Guidelines

10--2012

Reducing Solvent Use from Parts Washers

Background/Rationale:

Many businesses have facility or vehicle maintenance departments that make frequent use of parts washers or use large volumes of solvents that could be reduced or recycled/reused rather than be disposed of as hazardous waste. The majority of older model parts washers use toxic cleaning solvents which are hazardous materials and which must be used and disposed of carefully to avoid harm to employees and/or the environment. Many of these solvents contain volatile organic compounds (VOCs) that contribute to poor air quality, may be harmful when inhaled, and which may pose a fire hazard. Any business seeking to reduce liability and to make operations more sustainable should consider using a series of best management practices regarding parts washers, and changing to aqueous based parts washers or recycling large volumes of solvents. This will reduce waste disposal costs, reporting requirements, and improve the health and safety of the work environment. Reducing the use of hazardous solvents and their production will, in turn, help reduce greenhouse gas (GHG) emissions and any adverse environmental impact associated with excess emissions.

Some companies may find that employees are familiar and comfortable with older parts washer technology with solvent based cleaning, and that they may resist change, claiming that aqueous based parts cleaners don't work as thoroughly or as quickly as solvent based cleaners. Many improvements have been made in recent years to aqueous based technology and case studies of successful use abound. The benefits of eliminating use of toxic chemicals outweigh the barriers to change.

The material contained in these guidelines is intended for use by persons who have a basic level of technical training/competence and familiarity with source reduction concepts and strategies.

Step 1: Assess the Current Situation/Define the Scope of the Situation

1.1. Collect and analyze information about current operations, including but not limited to:

- identify key sources of information (see Appendix 1):
  - the environmental cause champion
  - maintenance, facility, and/or shop supervisor(s) or equipment users
  - purchasing or accounts payable personnel
  - key suppliers/vendors
- collect pertinent documents and information (see Appendix 1):
  - policies/procedures related to use of parts washers/solvents
    - formal/informal guidelines/expectations regarding use/disposal
  - purchasing and disposal invoices to determine annual amount/volume of solvent used and cost per year of operating each parts washer
  - equipment specifications
  - MSDS for solvent used

- keep track of, document and distinguish between key assumptions, known or reported data, and information which is calculated (see Appendix 1)
- conduct use and cost analyses by observing, interviewing staff, reviewing existing information and developing supplemental data (see Appendix 1):
    - determine type (filtering or recycling) and capacity of equipment
    - determine equipment energy use from review of the equipment specifications or monitoring with a plug-in power analyzer such as the Watts-Up Pro.
    - identify specific application(s) or purpose for equipment/solvent use (e.g., wheel bearings, fuel injectors, bicycle parts); who uses it for what purpose
    - determine annual number of uses per parts washer
    - determine kind of solvent used and characteristics of it (see MSDS sheet info)
    - determine annual volume/weight of product used and unit cost
    - conduct material balance analysis to determine annual volume of waste generated: amount evaporated/waste produced
    - identify frequency, volume, and costs associated with disposal of solvent (e.g., labor/time, fees, reporting, etc.)
- conduct life cycle assessment using reference material cited below to determine global warming potential impact of greenhouse gas emissions associated with product use, waste reduction and/or costs saved (see Appendix 3)

1.2. Conduct necessary research and calculations using the following useful material:

The following references are examples of those that can be of use to help identify full costs of using parts washers and hazardous solvents:

1. *Parts Washers*, Nebraska Department of Environmental Quality Environmental Guidance Document, 05-183, December 2005, available online at: http://www.deq.state.ne.us/ (type the document number into the search for PDF)

2. *Aqueous Parts Cleaning*, US EPA Department of Toxic Substances Control, Best Environment Practices for Auto Repair and Fleet Maintenance, November 1999, available online at: http://www.epa.gov/region9/waste/p2/autofleet/autoclean.pdf

The following reference(s) are used to calculate life cycle impact on greenhouse gas emissions for the wastes to be reduced as well as for the net impact of implementing alternative practices:

1. U.S. EPA' Pollution Prevention (P2) Greenhouse Gas (GHG) Calculator, available online through the National Pollution Prevention Roundtable at: http://www.p2.org/category/general-resources/p2-data-calculators/

2. U.S. EPA, Clean Energy. "eGRID 2007 Version 1.1." February 2009. Dowloadable ZIP file: eGRID20071_1year05_aggregation.xls, tab NRL05 and US05 available online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html#download

3. US EPA, Downloadable Document: "Unit Conversions, Emissions Factors, and Other Reference Data, 2004." Table I, Page 1 available online at: http://www.epa.gov/climatechange/emissions/downloads/emissionsfactorsbrochure2004.pdf

