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Process Energy Optimization Level-I Review

Tobyhanna Army Depot, PA

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Construction Engineering
Research Laboratory

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Final Report

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ABSTRACT: Tobyhanna Army Depot is a large communications-electronics fabrication/overhaul facility located in Monroe County, PA. A review of the installation's records indicated that over half of the Depot's total annual cost of energy is used for the purchase of electricity, although electricity accounts for only 31 percent of the total energy consumption. This fact indicates that there may be opportunities for energy or process efficiencies at the installation, either by reducing the dependence on the relatively more costly fuel (e.g., by using alternative fuels), or by changing work processes to reduce overall energy consumption. In this work, the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) performed a Level-I energy audit at Tobyhanna Army Depot to identify opportunities for process energy efficiency improvements and reductions in pollutant emissions.

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Conversion Factors

Non-SI[*] units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic feet	0.02831685	cubic meters
cubic inches	0.00001638706	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(5/9) x (°F – 32)	degrees Celsius
degrees Fahrenheit	(5/9) x (°F – 32) + 273.15.	kelvins
feet	0.3048	meters
gallons (U.S. liquid)	0.003785412	cubic meters
horsepower (550 ft-lb force per second)	745.6999	watts
inches	0.0254	meters
kips per square foot	47.88026	kilopascals
kips per square inch	6.894757	megapascals
miles (U.S. statute)	1.609347	kilometers
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.006894757	megapascals
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square meters
square miles	2,589,998	square meters
tons (force)	8,896.443	newtons
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

[*] *Système International d'Unités* ("International System of Measurement"), commonly known as the "metric system."

Preface

This study was conducted for Headquarters, U.S. Army Corps of Engineers (HQUSACE) under Project 4A262784AT45, "Energy Technologies Applied to Military Facilities"; Work Unit CFE-X302, "Industrial Energy Assessment." The technical monitor was James Brandle, TYAD-DPW.

The work was performed by the Energy Branch (CF-E) of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL principal investigator was John L. Vavrin. Dr. Tom Hartranft is Chief, CEERD-CF-E, and Mr. L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Gary W. Schanche, CEERD-CV-T. The technical editor was William J. Wolfe, Information Technology Laboratory. The Director of CERL is Dr. Alan W. Moore.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL John Morris III, EN and the Director of ERDC is Dr. James R. Houston.

1 Introduction

Background

Tobyhanna Army Depot (TYAD) is a government-owned and operated facility located in Coolbaugh Township, Monroe County, PA. The Depot occupies approximately 1300 acres, including the 400-acre industrial area. Tobyhanna Depot is the largest communications-electronics fabrication/overhaul facility in the Department of Defense (DOD). TYAD's workforce of 3160 civilian and 21 military personnel makes the Depot the area's largest employer. More than 200 job skills are required to support the depot's main mission of fabrication and repair of all types of communications and electronic systems, including voice, data, wire, and satellite communications; electronic countermeasure; night vision; and photo and power systems.

Tenant activities located at the depot include the Defense Distribution Depot–Tobyhanna; the U.S. Army Materiel Command Logistics Support Activity Packaging, the Storage, and Containerization Center; the U.S. Army Medical Materiel Agency – Medical Maintenance Operations Division – Pennsylvania; the Joint Visual Information Services Distribution Activity; the U.S. Army District TMDE Support Center – Tobyhanna; the Army-Air Force Exchange Service – Tobyhanna; Defense Commissary Agency – Tobyhanna; the Defense Reutilization and Marketing Office (DRMO) – Tobyhanna; the U.S. Fish and Wildlife Service, the Eastern Pennsylvania Field Office; the U.S. Army Corps of Engineers – Baltimore District – Northeastern Resident Office.

Over half of the energy costs are used for the purchase of electricity and the rest for the purchase of other fuels, e.g., oil, gas, etc. (Coal has not been used at the site since Fiscal Year 2001.) Note that the cost of electricity is over 50 percent of the total energy cost, but only 31 percent of the total energy consumption. This fact indicates that there may be opportunities for energy or process efficiencies at the installation, either by reducing the dependence on the relatively more costly fuel (e.g., by using alternative fuels), or by changing work processes to reduce overall energy consumption. Tobyhanna requested the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) to perform a Level-I energy audit at Tobyhanna Army Depot to identify opportunities for process energy efficiency improvements and reductions in pollutant emissions.

Objectives

The overall objectives of this work is to maintain the readiness of DOD industrial installations by lowering operating costs—by optimizing process and energy efficiencies. Specific objectives of this project were to identify opportunities for process energy efficiency improvements and reductions of pollutant emissions at Tobyhanna Army Depot, PA, using the process energy and pollution reduction (PEPR) tool and the process optimization guide (both developed by CERL).

Approach

This work involved the following steps:

1. An installation willing to participate in the process was identified and selected.
2. Site personnel were trained to use the PEPR analysis tool (along with other software tools).
3. A Level-I energy optimization audit was conducted (with an outside agency and an ESPC contractor)
4. Findings were gathered and analyzed, and recommendations were formulated.
5. Plans were made to monitor the implementation of the Level I recommendations.

Mode of Technology Transfer

The information derived from this work will be submitted to the subject installation. It is anticipated that the results of this work will contribute to further training of Corps, District, and Army installation personnel, via implementation through ACSIM. It is also planned to disseminate this information through workshops presentations and professional meetings.

This report will be made accessible through the World Wide Web (WWW) at URL:

http://www.cecer.army.mil

2 The Process Energy and Cost Optimization Initiative

Site Overview

Tobyhanna Army Depot is located in the town of Tobyhanna, PA, which is 1990 ft above the sea level at a latitude of 41° 11” and a longitude of 75° 25”. The site has an average 434 cooling degree-days and 6816 heating degree-days. The summer design temperature is 84 °F; the winter design temperature is 2 °F. The mean daily temperature range is about 20 °F. The incident solar radiation is at the level of 1086 Btu/sq ft/day and the ground temperature of about 49 °F. There are about 244 heating season days, but only 17 cooling season days per year. The depot is located in an area where the wind power class is 1.0.

The Depot’s 1985 baseline building area is 3,899,000 sq ft and the baseline energy consumption is 547,277 MBtu. The depot also has about 460 exterior lights (data taken from CERL’s *Renewables and Energy Efficiency Planning* [REEP Program] data base), which were assumed to be on 12 hr/day. The current breakdown of building area (Table 1) reflects an increase of about 15 percent from the 1985 baseline building area.

