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P2 PERFORMANCE MEASUREMENT TOOLS WORKBOOK

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CONTENTS

This document is an introduction to measuring DOE's P2 progress; this ground work should enable an understanding of the areas of concern. Basic concepts have been described and a method presented for measures of P2. This document contains:

- the background and requirements specific to performance evaluation of DOE's Waste Minimization and Pollution Prevention Program;
- the performance measurement recommendations and examples; and
- references to additional information and worksheets to perform calculations.

ACRONYMS & ABBREVIATIONS

BL	Baseline Waste Generation Quantity
CSO	Cognizant Secretarial Office
DOE	Department of Energy
EO	Executive Order
EPA	Environmental Protection Agency
ER/D&D/C&T	Environmental Restoration, Decontamination And Decommissioning, And Closure/Transitions Operations
ES&H	Environmental, Safety & Health
FFCA	Federal Facility Compliance Act
G	Goal
HW	High Level Radioactive Waste
LL	Low Level Radioactive Waste
M&O	Management & Operating Organization
P2	Pollution Prevention
P2RA%	Pollution Prevention Requirement Achievement
PP	Pollution Prevented Measure
PPOAs	Pollution Prevention Opportunity Assessments
pw	Primary Waste
R	P2 Waste Reduction Requirement
RCRA	Resource Conservation & Recovery Act
rm	Recoverable materials
ROI	Return on investment
SAFER	Streamlined Approach for Environmental Restoration
sw	Secondary waste
TRI	Toxic Release Inventory
TSCA	Toxic Substance Control Act
TSDR	Treatment, Storage, Disposal & Release
tw	Total Waste
WM	Waste Management
WMin/P2	Waste Minimization and Pollution Prevention

EXECUTIVE SUMMARY

The underlying purpose of the Department of Energy's (DOE) Waste Minimization and Pollution Prevention (WMin/P2) Program is compliance with the waste management regulations set forth by the DOE, the federal government, and individual state and local agencies[1]. In addition to these regulatory mandates, the increases in waste management costs and public interest in environmental issues have created other drivers to develop and demonstrate an effective WMin/P2 Program. The Waste Minimization Division (EM–334) must have adequate methods to calculate and roll up pollution prevention (P2) progress to meet the WMin/P2 requirements; these requirements support DOE and national objectives and direct funding. This document outlines a system to evaluate DOE's P2 progress towards the waste reduction requirements. The emphasis of these pollution prevention measurements is to evaluate whether P2 activities are effective, (i.e., has the required amount of waste been reduced as a result of the P2 activities) and to evaluate the cost management of P2 projects.

The performance evaluation system presented in this document encompass these aspects: (1) **site requirements** that apply to all DOE waste generating organizations, (2) a **baseline** that is not affected by short–term waste generation, and (3) **key indicators** that can be rolled up across DOE sites and across specific Cognizant Secretarial Officers' (CSO) sites. In a performance–based management system, requirements are the fundamental link between the planning and measurement process. The site requirements are "targets" at the process or activity level. Measuring DOE's P2 progress toward these requirements provides the necessary feedback to (1) compare performance with the requirements/standards (i.e., whether the reduction requirement of 50% by 1999 is achievable) (2) detect departures from planned levels of performance, and (3) restore performance to the planned levels or achieve new levels of performance.

The P2 performance evaluation measures are:

- P2 Waste Reduction Requirement
- Pollution Prevented Measure
- Pollution Prevention Requirement Achievement Measure
- Recoverable Materials Evaluation Ratio
- Environmental Restoration/Decontamination & Decommissioning/Closure & Transition Evaluation Ratio
- Pollution Prevention Opportunity Assessment Measure
- P2 Project Milestone Completion Measure
- Return on Investment Evaluation
- Gross Pollution Prevented $ Savings
- Net P2 $ Benefit

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[1] Strategic Plan, U.S. Department of Energy, April 1994.

1.0 INTRODUCTION

The Problem. The underlying purpose of the WMin/P2 Program is compliance with the waste management regulations set forth by the DOE, the federal government, and individual state and local agencies[2]. In addition to these regulatory mandates, the increases in waste management costs and public interest in environmental issues have created other drivers to develop and demonstrate an effective WMin/P2 Program.

Why is it a Problem? The performance indicator of successful P2 programs has been quantification of baseline waste generation against a reduction requirement in waste (volume or mass) and in waste management costs. The basis of this traditional measurement model is interval data consisting of the process material inputs (e.g., raw materials, chemicals, energy, etc.), throughputs (useful products, parts, etc.), and resulting waste quantity or of waste disposal cost (although manifested waste quantity does not include multi-media waste generated: air, water, scrap, etc.). In a manufacturing or production environment, a baseline of waste generated per unit produced (normalization of the waste data) can be tracked quantitatively because the processes are "well defined" and are subject only to minor changes. Given a unit production increase or decrease, the waste is relatively predictable because there is, 1) the accumulated historical data of the process and 2) experience. Because of this simplicity, the model can measure source reduction or more efficient use of resources equally well. A limitation of this model is the assumption that quantitative waste data is dependent only on production.

