Introduction to Energy Conservation and Production at Waste Cleanup Sites

ENGINEERING FORUM ISSUE PAPER

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1.0 Abstract

The U.S. Environmental Protection Agency (EPA) has always worked to improve management of hazardous waste cleanup projects. Net energy savings through conservation and energy production is one strategy for improvement. Presidential Executive Order 13123, "Greening the Government Through Efficient Energy Management," states that each federal agency shall strive to expand the use of renewable energy within its facilities and in its actions by implementing renewable energy projects.**(1)**

EPA has prepared this issue paper to raise awareness and help project managers recognize the need to consider energy conservation and production during the design and operation and maintenance (O&M) of waste cleanup projects. These include projects initiated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) commonly known as Superfund, the Resource Conservation and Recovery Act (RCRA), and by EPA's Underground Storage Tank (UST) and Brownfields waste clean up programs.

Although energy conservation is an important priority, meeting remediation goals is the most important. However, with more than one way to reduce energy use, the ability to meet remediation goals and operate cleanup projects efficiently can be accomplished.

2.0 Background

This issue paper was developed by EPA's Engineering Forum, with support from the U.S. Army Corps of Engineers (USACE), to help EPA and other project managers consider ways to conserve and produce energy at waste cleanup sites. The Engineering, Federal Facilities, and Ground Water Forums, established by EPA professionals in the ten regional offices, are committed to identifying and resolving scientific, technical, and engineering issues impacting the remediation of

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Superfund and RCRA sites. The forums are supported by and advise OSWER's Technical Support Project, which established Technical Support Centers in laboratories operated by the EPA Office of Research and Development, Office of Radiation Programs, and the Environmental Response Team. The centers work closely with the forums, providing state-of-the-science technical assistance to EPA project managers.

EPA's Engineering Forum members recognized the need to consider energy reduction and energy production during the design and O&M of Superfund, RCRA, UST, and Brownfields waste site cleanup systems. This issue paper describes four case studies that highlight two methods of energy generation and two methods of energy conservation: 1) landfill gas directed to operate microturbines as an example of a distributed electrical system; 2) landfill generated methane gas used to fuel four internal combustion engines providing 3200 kW (gross) power generating capacity; 3) an energy savings realized through control of lump sum O&M contracts; and 4) energy saving opportunities through reusing system components, reduction of space heating requirements, and redesign of the system to accommodate continuous extraction and treatment.

This issue paper also introduces an energy checklist that was developed as a tool to aid the project manager in conducting energy audits on their cleanup system designs. A sample energy checklist has been tested at two of the Superfund sites used as case studies.

This issue paper covers all waste programs and complies with the "One Cleanup Program" philosophy of the Office of Solid Waste and Emergency Response (OSWER).**(2)** The goal of the One Cleanup Program is "to manage all waste programs so that resources, activities, and results are more effectively coordinated and easily communicated to the public." This paper also supports the Resource Recovery Challenge Program, or RCC.**(3)** The RCC is a major national effort to find flexible, more protective ways to conserve our valuable resources through waste reduction and energy recovery activities that improve public health and the environment. Conserving energy at waste sites supports one of the three primary goals of the RCC, which broadly states "conserve energy by using better materials and design, and recover energy from things now viewed as waste."

Many systems implemented to clean up waste sites may be using energy for decades (*e.g.*, groundwater pump-and-treat, soil vapor extraction). Stakeholders involved in the system design and O&M may want to consider energy use as a parameter for optimization and cost savings. In addition, some waste sites are capable of actually generating energy. These include landfills that produce methane gas and sites with open space that could accommodate, for example, photovoltaic arrays or wind turbines to produce electricity. These potentials should be considered during design, construction, and O&M as energy is used during all phases of a system's life cycle. This paper concentrates on the design, construction, and O&M portions of the life cycle.

Selecting a remedy for a site cleanup involves a number of criteria; for example, effectiveness, safety, cost and community acceptance. Energy, either used or produced, is not a specific criterion, but could be inherent in others. Relative energy needs for each choice can be broad. For example, a system such as a permeable reactive barrier might require much less energy than most thermal technologies (six-phase heating, steam injection, *etc*.). The need to minimize the remediation timeframe (typically shorter for thermal technologies) can be balanced with energy use. Some remedies may not seem energy intensive (such as groundwater plume control), but, operated for decades, can become so. For the most energy intensive technologies (such as most thermal technologies), even small increases in energy efficiency or conservation can have large effects.

Another example of energy considerations influencing remedy selection is using an internal combustion engine to treat petroleum hydrocarbon vapors. In this treatment system, the contaminant actually serves as fuel for its own treatment system operation (or transfer, in this case). Because UST sites are the largest category of hazardous waste sites in terms of the number of sites, increased use of this treatment system might result in substantial nationwide energy savings.

The idea of energy savings at waste cleanup sites has gained momentum since the energy crisis in the western United States in 2001, with its unexpected rolling blackouts and price hikes. In the summer of 2001, a combination of decreased availability, corporate error, and other factors caused consumers in some western U.S. states to face power losses and higher electricity prices. This situation led to some successful conservation, but also made industry and consumers aware of the need to continue this practice. Prior to that, Executive Order 13123 (*Greening the Government Through Efficient Energy Management*), global climate change issues and the principles of sustainable development brought energy saving issues to the forefront. Section 204 of the Executive Order reads in part as follows:

"Renewable Energy. Each agency shall strive to expand the use of renewable energy within its facilities and in its activities by implementing renewable energy projects and by purchasing electricity from renewable energy sources."

Section 404 of the Executive Order further states: "Agencies shall incorporate energy-efficient criteria consistent with ENERGY STAR® and other Federal Energy Management Program (FEMP)-designated energy efficiency levels into all guide specifications and project specifications developed for new construction and renovation, as well as into product specification language developed for Basic Ordering Agreements, Blanket Purchasing Agreements, Government Wide Acquisition Contracts, and all other purchasing procedures."

One tool that this issue paper proposes to help project managers conserve energy use is a checklist, such as the generic checklist or "audit protocol" in Appendix A. Such a checklist, whether generic or technology-specific, would help the project manager determine potential energy savings during the design phase, O&M, and each follow-on five-year review. The five-year review is a site-specific reporting tool that determines whether a remedy is protective of human health and the environment through an evaluation of its implementation and performance. These periods are the appropriate times for this evaluation as well as for other optimization efforts.

The checklist in Appendix A is not customized for all types of sites; for instance, a landfill, mine or groundwater cleanup site presents different opportunities for energy savings or production. The list of cleanup technologies used today is fairly extensive and energy needs vary, but this generic checklist is intended to illustrate possible savings opportunities from some of these sites. The goals of this issue paper are to:

- Raise awareness of the need to consider energy saving and energy production opportunities at waste sites.
- Identify resources that may provide energy saving and production opportunities at sites.
- Provide an example of an energy saving checklist for remediation systems, such as the USACE has done for groundwater pump-and-treat systems using Remedial System Evaluation (RSE) checklists. A number of RSE checklists are available from USACE, including those on pump-and-treat systems, landfill gas collection, and soil vapor extraction systems. These checklists do not explicitly address ways to increase energy efficiency or conservation, but do offer suggestions for reducing energy requirements.
- Present findings of case studies (checklist use, *etc.*) and ways project managers can save or produce renewable energy at their sites.

3.0 Classification of Remedies

Federally mandated waste cleanup programs include Superfund, RCRA, UST, and Brownfields.

The Superfund program was established to clean up abandoned hazardous waste sites; RCRA to make sure operating sites handle waste properly; the UST program to manage the storage in underground storage tanks and releases of hazardous substances from them; and Brownfields to help communities identify, cleanup, and reuse contaminated properties. Environmental remediation technologies have been used for decades to clean up contaminated media at these sites. The number of cleanup technologies used today is fairly extensive and their energy requirements vary widely. Energy audits (checklists), which need to be site-specific, are affected by factors such as equipment and operational procedures used. These factors vary by technology and the state of its development. Therefore, checklists should be optimized for the type of site under consideration.