Table 1. Current breakdown of TYAD building area.

Area Description	Area (sq ft)
Training	46,000
Maintenance and production	1,590,000
Research, development, and testing	27,000
Storage	2,257,000
Hospital and medical	9,000
Administration	260,000
Barracks	50,000
Common facilities	135,000
Family housing	81,000
Other	45,000
Total	***4,500,000***

Similarly, the latest annual energy consumption is about 564,528 MBtu, which comprises of 51,358 MWh of electricity and about 389,243 MBtu of energy from oil, gas, etc. This represents an increase of about 3.1 percent from the 1985 baseline energy consumption. However, it should be noted that the current total building area is 15 percent greater than the 1985 baseline building area.

It is worthwhile to note that, while electricity cost is over 50 percent of the total energy cost, it represents only 31 percent of the total energy consumption. Presently there is no on-site generation of electricity and the peak demand for electricity is about 9500 kW.

The Depot maintains water and sewer utilities as well. About 20 miles of water distribution piping deliver 121,175,101 gal per year. About one-third of the piping is used for hot water and steam distribution. The sewer service on the other hand uses 89,389,705 gal per year. The difference between these two water consumption volumes — 31,785,396 gal per year — represents an apparent water loss somewhere in the system, since that volume does not showing up in the sewer. Some loss can indeed be attributed for usage such as drinking, cooking, evaporative loss in the cooling towers, and any for the lawn care. However, this difference of about 26 percent is higher than expected. Further if the difference were due to steam losses then the energy and cost penalty would be that much more severe. This difference should be closely monitored for any increase as the leaks (piping or otherwise) only will continue to get worse.

Project Initiation

The goals of the audit were to analyze the energy usage for the entire depot, to perform a walkthrough energy assessment of Buildings 9, 10(A), 10(C), and to identify major energy and operational cost savings opportunities. This Level-I Process Energy Optimization review included the following five major tasks:

1. Analysis of background information
2. 1-day Process Energy Optimization workshop
3. 3-day Level-I energy audit
4. 1-day out-briefing
5. Preparation of the summary report.

During the on-site visit, a 1-day Process Energy optimization (PO) workshop was held. Participants received a 3-ring binder containing detailed information. Additionally, a mini-CD, “Energy Savers Home Navigator” prepared by the USDOE and a booklet, “Energy Savings for the Homeowner” were also given to everyone. Table 2 lists the topics covered in this workshop. At conclusion of the workshop, each participant was asked to fill out an evaluation questionnaire. After the 3-day Level-I audit review (on the 5^{th} day), an out-briefing session was held.

A Process Energy Optimization is a review of various energy consuming processes with a primary goal of minimizing the end energy usage. However, there are situations when it is possible to reduce the energy utility costs while maintaining same energy usage (or by even increasing it). Hence the broader goal of the process optimization should be to reduce the operating costs. Some examples of cost reduction that do not involve lowering the energy usage are: obtaining a better utility rate including time of usage (TOU) rate, rescheduling of operations to achieve load staggering as opposed to load stacking, use of energy storage systems, and use of the latest energy management control systems and technologies such as occupancy or motion sensors.

Successful process energy and cost optimization requires knowledge of such details as:

- the site’s load characteristics
- historical energy trends, and the broad breakdown both in terms of demand (kW) and energy (kWh) of those trends
- total energy costs (and the broad breakdown of those costs)
- current utility rate structure and all available options especially any anticipated increases in energy use, and planned operational changes or expansions.

It is also imperative to take proper care while assessing the impact of process energy optimization. In particular, data should be compared only on a relevant basis of normalization such as: hours of operation, degree-days, square footage, production volume, the amount of sales, etc. Often it is necessary to use multiple normalization factors.

Table 2. Broad topics covered during 1-day process energy optimization (PO) workshop.

Introduction, acknowledgements, participants
National and residential energy usage, economic evaluation of energy projects
TYAD, candidate buildings, utility analysis, priorities, and goals
Typical opportunities: energy efficient products, energy efficient electric motors, compressed air systems, lighting, etc.
PO audit, organization, actions, responsibilities, and resources

In addition to the data normalization, attention should also be given to determine the best way to assess the success of an optimization initiative. One could compare the post-optimization energy and cost figures with those from the past ("baseline approach") or with the industry norm ("benchmark approach"). Further, to account for a product mix with each having different energy requirement, the results can be compared on a per equivalent product unit ("equivalent product approach").

Recycling can be another major component of the process energy optimization initiative. Incidentally, any reduction in the energy usage or increase in recycling would have a positive impact on the environment. With the era of utility deregulation and technological advancements, the philosophy should be that of Energy Management vs. Energy Conservation. In the Energy Management approach independent evaluations are done for both the energy and cost reductions. The traditional Energy Conservation approach seeks cost reductions through lowered energy usage alone.

In general, the process energy and cost optimization initiative should be used to identify any Profit Centers which may be hiding in the plant operations. For any economic analysis and decision making, the life cycle cost approach should be used instead of over emphasizing first or initial costs. Also, to truly minimize the impact on the environment, one should consider both types of energy efficiencies viz., site-efficiency and source-efficiency.

3 The Level-I Audit

Electrical Profile for TYAD

While the TYAD schedule makes three shifts of operation possible: 07:30-16:00, 16:00-24:00, and 24:00-08:00, TYAD presently employs only the first and third shifts. Until March 2001 TYAD bought electricity from EnergyPlus. TYAD currently receives a bundled power from PPL at LP5 rate. The effective capacity-rate or demand-rate is about $6/kW.

Figure 1 shows the Depot's historical demand (kW) data. However, data was not provided for the post-September 2001 period. Figure 1 shows that the seasonal variation in the demand is low. This indicates that the electric load for the comfort conditioning is only a small fraction of the total load. Since the heat is supplied by non-electric energy and since Tobyhanna has only 17 seasonal cooling days, the demand trend is expected. The peak demand is around 9500 kW.

Candidate Buildings

It was decided to conduct a Level-I audit be on Bldgs 9 and 10 (A&C). Bldg 9 has an area of about 51,000 sq ft while the Bldg 10 occupies about 78,000 sq ft. Both buildings are about 50 years old, and the two buildings are submetered separately; Bldg 10 has two submeters. Figure 2 shows historical energy (kWh) data for the candidate buildings. Figures 3 and 4 show the building layouts.

