handle these goods, the less your energy costs.
 - Analyze consigned-guaranteed sales policies as to the energy impact of returned goods. A consigned-goods policy can be very costly to your firm. Yet industry trade practices often dictate that such a policy be offered to customers. Can trade practices be modified?

- Consider geographic aggregation points (your own or public warehouses) for returns. Small shipments of returned goods over long distances can be very costly. Can you develop an agent relationship for periodically aggregating returned goods for a consolidated shipment to a plant or home office? This is an area of potentially high energy savings.

8. Speculation versus Postponement in Stock Keeping Unit (SKU) Development--Can you maintain larger quantities of goods in bulk and still, in a timely fashion, serve ultimate customer needs for smaller quantities? If you can, distribution energy costs can be greatly reduced.

- Determine the amount of possible postponed production to individual customer needs versus the creation of individual stock-keeping-units (SKU's) for "speculative" inventories. An item analysis of inventories will indicate the amount of possible postponement.
- Consider the costs for "remote packaging" of SKU's in light of customer needs for items that could be shipped down the distribution channel in large quantities. Remote "consumer" packaging costs will increase but transportation and handling costs will decrease in moving the parent "bulk" product to market.
- Consider inventory ordering practices and alternative transportation services to determine order sizes and to take advantage of "in-transit" inventories. The use of longer-service-time transportation modes, combined with the correct F.O.B. delivered terms, can enable your firm to postpone the financial payment and costs associated with holding inventories. Such postponement enables you to better manage your cash flow and cut your facility inventory carrying capacity needs.

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Energy Management Plan

The first step in developing this plan is to do an energy survey, which will show you how much of each kind of energy your business uses during a given month. The survey is similar to your double-entry accounting system in that one series of entries consists of the amounts of energy purchased during the month, and a second series lists the uses of this energy. It may be necessary to estimate some sources or uses of energy, since the two series must balance.

This plan takes a little time. But it will pay you back in terms of knowing just where your energy dollars are going and in knowing which problem areas you should zero in on.

General Energy Survey

Follow the "step-by-step" procedure for the general energy survey by referring to your monthly fuel and utility bills. Use all of your bills from at least the last twelve months and summarize the monthly use and cost of energy by month for the year. The amount and the cost of each type of energy must be entered separately. Figure 1 is a sample format.

Figure 1

GENERAL ENERGY SURVEY WORKSHEET

(Use Supplementary Worksheet for your records)

Month _____

<u>Energy Type</u>	<u>Amount</u>	<u>Unit Price</u>	<u>Cost</u>	<u>BTU's</u> (see Fig. 2)
1. Electricity (KWh)				
2. Natural Gas (Mcf or Kcf)				
3. Fuel Oil (Gal.)				
4. Gasoline (Gal.)				
5. Propane, (Gal.)				
6. Coal (Ton)				
7. Diesel (Gal.)				
8.				
9.				
10.				
Total			\$ _____	_____ BTU's

Note: Your electric bill indicates a demand charge (measured in KW) in addition to a charge for actual energy use. You should record these charges separately. Demand charges, which range from \$5 to \$9 per KW, represent the utility company's effort to defray the cost of facilities needed to meet peak demand levels but unused during normal demand periods. Though you may not save energy as such, you can save dollars by cutting your demand charge through load management.

After listing the amount of energy used, unit price, and cost, you must convert each type of energy used to the common BTU unit, using Figure 2. This conversion will allow you to tabulate the total energy used, to compute the energy used for each dollar of sales, and to evaluate on a monthly basis your energy conservation plan. The General Energy Survey shows you how much energy you are using and how usage varies with the time of year and with sales volume.

Figure 2

ENERGY CONVERSION TABLE

By Type

<u>Type</u>	<u>Unit</u>	<u>BTU's per unit</u>
1. Diesel	Gal.	138,700
2. Natural Gas	Mcf or Kcf (ccf=100,00 Btu or 1 Therm)	1,000,000
3. Fuel Oil (#2)	Gal.	140,000
4. Gasoline	Gal.	125,000
5. Propane	Gal.	91,700
6. Coal (Bituminous)	Ton	25,400,000
7. Electricity	KWh	3,412
8. Kerosene	Gal.	135,000

Your General Energy Survey will answer the following important questions when conducted over time. What is your total energy cost? Is the cost increasing? Is energy consumption an important fraction of total operating cost? Are energy costs apt to become more significant?

Moreover, the survey will provide you with the basis for determining whether your future energy conservation efforts are actually reducing the amount of energy used for each dollar of sales or by any other meaningful measure. Having a standard BTU measurement is especially crucial during these inflationary times: you may find yourself paying the same or more for energy in the future; but if your BTU total drops, you know you're saving energy.

Comprehensive Energy Survey

The comprehensive energy survey is designed to show you specifically how you are using your energy. Using Figure 3, compute your survey, considering one energy user at a time to discover how the month's supply was used. Now you can evaluate your energy use: Is each use essential? Can specific uses be reduced? This is the next step to saving energy dollars.

Figure 3

COMPREHENSIVE ENERGY SURVEY WORKSHEET

(Use Supplementary Worksheet for your records)

Month _____

<u>Usage</u>	<u>Watts, etc.</u>	<u>Hours</u>	<u>Units</u>	<u>BTU's</u>
1. Exterior Lighting				
2. Interior Lighting				
3. Space Heating				
4. Air-Conditioning				
5. Ventilation				
6. Delivery				
7. Refrigeration				
8.				
9.				
10.				