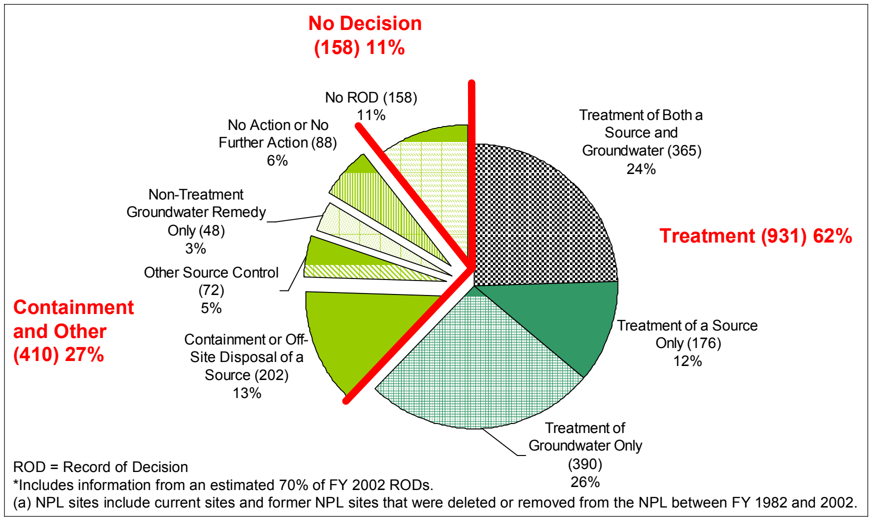

FIGURE 1 – Superfund Remedial actions: actual remedy types on the National Priorities List (FY82-02). Total sites = 1,499.

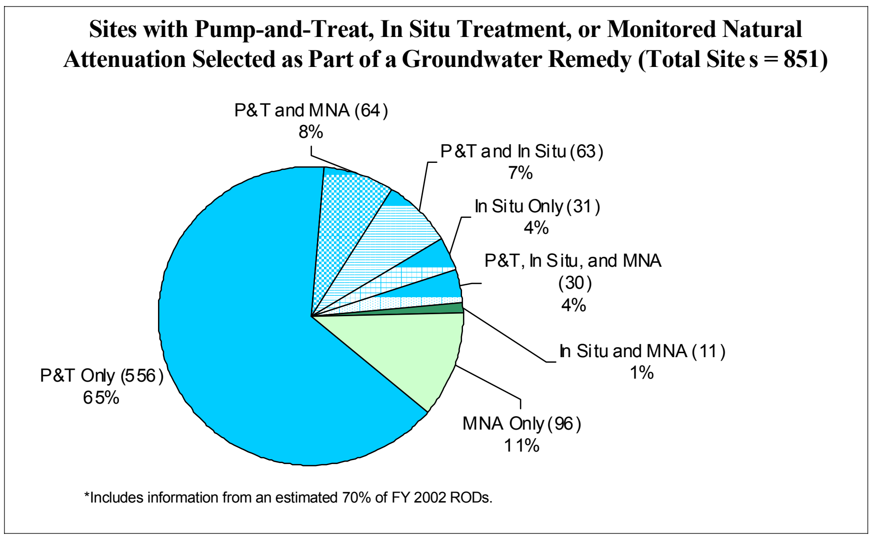

FIGURE 2 – Superfund remedial actions: groundwater treatment remedies (FY 82-02)

A generic checklist for a Superfund fund-lead site (cleanup paid for by EPA) is included in Appendix A. Project managers might also use the checklist to suggest to potentially responsible parties (PRPs) how they can incorporate energy saving measures at enforcement-lead sites where PRPs pay for the cleanup.

The checklist in Appendix A was written as part of a groundwater pump-and-treat optimization task undertaken by OSWER's Office of Superfund Remediation and Technology Innovation at two Superfund fund-lead sites, and much of the information is geared towards groundwater pump-and-treat systems. Questions applicable to other specific remedies need to be developed for use at other sites. USACE RSE checklists provide additional questions on specific remedies.**(4)**

Figures 1, 2, and 3, taken from *Treatment Technologies for Site Cleanup: Annual Status Report*, show statistics on types of waste cleanup technologies used at Superfund sites. **(5)** These technologies also can be used at RCRA, UST, and Brownfields sites. Figure 1 shows types of remedy used at Superfund sites; Figure 2 is a breakdown of groundwater remedies used at Superfund sites. Source control treatment technologies (physical, chemical, and biological) applied to soil and groundwater are presented in Figure 3.

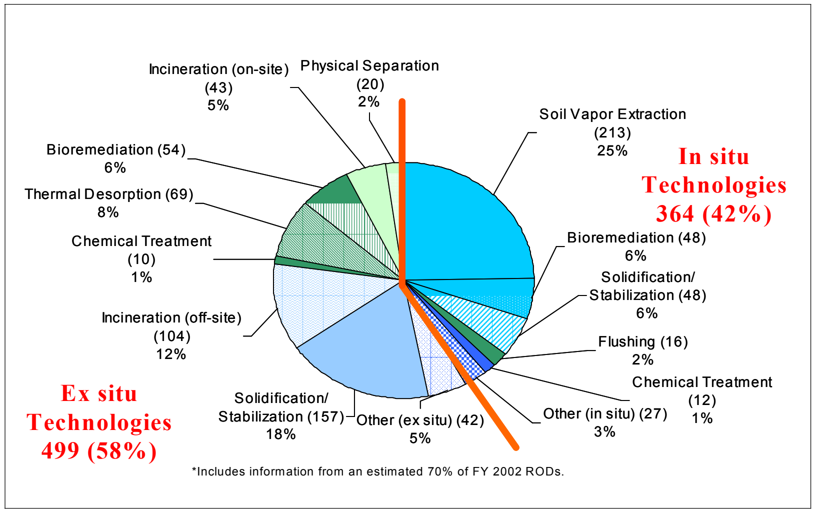

FIGURE 3 – Superfund remedial actions: source control treatment projects (FY 82-02)

4.0 Data on Energy Production and Conservation at Waste Cleanup Sites

Energy production at waste sites can be accomplished in a number of ways. Wind-generated power, geothermal power, and photovoltaic cells are a few examples. Collection of methane gas from landfills offers what may be the most widely used method of energy production at waste sites. This will be discussed in more detail in Section 4.1. Power from photovoltaic cells has been used to operate irrigation, drinking water, and groundwater extraction wells, and at desalination facilities.

Incorporating energy generation into waste cleanup systems facilitates operation of cleanup systems in remote areas (such as mining sites) and may even offer an opportunity for operators to sell power back to a distribution system, advancing the goals set forth in section 204 of Executive Order 13123. Information in this section is based on data and experiences from the U.S. and Europe. Some of these sites (as the case studies show below) will be able to sell enough energy to cover O&M expenses. Additional information sources and websites are listed in Appendix B.

4.1 Energy Generation at Two Landfill Sites

Some waste sites can actually serve as energy sources. For example, electricity (so-called "green power") can be generated by combustion of naturally produced methane emitted at many landfills. More information on energy recovery from landfill gas is available from USACE.**(6)**

4.1.1 Case Study 1: Microturbine Use at Operating Industries Inc. (OII) Landfill, Monterey Park, CA

The Operating Industries Inc. Landfill in Monterey Park, California, is a closed 190-acre landfill divided into north and south parcels by the Pomona Freeway. It operated from 1948 to 1984 and was listed as a Superfund site in 1986. It contains an estimated 38 million cubic yards of municipal solid waste and more than 330 million gallons of liquid industrial waste. The remedy for the South Parcel includes a cap and a landfill gas collection system that extracts high BTU-value methane at a rate of 2,500 cubic ft/min for treatment and use as fuel to power a microturbine system that generates electricity.

Pretreatments are required for landfill gas. Typically, landfill gas is run through an air/water separator and a particulate filter before it is introduced into systems such as microturbines. The off-gas from microturbine systems also needs to be treated to remove sulfur-containing compounds.

Microturbines are an example of a distributed electrical generation facility, which means that it does not need to be hooked up to the grid to be useable. They can operate on many types of fuel, including landfill gas. Microturbines are presently available in 30kW, 70kW, 80kW, and 100kW units. For more information on microturbines, see the EPA website "Inside The Greenhouse."**(7)** Such systems offer many benefits:

- Tolerance of lower methane content fuels (35 percent methane, perhaps less).
- Low nitrous oxide (NOx) emissions (lower than one tenth of the NOx emissions of reciprocation engines).
- Government grants, such as EPA's Landfill Methane Outreach Program (LMOP), may be available for microturbine application.**(8)**

<u>Microturbine Costs</u>

Capital costs for a microturbine are about $2500 per kW of capacity. The long-term nonfuel operation and maintenance costs are between 1.5 and 2 cents per kWh. This compares favorably with the 15 cents per kWh charged to commercial/industrial customers in California. Note that utility costs in the United States will vary with location. According to the ENERGYSTAR website, the national average cost is 8.47 cents per kWh.**(9)**

<u>Construction Costs</u>

Construction costs totaled $1.05 million plus utility interconnection costs of $105,000 to install the system of six microturbines. Projected O&M costs are 2 cents per kWh. Annual estimated cost savings in excess of $400,000 are anticipated.