Candidate Bldg 9

Bldg 9 is 51,074 sq ft in size. The Mobile Equipment Refinishing Division (the prime tenant, with 46 personnel) runs two shifts (1st and 3rd) in the building. The Mobile Equipment Division performs:

- paint preparation such as acid pre-wash and priming
- final painting, using all VOC compliant coatings, including epoxies, alkyd enamels, and (CARC) polyurethane topcoats in both single and three camouflage patterns
- undercoating, stenciling, and unmasking operations

- preparing metal and composite materials for both electroplating and painting, which involves removing paint coatings by chemical stripping, steel and aluminum oxide blasting, sanding, and grinding
- steam cleaning, power washing, polycoating, irradiating, and masking prior to painting.

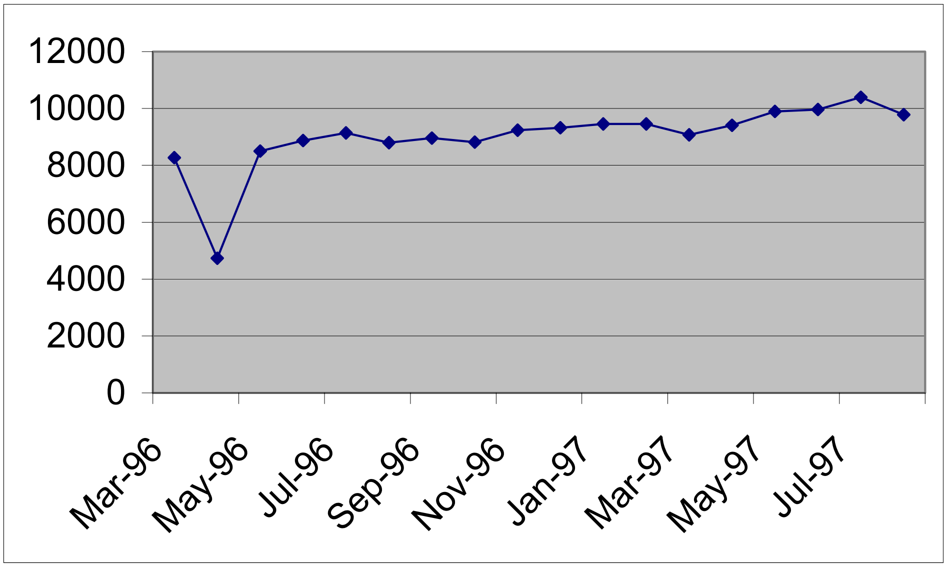

Figure 1. TYAD capacity or demand (kW).

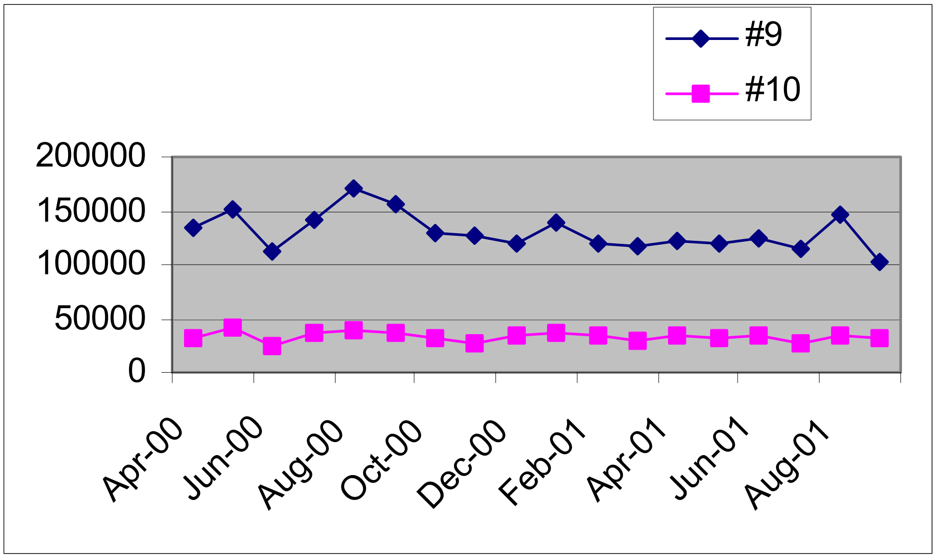

Figure 2. Bldgs 9 & 10 energy (kWh).