Total BTU's _____

How to Figure Electrical Use

First, estimate the amount of electricity used for exterior and interior lighting: 1) Count the number of light bulbs and fluorescent tubes, recording their ratings in watts (add 20% for fluorescent tubes). 2) Multiply by the number of hours used each month. This provides you with watt hours used each month. 3) Now divide by 1,000 to get KWh.

Example: If you have 100 75-watt fluorescent tubes which are used 260 hours a month, the following computation would be made:

$$\frac{100 \times 75 \times 1.20 \times 260}{1,000} = 2,340 \text{ KWh per month}$$

It is extremely difficult to accurately determine electric motor consumption. However, a reasonable estimate can be made from the information on the motor name plate and by determining the hours

of use. For example, if you use a motor 260 hours each month, and it is rated at 115 volts and a full load current of 5.5 amperes, the following computation is made:

$$115V \times 5.5A = 632.5 \text{ watts for each hour of operation.}$$

However, motors seldom operate at full load and an average must be estimated (70% of full load is a typical average and is generally safe to use). With an estimated actual load of 70% and with 260 hours of use, the following computation would be made:

$$\frac{632.5 \text{ watts} \times .70 \times 260}{1,000} = 115 \text{ KWh}$$

If you have a motor which is labeled "3 phase," the calculation of watts is voltage times amperes times 1.732. For example, a 220-volt, "3 phase" motor rated at a full load current of 2.2 amperes will use $220 \times 2.2 \times 1.732$, which equals 838 watts at full load. If the motor has an estimated monthly use of 260 hours with a load of 70%, the following computation would be made:

$$\frac{838 \text{ watts} \times .70 \times 260}{1,000} = 152.5 \text{ KWh}$$

It is often difficult to estimate the hours of actual operation of an electric motor, particularly when it is controlled with a thermostat (such as the compressor motor of an air-conditioner, or the fan on a heating unit). If you want to determine the exact hours of use for the motor, have an electrician connect a simple electric clock across the motor terminals.

Electric heating elements are rated in watts and no correction factor is involved. The KWh usage is the wattage times the hours of operation each month, divided by 1,000.

The total BTU's of the Comprehensive Energy Survey should be approximately equal (within 10%) to the BTU's used according to your actual energy bills. If it is not, you may have missed some sources of energy use, or you may not have estimated the time of operation correctly. If you have trouble estimating your energy use, a representative from your local utility can probably help you find the discrepancy.

The survey procedure for oil and gas is the simple process of measuring the fuel used. If the fuel being surveyed has only one use, such as a space heating furnace, you simply record actual consumption. However, if the fuel is used for a number of purposes, it may be necessary to install flow meters which measure gallons or cubic feet of gas to obtain accurate estimates of consumption.

After the Comprehensive Energy Survey has been completed, you should be sure that the quantity of energy used equals the amount of energy received. If the survey balances, identify the areas of significant energy use and also look for consumption variations.

Walking Survey

Next, make a walking survey of your building. Notice the use of lights, heating/cooling and ventilating equipment, and anything else that uses energy in your building. Force yourself to think of what type of energy (electricity, etc.) each piece of equipment used, approximately how long it works every day, and how it relates to your business objectives. Look for waste! For each energy user ask yourself, "Do I need this?" "Can the same results be achieved more efficiently?"

In the course of this walking tour, write down any maintenance problems you find on the way, scheduling and other ideas you get, and the questions you want to check out later. Be critical. It may pay!

Next, inspect your building. Look for cracks around windows and doors. Try to find out the amount of insulation you have in the walls and the attic. Check to see if your windows are single, double, or triple glazed.

Your walking tour may be more effective if you take along your maintenance persons and others who will be involved in your energy program.

Armed with the information from the three surveys (General Energy Survey, Comprehensive Energy Survey, and Walking Survey), you are now ready to consider the specific energy conservation measures.

First Steps

When you consider the tips in this guide, particularly the Warehousing and Distribution Management section, in light of the foregoing management plan, you will no doubt discover areas that will require an investment to save money.

But before you spend any time or money on energy retrofitting, be sure to do those basic steps that cost nothing and provide some of the greatest potential returns. Develop good "thinking habits": Be sure your buildings, machines, and vehicles are maintained properly. Caulking and weatherstripping, vehicle tune-ups, and correct operation and maintenance of equipment are essential first steps.

Next, have your line personnel regularly consider the suggestions in operations improvements included in each unit of this guide.

For the more expensive steps, a simple formula will show you the payback period for any energy investment, so that you can decide if the expense is a wise investment for your firm. Don't forget that with inflation and rising prices, the life-cycle cost of operating a given item becomes far more important than purchase price alone.

Cost-Benefit Analysis

Divide the cost of the step being considered (purchase price plus installation) by the estimated yearly savings to be derived. The result is the payback (in years) for the step you're considering. That formula is:

$$\frac{\text{COST (purchase price plus installation)}}{\text{ESTIMATED YEARLY SAVING}} = \text{PAYBACK (in years)}$$

Any payback of less than two years is always an excellent investment. And you are the best judge of the value of steps requiring a longer payback.

You may be surprised to learn that many expensive energy-saving steps will not be cost-effective for you. For example, after a given amount of insulation has been installed in a warehouse, you reach a point of diminishing returns if you add more. The cost-benefit analysis will help you make this decision for your firm.

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