Step 2: Identify Feasible P2 Opportunities

2.1. In General:

- analyze the purposes for the use of the equipment and cleaning solutions and the characteristics needed that result in the choice of parts washers and solvents/solutions used
- research types of parts washers and cleaning solutions and include relevant vendor information (the vendor information included in these guidelines is for example only)
- keep track of, document and distinguish between key assumptions, known or reported data, and information which is calculated
- include a thorough cost analysis, comparing suggested modifications with current practices, and use a chart to compare current to proposed costs:
    - be specific on the "unit" for application, i.e. which uses or applications to modify
    - calculate amount/cost of annual product used and determine feasibility of using alternative aqueous product or equipment
    - calculate capital costs for switching to aqueous washers: supplies and labor
    - calculate possible maintenance costs
    - calculate pay back periods for return on investment
- look for hidden costs: contract surcharges, evaporative losses, regulatory fees, installation costs, training of employees in new system and waste management
- identify how to monitor/measure impact, e.g. monitor savings, follow up survey to determine user satisfaction

2.2. Selected strategies to consider, including techniques and calculations to perform:

- improve management of parts washers (see Appendix 2, Examples 1a-e):
    - conduct employee training
    - pre-wipe parts to remove excess grease or oil
    - close parts washer lid
    - test solid waste from parts washer
    - wear protective clothing while operating parts washer
- install an outlet timer if the parts washer uses electricity for any purpose (see Appendix 2, Example 2)
- reduce hazardous waste (see Appendix 2, Examples 3a-b):
    - install a solvent distillation/recycling unit
    - change from solvent based to aqueous based parts washer
- calculate life cycle impact on greenhouse gas emissions compared to current processes (see Appendix 3 for examples)

Step 3: Identify Barriers to and Benefits of Implementation for Each Opportunity

After analyzing the use of parts washers and how they are managed onsite, and identifying feasible opportunities for realizing savings and reducing exposure to toxic chemicals, you will want to make as strong a business case as possible for making changes to include the use of aqueous based parts washers and/or making improvements in managing existing solvent based washers.

Based on experiences over the past 15 years, the P3 program has found that simple projects with thorough documentation and short pay back periods or projects with compelling liability reduction or use of newer and improved technology have a greater likelihood of being implemented. For example, a suggestion for using the latest model of proven effective aqueous based parts washers in lieu of solvent based parts washers is now more likely to be implemented than in the past, when less effective solutions and equipment were available.

On the other hand, suggestions for which a cost/benefit analysis has not been fully documented or potential vendors have not been identified are unlikely to be implemented. Interestingly, even though savings and improved health and safety may be well documented, this opportunity involves changing employee behavior and perception of efficiency and effectiveness, therefore may not be implemented due to the employee resistance to change. Employers are typically sensitive to employees' perceptions.

Benefits of using aqueous based parts washers are decreased exposure to toxic VOCs, elimination of hazardous waste, decreased maintenance time/costs related to processing and reporting hazardous waste, and increased employee awareness of environmental stewardship. Perceived barriers include capital costs of replacing equipment, implementation logistics, and employee concerns regarding efficiency/effectiveness of alternative equipment/products. See Appendix 2 for examples of implemented P2 suggestions from the Nebraska intern program. These are annotated to make it clear what information is needed to perform these calculations for a different facility and to explain why some suggestions were implemented and others were not.

Common Barriers:

Beliefs & Attitudes

- resistance to change—employees set in ways and trust the efficiency and effectiveness of time proven solvent based parts washers
- other/higher strategic priorities—the company may have other issues is sees as more important to address in the short run
- misinformation or lack of understanding about how use of solvents affect the individual and the environment

Costs and Investments

- cost of purchasing new equipment
- time/costs for re-training employees in proper use of aqueous based parts washers

Technical Issues: What to Do and How

- amount of different/conflicting vendor information about parts washers can overwhelm
- concern re: managing logistics and employee responses to process changes
- concern re: quality of product/effectiveness of new application method

Common Direct and Indirect Benefits:

Company Image

- employees will experience a healthier/safer working environment
- demonstrates social responsibility and best management practices; improves/develops a positive public image, sets an example/sets pace for the industry

Cost Savings

- reduces costs
  - waste management contract eliminated
- reduces regulatory burden, time/money spent on compliance paperwork, and liability risk associated with the use and disposal of hazardous materials/wastes.

Education

- educates employees and general public in efficiency and responsibility when information is posted about the change and why it was made

Public Health and Environmental Impact

- reduces impact on individual employee health
  - eliminates toxic VOCs inhaled
- reduces impact on the environment:
  - reduces amount of harmful air and solid wastes generated
  - conserves/preserves/provides clean environment/quality of life for future generations

Step 4: Make the Business Case for Change

4.1. Develop a written report for submission to decision makers.

- include a thorough waste assessment with process descriptions, flow charts and material balance representations.
- outline specific P2 Opportunities/Suggestions with the following information:
  - recommended action
  - brief summary of current operations
  - cost of implementing recommendation: don't forget to consider labor costs and savings in your economic analyses.
  - summary of benefits:
    - potential cost savings ($)
    - waste reduction(s)
    - simple payback
    - indirect benefits: safety, risk/liability reduction, GHG reductions, etc.
- always identify how to monitor/measure impact for future analysis
- incentives to change: conclude the report with a summary of the benefits to be realized from implementing the recommendations made. Stress environmental stewardship. Call for action!
  - you may want to reference previous successes in similar businesses as a selling point.
  - see Appendix 2 for examples of similar projects which have been implemented