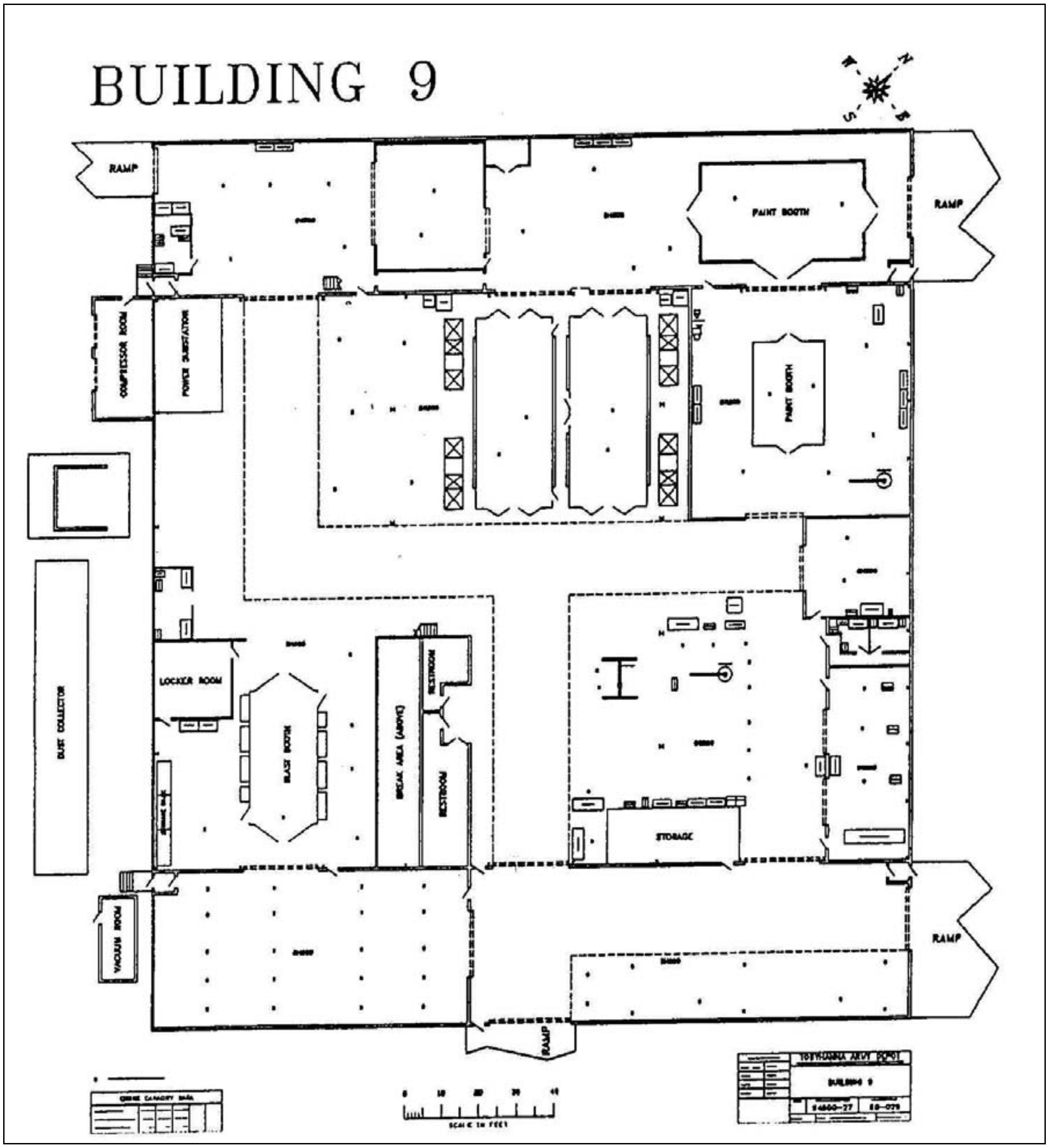

Figure 3. Bldg 9 layout.

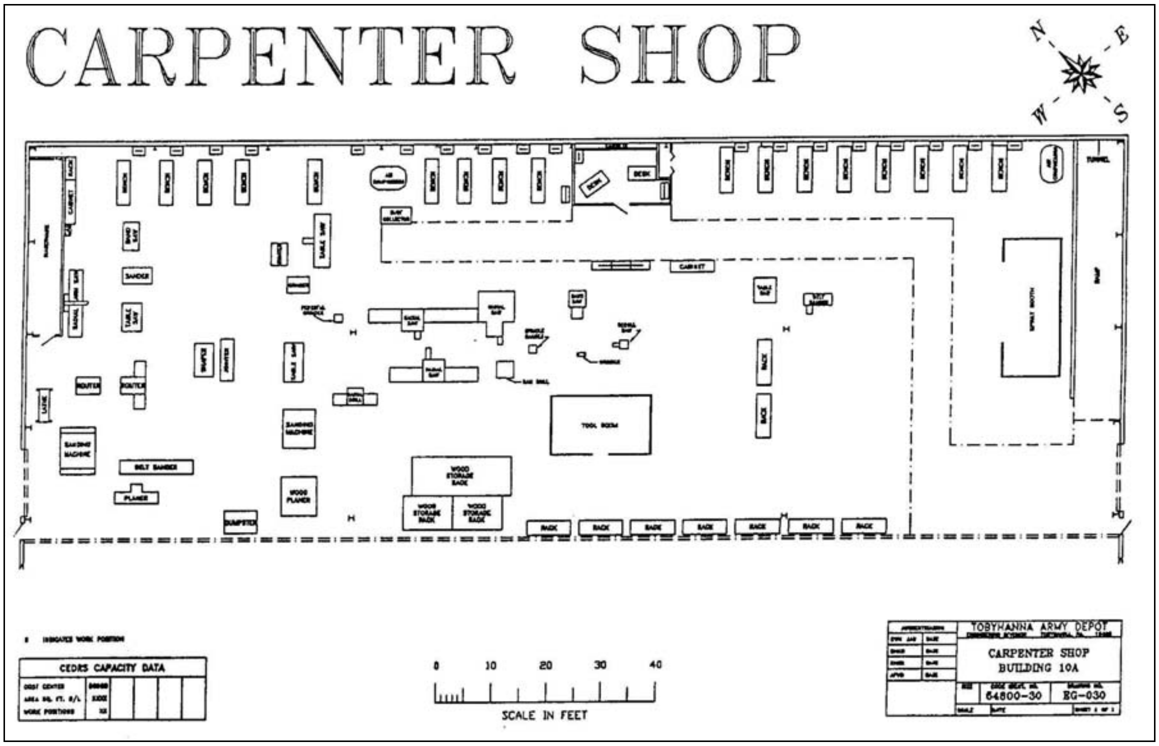

Figure 4. Carpenter Shop layout.

The Mobile Equipment Division uses the following equipment:

- steel blasting equipment for trailers up to 45-ft. long (approx. 900 sq ft)
- two paint/cure cabins 50 ft. in length (1000 sq ft each)
- one paint booth with a pit for wheeled vehicles and trailers (approx. 500 sq ft)
- one paint booth large enough to handles items such as power units and HMMWV's
- one large vehicle paint booth (approx. 1200 sq ft)
- steam cleaning room (approx. 500 sq ft)
- a rain test capability for all Army and Air Force workload (approx. 200 sq ft).

Vehicle/generator Division also allots a portion of the space within the building, approx. one-fifth of the building footprint.

Noted that the air-drying takes about 24 hrs before the next step can begin. Forced drying takes about 3 hours before the next step begins. Painting and drying can take place in the same (large) room, of which there are two. Paint is stored in lockers, in 1- and 5-gal buckets. High-pressure water (160 °F) and soap are used to clean the components in preparation for painting. The blast room uses stainless steel as a medium for blasting the components in preparation for painting.