A familiar example of the difficulties in limiting the focus of data collection to strictly quantitative waste data is found in the practice of cleaning with certain solvents that are undergoing regulatory elimination. Often nearly twice the amount of the replacement solvents must be used to perform the same cleaning specification; the solvent waste streams consequently increase by 100%. In the traditional model, secondary factors, such as toxicity or material compatibility and product quality are generally ignored. Thus, tracking the quantities of waste generated can be insufficient for evaluating performance of a waste minimization and pollution prevention program.

A further consideration in tracking P2 progress is the aggregating of the progress data within the DOE complex. The Complex comprises numerous sites in several states. These facilities range from single-mission to multiple-disciplinary, and from quite small to very large. Because of the diversity of technologies, processes, and activities, a wide variety and number of waste streams are generated, many of which are single-time activities. Competing priorities and shrinking resources often prevent the collection of relational data required to normalize the waste data and the analysis is not necessarily meaningful because these waste streams change constantly.

[2]Strategic Plan, U.S. Department of Energy, April 1994.

Why a solution is necessary? Obtaining concrete measurements of progress in waste minimization and pollution prevention is recognized as important; it demonstrates results to employees, management, regulatory agencies, and the public. Therefore, a performance evaluation system that addresses the complexities, (i.e., recognizes that processes vary in the quantity of pollution they generate, as well as in the perceived risk and hazards associated with an operation) while also providing consistent data throughout the DOE complex, is necessary. In addition, the performance evaluation system provides critical information to evaluate, manage, and implement changes. Furthermore, P2 performance evaluation measures:

- Help in comparing waste reduction at similar facilities.
- Provide a basis for transferring information and technology to similar processes or facilities.
- Aid in motivating employees and management.
- Help justify future pollution prevention projects.

Purpose of this document. This document outlines an evaluation system of DOE's P2 progress towards requirements for waste reduction. The purpose of the pollution prevention measures are to determine if P2 activities are effective (i.e., has the required amount of waste been reduced or avoided as a result of the P2 activities) and provide a basis for evaluating the cost management of P2 projects. The emphasis of these measures are to yield complex-wide information while allowing individual sites to choose specific, useful measures most appropriate for their activities.

2.0 BASIS OF REQUIREMENTS

2.1 Top-Down Planning and P2 Requirements. The DOE has made a commitment to protect the environment and public health and to bring about cost savings to taxpayers through pollution prevention efforts. Supporting this commitment is one of DOE's Waste Minimization and Pollution Prevention Program's principal objectives, *"to maximize all opportunities for the elimination or minimization of waste in all of the Department's operations."*

> *"The Department of Energy is committed to pollution prevention not only as a strategy to reduce waste generation but also as its preferred approach to protect the environment, reduce future risks and costs associated with managing wastes and pollutants, and improve energy efficiency."* - Secretary of Energy Hazel R. O'Leary, December 27, 1994

The basis for determining P2 performance requirements are documented in several federal and DOE directives; the major requirements applicable to DOE sites are summarized in Table 1.