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4.2. Make an oral presentation to summarize your findings and call to action:

- focus on pertinent details of waste assessment and P2 opportunities
- make it interesting yet include sufficient technical detail to be convincing and make the business case for change—include a picture of the product/change in action
- develop a final "impact" slide with table of metrics—call for action/change
- allow time for question/answer period

4.3. Advocate for change based on metrics/facts and environmental ethic:

- use informal interactions to establish trust in your abilities and to build a foundation for change
- use written report and formal presentation to communicate your findings and provide the formal information/rationale for implementing recommendations
- emphasize sustainability (triple bottom line) and preserving resources for future generations—energy conservation and the relationship to greenhouse gas emissions is particularly important for compressed air system operations

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4.4. Report potential Greenhouse Gas (GHG) emission reductions as an important indirect benefit:

- include in written report and oral presentation
- include explanation of why GHG emissions are relevant/of concern to all businesses
- calculate potential carbon dioxide equivalent (CO_2e) emission reductions for each recommendation
- include an appendix in written report documenting calculations (see Appendix 3 for details and an example of calculations for aerosol can options)
- see Appendix 4 for additional tips for making the business case for change

Appendix 1
Example Waste Assessment for Parts Washer

Note: *An example of a waste assessment for parts washer use and waste is included below. It addresses one or more of the steps needed to accomplish a thorough assessment. We have attempted to clarify for the reader what information is known or reported, what is logically assumed, and what has been calculated. This is embodied within the example narrative for easy reference. In an actual report, many of these details would likely be in attached appendices so as not to interrupt the flow of the report.*

Example #1: Assessment of Parts Washer and Solvent Use

Currently, the facility has two solvent-based parts washers used to clean dirty vehicle parts. Each parts washer has a solvent capacity of 30 gallons. The parts washers are usually left open and are readily available to the 10 mechanics in the area whenever they are needed. An electric pump in the parts washer automatically and periodically cycles on to force the solvent through a mechanical filter to clean it. This "recycling" of the solvent can last from 1 to 5 minutes according to the mechanics and occurs usually once a week. Filtering occurs regardless of the frequency of use of the parts washer. The Safety-Kleen Premium Solvent used by the equipment, is filtered and recycled within the parts washer, reusing nearly 100% of the solvent, but some is lost throughout the process by being splashed or spilled during the washing of the parts, or some may remain on the parts, and some will evaporate. Safety-Kleen maintains the equipment and replenishes the solvent every 16 weeks. The material collected on the filter and the filter itself are disposed in the dumpster as part of the maintenance process. In one year 800 pounds of fresh solvent is purchased and 30 pounds of material is discarded in the landfill. The cost of this service is $2160/year. The Premium Solvent is filtered and recycled within the parts washer as shown below in Figure 1.

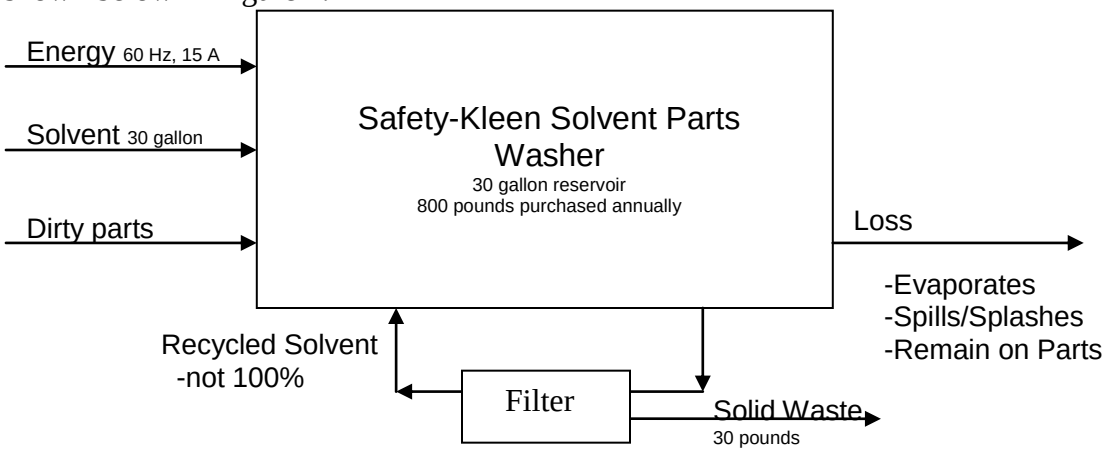

Figure 1: Flow Diagram for Safety-Kleen Solvent Parts Washer, Model 250

The Premium Solvent has a high flashpoint (148°F) and a relatively low flammability (2 on a scale from 0-4) but it does not qualify as completely non-hazardous. The Material Safety Data Sheet for Premium Solvent (#82658) can be found on the Safety-Kleen website (www.safety-kleen.com). The Premium Solvent evaporates into the air within the shop and has both acute and chronic health hazards. This evaporation is shown by the fact that Safety-Kleen has to add additional solvent periodically. Solvent evaporation is primarily due to the large exposed surface area during cleaning and the parts cleaner being left open between uses.