Candidate Bldg 10 (A&C)

Bldg 10 has three primary missions:

1. Carpentry shop
2. (Non-wood) carton making
3. Trailer assembly.

Area 10A: Carpentry Shop

The Carpentry Shop is used for packaging and shipping, special order projects, and construction of skids. It has compressed air, a spray booth, and an expansive wood shop. It uses a vacuum hose at each saw to gather sawdust. The equipment to create this vacuum is located outside. The activities are woodworking, fabric application, production support services directorate. The shop takes up approximately half the bay while the other half is the Box and Crate shop belonging to Defense Logistics Agency (DLA). Some of the machines within the Carpenter shop include several stationary 12-in. table saws, a 36-in. surface planner, a 36-in. abrasive planner, a 8-ft abrasive bed sander, two overhead routers, a wood lathe, a jointer, a shaper, several drum and disc sanders to include a sawdust collector and paint booth. The mission for the carpenters includes fabrication of multiple compartments, chests and cases, which involves cutting, shaping, pattern making, assembling. Construction of tables, interior fixtures for vans and shelters to include ceiling tiles, Formica covered panels and floor tiles. The shop also fabricates non-metallic and non-wood items such as fiberglass lay up, epoxies, and Kevlar.

Area 10C: Trailer Assembly

Bldg 10 is also used to assemble a trailer and generator set, and to apply name plates. Some generator testing is done with the new equipment, and personnel also test all the generators from warehoused vehicles that come to the shop. The facility uses compressed air.

Activities include power unit set assembly, vehicle/generator division, and production support services directorate. The functions are to set up assembly of power units, which involves bolting generators to trailers to form a power unit configuration. Personnel do electrical load testing of generators, and inspect and replace parts such as lights, wiring harness, tires, batteries, mechanical breaks and a wide assortment of parts affiliated with generators and trailers.

Electric Motors and Fans

It has been a common practice for many years to oversize motors. This old practice of oversizing was begun when electricity was less expensive. Currently, a typical industrial motor operating a large percentage of the time consumes about five to ten times its capital cost in electricity every year. In common terms, this is analogous to spending $100,000 a year on gasoline for a $10,000 car. Under such circumstances, small gains in efficiency translate into big gains in savings. Efficiency is easily improved by purchasing energy efficient motors, by sizing motors more precisely, and when applicable, by installing variable-speed drives.

Energy-efficient motors use less energy to accomplish the same amount of work. Depending on the size, type, and manufacturer, such motors typically cost 10 to 30 percent more than the standard models, but because of superior design and higher quality production, these motors tend to be more reliable, produce less waste heat, and run more quietly than comparable standard models. For example, a 50 hp motor that is 20 years old and operates 5000 hours a year can be replaced with a newer energy-efficient motor with a rate of return on investment of about 40 percent (or a 2-year payback).

Downsizing oversized motors is also a very good idea because motors are inefficient when running at less than 50 percent of rated load. Oversized and underloaded motors waste energy and money. The scope of the problem is broad; audits indicate that about 30 percent of all industrial and commercial motors operate at less than 50 percent of full load, resulting in substantial inefficiency costs. For these reasons, special attention was paid to electric motors and fans. Table 3 provides an inventory of the electric motors and fans in Bldgs 9 and 10 (A&C)

Table 3. Inventory of electric motors and fans.

Category	hp	Operating hours	Age (yrs)	No.	Bldg. Location
Steel blast dust collector	75	8.5 hr/day	4	1	9
Paint booths	20	8.5 hr/day	10	2	9
Paint booths	15	8.5 hr/day	15	1	9
Paint booths	15	8.5 hr/day	30	1	9
Exhaust fans	2 – 1/6	runs as needed	15	13	9
Air-handling motors	10	runs as needed	15+	3	9
Air-handling motors	30	runs as needed	15+	3	9
Saw dust collector	50	8.5 hr/day	20	1	10A
Exhaust fans	1/4	8.5 hr/day	1	2	10A
Exhaust fans	1/2	8.5 hr/day	12	2	10C

4 Findings from the Level-I Audit

Researchers visited Bldg 9, 10 (A&C). For the most part, these buildings appear to be well maintained; processes operate in a safe manner. The waste solvents are recycled and waste is handled soundly. Researchers detected no compressed air leaks. The lighting level and space temperatures seemed generally appropriate. Researchers noted a number of opportunities to achieve process and energy efficiency savings. Researchers also inspected painting, media blasting, and compressed air system operations in Bldg 1E. No improvement opportunities were found in this state-of-the-art facility and equipment.

Reducing the Demand (kW) via Operational Scheduling Changes

Analysis of detailed Demand vs. Time data should be carried out for determining how and when the billing demand is encountered. Under the current bundled rate, the demand related charges are about 20 to 25 percent of the total electricity bill. The net or effective unit demand charge is about $6/kW. The monthly billing demand is consistently around 9,500 to 10,000 kW. Whenever possible, high demand (kW) operations should be scheduled sequentially or staggered. It should be noted that there is no major cost associated in this approach and that the savings are immediate.

Now, if the demand can be lowered by 10 percent (or by 1000 kW), the savings would be about $70,000 per year without incurring any additional costs.

Developing "Turn it Off When Not Needed" Strategy

Analysis should be performed to address the question, Are there any pieces of equipment or lights that are unnecessarily left "on"? If the answer is "yes," a simple yet effective "Turn it Off When Not Needed" strategy may yield significant savings. The TYAD, while operating under two-shifts, has a rather high Load Factor, around 0.80 to 0.85, which indicates that most things are "on" most of the time.

Assuming even a 1 percent reduction in the overall energy usage, the savings would amount to about $25,000 per year without incurring any additional costs.

Fitting Exterior Lights with Motion Detector or Photocell

There are about 460 exterior lights, which are "on" most of the time. Significant savings can be achieved if some of these lights are fitted with photocell or motion detector type of control. Assuming that:

- exterior lights are 200 Watts each
- exterior lights operate for about 12 hours a day
- a possible reduction of 70 percent in the On-time for about 60 percent of the lights,

then the cost of appropriate detectors is $20 each.

The savings are $8460 per year at an initial cost of $5520, which amounts to a payback of about 8 months (an ROI ~110 percent).

Reducing the Loss of Water or Steam

Presently the water usage is 121,175,101 gal per year while the sewer volume is 89,389,705 gal per year. The difference between these two water consumption volumes is 14,685,000 gal per year, which represents a loss of water somewhere in the system (since it does not show up in the sewer). Some loss can indeed be attributed for usage such as drinking, cooking, evaporative loss in the cooling towers, and any for the lawn care. However, this difference of about 18 percent is higher than expected. Further if the difference were due to steam losses then the energy and cost penalty would be even more severe. This difference should be closely monitored for any increase as the leaks (piping or otherwise) only will continue to get worse. Further, every effort should be made to identify the points of major water consumption with an eye towards detecting major losses of water or steam and reducing those losses.