Table 1. Major P2 Program Directives & Goal Setting Requirements

P2 Program Component	Reference	Directive & Goal Requirement	Baseline
Goals	RCRA 58 FR 31114-3112 Sec 3002(b) and 3005(h)	"Set explicit goals for reducing the volume and toxicity of waste streams that are achievable within a reasonable time frame..."	
	DOE Order 5400.1 Sec 6 (also: 5400.1 Chapter III #4(b) #4(c))	"WMin is a Department-wide goal and a line management responsibility."	
	DOE Order 5820.2A Radioactive Waste Management Chapter III 3. Requirements c. (2) Waste Generation Reduction.	"All DOE-low-level waste generators shall establish auditable programs (goals, incentives, procedures, and reports) to assure that the amount of low-level waste generated and/or shipped for disposal is minimized."	
	DOE WMin/PP Crosscut Plan	"..establish site-specific, qualitative and quantitative WMin/PP goals."	
	EO12856 Federal Compliance with Right-To-Know Laws Sec 3-302 (a) & (d)	"..develop voluntary goals to reduce the agency's total releases of toxic chemicals to the environment and off-site transfers for treatment and disposal by this order by 50 percent by December 31, 1999."	
	EO12873 Federal Acquisition, Recycling, and Waste Prevention Sec 601 & Sec 602	"..set annual goals to maximize the number of recycled products purchased, relative to non-recycled alternatives..." "..establish a goal for solid waste prevention and goal for recycling to be achieved by 1995.."	
	Proposed DOE goal to comply with EO12856 for sanitary waste	DOE will recycle at least 25% of its annual solid waste stream by December 31, 1995, and at least 50% by December 31, 1999 (5% Solid waste generation reduction per year). Sites with 100 or more employees will establish individual site-wide goals consistent with the DOE goal.	Baseline is established from the total amount of solid sanitary waste annually
P2OAs	RCRA 58 FR 31114-3112 Sec 3002(b) and 3005(h)	"..identify opportunities at all points in a process where materials can be prevented from becoming a waste...analyze WMin opportunities...."	
	EO12856 Federal Compliance with Right-To-Know Laws Sec 3-302 (a) & (d)	"..agencies shall conduct assessments of their facilities as necessary to ensure development of such plans and of the facilities' pollution prevention programs."	
Cost	RCRA 58 FR 31114-3112 Sec 3002(b) and 3005(h)	Establish a cost allocation system	
	EO12856 Federal Compliance with Right-To-Know Laws Sec 4-404	Federal agencies shall place high priority on obtaining funding and resources needed for implementing PP by identifying, requesting, and allocating funds through the A-106 and A-11 budget request process... apply life-cycle analysis and total cost accounting principles to all projects to meet the requirements of the order	
	EO12873 Federal Acquisition, Recycling, and Waste Prevention Sec 401	"..In developing plan, drawings, work statements, specifications, ... consideration of use of recoverable materials, reuse of product, life-cycle cost, recyclability, waste prevention (including toxicity reduction or elimination), and ultimate disposal ..."	

Table 1. Major P2 Program Directives & Goal Setting Requirements (con't)

P2 Program Component	Reference	Directive & Goal Requirement	Baseline
Reporting	40 CRF Part 262 Standards Applicable to Generators of Hazardous Waste Subpart D	Biennial Report by 3/1 of each even numbered year including information of quantitative changes and efforts undertaken to reduce volume and toxicity of waste generated	
	EO12856 Federal Compliance with Right-To-Know Laws Sec 3-304 (a-c)	Each federal agency shall comply with Section 313 of EPCRA and Section 6607 Pollution Prevention Act of 1990 regardless of SIC of the activity or site -- each facility is required to file an annual Toxic Chemical Source Reduction and Recycling Report	first DOE TRI report due 7/1/95 for CY1994
	Federal Facility Compliance Act of 1992 (FFCA)	The Secretary of Energy is required to submit an inventory of mixed waste and waste minimization actions	first report March 21, 1993
	EO12856 Federal Compliance with Right-To-Know Laws Sec 3-302	" the agency shall report on such toxic pollutants annually under the provisions of Section 3-304 of this order, or though an agency report that is made available to the public"	
Toxic Chemical Reduction	EO12856 Federal Compliance with Right-To-Know Laws Sec 3-302 (a) & (d)	"..develop voluntary goals to reduce the agency's total releases of toxic chemicals to the environment and off-site transfers for treatment and disposal by this order by 50 percent by December 31, 1999. .." "..each agency shall establish a plan and goal for voluntarily reducing its' own manufacturing, processing, and use of extremely hazardous substances and toxic chemicals. .."	The first year in which releases of toxic chemicals to the environment and off-site transfers of such chemicals for treatment and disposal are publicly reported. The baseline amount shall be the aggregate amount of toxic chemicals reported in the baseline year. In no event shall the baseline be later than the 1994 reporting year."
	EPA 33-50 program	Reduce releases and off-site transfers of 17 chemicals from 1988 levels by 33% by the end of 1992 and 50% by the end of 1995 Reduce purchases by Dec 31, 1996	
	DOE Proposed goal for reduction of toxic chemicals	DOE will reduce its releases of toxic chemicals to the environment and off-site transfers for treatment and disposal by 50% by December 1999	Baseline is CY1993
Acquisition, Procurement and Recycling	EO12856 Federal Compliance with Right-To-Know Laws Sec 3-303 (a) & (b)	"..eliminate or reduce the unnecessary acquisition of products containing extremely hazardous substances or toxic chemicals ...by 1999, agencies shall make all appropriate revisions to their specifications and standards. .."	
	RCRA Sec 6002	"..develop an affirmative procurement program which will assure that items composed of recovered materials will be purchased to maximum extent practicable"	
	EO12873 Federal Acquisition, Recycling, and Waste Prevention Sec 601& Sec 602	"..100% of all products purchased each year in each of EPAs Guidelines Items categories, shall contain recycled materials meeting EPAs guideline criteria. .." Agencies shall strive to increase the procurement of products that are environmentally preferable or that are made with recovered materials 50% purchase of materials containing recycled goods by 9/30/96	
	DOE Proposed Goal to comply with EO12873	50% of purchased materials will contain recycled goods by 9/30/96	Baseline is established from the total amount of purchased materials annually
	EO12843 Procurement Requirements & Polices for Federal Agencies for Ozone-Depleting Substances Sec 1, 3 & 3(a)	"..revise procurement practices and implement cost-effective programs both to modify specifications and contracts that requires the use of ozone-depleting substances (ODSs) and to substitute non-ODSs..."	