Appendix 2
Examples of P2 Opportunities for Parts Washers

Note: *Several examples opportunities for improving procedures related to the use of parts washers are included below. Each of these addresses a different way to improve practices and achieve direct and/or indirect savings and each uses different techniques for encouraging implementation. In these examples, calculations are embodied within the narrative for easy reference, although in an actual report, these would likely be in appendices at the end so as not to interrupt the flow of the report.*

Area #1: Improve management of parts washers (adapted from original work by Kate Johnson, 2008, and Matt Jensen, 2004; and reassessment reports by Aina Kekilova, 2012 and Patrick Stanley, 2009)

Example #1a: Conduct employee training

Conduct annual training on best practices/procedures and/or post reminder signs in parts washer area. Knowing how to properly use equipment and being occasionally reminded of best practices will reduce risks and increase safety.

Implementation Status: Implemented

The shop manager does address this issue in group supervision meetings with the mechanics. Posting reminder signs in the area would be an additional step that could be taken.

Key Benefits and Barriers: Implementation was straightforward, with no direct cost involved. Reductions in solvent use or costs were not quantified by clients.

Example #1b: Pre-wipe parts to remove excess grease or oil

By pre-wiping parts before placing them in the parts washer, the parts washer solvent will last longer. Reusable shop towels are recommended for pre-wiping. This simple suggestion can be implemented through supervision with employees or a reminder sign for employees near the parts washer.

Implementation Status: Implemented

The shop manager does address this issue in group supervision meetings with the mechanics. Posting reminder signs in the area would be an additional step that could be taken.

Key Benefits and Barriers: Implementation was straightforward, with no direct cost involved. Reductions in solvent use or costs were not quantified by clients.

Example #1c: Keep parts washer lid closed when not in use

Closing the lid on the parts washer when it is not in use would decrease the amount of solvent evaporating. This would lessen the odor during the filtering process and increase worker safety.

Implementation Status: Implemented

This suggestion is usually implemented, but employees are not 100% compliant. It is further suggested that this be addressed in supervision/training and that reminder signs be posted near the parts washers.

Key Benefits and Barriers: Implementation was straightforward, with no direct cost involved. Reductions in solvent use or costs were not quantified by clients.

Example #1d: Test solid waste from parts washer

To ensure that the solid waste disposed of with the filter is not hazardous and is safe to dispose of into the landfill, consider asking Safety-Kleen to test the solid waste for you, as part of their service plan. Testing could avoid potential regulatory compliance issues related to improper waste determination.

Implementation Status: Implemented

Safety Kleen is contracted with to manage this function.

Key Benefits and Barriers: Implementation was straightforward, with costs covered by existing contract. Reductions in solvent use or costs were not quantified by clients.

Example #1e: Wear protective clothing while operating parts washer

The solvent is hazardous in the parts washer and may cause damage upon contact with eyes and skin, wearing safety glasses and gloves would prevent harmful effects and increase worker safety.

Implementation Status: Implemented

Employees routinely wear personal protective clothing/equipment.

Key Benefits and Barriers: Implementation was straightforward, with no additional direct costs involved. Reductions in solvent use or costs were not quantified by clients.

Example #2: Install an outlet timer

The parts washer is currently left plugged in 24 hours a day, 365 days a year since the automatic recycling pump operates on a timed schedule. One simple solution to reduce energy usage would be to purchase a programmable outlet timer that would turn the parts washer off during non-work hours and weekends. According to measurements taken with the Watts-Up Pro Electricity Monitor**,** the parts washer uses 2467 kWh of energy when plugged in all year. It is estimated that a simple plug-in outlet timer could reduce this usage by one third. This will save **822 kWh.** At the electricity rate of $0.05/kWh, a savings of **$40 per year** could be realized. The payback period would be only **2.6 months.** All calculations are shown in below.

Calculation of Cost Savings and Potential GHG Reduction for Outlet Timer

Known Values:
--Example timer costs $8.99
--Measured electricity use equals 6760Wh/day (Watts-Up Pro Electricity Monitor)
--Cost of electricity = $0.05/kWh

Assumptions:
--Parts washer is plugged in 24/7 for 365 days/year
--Shop is operational for 8 hours/day
--Timer can reduce energy use by 1/3
--There is no labor or maintenance involved in installing the timer

Calculations:

--Cost of current energy use:

6760Wh/day x 365days/yr x 1kWh/1000kWh x $0.05/kWh = **$123/yr**

--Cost Savings:

1/3 x $123 = **$40/yr**

--Energy Savings:

1/3 X (6760Wh/day x 365days/yr x 1kWh/1000kWh) = **822 kWh**

--Simple Payback Period:

Capital cost / difference in operating costs

$9/$40/yr = 0.2 yr (**2.6 months**)