If even 10 percent of this losses are averted, the savings of $7000 per year can be realized based solely on the water utility costs. However, if the same 10 percent reduction also represents averting the loss of steam or heated water, then the total savings (water utility plus energy cost for heating) would be $17,650 per year. It is anticipated that in-house expertise would be able to identify these leaks and fix them without incurring any additional costs.

Implementing Electrical Motor Management Program

The importance and benefits of precisely sized energy-efficient motors was discussed earlier. For this Level-I audit, older motors (15+ years) with a consistent run-time or hours of operation were targeted first for an evaluation to determine the resulting savings when upgraded to energy-efficient motors. Table 4 lists the calculated results.

An Electrical Motor Management Program should be implemented. It is better not to opt for “like replacement,” or to replace a motor only on catastrophic failure (when it simply stops working). A more constructive approach is to target older, large-size motors, and evaluate them for high efficiency motor replacement. The applications include exhaust fans, pumps, air-handling units, compressors, etc. Also note that the new motors not only have high efficiencies, but they have much better part-load efficiencies as well.

Table 4. An upgrade to energy-efficient motors and the resulting savings.

Category	hp	Operating hours	Age (yrs)	Bldg.	Demand & Energy Savings/year ($/yr)*	Cost ($)	Simple pay-back (yrs)*
Steel blast dust collector	75	8.5 hr/day (2,000 hr/yr)	4	9	(new motor)		
Paint booths	20	8.5 hr/day (2,000 hr/yr)	10	9	(new motor)		
Paint booths	15	8.5 hr/day (2,000 hr/yr)	15	9	105	512	4.9 (ROI ~15%)
Paint booths	15	8.5 hr/day (2,000 hr/yr)	30	9	105	512	4.9 (ROI ~15%)
Exhaust fans	2 to 1/6	as needed	15	9	(nonconsistent hrs)		
Air-handling motors	10	as needed	15+	9	(nonconsistent hrs)		
Air-handling motors	30	as needed	15+	9	(nonconsistent hrs)		
Saw dust collector	50	8.5 hr/day (2,000 hr/yr)	20	10A	312	1223	3.9 (ROI ~19%)
Exhaust fans	1/4	8.5 hr/day (2,000 hr/yr)	1	10A	(new motor)		
Exhaust fans	1/2	8.5 hr/day (2,000 hr/yr)	12	10C	(new motor)		

Notes:

1. These savings and paybacks are based on only one shift of operation. If all the three shifts are in operation, the savings will be about 2.2 times higher and the payback will be quicker.
2. These savings are for Bldgs 9 and 10 (A&C) only. For the entire TYAD the savings will be in excess of $25,000 per year.

The payback would range from 1.5 to 6 years depending on motor size, age, number of operating hours, and the loading pattern. For example, motors that can be targeted for efficiency improvement include:

- Bldg 10A Saw-Dust Collector: 50 hp, 20 years old
- Bldg 10A Roof Top Units: three motors, 10-30 hp, 15 years old
- Bldg 9 Paint Booths: four motors, two @15 hp, two @20 hp; 10-30 years old.

Combined Heat and Power (Co-Generation) Option

At TYAD there is a year-round consistent demand for both electricity and heat. The breakdown is roughly 31 percent for power (electricity) and 67 percent for heat (thermal). This is an ideal situation for exploring an application of Co-generation or Combined Heat and Power (CHP).

Consider a 1000 kW CHP unit at an initial cost of about $1,250,000 producing electricity at a cost of 2 ¢/kWh with a dedicated operator at an annual salary of $100,000. This CHP unit when used to offset both the electric and heat requirements would yield a net (after the $100,000 to the operator) savings of $244,000 per year, which translates into a payback period of about 5 years (or an ROI ~5 percent).

Co-generation of electricity (Combined Heat and Power) either via gas/oil generators or through use of Fuel Cells (in cooperation and potential funding from CERL) should be explored.

Energy Costs

In absolute terms, energy costs may be only 2 to 3 percent of the total budget. But, if one would divide the total budget into Fixed and Variable costs, the impact of any energy bill savings will be apparent. It is important to re-think of Energy Costs as a Potential *Profit* Center. There can be various process optimization opportunities such as: energy, raw materials, throughput of product, human resources, environmental impact and overall costs. The goal of any process optimization audit has to be to improve the process profitability. An analysis of the TYAD electrical energy data reveals that:

- There is not much seasonal impact in energy consumption.
- As of March 2001, EnergyPlus has not been supplying the energy. Electricity is currently being purchased as a bundled commodity from Pennsylvania Power and Light Company (PPL). Under the new bundled rate (LP-5), de-

mand (capacity) related charges amount to about 20 to 25 percent of the total electricity bill. The study of LP-5 rate indicated that there is currently no power factor related penalty. In the future, if there is a significantly lower power factor (lagging) and also an associated severe penalty, use of capacitor banks should be explored. Regarding the change of utility purchase from EnergyPlus to PPL, the PPL engineers told us that it was "by default." If this change was made without a utility rate analysis, such an analysis should be done to ensure that the Depot is being charged the appropriate rate. Such analysis should be performed *at least* once every year. Also, the continuity of kW credits should be looked into and factored in the rate analyses.

- The concept of Load Factor (LF) offers a useful measure for evaluating energy use. Load Factor is a ratio of total kWh, divided by the product of Billing Demand times the operating hours:

$$LF = \frac{\text{Total kWh}}{\text{Billing Demand * Operating Hours}} \quad \textbf{Eq. 1}$$

A low-LF may indicate short-pulsed, high-demand processes such as induction furnaces If there is no demand charge then low-LF is tolerable. If there is a demand charge, a low-LF may indicate that DSM (Demand Side Management) techniques should be implemented. A high-LF, on the other hand may indicate that everything is operating steadily. Steady operation may be acceptable for an office building with a smaller variation coming from the seasonal weather conditions, it could also mean that all power-consuming equipment is turned on all the time. TYAD has a LF of about 0.8 to 0.85 based on two shift operation. The demand (9,500 to 10,000 kW) related charges are about $6/kW under the current bundled rate. Every 5 percent reduction in demand can realize about $36,000 of savings per year, or, for every 5 percent reduction in demand, the electrical bill will reduce by about 1.2 percent. For the past 2 years, Bldg 9 consumes about 102,000 kWh/month while Bldg 10 (A&C) consumes about 32,720 kWh/month. Assuming a similar load factor for the entire installation, the demand in Bldg 9 would be about 236 kW while in Bldg 10 (A&C) it would be about 75 kW.