The landfill operators shared a number of lessons learned from the implementation of their microturbine system:

- Brief stakeholders early in the process. This includes local utilities, any land use contacts (in this case the state transportation agency, CalTrans), and federal, state, and local environmental agencies.
- Obtain a "power interconnection" application (to sell power back to the grid) from the utility first, as this is a critical path item. The local electrical utility may not want to purchase back excess power, or even allow hook up to the grid if extra, supplemental power is needed.
- Ensure that the microturbine system can accept the fuel that the landfill can provide to operate their turbines. Not all microturbines accept all mixtures of fuels.
- Research the microturbine manufacturer that you plan to use. Often, experience is limited to the equipment and support stops once the sale is made. Operators should also be concerned with hookup, testing, operation and maintenance, *etc*. A turnkey operation, which provides a completely operational product upon delivery, is most desirable.
- USACE recommends getting a service contract for the microturbine system, which details the costs and time for implementation of the system.

4.1.2 Case Study 2: Power From Landfill Gas, Douglas County Landfill, Omaha, Nebraska

The Omaha Public Power District (OPPD) installed an energy recovery system at the Douglas County landfill near Elk City, Nebraska. Though it is not a Superfund or RCRA subtitle C corrective action site, but rather a licensed county landfill, it can provide useful case study information for a Superfund or RCRA site. OPPD was one of four national winners of an EPA award under the Landfill Methane Outreach Program.

The landfill currently generates 1150 cubic feet per minute (cfm) of gas with a composition of 51 percent methane, 46 percent carbon dioxide, 2 percent nitrogen, and 1percent oxygen. The landfill gas is fuel for four Caterpillar 800 kW internal combustion (IC) engines that provide a total of 3200 kW (gross) and 3056 kW (net) power generating capacity. A gas chromatograph provides continuous monitoring and periodic recording of landfill gas compositions. Automatic shutdown and remote alarms prevent engine damage or air emission violations. The gas generation is expected to peak in the year 2038 with the potential to generate 18 MW of electricity. Landfill gas production is expected to decrease in 2058. A minimum methane concentration of 45 to 47 percent is needed to run the engines. Gas wells on the landfill are spaced at 300-foot centers with 10 inches of water vacuum at the well-head, 25 to 30 inches of water vacuum at the inlet to the blower on the landfill, and 5 inches of water at the exit of the blower. A positive displacement blower in the generator building raises the gas pressure before it enters the IC engines. The only pretreatment of the gas is condensate removal in knockout tanks on the landfill and in the generator building. Neither production rate nor gas composition show seasonal differences.

New Source Performance Standards require that 98 percent of the nonmethane organic chemicals in the gas be removed. To meet this requirement initially, landfill gas was flared while the power station was under constructed. The flare has a 750 to 3000 cfm capacity. The completed generating facility does not use all available gas, and the flare is maintained to burn the excess. The gas is conveyed from the landfill to the generating building in buried 18-inch HDPE pipes. Condensate is trucked to the landfill and discharged into a shallow reinfiltrate sump on the landfill. The IC engines run continuously with an online utilization factor of nearly 100 percent.

An operator is at the site 40 hours per week, with one on call the rest of the time. Engine oil is changed every 600 hours; cylinder head overhaul is done annually; and engine rebuilding is done every five years. An additional facility may be built near this one in the future to use the additional gas generated from landfill sections receiving wastes. The energy recovery facility is owned by OPPD and operated and maintained by Waste Management, Inc. (WMI), which also operates the landfill.

IC engines-generators are in a 30- by 150-foot generator building. The switching gear and office/maintenance area are in separate parts of the building. Electricity generated, part of the OPPD base load, goes underground to a pole 300 feet from the building and then to an above ground line where it enters the distribution system.

<u>Findings</u>

Landfill operators incorporate green power production into their operations for these reasons:

- Energy generation is an alternative to landfill off-gas treatment, thereby eliminating the need for an additional air pollution permit.
- Energy generation may provide energy self-sufficiency at the site.
- Energy production is in compliance with Executive Order 13123, Section 204 (Renewable Energy).
- This operation makes the purchaser of green power eligible for the Green Power Energy Award, by the Department of Energy, through its Federal Energy Management Program .**(10)** Such incentives for green power purchase are tightly linked with the local demand for green power.

4.2 Energy Conservation at Pump-and-Treat Remediation Sites

The following energy-saving case studies were derived from a process funded by EPA aimed at optimizing O&M of groundwater pump-and-treat remedial systems at Superfund sites. Although these two cases describe groundwater pump-and-treat systems, the process also is applicable to other cleanup technologies. EPA researched only two sites in the study; therefore the reported findings are limited by the small sample size.

4.2.1 Case Study 3: Groveland Wells Visit (5/1/02)

This site in Massachusetts was the location of a plastics and metal parts manufacturing business. Between 1969 and 1984, contaminants were released from the site as a result of discharges and spills. Two municipal drinking water wells were closed as a result of the contamination. Cleanup remedies include ultraviolet (UV)/oxidation treatment of volatile organic compound (VOC)-contaminated ground water and monitored natural attenuation for the "lower concentration" portions of the VOC plume.**(11)**

Energy-intensive UV/oxidation technology, which completely destroys the contaminants, was chosen for the cleanup in part to alleviate community concerns expressed during the public comment period. Contaminant destruction, not just transfer to another media, was preferred.

The UV lamps in these systems typically use a lot of power. For example, a 350 gallon per minute (gpm) groundwater pump-and-treat system may need 3250 kWh of power to run 24 hours a day with a UV/H_2O_2 system. In this case, actual groundwater contamination concentrations were far lower than the system was designed to remediate. As such, the system may have been over-designed for this particular application.

The contractor designed the remediation system to specification at a fixed price cost, which included a building, equipment, redundancies, monitoring, sampling, and analysis. Energy was not explicitly addressed in contracts, O&M procedures, or directives. Energy consumption and costs might have been controlled through a lump sum O&M contract rather than the contractual method used at this site.

In this case, fundamental remedy changes would require reopening the Record of Decision (ROD), but would save energy by replacing the UV/oxidation system with an alternative VOC treatment technology. Any additional benefits of energy conservation or production options would require changes in the overall site management strategy, but a less energy intensive system probably would not have been accepted by this community, which specifically wanted a contaminant destruction technology implemented rather than a transfer technology. Cost sharing is another consideration: at this site, EPA pays for the first 10 years of O&M, after which the state assumes responsibility.

4.2.2 Case Study 4: Bog Creek Farms Site Visit (6/19/02)

This site in semirural Monmouth County, New Jersey, contains elevated levels of VOCs and other contaminants in groundwater. A four-acre disposal area was located on the 12-acre Bog Creek Farm site, which contained a pond, bog, and trench. In 1973 and 1974, organic solvents and paint residues were dumped around a trench in the eastern part of the property. Waste sampling revealed a wide variety of VOCs and heavy metals. The source of the waste was believed to be offsite and was transported and disposed in onsite trenches.

Remedies for the site included excavation, regrading, and groundwater pump-and-treat. Pump-and-treat includes extraction, multistage treatment, and reinjection. Multistage treatment involved an oil/water separator, equalization tank, pH adjustment tank, chemical addition coagulation/flocculation tanks, Lamella clarification/thickening system, Dynasand up-flow filter, two air strippers, two liquid stream carbon adsorbers, three air stream carbon adsorbers, two effluent holding tanks, one plate filter press, chemical feed systems, and other support systems and equipment.

A number of energy saving opportunities were observed. The treatment system was incrementally designed and installed. System components from the source control phase (during which bog and groundwater were treated) were reused. Structures were added in 1996. A batch treatment system was used and there appeared to be many redundancies in the treatment train.

Operational delays, including power interruptions, have occurred. Space heating for equipment and operators in separate buildings is a significant energy use.**(12)** Heated buildings are insulated but "natural" infiltration (open doors and louvers) is used to operate the treatment equipment and control vapors from open-top tanks. The treatment plant building was sized to house the tanks and equipment to treat ground water at a flow rate up to 160 gpm.

The treatment system operates five days per week, with extraction continuing the other two days, until the 78,000 gallon equalization tank reaches capacity. The system was designed for semi-continuous treatment, rendering the design flow rate much higher than that required for continuous extraction and treatment. If the system was redesigned for continuous extraction and treatment, the design flow rate could be reduced to about 50 gpm, which would significantly reduce the energy and space requirements for the treatment building. Another, more obvious energy saving opportunity involves reducing space heating demand.

Findings

EPA found that incremental energy saving and production opportunities could result if certain measures were taken. These measures included:

- Implementing recommended changes from the earlier RSE may have reduced energy consumption and costs at both sites.

- Automation of treatment equipment, though some space conditioning (*i.e.*, temperature control) may still be required.

- Elimination of natural infiltration in main treatment building of Bog Creek Farms site (cold air in the winter months).