Implementation Status: Not yet reassessed to determine impact

Area #3: Reduce Solvent Use

Example #3a: Install a solvent distillation unit/recycler

Purchasing a recovery unit to save and reuse solvent will result in a reduced number of service visits required to keep the parts washer working. This recovery unit will eliminate the need to hire a company for regular cleanings, and represents a step towards pollution prevention within the garage facility. Implementation of this unit will allow a longer life of the solvent that is being used. The distillation process heats the used solvent until it evaporates. The vapors accumulate in a condenser and are separated into a drum. The collected solvent is then cooled down and is considered a 99% pure distillate. All the impurities that are removed from the solvent are collected in a bag that then can be sealed up and disposed of as general solid waste. By purchasing a recovery unit like the ones sold by Finish Thompson Solvent Distillation Equipment (www.finishthomson.com), the parts washer service contract with Safety-Kleen would be eliminated **saving $2,160 annually**, although an increase in electricity use will be realized.

Implementation Status: Not yet reassessed to determine impact

Note: In another project reassessed by Patrick Stanley, 2009, where a much larger volume of solvent was used in processing parts, a similar recommendation was made and **implemented.** A solvent recycler has been installed and the company reports saving approximately $28,000/year and 118,000 pounds of solvent from needing to be purchased and subsequently disposed.

Key Benefits and Barriers: Potential savings were well documented and implementing the recommendation was straightforward, although it did take several years for the company to budget for and implement the capital expenditure and to collect savings data (from suggestion in 2004 to implementation and subsequent reassessment in 2009).

Example #3b: Change from solvent-based parts washer to aqueous-based parts washer

There are several benefits to switching to an aqueous-based parts washer instead of the solvent based system currently in place. These benefits include reduction of air emissions and reducing employee exposure to hazardous chemicals. An aqueous-based parts washer also shows the continual commitment

by the facility to improve their environmental impact and reduce the use of toxic materials in the workplace.

Table 1 below outlines the cost of switching to an aqueous-based parts washer. The analysis compared the current method to switching to one 80 gallon aqueous-based parts washer serviced by Heritage Crystal Clean every 12 weeks. Information on the vendor and example washer can be found on their website at www.crystal-clean.com. Calculations are shown below.

Table 1. Current Parts Washer Costs Compared to Aqueous-Based Parts Washer

	Capital Cost	Annual Service Costs	Savings Compared to Current Annual Costs
Current Solvent Based Parts Washer	$0	$2,610/yr	
Purchasing Aqueous-Based Parts Washer -	$3,970	$1,830/yr	$780/yr
Leasing Aqueous-Based Parts Washer	$0	$2,770/yr	

Example Analysis/Calculations for Parts Washers

Current Cost of Using Safety-Kleen for Maintaining Solvent Based Parts Washer
--maintenance fee = $108.75 / month / unit
--facility currently owns two units
--cost of maintenance:
$108.75 / month / unit * 2 units * 12 month / year = **$2,610 / yr**

Cost of Purchasing Aqueous-Based Parts Washer from Heritage Crystal Clean
--initial purchase cost = **$3,966.30/unit**
--only one replacement unit will be needed
--service cost:
$423.15 for 12 wks = $423.15 / 12 wk * 52 wk / yr = **$1,830 / yr**

Payback Period for purchasing the aqueous-based parts washer
$3970/ ($2610/yr – $1830/yr) = **5 years**

Because of the relatively long payback period the company could consider leasing a parts washer instead of purchasing, but a 5-year payback period is a good investment when employee health/safety is improved.

Implementation Status: Not Implemented

Implementing this recommendation would have reduced air emissions and exposure of employees to hazardous chemicals and resulted in annual savings of approximately $330. This option was investigated but not implemented.

Key Benefits and Barriers: Implementation was rejected due to the small cost savings and the mechanics perceptions that extra time was involved in washing parts and the cleaning solution was less effective.

Note: In another project reassessed by Sean Brozek in 2007, the company did implement the suggestion to replace solvent based parts washers with aqueous based ones. The findings were reported as follows:

Suggestion	Rationale	Result	Benefit	Measurable Benefit
Replace solvent-based parts washers with aqueous parts washers	To reduce the amount of hazardous materials used in the facility and provide a safer work environment for employees.	Replaced approximately 1/3 of the facility's parts washers with aqueous-based washers. Currently looking into replacing more.	▪ Reduces health and safety risks to employees. ▪ Reduces air emissions. ▪ Eliminates need for a costly ventilation system to maintain air quality.	▪ **6.4 pounds per gallon of VOCs reduced per gallon of aqueous solvent used**

Appendix 3
Greenhouse Gas Reductions Explanation and Calculations

Relevance of Greenhouse Gas Emission Estimates

This issue is an increasingly important one for business decision makers as it relates to regulations, stakeholder interests and day-to-day business operations and energy use.