Bldg 9 requires heat (even through the summer) for use in the Painting/Drying booths. It may be possible to use steam as a source of heat for the high-pressure washing. The current process design uses electricity to heat water. It may be possible to use steam heating by direct steam injection. The payback for this process improvement can be attractive, usually less than 1 year.

5 Conclusions and Recommendations

Conclusions

This work has identified opportunities for process energy efficiency improvements and reductions of pollutant emissions at Tobyhanna Army Depot, PA, using the process energy and pollution reduction (PEPR) tool and the process optimization guide (tools both developed by CERL).

Note that this work reviewed and analyzed only Bldgs 9 and 10 at TYAD, and in these buildings, only first shift operations were assessed. For the most part, these buildings appear to be well maintained and processes operate in a safe manner. Waste solvents are recycled and waste is handled soundly. Researchers detected no compressed air leaks. The lighting level and space temperatures seemed generally appropriate.

This study concludes that a number of opportunities were available to TTAD for process improvements (Ch. 4). The savings from six opportunities amount to about $395,110 per year with the 1 MW CHP option, or $151,110 per year:

1. Reducing the demand (kW) via operational scheduling changes
2. Developing a "turn it off when not needed" strategy
3. Fitting exterior lights with motion detector or photocell
4. Reducing the loss of water or steam
5. Implementing electrical motor management program
6. Combining heat and power (co-generation).

Recommendations

Reducing the Demand (kW) via Operational Scheduling Changes

Analysis of detailed Demand vs. Time data should be carried out for determining how and when the billing demand is encountered. Under the current bundled rate, the demand related charges are about 20 to 25 percent of the total electricity bill. The net or effective unit demand charge is about $6/kW. The monthly billing demand is consistently around 9,500 to 10,000 kW. Whenever possible, high demand (kW) operations should be scheduled sequentially or staggered. Note that there is no major cost associated in this approach and that the savings are immediate.

Developing "Turn it Off When Not Needed" Strategy

TYAD has a rather high Load Factor, around 0.80 to 0.85, which indicates that most energy-consuming things are "on" most of the time. A simple yet effective "turn it off when not needed" strategy may yield significant savings.

Fitting Exterior Lights with Motion Detector or Photocell

About 460 exterior lights "on" most of the time. Some of these lights should be fitted with photocell or motion detector controls.

Reducing the Loss of Water or Steam

TYAD water usage is presently 121,175,101 gal per year while the sewer volume is 89,389,705 gal/year. This represents a loss of water in the system. It is recommended that every effort be made to identify the major losses of water or steam, and to reduce those losses.

Implementing Electrical Motor Management Program

For this Level-I audit, it is recommended that older motors (15+ years) with a consistent run-time or hours of operation be targeted first for an evaluation to determine the savings that may result from upgrading to more energy-efficient motors.

Combined Heat and Power (Co-Generation) Option

At TYAD there is a year-round consistent demand for both electricity and heat—an ideal situation for exploring an application of cogeneration or combined heat and power (CHP). Specifically, it is recommended that TYAD consider a 1000 kW CHP unit at an initial cost of about $1,250,000 producing electricity at a cost of 2 ¢/kWh with a dedicated operator at an annual salary of $100,000. This CHP unit when used to offset both the electric and heat requirements would yield a net (after the $100,000 to the operator) savings of $244,000 per year, for a payback period of about 5 years (or ROI ~15 percent).

Co-generation of electricity (Combined Heat and Power) either via gas/oil generators or through use of Fuel Cells (in cooperation and potential funding from CERL) should also be explored.

Electric Rate Analysis

It is recommended that TYAD conduct an annual rate analysis to ensure that the Depot is charged appropriately. If a power factor penalty charge is incurred, it is recommended that TYAD explore the use of capacity banks, and check on the possibility of KW credits.

Other Opportunities

Researchers noted a number of other areas that may yield further savings:

- Bldg 9 has a large number of T-12 lights. These lights should be replaced with T-8s. The payback is around 1.5 to 2 years the hand-blasting area of Bldg 9, about 25 to 30 percent lamps were either not working or missing, while the ballasts are still drawing current. Each of these ballasts costs about $2.5 per year per shift. Lamps that are missing or ineffective yield no substantial payback.
- TYAD currently has an Energy Savings Performance Contract (ESPC) in place. If an additional per-visit charge is built into the ESPC contract, then scheduled area re-lamping would yield significant savings. (Changing light bulbs one or a few at a time should be avoided.)
- As much as feasible, replace electric reheat with steam reheat in all the air-handling units.
- In Bldg 9 in the high pressure washing area, a bare steam pipe needs to be insulated.
- Installation of a small exhaust fan in the Northwest corner would make the space temperatures more even.
- In Bldg 10 (A), the low-pressure sodium lights should be replaced with high-pressure sodium. The change will result in improved light quality without the yellow tinge.
- Whenever feasible, steam space heaters should be replaced with direct gas-fired radiant unit heaters.
- TYAD currently has a contract for disposal of the waste solvents. Use of a Paint Gun washer to do this operation should be considered, including recycling of solvent in-house.
- TYAD has a year-round consistent demand for both electricity and heat. Application of co-generation should be explored.

- An application of a Fuel Cell demonstration project at TYAD should be considered, especially since CERL maybe able to fund the feasibility study.
- Also, use of the FLASHJET coatings removal process in Spray Painting operations should be considered. At present the Corpus Christy Army Depot (CCAD) uses this technology, which has demonstrated a payback of around 4 to 5 years.
- In the Spray Painting operations, instead of the Conventional Non-HVLP process (40 percent paint transfer efficiency), consider use of HVLP (75 percent efficient) or Electrostatic HVLP (90 percent efficient). HVLP stands for high-volume, low-pressure process. Again, presently CCAD uses this technology.
- Replace standard V-Belts with cogged V-Belts. This change provides energy savings through reduction of belt slippage on drive pulleys, and can yield about a 2 percent savings with a payback ranging from 6 months to a year. Previous examples of successful projects benefiting from this change include chiller fans and grinders.
- At the minimum, every effort should be made to specify and purchase only energy-efficient products that carry the EPA/DOE Energy Star label. The Federal Energy Management Program (FEMP) of the U.S. Department of Energy has an extensive set of current recommendations for a wide variety of energy-efficient products. The procurement guide, "Buying Energy Efficient Products," is available at http://www.eren.doe.gov/femp/procurement or by calling 1-800-363-3732. For more information on Energy Star labeling, visit http://www.energystar.gov or by calling 1-888-STAR-YES. The Appendix to this report includes other (electronic) sources of information on energy efficiency.