- Using distributed energy resources (DER), defined as: "small-scale power generation technologies (typically in the range of 3 to 10 kW) located close to where energy is used (*e.g.*, a home or business) would provide an alternative to or an enhancement of traditional electric power system."**(13)**

- Heat generation using geothermal heat pumps (GHPs) could be profitable (with a 4- to 5-year payback derived from low cost and maintenance). A geothermal source needs to be close to the site to make it economically viable. GHPs use the Earth as a heat sink in the summer and a heat source in the winter, relying on the relative warmth of the Earth for heating or cooling. Through a system of underground (or underwater) pipes, GHPs transfer heat from the warmer earth or water source to the building in the winter, and take the heat from the building in the summer and discharge it into the cooler ground or water source. As such, GHPs do not generate heat, but move it from one area to another. In the end, they use 25 to 50 percent less electricity than conventional heating or cooling systems.**(14)**

Generic Audit Protocol

A generic energy audit protocol is shown in. Appendix A. This generic checklist can be used as a boilerplate for more technology-specific checklists. Figure 4 presents a quick look at some types of energy saving items (specifically for groundwater pump-and-treat systems) that are considered in Appendix A.

Ground Water Extraction for Treatment					
Well No.	Pumping Rate (gpm)		Hrs. pumping per day	Dist. To Treat. Unit (ft.)	Elevation Change to Treatment Unit (ft.)
	Design	Actual			

FIGURE 4(a) — Energy saving items to be considered in audit checklists.

Pumps, Motors & Other Equipment Used						
Major Component Type	Wells Served	Make/ Model	Capacity/ Size	No. Units	Power Requirement/ Output	Hrs. Used/ day

FIGURE 4(b) — Energy saving items to be considered in audit checklists.

4.3 Example of Cost Effectiveness at Pump and Treat Sites

Mechanical and electrical components comprise a cleanup system at a groundwater pump-and-treat site. Among them are pumps, blowers, air compressors, and other equipment. Many have motors with different power requirements. The power is measured as horsepower (hp) and the use depends on the amount of air or water they must move and how high they must move it. In some cases, oversized motor-loads (pumps, blowers, *etc*.) may have been used.

For example, assuming 75 percent motor efficiency and $0.10/kilowatt-hour (kWh), 1 horsepower = $70/month with the system running 24 hours/day and 7 days/week.

Savings from replacing a 50-hp blower with a 15-hp blower	
50 hp × $70/month/hp	$ 3,500/month
15 hp × $70/month/hp	(1,050/month)
	$2,450/month

Payoff time is less than one year, assuming a capital cost of $25,000 to replace the blower. If you use the average rate for power in California ($0.15/kWh), the operational cost would be greater. But the savings would also be greater and the payoff time even shorter than the example above (because the equipment cost is constant).

Although a 50-hp motor running at only a 15-hp rate would be inefficient compared to just using a 15-hp motor, the inefficiency would not likely result in a savings as great as indicated above. You may need to compare efficiency curves for the two motors to see if the economics justify replacing the 50-hp motor with a 15-hp motor. The illustration is added here to show the difference in cost to run the two motors at full capacity.**(15)**

Findings

The following steps can be taken regularly to reduce the use of oversized motors:

- Inventory all motors.
- Note their power requirements (in horsepower).
- Use manuals and O&M data to compare specifications to the actual task.
- Conduct a cost-benefit analysis of replacing oversized equipment or installing a variable speed drive that will allow an operator to control its power usage.
- Replace with equipment that demonstrates significant cost savings (*i.e.*, compare the cost of replacement in a few years).

4.4 Energy Saving Performance Contracts

According to the U.S. Department of Energy (DOE), more than 90 energy-saving performance contract (ESPCs) delivery orders have been awarded.**(16)** ESPCs, which are agreements with energy service companies (ESCOs), also are widely used in Europe for identifying and evaluating energy-saving opportunities on projects.

Under an ESPC, an ESCO will identify and evaluate energy-saving opportunities and then recommend a package of improvements to be paid for through savings. The ESCO will guarantee that savings meet or exceed annual payments to cover all project costs, usually over a contract term of 7 to 10 years. If savings do not materialize, the ESCO pays the difference. To ensure savings, the ESCO offers staff training and long-term maintenance services. This service, often used for energy use in buildings, may have an application to waste cleanup sites and could be investigated on a case-by-case basis.

Many types of energy saving improvements can be funded through existing budgets, as illustrated in Figure 5. This particular illustration, from DOE, shows various cost savings that can be realized in the overall budget once these ESCO contracting techniques are implemented.

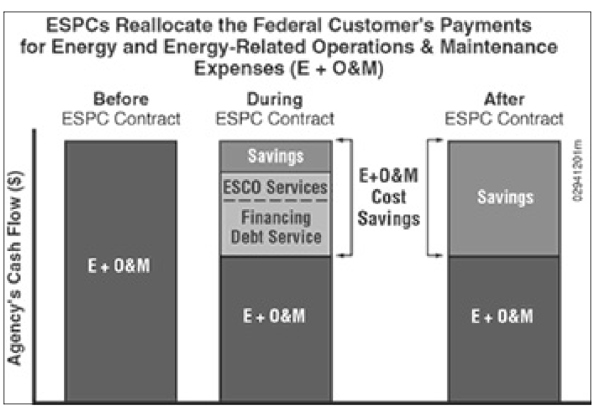

FIGURE 5 — Energy Related Expense Illustration
ESPC = Energy Saving Performance Contract
ESCO = Energy Service Company
Source: www.eren.doe.gov/femp/financing/espc/how.html

Rarely is a waste cleanup site project's design and construction contract associated with its O&M contract. This can be the weak link in trying to save money over the life of the project because the design has no connection to long-term operation.

Findings

DOE's Federal Energy Management Program (FEMP) can help to secure financing for energy efficiency improvements through Super Energy Saving Performance Contracts (Super ESPCs). Through ESPCs, federal agencies can improve energy efficiency at their facilities without depending on congressional appropriations for capital improvements. ESPCs also help meet these agencies meet energy, water, and emissions-reduction goals.**(10)**

Project managers can take a screening test to find out if an ESPC may help. Based on experience from more than 90 ESPC projects at federal properties (see www.eren.doe.gov/femp/financing/espc/how.html), FEMP's technical and project financing experts can provide:

- Help to determine which contracting mechanism best fits your need.
- Education and advisory support to agency staff on legal, technical, financial, and contractual issues.
- Training for agency acquisition teams.
- User-friendly guidance documents.
- Help in developing requests for initial proposals and task or delivery orders.
- Help in reviewing price and technical proposals.
- Experienced project facilitators to guide you in developing and implementing a project.

4.5 Incorporating Energy Audits Into Remedial Systems Evaluation (RSE) Checklists

Two specific groundwater remedy case studies are presented in Section 4.2. In this section, energy-saving questions are proposed for other waste cleanup technologies. USACE has helped EPA develop checklists for project managers to use for optimizing various remediation systems. As mentioned above, these are called "RSE checklists" and provide useful information for this issue paper.

RSE checklists look at savings through manpower reduction, reduced energy needs (usually reduction in electrical use), and reduced chemical use. Ways to reduce energy at waste cleanup sites are included in these checklists. Energy production from using landfill gas or installing photovoltaic solar arrays on the site are normally not considered during RSE inspections. Although RSE checklists do not address energy savings during the design phase, they could be considered.

One suggestion for the most effective direction for energy conservation and production at waste cleanup sites is to create tailored checklists that apply to individual technologies. Energy efficiency items extracted from the USACE RSE checklists are included in the following sections.

General

- Determine if the treatment operation is still necessary or whether influent concentrations have decreased such that operation can be terminated.

- Are more cost-effective treatment alternatives available to meet treatment requirements? Any modifications should be based on present worth analysis compared to operating cost of the current system.

- Electrical rates are often based on peak loads. The higher the peak load, the higher the electrical rate per kWh. Thus, reducing the peak load may reduce electrical energy costs. Contact the electrical utility for rates. Peak loads can be reduced by sequencing motor startups, doing high energy batch operations separately, using variable frequency motor drives on wells that start at low frequencies and increasing frequency slowly to reduce peak load during startup, starting up large pumping wells separately, shutting down pumping wells during peak load hours if the cone of depression can be maintained without operating the wells 100 percent of the time or by pumping more during off-peak hours each day, lowering building lights in unoccupied process areas, and monitoring building air for compliance with OSHA standards to see if air exchanges in the building can be reduced.

Metals Precipitation

- Are mixing rates the same as those in the design specifications? Perform mixing calculations to see if mixing energy can be reduced and still meet treatment requirements. During some RSE inspections, metals precipitation units were treating only iron and/or calcium to prevent fouling of downstream equipment. In these situations, bypassing the unit completely or installing a less expensive method of removing or sequestering the iron and calcium may be evaluated.

Activated Carbon Adsorption Units

- If spent carbon is regenerated on site, can energy be saved? Are the inlet gas flow rates the same as those in the design specifications?

- For vapor phase granular activated carbon (GAC), calculate the gas loading rate and verify that it is less than 80 cfm/sq ft (preferably between 20 and 60 cfm/sq ft). For liquid phase GAC, calculate the liquid loading rate (normally 1–7 gpm/cu ft). (Higher loading rates will cause high pressure drop and high energy use.)