There are several important dimensions of analysis for any pollution prevention opportunity. One is certainly direct environmental impact (e.g. reductions in solid or hazardous waste, water use, air pollution, or energy use). Another important dimension is cost. Yet another is the intangible (not quantifiable) impact, such as reduced liability, increased worker safety/satisfaction, or improved corporate image. A final important dimension is indirectly estimating the impact on greenhouse gas (GHG) emissions that can be achieved by implementing any given pollution prevention opportunity.

GHGs include a number of different gases such as carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons and water vapor. These gases contribute to the "greenhouse effect" in the Earth's atmosphere. While GHGs make the planet warm enough to be habitable, an excessive amount of these gases is believed to be building up in the atmosphere and causing the average global temperature to rise, leading to climate change and instability. A significant spike in GHG concentrations in the atmosphere has occurred since the industrial revolution, pointing to the man-made nature of this change. This is why a new emphasis, and discussion of possible regulations, has been placed on reducing GHG emissions in all parts of our society, including government, business and industry.

The most widely recognized unit for measuring GHG emissions is carbon dioxide equivalent (CO2e). Each of the GHGs has a different capacity to heat the earth's atmosphere, called its global warming potential (GWP). Carbon dioxide (CO2) has a GWP of 1, so in order to standardize reporting, when GHG emissions are calculated, they are reported as equivalent to a given volume of CO2.

Array of Calculation Tools

Reductions in GHG emissions can be estimated using a variety of calculation tools and computer models. The direct environmental/cost benefits estimated or realized are used as quantified input for these calculations, therefore the resulting GHG emission reduction estimates are considered indirect benefits. Some commonly used tools are listed below:

--Nationally recognized conversion factors from the U.S. Department of Energy and the American Water Works Association: these are used to estimate GHG emissions for electricity, natural gas, and water use. For example, kilowatt-hours (kWh) of electricity used can be converted to GHG emissions using a factor of 1.404 pounds CO2 e per kWh.

--EPA's WAste Reduction Model (WARM): this tool is used to determine GHG emissions related to solid waste. This online calculator uses a life-cycle approach to determine the change in GHG emissions caused by alternative end-of-life waste management decisions or disposal methods for a number of different kinds of wastes. For example, using the weight of a solid waste diverted from a landfill and recycled, an approximate reduction in GHG can be calculated. WARM is periodically updated and new material types are added by the EPA as new information from climate change research becomes available.

--Economic Input Output Life Cycle Assessment (EIO-LCA): this model used to estimate GHG reductions has been developed by researchers at Carnegie Mellon University. This model provides a

useful approximation of GHG reductions through the full life-cycle production of a material or chemical, based on the cost savings from reductions in use. For example, if a business reduces its purchase of lights by $50,000, the EIO-LCA estimates the GHG emissions to produce the lights through the mining, manufacturing, packaging and delivery (to list a few) steps in the process of getting the lights to the end user.

--Recycled Content (ReCon) Tool: EPA created the ReCon Tool to help companies and individuals estimate life-cycle greenhouse gas (GHG) emissions and energy impacts from purchasing and/or manufacturing materials with varying degrees of post-consumer recycled content.

--Pollution Prevention (P2) Greenhouse Gas (GHG) Calculator: designed by U.S. EPA in conjunction with a panel of professionals from the P2 community with state and local governments, business facilities, grantees, and project managers in mind. The tool was reviewed in national webinars and conferences reaching over 600 participants and reworked to be more robust and user friendly. The tool is available in an Excel format and finalized as of November 2011. U.S. EPA will periodically update the tool as new information and data sources become available. It is designed to help calculate GHG emissions reductions in metric tons of carbon dioxide equivalent (MTCO2e) from electricity conservation, green energy, fuel and chemical substitutions, water conservation, and improved materials and process management in the chemical manufacturing sector.

Selecting the Most Appropriate Tool(s):

When using one of these models to estimate GHG emission reductions for a client, always provide an explanation of which model was used, why it is most relevant for the issue at hand, what assumptions were applied, and the importance of reducing GHG emissions as a business and global sustainability strategy. The EPA P2 GHG Calculator has conversion factors that easily convert reductions in energy use to reductions in GHG emissions. If a reduction in solvent use is quantified, the EIO-LCA or WARM models can be used.

A summary sentence stating the amount of GHG reduction should be included in the report with each recommendation, as applicable, e.g. "installing an outlet timer" will save **$41/year and over 800 kWh/year**, which **reduces greenhouse gas emissions by about 0.8 metric tons of CO_2 equivalents/year**. A detailed appendix should also be developed which shows how the GHG emission reductions were calculated. An example of such an appendix for a recommendation resulting in energy reduction is provided below.