2.2 Bottoms-Up Measures For P2 Performance Evaluation. In a performance–based management system, requirements are the fundamental link between the planning and measurement process. The P2 evaluation structure is a bottoms–up effort beginning at the project level from generator–specific information. The expected performance of each P2 project or "target" may represent a specific P2 project (or activity) or collections of P2 projects (e.g., completion of projects that result in waste avoidance in an operation). The performance of these projects (i.e., measures) are then aggregated across waste streams, divisions, sites, etc., to evaluate efforts in relation to the specified requirements. The site requirements are "targets" at the process or activity level. Measuring DOE's P2 progress toward these requirements provides the necessary feedback to (1) compare performance with the requirements/standards (i.e., has the required amount of waste been reduced as a result of the P2 activities) (2) detect departures from planned levels of performance, and (3) restore performance to the planned levels or achieve new levels of performance.

2.3 Assessing the P2 Performance Measures Process. The performance evaluation measures presented in this workbook are to address some of the complexities of measurement and identify the need for consistent data throughout the DOE complex. Measurements of progress in waste minimization and pollution prevention are essential in demonstrating results to employees, management, regulatory agencies, and the public. Therefore, application of these performance evaluation measures needs periodic evaluation and improvement. Some possible mechanisms for assessing and improving are:

(1) An assessment by a knowledgeable and independent panel. The panel can be tasked with evaluating these measures (and any others they may develop) against specific evaluation criteria. The recommended criteria for evaluating these methods include:

- accuracy,
- consistency over time,
- ease of aggregating within facilities, site, and across DOE, and
- availability of data for the method and application to different types of DOE processes, facilities, and activities.

(2) A review of the measurement and performance evaluation system by the DOE Waste Reduction Steering Committee.

(3) A review by key representatives from multi-disciplines (e.g., P2, waste management, waste generators, accounting, etc.) and cross-cutting organizations (e.g., CSO, field, etc.) for implementation feasibility.

(4) Field testing and documenting the measurements at interested sites to refine the approaches and document lessons learned.

(5) As work continues in the cost management calculations, provide information and further guidance on application to P2 performance measurements.

3.0 APPLICATION OF P2 PERFORMANCE EVALUATION TOOLS

P2 Measurements. This section outlines performance measures developed to evaluate DOE's P2 progress toward requirements for waste reduction. The specific purpose of these pollution prevention measurements are to evaluate whether P2 activities are effective (i.e., has the required amount of waste been reduced as a result of the P2 activities) and to assist in and demonstrate a conscious effort in cost management of P2 projects. The emphasis of these measures are to yield complex-wide information while allowing individual sites to choose specific, useful measures most appropriate for their activities.

3.1 Step 1: Requirements for P2 Measures.

As a first step in developing performance measures, reduction requirements for all site pollution prevention programs are necessary. The primary requirement of DOE's pollution prevention program is to reduce the amounts of material destined for treatment, disposal, storage, or release — *Prevented pollution in all media.* A second requirement is to provide incentives for changing waste generating activities — *Improve cost management (of pollution prevention).* These efforts apply to all operations including continuing work and one-time initiatives. Benefits of meeting these P2 requirements are lower risks and liabilities from using or discarding hazardous materials and improved Environment, Safety & Health (ES&H) for workers and the public. A summary of the major directives and requirements for establishing site-specific P2 Program requirements is provided in Table 1 (Section 2.2, pages 4 and 5).

3.2 Step 2: Defining the Process, and Products.

The framework for establishing P2 measures is illustrated in the process flow diagram of the Waste Minimization and Pollution Prevention Management system, Figure 1. Each block represents a process that could be separated into sub-processes for more detailed examination; however, this high-level diagram is appropriate for visualizing the complex-wide process. Products of each process block represent the contribution each makes to the final products; the final products are restatements of the system's desired results:

- Prevented pollution in all media,
- Improved Cost Management, and
- Improved ES&H for workers and the community.