- How are the carbon beds monitored for contaminant breakthrough to determine when regeneration is necessary? (Changing carbon beds before they break through will require more energy to regenerate them or more energy to manufacture new carbon. Accurate monitoring and estimation of carbon bed breakthrough should be part of the system, so as to get full use out of the beds).

- Have concentrations in the influent to the bed dropped enough to allow the beds to be shut down?

- When two GAC vessels are configured in series, the lead vessel can usually be allowed to breakthrough, as the lag vessel will prevent unacceptable levels of contaminants from being released in the effluent.

Air Stripping

- Determine if the air stripper operation is still necessary, or whether the influent concentrations decreased so that the operation can be terminated.

- Are the liquid and vapor flow rates the same as those in the design specifications? Perform air stripper design calculations and check the manufacturers design information to see if the air rate can be reduced and still meet the desired treatment requirements. The air rate can often be reduced if the water flow rate has decreased.

- Compare the present air emissions to the regulatory limits to determine if the off-gas treatment (carbon, thermal oxidation, *etc*.) can be reduced or discontinued.

Vapor/Off-Gas Blower and Piping System

- A poor match of blower capacity and required flow rate will affect process efficiency and performance. O&M costs of a blower and associated off-gas treatment may require a significant long-term financial commitment.

- Are the flow rates appropriate for effective remediation in the current circumstances? Check the submissions to verify that the blowers or fans are appropriate for the conditions.

- Are any blowers throttled down to nearly shut-off to achieve the required flow rate? (Severely throttled blowers operate less efficiently and may require more maintenance.)

Vapor Extraction Subsurface Performance

- Are monitoring points distributed adequately to determine vacuum distribution, flow paths, or containment? Incorrectly distributed vacuum wells may result in more air flow than is needed for adequate vapor capture.

Filtration System Performance

- Have contaminants or contaminant concentrations in the water stream changed to the extent that other treatment alternatives are more energy efficient?

Groundwater Extraction System Subsurface Performance

- Is the pumping properly distributed to capture the plume with minimum total volume of water for treatment? (Poorly distributed pumping may result in more energy use than is needed to contain the plume.)

- If the cleanup objectives have not yet been met, but an asymptote reached, has mass removal been sufficient to allow the extraction system to be turned off and monitored natural attenuation used to achieve the cleanup objective?

Bioventing Subsurface Performance

- Are the pressure/vacuum distributions consistent with design predictions? Does the pressure/vacuum distribution (in three dimensions) indicate good oxygen delivery and prevention of migration to potential receptors? Is the air injection or extraction properly distributed among the wells to optimally treat the target zone effectively? Improving the distribution may increase the amount of energy needed.

- Has the system been evaluated to determine if blowers can be replaced by a passive bio-venting system? The Department of Defense, under the Environmental Security Technology Certification Program, funded a demonstration of such a system where natural pressure drives the system.**(17)**

Landfill Off-Gas Treatment

- If the landfill gas supplied to the thermal oxidation unit is approaching the lower operating limit for methane concentration or if the gas generation rate has decreased significantly, consider the following to reduce energy use: vent the landfill gas to the atmosphere, if permissible; replace the thermal oxidizer with a smaller or more efficient unit; determine if retrofit and replacement of the burner with a small unit is feasible; determine if the carbon units are still required, or if the flare unit alone can provide the required destruction efficiency.

- Is there enough landfill off-gas to capture and use as a fuel? Is there a market to make energy production economically viable? Would the future land use for the site allow for siting of photovoltaic arrays for possible energy generation? (See case study in Section 4.1).

In-Situ Air Sparging Subsurface Performance

- Has the system reached its cleanup objectives? Is the operation still necessary or have the concentrations decreased so that the operation can be terminated?

- If the cleanup objectives have not yet been met, but an asymptote reached, can the system be turned off and monitored natural attenuation be allowed to achieve the cleanup objective?

- Is the air flow unevenly distributed among the various wells in a multiwell system? Improving the distribution may decrease the amount of energy needed. Uneven distribution may be due to incorrect flow control valve settings, differences in depth of water in various wells, well clogging, inconsistent well construction, or significantly different pressure drops in certain piping legs.

Advanced Oxidation Technologies

- Can any of the UV lamps be turned off without reducing treatment efficiency?

- Do any of the lamps need to be replaced? Lamp life varies based on the type of lamp used. The low-wattage lamps typically have a useful life of one year. Medium-pressure and medium-pressure doped lamps have a useful life of less than six months. Although the lamps may still be operable, they may lose the ability to emit light at the wavelengths necessary to oxidize the contaminants.

Extraction, Injection, and Monitoring Wells Performance

- Poor well performance can result in increased energy costs. This poor performance can be caused by poor selection of well location or screened interval, poor screen design, selection of inappropriate well construction materials, poor construction, ineffective development, and inappropriate pump selection.

Vapor Thermal Oxidation Performance

- Evaluate replacing a simple thermal oxidizer or flare with a catalytic reactor if the vapor treatment will continue for a long time. This permits oxidation at a lower operating temperature and uses less auxiliary fuel. Initial costs are high, so the advantages and disadvantages must be evaluated carefully before replacing the existing unit.**(18)**

4.6 Analyzing Energy Related Problems

In Europe, graphical tools called "Sankey Diagrams" are widely used to visualize energy balances. In other words, they are used to display energy flows and quantitative process relationships. The purpose of the diagram is twofold:

- To show how much relative quantities of energy are being used by the system, and
- To provide the user with potential opportunities for making energy-saving changes by concentrating on the most energy intensive activities.

The end result is a thorough understanding of all the process steps and their interrelationship. Sankey diagrams have proven to be an outstanding tool in environmental technology projects for analyzing material and energy related problems.

Sankey diagrams help to easily identify where energy needs originate, where the maximum consumption is directed, and where the place for changes with maximum impact in the system exists.

The flows can also be partitioned according to their end use. At each partition, some of the resource flow may be lost as waste or leakage. The ratio between the input resource flow and the useable output is a measure of the primary efficiency of the resource system.

When resources are partitioned into end-uses, calculating a secondary or "eco-efficiency" is possible. This refers to the ratio of useable input to the total use value (or service) provided by the system. Use-value is reduced by waste or leakage; it is increased to the extent that the resource flows incorporate looping or cascading of flows (*i.e.*, the recycling or reuse of the resource by the same or other end uses).

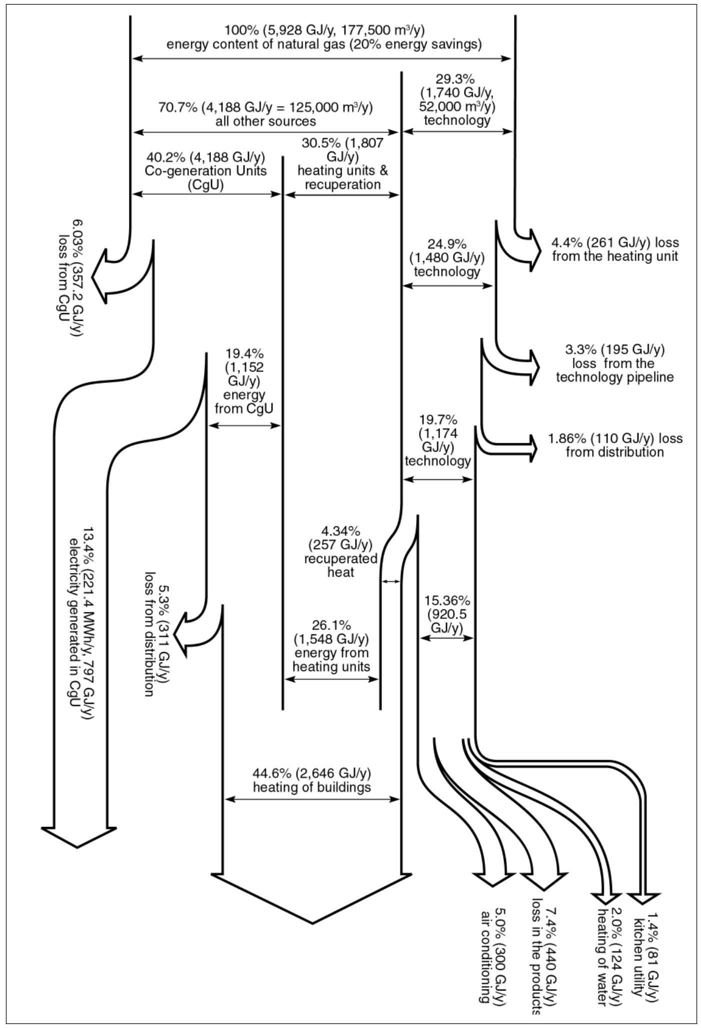

FIGURE 6 — Example Sankey Diagram

Software is available to help draw a Sankey diagram. It can be one of the tools used by the project manager to analyze the energy flows at waste cleanup sites. Sankey diagrams allow you to visualize cost information as well. The Sankey diagram in Figure 6 could represent a complete treatment system and its power needs. It illustrates the small and large flows of energy resources or cost, according to the functional input (*e.g.*, well motors, air strippers, lighting, *etc*.), and can be used to increase system conservation. By observing the energy needs of the input and output requirements from a top level view, a system operator might be able to make appropriate changes to the energy load to reduce energy needs without affecting required outputs.**(19)**

5.0 Summary

Information and tools are available for successful implementation of energy conservation and production at waste cleanup sites. Four case studies were presented, including three Superfund sites, to illustrate consideration of energy efficiency at remedial sites. A number of findings were compiled.