Example Greenhouse Gas Calculations

Example 1: Greenhouse Gas Calculations for Use of Outlet Timer
Opportunity: Install outlet timer on parts washer
Electricity Reduction = 822kWh/yr
822 kWH/yr * 2.104 lbCO2E/kWH * 1 MTCO2E / 2,204.6 lbCO2E = **0.8 MTCO2E**

Sources:
U.S. EPA, Clean Energy. "eGRID 2007 Version 1.1." February 2009. Dowloadable ZIP file: eGRID20071_1year05_aggregation.xls, tab NRL05 and US05 available online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html#download

US EPA, Downloadable Document: "Unit Conversions, Emissions Factors, and Other Reference Data, 2004." Table I, Page 1 available online at: http://www.epa.gov/climatechange/emissions/downloads/emissionsfactorsbrochure2004.pdf

Example 2: Greenhouse Gas Calculations for Use of Alternative Parts Washer
Opportunity: Replace current solvent based parts washer with aqueous-based parts washer.

Reduced cost of paper towels **$24,300**
Increased electricity usage by **390 kWh / yr**
Service Cost of existing solvent-based parts washer: **$2,610 / yr**
Purchase price of new aqueous-based parts washer: **$3,966.30/unit**
Service Cost of new aqueous-based parts washer: **$1,830 / yr**

Using the EIO-LCA model the switch to an aqueous-based parts washer will result in an approximate reduction of **1.6 MTCO2E.** Specific details are shown below.

Use of solvent-based parts washer:
www.eiolca.net
US 2002 Benchmark, Industry: Management, Administrative and Waste Services, Sector: "Waste Management and remediation services" sector to service costs for both the solvent-based parts washer and aqueous-based parts washer (other similar chemical production sectors give similar results).

Greenhouse Gases
$**2,610** input ➔ 6.91 tCO2E * 2000 lb / ton ÷ 2204.6 lb / metric ton = **6.3 MTCO2E**

Example of EIOLCA output:

Sector #562000: Waste management and remediation services
Economic Activity: $2.6 Thousand Dollars
Displaying: Greenhouse Gases
Number of Sectors: Top 10

Documentation:
The environmental, energy, and other data used and their sources.
Frequently asked questions about EIO-LCA.

This sector list was contributed by Green Design Institute.

Change Inputs (Click here to view greenhouse gases, air pollutants, etc...)

	Sector	Total t CO2e	CO2 Fossil t CO2e	CO2 Process t CO2e	CH4 t CO2e	N2O t CO2e	HFC/PFCs t CO2e
	Total for all sectors	*6.68*	*0.809*	*0.042*	*5.74*	*0.079*	*0.014*
562000	Waste management and remediation services	5.96	0.218	0	5.67	0.065	0
221100	Power generation and supply	0.239	0.236	0	0.000	0.001	0.002
S00700	General state and local government services	0.091	0.091	0	0	0	0
211000	Oil and gas extraction	0.058	0.016	0.011	0.031	0	0
324110	Petroleum refineries	0.040	0.040	0	0.000	0	0
331110	Iron and steel mills	0.034	0.013	0.021	0.000	0	0
484000	Truck transportation	0.026	0.026	0	0	0	0
481000	Air transportation	0.026	0.026	0	0	0	0
492000	Couriers and messengers	0.018	0.018	0	0	0	0
486000	Pipeline transportation	0.012	0.006	0.000	0.007	0	0

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Carnegie Mellon University Green Design Institute. (2012) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2002 (428) model [Internet], Available from: <http://www.eiolca.net/> [Accessed 25 Sep, 2012]

Use of aqueous-based parts washer

For purchase of new parts washer:
US 2002 Benchmark, Industry: Machinery and Engines, Sector: "Other Commercial and Service Industrial Machinery Manufacturing" (**#333319**) sector to the new parts washer purchase (other similar machinery manufacturing sectors give similar results). To be conservative, assume a five year life of parts washer, and divide the GHG from the machinery manufacture by give for an annual value.

Greenhouse Gases
$**3,966.30** input ➔ 2.11 tCO2E * 2000 lb / ton ÷ 2204.6 lb / metric ton ÷ 5 years= **0.4 MTCO2E**

For annual use of aqueous-based parts washer:
US 2002 Benchmark, Industry: Management, Administrative and Waste Services, Sector: "Waste Management and remediation services" sector to service costs for both the solvent-based parts washer and aqueous-based parts washer (other similar chemical production sectors give similar results).

Greenhouse Gases
$**1,830** input ➔ 4.63 tCO2E * 2000 lb / ton ÷ 2204.6 lb / metric ton = **4.2 MTCO2E**

Total Net MTCO2E Reduction
6.2 MTCO2E – 4.2 MTCO2E - 0.4 MTCO2E = **1.6 MTCO2E**

Incentives to Change
By switching to a aqueous-based parts washer, an approximate reduction in greenhouse gas (GHG) reduction of **1.6 MTCO2E**, GHG calculations are one way to see the impact a project has on the environment.

Appendix 4
Tips for Making the Business Case for Change

Tip # 1: Writing an Executive Summary

An executive summary is a brief overview of a report designed to give readers a quick preview of its contents. Its purpose is to consolidate the principal points of a document in one place. After reading the summary, your audience should understand the main points you are making and your evidence for those points without having to read every part of your report in full. It is called an executive summary because the audience is usually someone who makes funding, personnel, or policy decisions and needs information quickly and efficiently in order to make decisions and respond appropriately.