Additional Opportunities

It is recommended that TYAD perform a Level-II Process Energy Optimization (PO) audit to develop the detailed information regarding:

- analysis of the TYAD demand for achieving demand reduction by rescheduling a few select operations
- a "Turn it Off when Not Needed" strategy
- identifying the points of major water consumption with an eye towards detecting major losses of water or steam
- electric Motor Management Program for the entire TYAD
- indoor lighting efficiency improvement
- exterior lighting operational improvement

- co-generation of electricity (Combined Heat and Power) either via gas/oil generators or through use of Fuel Cells (in cooperation and potential funding from CERL).

Thorough Level-I audit information should be developed for the other shifts in Bldgs 9 and 10, and for other buildings at TYAD, and a Level-II Process Energy Optimization (PO) audit should be undertaken to develop the detailed information regarding the six principal improvement opportunities.

Acronyms

Btu	British Thermal Unit
CERL	Construction Engineering Research Laboratory
CHP	Combined Heat and Power
DOE	U. S. Department of Energy
DSM	demand side management
EPA	U.S. Environmental Protection Agency
ESPC	Energy Service Provider Contract
FEMP	Federal Energy Management Program
hp	horsepower
HVLP	high volume low pressure
kW	kilowatt
kWh	kilowatt-hour
lb	pound
LF	load factor
MBtu	million British Thermal Unit
MW	million Watt
MWh	million Watt-hour
PO	process optimization
PPL	Pennsylvania Power and Light Company
ROR	rate of return
ROI	Return on Investment
TYAD	Tobyhanna Army Depot, Pennsylvania
USDOE	U. S. Department of Energy
yr	year

Appendix: Web Sites Offering Further Information on Energy Efficiency

Government:

www.rebuild.org
Rebuild America is a network of community partnerships made up of local government and businesses that saves money by saving energy.

http://www.commerce.state.il.us/com/energy/
Illinois Department of Commerce and Community Affairs (DCCA).

www.energy.gov/house/sub/consumers.html
DOE "House" site — expert advice on home improvements that will save you money and improve your comfort.

www.eren.doe.gov/buildings/documents/high_heating_bills.html
Reduce your heating bills this winter.

www.eren.doe.gov/
DOE Energy Efficiency and Renewable Energy Network – comprehensive resource for DOE's energy efficiency information, plus access to more than 600 links and 80,000 documents.

www.eren.doe.gov/power
DOE Office of Power Technologies — developing clean, competitive power technologies for the 21st century, including renewable energy (solar, wind, geothermal, and biomass), energy storage, hydrogen, and superconductors.

www.nrel.gov
National Renewable Energy Laboratory – DOE's premiere laboratory for renewable energy and energy efficiency research, development and deployment.

www.eren.doe.gov/state_energy/states.cfm
DOE — Select a state for information on energy use, renewable resources, state incentives for renewable energy, and more …

www.epa.gov/energystar/
EPA Energy Star Program — lists of ENERGY STAR qualified products, and a store locator to help you find qualified products at a retailer near you.

www.epa.gov/cpd.html
EPA Climate Protection Division — committed to reducing greenhouse gases through energy-efficiency and cost-effective partnerships with industries in all sectors of our economy.

Non-Profit Organizations:

www.solstice.crest.org
SOLSTICE – One of the most comprehensive sites available for information on renewable energy, energy efficiency, and sustainable living.

www.caddet-re.org
CADDET Renewable Energy Provides Information and Project Examples on the following technologies: Geothermal, Biomass, Waste, Hydro, Solar, Wind, and PV.

www.solarenergy.org
Solar Energy International – Renewable energy education and sustainable development.

www.dcs.ncsu.edu/solar/dsire/dsire.html
Database of State Incentives for Renewable Energy — Renewable Energy Information Resources for Consumers, Business, Industry and Government.

www.aceee.org
American Council for an Energy Efficiency Economy — dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection.

www.ase.org
Alliance to Save Energy — coalition of prominent business, government, environmental, and consumer leaders who promote the efficient and clean use of energy worldwide.

www.citizen.org/CMEP
Public Citizen's Critical Mass Energy Project (CMEP) — voice promoting renewable and energy efficiency technologies, watch-dogging nuclear safety issues, ensuring that environmental and consumer interests are protected as the electric utility industry deregulates.

www.energyideas.org
Energy Ideas Clearinghouse (EIC) — fast, centralized access to comprehensive and objective information, education, resources, and technical assistance for increasing energy efficiency.

www.ucsusa.org
Union of Concerned Scientists — alliance scientists from across the country conducts technical studies on renewable energy options, the impacts of global warming, and other related topics.

Interactive / Kids

www.lead.org/leadnet/footprint/intro.htm
Calculate Your Ecological Footprint, 13 simple questions will assess your use of nature.

www.energy.ca.gov/education
Energy Quest — California Energy Commission's educational site for kids.

www.epa.gov/kids
EPA's Explorers' Club — Energy Education for kids ages 5 to 12.

www.dti.gov.uk/renewable/ed_pack
Planet Energy — Renewable Energy Education for kids ages 7 to 11 and 12 to 16.

Links Index

www.aceee.org/altsites/index.htm
List from the American Council for an Energy Efficiency Economy.

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14. ABSTRACT

Tobyhanna Army Depot is a large communications-electronics fabrication/overhaul facility located in Monroe County, PA. A review of the installation's records indicated that over half of the Depot's total annual cost of energy is used for the purchase of electricity, although electricity accounts for only 31 percent of the total energy consumption. This fact indicates that there may be opportunities for energy or process efficiencies at the installation, either by reducing the dependence on the relatively more costly fuel (e.g., by using alternative fuels), or by changing work processes to reduce overall energy consumption. In this work, the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) performed a Level-I energy audit at Tobyhanna Army Depot to identify opportunities for process energy efficiency improvements and reductions in pollutant emissions.

15. SUBJECT TERMS

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