In addition to the energy saving opportunities observed at the three visited sites, there also may be a number of opportunities for energy production at waste sites. Depending on the waste site characteristics, these energy production opportunities may include methane gas collection at landfills, geothermal production, wind turbine generation, or the use of waste cleanup site land (*e.g.*, landfill surface) for the staging of photovoltaic arrays.

5.1 Site Visit Findings

The site visit findings, which are qualitative, can be summarized as follows:

- Greater awareness and skill building for improved performance will be required to achieve improvements.

- An integrated, life cycle perspective is needed. The designer of a waste cleanup system should work closely with the end-user or operator of that system to ensure efficient energy use by the system.

- Energy use may not be the driver for cost savings, but should be considered in a broader evaluation. Although waste remediation systems can be quite costly, the energy piece appeared to be "relatively small" at the two groundwater sites.

- As a result of case studies presented here, the present state of considering energy production or conservation at waste cleanup sites appears underused. Energy efficiency at these sites may be achieved by implementing various regulatory, communication, and economic measures.

6.0 Acknowledgments and Contacts

This paper has been written to help project managers and others become aware of the need to consider energy efficiency at waste cleanup sites. It is a first step in conserving and possibly producing energy at waste cleanup sites.

Compiling this information was an effort for which many people should receive credit. Mr. Ed Mead brought ideas from USACE on incorporating energy audits into existing RSE checklists. Thanks are also in order to members of the Superfund Forums and especially to the Engineering Forum, which accepted the original proposal. In particular, thanks to the individuals from throughout U.S. EPA and the U.S. Army Corps of Engineers who took the time to review this issue paper, including Jon Bornholm (Region 4), David Burden (NRMRL-Ada), Charles Coyle (USACE), William Crawford (USACE), Ed Finnerty (Region 2), Rene Fuentes (Region 10), Derrick Golden (Region 1), Timonie Hood (Region 9), Sven-Erik Kaiser (OSWER), Ivars Licis (NRMRL-Cincinnati), Kelly Madalinski (OSWER), Ed Mead (USACE), Kendra Morrison (Region 8), Martha Otto (OSWER), Nancy Porter (OSWER), and Lance Richman (Region 9).

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APPENDIX A: Example of Audit Protocol

Energy Conservation and Production at Waste Cleanup Sites
for Fund-Lead Superfund Sites
(Audit Protocol)

Background

Facility/Site Name: ___________________________
Street Address: ______________________________
City: ______________________________________
State, Zip: __________________________________
Phone: _____________________________________

Total Site Size (acres): _________________________

Site Contact: _________________________________
Position/Responsibility: ________________________
Employer: ___________________________________

RPM Name: _________________________________

Phone No.: ___________________________________

Principal Contaminants Present: ____

Human Health/Environmental Threats: ____

Summary of Site Conceptual Model: ____
____
____
____

System Goals and Exit Strategy: ____
____
____

General Remedial Strategies Employed

Source Control: ____
Groundwater Plume Capture: ____
Groundwater Treatment: ____
Effluent Management: ____
Air Pollutant Emissions Management: ____________________________________
Treatment Residue Management: ____
Monitoring: ____
Other: ____

Health & Safety Plan required? ____

<u>Site Visit</u>

Visit Leader: ____________________

Affiliation: ____________________

	Day 1	Day 2
Date:		
Auditor Name:		
Time of Arrival:		
Weather Conditions:		
Hazards Present?		

Site Visit Participants:

Name:					
Affiliation:					
Comments:					

Initial Meeting Comments: ____________________

Walk-Through Observations: ____________________

General Site Conditions	***Yes***	***No***	***Comments***
Equipment is in good repair?			
Access controls in place and effective?			
Site free of trash and uncontrolled materials?			
Site personnel appear to be knowledgeable of all major site conditions/issues?			
Equipment and processes are consistent with site background documents and periodic reports?			

Site Staffing and Operation

No. full-time remedial systems operators: ________ Name(s): ____________________
Daily commuting distance and travel mode(s): ____________________
Vehicle miles traveled/day: ____________________

No. part-time remedial systems operators: ____________________
Periodic commuting distance and travel mode(s): ____________________
Vehicle miles traveled/month: ____________________

Buildings and other Permanent Structures

Building No. / Name	Purpose(s)	No. floors	Total Area (sq. ft.)	Year built/ renovated	Scheduled Occupation (days/hrs.)

Building Systems

Building/Structure No./Name:							
System/Function	**Major Components**	**Makes/ Models**	**Capacity/ Size**	**No. Units**	**Power Requirement/ Output**	**Energy/ Power Source**	**Hrs. Used/ day**
Building shell (walls, roof, insulation, windows, doors)							
Heating							
Cooling							
Ventilation							
Lighting							
Hot water							
Potable water							
Sanitary waste							

Are ENERGY STAR products being used? _________ Where and for what? ___________________________
Are EO 13123 goals being considered/actively pursued? ____
Has an energy audit been performed? ____
Have energy efficient doors and windows been installed? ____
Do the buildings feel drafty? __________________ Stuffy? ____
Does the illumination seem adequate? ____
What is the approximate plug load of equipment & machines in each building? ______________________

REMEDIAL SYSTEM DESIGN AND OPERATION

Source Control

Are activities consistent with strategy? __________ Percent complete: ________%
If not, explain: ____
____

Material Removal

Material Removed: Off-site?	Moved	Rate (tons/mo.)	Cumulative (tons)

Material Movement/Transportation Methods & Equipment

Equipment Type	Make/Model	Capacity	Engine Size/Power	Hrs. Used/day

Off-Site Management

Material Transported: Name	Destination (City/County)	Location	Distance Required? (miles)	Permit

On-Site Source Control Technologies

Strategy (circle one): SVE Soil Washing Stabilization Capping Run-On Diversion Other _________

Major Component Type	Make/Model	Capacity/ Size	No. Units	Power Requirement/ Output	Hrs. Used/ day

Groundwater Plume Capture

Strategy Employed:____

____

Active / Passive (circle one) Stage of Implementation/Percent Complete __________________________

Plume Containment through Groundwater Pumping

Well No.	**Pumping Rate (gpm)**		**Destination**	**Distance from Well (ft)**	**Elevation Change (ft)**
	Design	**Actual**			

Disposition of Extracted Water: ____

____

____

Other Containment System Components					
Component Type	**Make/Model**	**Capacity/Size**	**No. Units**	**Power Requirement/ Output**	**Hrs. Used/ day**

Groundwater Extraction for Treatment

Well No.	**Pumping Rate (gpm)**		**Hrs. Pumping per Day**	**Distance to Treatment Unit(ft)**	**Elevation Change to Treatment Unit (ft)**
	Design	**Actual**			

Pumps, Motors & Other Equipment Used						
Major Component Type	**Wells Served**	**Make/Model**	**Capacity/ Size**	**No. Units**	**Power Requirement/ Output**	**Hrs. Used/ day**

Are valves throttled to control primary flow? ______
Are normally open pump bypass line(s) used for flow control or pump minimum flow protection? ______
Are multiple parallel pumps in place and number of operating pumps seldom changes? ______
Is a batch or cyclical start/stop system used with frequent pump cycling? ______
Is there significant cavitation noise at the pump or in the system? ______
Are system head or flow changes occurring? ______ Should they? ______
Are variable speed drives installed? ______ % of total ______
Are variable frequency motors installed to power the pumps? ______ % of total ______

Groundwater Treatment

Description of Treatment Train: ______

Equipment Used						
Major Component Type	**Wells Served**	**Make/Model**	**Capacity/ Size**	**No. Units**	**Power Requirement/ Output**	**Hours Used/Day**

What is the rate/throughput limiting step or component? ______
Which components are used in parallel? ______
Which are redundant/used for surge capacity or emergencies? ______

Effluent Management

Description of effluent management scheme: ____
____

Disposition	Quantity		Units	Discharge Point	Distance to Discharge Point (ft.)	Elevation Change to Discharge Point (ft.)
	Design	**Actual**				
NPDES outfall						
Reinjection						
On-site use						
Storage (specify) ____________						
Other (specify)						

Conveyance Equipment

Pumps, Motors & Other Equipment Used						
Major Component Type	**Wells Served**	**Make/ Model**	**Capacity/ Size**	**No. Units**	**Power Requirement/ Output**	**Hours Used/day**

Air Pollutant Emissions Management

Description of air emissions management scheme: ____
____
____

Control Method(s) (circle all that apply): Air Stripping GAC Filtration Cyclones Thermal Oxidation Other (specify) __________						
Component Type	Contaminant(s) Removed	Make/Model	Capacity/ Size	No. Units	Power Requirement/ Output	Hrs. Used/ day

What is the rate/throughput limiting step or component? ____
Which components are used in parallel? ____
Which are redundant/used for surge capacity or emergencies? ______________________________
Are valves throttled to control primary air flow? ____
Is a batch or cyclical start/stop system used with frequent pump/compressor/fan cycling? __________

Are variable speed drives installed? __________ % of total ______________________________
Are variable frequency motors installed?________ % of total ______________________________

Treatment Residue Management

Description of treatment residue management scheme:

Residue Name/ Type	Generation Point	Generation Rate (tons/month)	Hazardous Waste? (Yes/No)	Disposition on Site? (Where?)