3.3 Step 3: Developing P2 Measures.

Measuring DOE's P2 progress toward P2 requirements provides the necessary feedback to (1) compare performance with the requirements/standards, (2) detect departures from planned levels of performance, and (3) restore performance to the planned levels or achieve new levels of performance. The performance evaluation system presented in this workbook encompass these aspects: (1) **site requirements** that apply to all DOE waste generating organizations, (2) a **baseline** that is not affected by short–term

waste generation, and (3) **key indicators** that can be rolled up across DOE sites and across specific Cognizant Secretarial Officers' sites. Table 2 provides a summary and quick-look reference table of the measurements developed to evaluate DOE's P2 efforts; comprehensive definitions and examples for each measure follows the quick-look table.

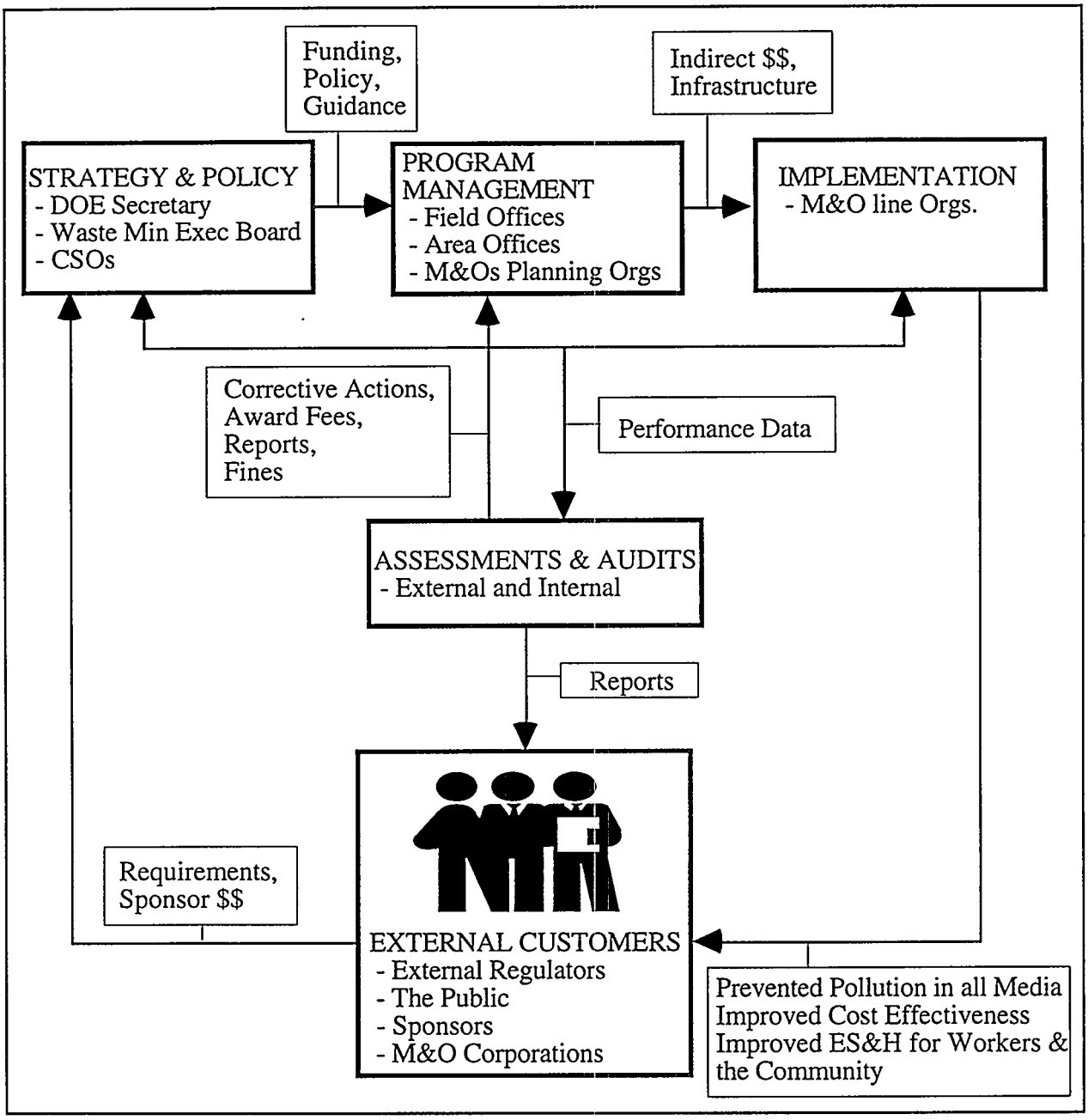


Figure 1. DOE's Waste Minimization & Pollution Prevention Management System

Measurement Objective	P2 Measurement	Description	Formula
Performance	P2 Waste Reduction Requirement (R)	Quantity of waste to be prevented/reduced to meet the reduction requirement from a specified baseline quantity.	R = BL * (G/100) BL = the quantity of waste or pollutant released during the baseline year G = quantitative waste reduction goal
	Pollution Prevented Measure (PP)	For each P2 component that measures the pollution prevented performance of completed projects.	PP = Σ quantity of pollution prevented
	P2 Requirement Achievement Measure (P2RA%)	For each P2 Program Component that measures percent requirement achievement.	P2RA% = (PP ÷ R) * 100 R = quantity to meet waste reduction requirement PP = Pollution Prevented
	Recoverable Materials Ratio (rm%)	For each P2 component that measures recoverable materials.	(rm ÷ tw) * 100 rm = quantity recoverable materials tw = quantity total waste
	ER/D&D/C&T Ratio (sw%) & (rm%)	For measuring the P2 component in environmental remediation, decommissioning & decontamination, and closure & transition operations.	(sw ÷ tw) * 100 sw = quantity secondary waste tw = quantity total waste & (rm ÷ tw) * 100 -- See above
Schedule/ Decision	PPOA Measure	For evaluating the number of assessments performed to the total number of assessments (e.g., PPOAs completed + to do + to review + etc.).	A ÷ B A= # of assessments completed B = total # of assessments
	Milestone Completion Measure	For all funded P2 projects a weighted completion measure of opportunity milestones.	Σ (a * b) ÷ Σ (a * 100) a = milestone weight b = project completion score
Decision/ Economic	Return on Investment (ROI%)	For each P2 component that measures the expected ROI of P2 projects • Current DOE ROI Calculation.	ROI% = [[(b-a) - d]/(c + e)] * 100 a = the annual operating costs after P2 project, b = the annual operating costs before P2 project, c = the initial capital investment , d = adjustment for depreciation[1] [(c + e) / useful life], e = the installation expense