Guidelines:

An executive summary should communicate independently of the report. It should stand on its own as a complete document.

It should explain why you wrote the report, emphasize your conclusions or recommendations, and include only the essential or most significant information to support those conclusions.

Use subtitles, bullets, tables, selective bolding or other types of organizational structure to add clarity to your summary

It should be concise—about 10% of the length of the full report.

It should be organized according to the sequence of information presented in the full report. Don't introduce any new information that is not in your report.

To help with organizing the executive summary, after you have written the full report, find key words; words that enumerate (first, next, finally); words that express causation (therefore, consequently); words that signal essentials (basically, central, leading, principal, major); and contrast (however, similarly, less likely).

Read the completed summary with fresh eyes. Check spelling, grammar, punctuation, details, and content. Ask someone else to read it.

Tip #2: Technical Writing Tips

Use these tips as a **checklist** as you prepare your report.

- **Proof reading.** Write your report, let it sit, then proof read it for grammar, jargon, clarity, multiple meanings, and technical correctness before submittal. Re-read the report from the recipient's point of view. Reading the report aloud may help.
- **Figures and tables.** Refer to each figure and table in the text prior to inserting it. Always place the figure or table in the report soon after you have referred to it. Include a title and number for all figures and tables, capitalizing the title when referring to a specific table or figure, e.g., "All of the wastes generated by the shop are listed in Table 1
- **Transitions.** Provide brief transition sentences between sections of the report and before a bulleted list to explain what the list consists of and how it is organized.
- **Parallel construction.** Use parallel construction in all numbered or bulleted lists. For example, all items should be a complete sentence or none should be; or all items might begin with an active verb, e.g., "use," "change," "remove" or a noun, like this list.
- **Format.** A general format/outline has been suggested, although this may need to be modified to address a client's requests. Generally you should:
  - Move from generalities to specifics, in each section and across the report as a whole.
  - Use page numbers.
  - Keep section headings with the narrative that follows at page breaks.
  - Rarely split a table across two pages.
- **Abbreviations.** On first use, spell the term out completely, followed by the abbreviation in parentheses. For example, "Volatile Organic Compounds (VOCs) are another waste that could be minimized." Subsequently, just the abbreviation is sufficient unless it is used at the beginning of a sentence. Never start a sentence with an abbreviation or a numeral.
- **Professional tone.**
  - Avoid slang, informal terminology (inexpensive vs. cheap), or imprecise (there, that, it) language.
  - Be careful how you word suggestions. Avoid making recommendations outside of your area and level of expertise in source reduction and waste minimization.
  - Use tact and be positive in your conclusions. Remember a reader likes to be complimented, but can see through phoniness.
  - Be careful to confirm your information if you state it as a fact; or cite your source, e.g., "According to Mr. Jones, Plant Engineer, . ." or state that the information is a potential based on xyz assumptions.
- **Common errors.**
  - i.e. vs. e.g.: i.e. means "that is" or "in other words," and e.g. means "for example."
  - compliment vs. complement: a compliment is a nice comment, and a complement is a part of a whole
  - how many vs. how much: how many can be counted, and how much is uncountable, e.g., how many bottles of water vs. how much water.
  - policies vs. procedures vs. practices: policies are formal written positions or statements about some issue; procedures are written directives aimed at accomplishing a task or complying with a policy; practices are typically informal steps people take, which may or may not follow written policies and procedures

Tip #3: General Recommendations

General recommendations are made to help a company establish the culture and infrastructure needed to establish and sustain a commitment to source reduction and sustainability. Examples of commonly made general recommendations include:

1. A pollution prevention policy statement should be generated and periodically updated by management to formally reflect management's commitment to incorporating pollution prevention in the company's operations. Some examples of formal policy statements follow:

> *This company is committed to continued excellence, leadership, and stewardship in protecting the environment. Environmental policy is a primary management responsibility, as well as the responsibility of every employee.*
>
> *The corporate objective is to reduce waste and achieve minimal adverse impact on the air, water, and land through excellence in environmental control.*
>
> *Minimizing or eliminating the generation of hazardous waste is a prime consideration in process design and plant operations and is viewed by management as having a priority as high as safety, yield, and loss prevention.*

2. To further implement the corporate pollution prevention policy, one or more "cause champions" should be selected to lead the pollution prevention program and overcome the resistance present when changes are made to existing operations. These "cause champions" may include a project manager, an environmental coordinator, or anyone else dedicated to implementing the pollution prevention ideal and company policy. These individuals must be given authority by management to carry out the policy.

3. Input from employees should be considered, encouraged, and valued. Since the employees must deal with the waste, they may have insight into how a specific pollution prevention opportunity may be implemented. Many companies offer incentives to employees who suggest innovations to minimize or reduce waste generation.

4. Goals should be established to help implement and track the progress of the corporate pollution prevention policy. Specific, quantitative goals should be set that are acceptable to those willing to work to achieve them, flexible to changing requirements, and achievable with a practical level of effort. To document the progress of the pollution prevention goals, a waste accounting system should be used.