Residue Management Methods

Residue Name/Type	Method(s)	Purpose	Typical Impact

Residue Management Equipment

Equipment Type	Make/Model	Capacity	Engine Size/Power	Hrs. Used/day

Off-Site Management

Material Transported: Name	Destination (City/County)	Location	Distance Required? (miles)	Permit

Is interim storage used? ______________________ Duration? ________________________________
Location & Methods? ____
Is material/energy recovered? ____
On-site disposal unit features ____
____

Environmental Monitoring

Groundwater Monitoring

No. wells ________________________ Frequency of Sampling ______________________________
Parameters evaluated ____
Shipping location, distance, and method for off-site lab analysis _______________________________
____

Pumps, Motors & Other Equipment Used						
Major Component Type	**Wells Served**	**Make/ Model**	**Capacity/ Size**	**No. Units**	**Power Requirement/ Output**	**Hrs. Used/day**

Monitoring of Other Environmental Media

Medium	Parameters Evaluated	Sampling Method(s)	Sampling Location(s)	Sampling Frequency	Analysis Method(s)

Powered equipment used: ____
Shipping location, distance, and method for off-site lab analysis: ______________________________
____

General Site Conditions and Practices

Process/Equipment Use and Interactions

Is heat recovery employed? ______ Heat recovered from ______________________
Recovered heat used for ____________________ at ______________________
Which processes/equipment are operated in batch mode? ______________________
Which processes/equipment are operated continuously? (24/7) ______________________
Which are operated?:

1st shift only: ______________________
Overnight/weekends ______________________
Instantaneously on demand ______________________
When convenient ______________________

Operating Parameters and Costs

Are system components metered separately? ____________ If so, which ones? ______________________
Has training on energy efficiency practices provided to designers & operators? ______________________
Have energy performance/cost goals and metrics been established? ______________________
Are energy metrics normalized to throughput? ______________________
Are energy bills reviewed and analyzed? ______________________
Are energy consumption and cost trends monitored & investigated? ______________________
Have equipment/system O&M schedules been developed? ______________________
Does documentation exist showing that they have been followed? ______________________
Is outsourced energy management (*e.g.*, through a Super ESCO or UESC) available? ________________

Equipment Procurement Practices

All equipment purchased new? _____________ If not, note exceptions ______________________
____
Motor Master used to spec motors/ define operating conditions? ______________________
Other DOE OIT or other diagnostic tools used to specify equipment size/characteristics? ______________
____
Energy Star or equivalent (top 25%) equipment specified? ______________________
Outsourced energy mgt. (Super ESCO/UESC) considered? ______________________

Performance Data

Operating hrs./mo. for overall treatment system: ______________________
No. of regulatory excursions: ______________________

Monthly electricity use (kWh): ______________________
Monthly gas use (cu. ft.): ______________________
Monthly energy costs ($): ______________________
No. of NOVs: ______________________
% of design optimum: ______________________

APPENDIX B: Resources

<u>Existing Relevant Data and References</u>

Remedial Design/Remedial Action Handbook
U.S. EPA, Office of Emergency and Remedial Response, Washington, DC.
EPA 540-R-95-059, OSWER-9355.0-04B, 317 pp, June 1995.
www.epa.gov/superfund/whatissf/sfproces/rdrabook.htm

Comprehensive Five-Year Review Guidance
U.S. EPA, Office of Emergency and Remedial Response, Washington, DC.
EPA 540-R-01-007, OSWER Directive 9355.7-03B-P, 60 pp, June 2001
www.epa.gov/superfund/resources/5year/index.htm

<u>Federal Government Websites</u>

The following list of websites provide online, readily available sources of information and technical assistance concerning energy efficiency and energy production technologies that may be of interest at all waste cleanup sites. These websites were accurate as of January 26, 2004.

The listing provides for each site a brief description, specific features of interest, as appropriate, and an indication of the site's overall utility for the purposes of energy efficiency at remedial sites.

Information is furnished on the following topics:

- Federal agency energy efficiency/production programs
- General interest energy efficiency industry and public sector programs, partnerships, and consortia
- Technology-specific sites (solar, geothermal, wind, other)
- Energy service companies and utility performance contractors
- Relevant state and EPA regional energy-related web sites

<u>U.S. Environmental Protection Agency</u>

www.epa.gov	Main website for U.S. EPA
www.epa.gov/cleanenergy/	Website for EPA's Clean Energy Program. Basic information on alternative energy resources, including solar, wind, biomass, geothermal, and hydropower, and links to relevant websites. Case studies of federal facilities using or developing clean energy technologies.
www.epa.gov/chp	This webpage described a voluntary EPA program called "Combined Heat and Power" or CHP, a partnership which "seeks to reduce the environmental impact of power generation by fostering the use of CHP." CHP is described as "a more efficient, cleaner, and reliable alternative to conventional generation."

www.epa.gov/globalwarming/actions/waste/w-online.htm

EPA created this webpage, called "WARM", to help solid waste planners and organizations track and voluntarily report greenhouse gas emissions reductions and energy savings from several different waste management practices. It employs a worksheet to describe the baseline and alternative MSW management scenarios that can be compared. You can enter material tonnage information and calculate landfill gas emissions information.

www.epa.gov/mswclimate/greengas.pdf

This file is a solid waste management tool that is titled "A Lifecycle Assessment of Emissions and Sinks."

<u>U.S. Department of Energy</u>

www.energy.gov	Main website for U.S. Department of Energy
www.eren.doe.gov/	Website of DoE's Energy Efficiency and Renewable Energy Network (EREN). Very comprehensive website covering energy efficiency and renewable energy for all interested parties, broken down into individual resource topics. Includes financing information for communities and states, technology descriptions, links to other relevant technical and government websites, and analytical tools.
www.eren.doe.gov/femp	Website for DoE's Federal Energy Management Program. Very comprehensive website primarily targeting federal agencies. Large section on technical assistance, including analytical tools, building design, and energy guides. Includes information on the New Technical Demonstration Program (NTDP), technologies index, and federal facilities success stories.
rredc.nrel.gov	Website for Renewable Resource Data Center (RReDC), supported by DOE. Website includes information on biomass, geothermal, solar radiation, and wind energy resources, as well as dynamic maps of renewable energy resources that determine which energy technologies are viable solutions throughout the United States. Each resource section has software models, databases, and links to other relevant sites.
www.eia.doe.gov	Website of the Energy Information Administration. Website contains official energy statistics about energy demand, use and production in the United States from the U.S. government. Very useful when energy use statistics are needed. Statistics grouped by geography, fuel, sector, and price.
www.pnl.gov	Website for the Pacific Northwest National Laboratory. Includes information on innovative energy projects. Sections on energy and

	engineering, fuel cell technology, and the Decision Support for O&M software program to determine equipment efficiency.
www.nrel.gov	Website for the National Renewable Energy Laboratory. Very comprehensive website with information on many energy resources. Describes recent research projects and programs. Links to the Center for Building and Thermal Systems, which has information on building materials, geothermal, solar energy, test sites, publications access, and computer models for energy analyses.
eande.lbl.gov	Website for the Lawrence Berkeley National Laboratory (Energy and Environment Division). Contains detailed information on the research conducted at LBNL, as well as reports on energy use. Includes a Building Technologies Program, which focuses on building illumination and includes building energy analysis tools.
www.sustainable.doe.gov	Website for DoE's Smart Communities Network website. Focuses on sustainability. Topics covered include green buildings and financing, including links to active funding opportunities throughout the country. Includes many case studies of successful green buildings.
www.oit.doe.gov	Website for DoE's Office of Industrial Technologies. They work in partnership with U.S. industry to develop and deliver advanced technologies that increase energy efficiency, improve environmental performance, and boost productivity.
www.eere.energy.gov/inventions/	Also under DoE's Office of Industrial Technologies, the Inventions and Innovation (I&I) program provides financial assistance at two levels—up to $40,000 (Category 1) or up to $250,000 (Category 2)—for conducting early development and establishing technical performance of innovative energy saving ideas and inventions.