Economic	Gross P2 Project $$ Savings	The gross P2 project savings is the sum of all avoided/saved costs due to P2 projects.	Gross P2 Projects Savings = Σ (avoided waste management costs + avoided purchases + revenues from recoverables + etc.)
	Net P2 $$ Benefit	Calculates the cumulative dollar saving over the life of the P2 project to determine the dollar benefit of P2 projects.	Net P2 $$ Benefit = [(b * L_y)] - [(c + e) + (a * L_y)] see ROI% L_y = the expected life of P2 project

[1]Depreciation can be ignored for projects with a useful life of more than 10 years.

3.3.1 P2 Waste Reduction Requirement. The first step in establishing the performance evaluation measures is to identify and quantify the requirement; this provides a numeric target as the basis to evaluate progress in P2 activities. To establish the numeric requirement, the following information is required: 1) the baseline waste generation quantity, and 2) the quantitative waste reduction goal. The quantified requirement equals the specified baseline quantity times the goal (expressed as a fraction); for example, using the RCRA hazardous waste type reduction goal of 50% by the year 1999 means that the baseline RCRA waste quantity is multiplied by 0.5 to determine the required quantity of prevented waste. The formula to determine the P2 Waste Reduction Requirement is:

$$R = BL * (G/100)$$

Definitions

- P2 Waste Reduction Requirement (R): the quantity of waste to be avoided/reduced to meet the reduction requirement from the specified baseline amount (further definition may be per waste type and year).
- Baseline Waste Generation Quantity (BL): the quantity of waste or pollutant released per waste type during the baseline year.
- Goal (G): a quantitative waste reduction target.

The following table illustrates the calculation of the P2 Waste Reduction Requirement:

EXAMPLE: *P2 Waste Reduction Requirement*

	Waste Types	RCRA	TSCA	Non-RCRA State-Reg
Goal (G)	Achievement target date	12/31/99	12/31/99	12/31/99
	Reduction goal	50%	50%	25%
Baseline (BL)	CY	1993	1993	1993
	Amount (kg)	150,000	12,000	8,000
Requirement (R)	Quantity required to meet reduction goal	75,000	6,000	2,000

3.3.2 Pollution Prevented Measure. For each P2 project, the cumulative sum of the expected waste reduction quantities establishes whether projects will achieve the reduction requirement. The Pollution Prevented measure includes only the quantity of waste reduced from

completed P2 projects. The formula to calculate the Pollution Prevented Measure is:

$$PP = \sum (quantity\ of\ pollution\ prevented\ from\ completed\ P2\ projects)$$

Definitions

- Pollution Prevented Measure (PP): the quantity of pollution prevented from completed P2 projects.
- Completed P2 Projects: completely implemented P2 projects.
- Approved P2 Projects: funded P2 projects which are authorized and scheduled for completion in the current year.
- Planned P2 Projects: P2 project has been identified, but is not funded and or scheduled for completion during the current year.

The expected waste reduction quantity from approved (i.e., funded projects which are partially implemented) or unfunded but planned projects are not included in the PP calculation but can be used for long-term performance forecasts. The following table is an example of quantifying the annual amount of pollution prevented as a result of completed P2 projects. When recording quantities of pollution prevented, the time frame of the measurement is multiplied by an appropriate[3] multiplier to get an annual quantity. The last column is used to convert the units of measure to uniform units (e.g., weight in pounds to kilograms, etc.). As shown below, a separate table could be used for each waste type (e.g., RCRA, sanitary, etc.). To calculate PP, the quantities (per waste type with same units) in the last column are added.

EXAMPLE: *Pollution Prevented Measure*

COMPLETED P2 PROJECT	WASTE TYPE	AMOUNT PREVENTED units/time	ANNUAL AMOUNT PREVENTED (x annual multiplier)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)/Yr.
Chlorinated Solvent Replacement	RCRA	50 kg/month	50 x 9 = 450 kg	450 kg
Install bulk solvent dispensing stations	RCRA	66.7 kg/month	66.7 x 12 = 800 kg	800 kg
Eliminate Freon 113 in metal degreasing	RCRA	30 kg/week	30 x 20 = 600 kg	600 kg
Replacement of Solvent Degreasers	RCRA	27.5 lbs/month	27.5 x 12 = 330 lbs	150 kg
TOTAL AMOUNT OF POLLUTION PREVENTED(PP) RCRA WASTE TYPE:				2,000 kg/Year

[3] The appropriate multiplier is the number of months, weeks, days, that the P2 project has resulted in the reduction of targeted waste generation (i.e., actual P2 implementation time). If the quantity of pollution prevented is from an intermittent or discontinuous activity, then the annual amount prevented is the calculated by summation of the known quantities.

3.3.3 P2 Requirement Achievement. The primary requirement of the pollution prevention program is to reduce the amounts of material destined for treatment, disposal, storage, or release, — *Prevented pollution in all media.* These efforts should apply to all operations including continuing work and one-time initiatives; successful projects should achieve the reduction requirements. The purpose of a performance measure supporting this requirement is to evaluate the amount of waste reduced as a result of P2 activities; in this document, this is called the Pollution Prevention Requirement Achievement (P2RA%) measure. The P2RA% is a key indication of performance. The extent of achievement is measured by comparison against a standard P2 requirement. P2RA% can also be used as a standard of comparison to estimate or judge progress toward requirements across dissimilar operations and within specific CSOs. This measure is based on information contained in the site–level plans already required by the DOE from many contractors. The P2RA% formula is defined as:

$$\textit{Pollution Prevention Requirement Achievement (P2RA\%)} = (PP \div R) * 100$$