<u>Other Federal Websites</u>

www.energystar.gov	Website for the Energy Star Program. Energy Star products for home and office applications are listed here. Includes products for lighting, HVAC, windows, roofing.
www.gsa.gov	Website for the GSA. Click through "Public Buildings" under "Buildings" and "Energy Management" under "Services" to discover a wealth of energy resources and resources available to public facilities. Promotes cost-effective and environmentally friendly utilities. Contact information provided, as well as links to related websites, publications, policies, and recent news.

www.denix.osd.mil/denix/Public/Library/Climate/ec.html

Website for the DoD's Defense Environmental Network and Information Exchange (DENIX) for Energy Conservation. List of relevant documents, presentations, and resources on DENIX.

www.hq.nasa.gov/office/codej/codeje/je_site/energy/about_energy.html

Website for NASA's Energy Efficiency and Water Conservation (EEWC) Program. Promotes saving water and energy and reducing costs. Site includes links to regulations, NASA policies, training courses, agency contacts, and other energy links.

General Energy Websites

www.crest.org

Website for the Renewable Energy Policy Project and the Center for Renewable Energy and Sustainable Technology (REPP-CREST). Has information about renewable energy, efficiency, and sustainable development. Separate sections for policy, hydropower, bioenergy, geothermal, wind, solar, hydrogen, and efficiency. Also contains links, FAQs, policy reports, and discussion groups.

www.ems.org/energy_policy/recycling.html

This website from a non-profit that provides journalists with information on environmental issues provides ideas on energy savings from recycling.

www.ase.org

Website for the Alliance to Save Energy (ASE), a non-profit coalition of business, government, environmental and consumer leaders. Targets consumers and energy industry, among others. Website contains technical papers and energy use checklists, as well as home and business energy checkup software.

www.advancedbuildings.org

This website is supported by a consortium of government and private organizations. Geared towards building professionals to improve the energy and resource efficiency of buildings. This is a Canadian website, but includes both American and Canadian manufacturers and information sources.

www.epri.com

Website of the Electric Power Research Institute (EPRI). Website focuses on global energy customers. Details research projects and project opportunities.

www.efficientwindows.org

The Efficient Windows website, sponsored by DOE's Windows and Glazing Program. Website provides information on and recommendations for energy-efficient windows.

Solar Energy Websites

www.solarenergy.net	Website for the Solar Energy Network. Website has links for solar products, including pumps and electric systems.
www.solarbuzz.com	Website for Solarbuzz, which is comprised of staff members of solar energy companies. Website includes solar energy news, information on solar products, financing and payback time calculators, and solar energy research topics.
www.ases.org	Website for the American Solar Energy Society (ASES). Website is mainly a vehicle to purchase solar energy publications.
www.solarenergy.org	Website for Solar Energy International (SEI). Primary focus is conducting workshops promoting solar energy.

Geothermal Energy Websites

geoheat.oit.edu	Website for the Geo-Heat Center. Website contains a wealth of information regarding geothermal resources, including maps, software, articles, and a directory of equipment manufacturers.
www.geoexchange.org	Website for the Geothermal Heat Pump Consortium (GHPC), which is a collaborative effort between the DoE, the EPA, and private sector organizations. Website has residential and commercial geothermal case studies and brochures, as well as installer information.
www.igshpa.okstate.edu	Website for the International Ground Source Heat Pump Association (IGSHPA). Focuses on ground source heat pump technology. Includes lists of installers, products, conference information, and FAQs.
www.geothermal.marin.org	Website for the Geothermal Education Office (GEO). Website focuses on geothermal energy education. Includes worldwide map of geothermal resources. List of other geothermal websites.

Wind Energy Websites

www.awea.org	Website for American Wind Energy Association. Website contains a wealth of information regarding wind energy, including maps, articles and reports, and project lists.
www.nrel.gov/wind	Website for the National Wind Technology Center. Includes the Wind Resource Assessment Handbook, wind maps, climatic data, case studies, and standards.
www.nationalwind.org	Website for the National Wind Coordinating Committee (NWCC). Website contains wind policy and technical papers, as well as technical assistance.

Other Renewable Energy Websites

www.fuelcells.org — This website is an activity of the Breakthrough Technologies Institute/Fuel Cells 2000. Website features a large amount of information regarding the use of fuel cells.

Energy Service Companies (ESCOs) and Energy Service Performance Contractors (ESPCs)

www.eren.doe.gov/femp/financing/espc.html

This website is the starting point for federal facilities to learn more about ESPCs. Website contains an overview of the program, FEMP assistance programs, contract tools, and case studies.

www.eren.doe.gov/femp/financing/espc/doe_qualified_escos.html

This website contains a list of DOE-qualified ESCOs that is frequently updated. The list contains contact information for all the ESCOs.

www.eren.doe.gov/femp/financing/espc/super_espc_escos.html

The energy service companies (ESCOs) that competed for the indefinite delivery, indefinite quantity (IDIQ) Super Energy Savings Performance Contracts (Super ESPCs) are listed here, by region and by technology.

State/EPA Regional Energy Websites

www.eren.doe.gov/state_energy/index.cfm

Website for DoE's EREN State Energy Incentives. Website looks at each state's renewable energy resources, technologies, and policies. Links to each state's energy office and regulatory commission.

www.naseo.org — Website for the National Association of State Energy Officials. Website includes links to every state government's energy office, and highlights pertinent energy issues.

www.energyideas.org — This website is a service of the Energy Ideas Clearinghouse (EIC). Focuses on the northwestern US, but has a comprehensive list of relevant websites, as well as research project information.

www.energy.iastate.edu — Website for the Iowa Energy Center. Website contains some educational articles. Mainly geared towards state residents. Very comprehensive list of energy-related website links, including many governmental sites.

www.energy.ca.gov — Website for the California Energy Commission. Geared toward state residents. Comprehensive list of state renewable energy programs. Includes estimated equipment and operating costs of various energy systems.

www.ciwmb.ca.gov/Organics/Conversion
This webpage, from the State of California's Integrated Waste Management Board, describes various biomass-to-energy and conversion technologies.

www.ecw.org — Website of the Energy Center of Wisconsin. Website has comprehensive information packages for various energy resource topics.

www.state.sc.us/energy — Website for the South Carolina Energy Office. Information on energy projects in residential, commercial, and public sectors, including case studies and financial assistance.

www.idwr.state.id.us/energy — Website for Idaho Energy Division. Includes contact information for alternative energy projects that includes technical assistance and loan programs. Also has section on energy efficiency.

www.deq.state.mt.us/energy/index.asp
Website for Energize Montana. Includes sections on energy efficiency for government entities, such as financing and utility cost savings, as well as renewable energy financing and technical information.

www.energy.cted.wa.gov/ — Website for Washington State Energy Policy Division. Includes technical publications as well as links to other state and regional energy websites.

www.epa.gov/NE/topics/envpractice/eefficiency.html
Website for EPA Region 1 (New England) - Energy Efficiency. Links to reports on energy efficiency from region and nation.

www.epa.gov/region02/p2/ — Website for EPA Region 2 – Pollution Prevention. Includes links to technical resources, projects, and grants in the region promoting energy efficiency.

www.epa.gov/reg3p2p2/building.htm
Website for EPA Region 3 (Mid-Atlantic) – Green Buildings. Links to other websites with green building information and products.

www.epa.gov/Region5/sue/index.htm
Website for EPA Region 5 – Sustainable Urban Environments. Links to reports on funding opportunities and a green building resource guide, which itself contains many links to energy efficiency sites.

www.epa.gov/Region7/p2/index.htm
Website for EPA Region 7 – Pollution Prevention. Links to the Green Rider Pack, a document that provides information on EPA programs that promote energy efficiency, as well as links to other federal websites.

www.epa.gov/Region8/conservation_recycling/index.html

Website for EPA Region 8 (Mountains and Plains) – Conservation, Recycling, and Pollution Prevention. Mainly contains list of external websites regarding energy efficiency.

www.epa.gov/region09/cross_pr/energy

Website for EPA Region 9 (Pacific Southwest) - Energy Issues in the Pacific Southwest. Links to other websites with energy policy and education issues.

yosemite.epa.gov/r10/oi.nsf/0/3d5de9da58cceb7288256981007cd907?OpenDocument

Website for EPA Region 10 (Pacific Northwest) – Sustainability. Contains information for various types of energy users and makes suggestions to increase efficiency. Links to regional financing programs, as well as successful case studies.