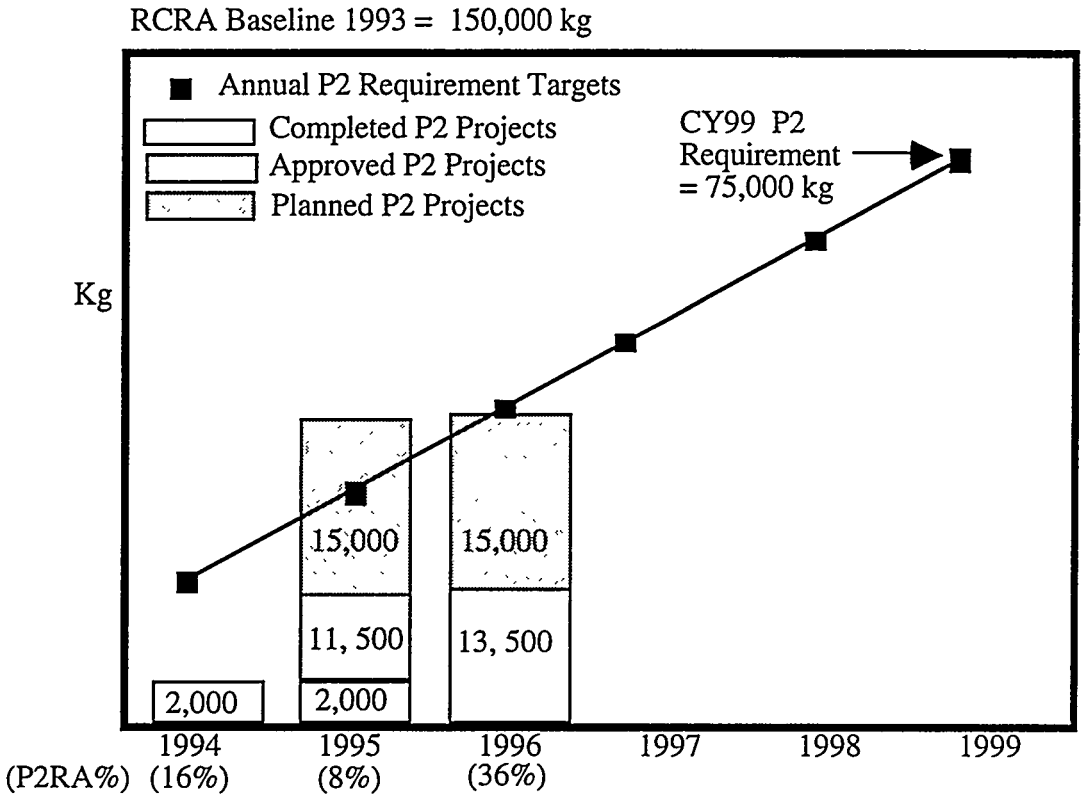
Definitions

- Pollution Prevention Requirement Achievement (P2RA%): the percent progress in meeting the waste reduction requirement.
- P2 Waste Reduction Requirement (R): the quantity of waste to be avoided/reduced to meet the reduction requirement from the specified baseline amount (further definition may be per waste type and year).
- Pollution Prevented Measure (PP): the quantity of pollution prevented from completed P2 projects.

The quantity of pollution prevented from completed projects is divided by the waste reduction requirement quantity and then multiplied by 100 to determine the percent achievement towards the requirement. The table and graph below (assuming a linear distribution of achieving the requirement) shows the annual targets for the RCRA hazardous waste type and the accumulated progress towards meeting the reduction requirement. To forecast long-term performance, projections of pollution prevented are included; these estimated quantities are based on CY95 approved and CY96 planned P2 projects. Using this information is particularly helpful for the decisions regarding prioritizing which P2 projects should be targeted for funding and also establishing milestone priorities.

EXAMPLE: *Pollution Prevention Requirement Achievement (P2RA%)*

	1994	1995	1996	1997	1998	1999
Cumulative P2 Requirement (R)	12,500	25,000	37,500	50,000	62,500	75,000
Completed P2 Projects (PP)	2,000	2,000	13,500	13,500	13,500	13,500
Approved P2 Projects[4]		11,500				
Planned P2 Projects[5]	11,500	15,000	15,000			
Remaining P2 Requirement	10,500	23,000	24,000	36,500	49,000	61,500
(PP ÷ R) * 100 = P2RA%	16%	8%	36%			



Requirement Achievement for RCRA Hazardous Waste (January 1, 1995)

Based on the RCRA hazardous waste type data used in the example, the P2 requirement was not met in CY94 and even if the approved P2 projects are completed on schedule in CY95, the P2RA% for CY95 would be 54%. However, if all of the CY96 planned projects are funded and completed (assuming CY95's projects were completed), then the requirement will be in line with the requirement target for CY96.

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[4] Approved P2 project must be completed in CY95 to be included in CY96 cumulative sum of completed projects.

[5] Planned P2 projects must be approved and completed in CY96 to be included in cumulative sum of completed projects for CY96.

3.3.4 Recoverable Materials Ratio. Most sites have several opportunities to show progress towards the requirements for recycling, reuse and recovery of materials. This measurement includes establishing recoverable material goals, the baselines for total waste quantities, and quantity of recovered materials to calculate performance. In addition, performance incentives for increasing this ratio could be established for each recycling/reuse opportunity. An important assumption for this measure of performance is that — *everything is considered waste.* The formula is defined as:

Recoverable Materials Ratio $rm\% = (rm \div tw) * 100$

Definitions

- Total waste (tw) includes: "all waste" destined for disposed to any media plus any recoverable, reused, or recycled materials.
- Recoverable materials (rm) includes: materials that still have useful economical, physical or chemical properties after serving their original purpose (examples: paper, scrap metal, cardboard, glass, etc.).

As shown in the following example, the progress towards the recoverable material requirement is measured. Although the example uses a common recoverable materials requirement, different targets could be established for each waste stream; through the summation of the individual waste stream recoverable materials quantities, an over-all progress ratio can also be determined.

EXAMPLE: *Recoverable Materials Ratio*

Waste Stream	A_1	A_2	A_3	$\Sigma (A_n)$
Recovery of materials goal	10%	10%	10%	10%
Total waste (m^3)	145	1.5	17.35	163.85
Amount of recovered materials (m^3)	25.5	.11	2.5	28.11
Ratio (rm ÷ tw) * 100	17.59	7.33	14.41	17.15

3.3.5 ER/D&D and C/T Ratio. To determine the appropriate performance and tracking parameters in environmental restoration, decontamination and decommissioning, and closure/transitions operations (ER/D&D/C&T) it is important to establish a common understanding of the major activities associated within these processes. The Streamlined Approach for Environmental Restoration (SAFER) process framework provides common process elements for ER/D&D/C&T operations (Planning, Assessment/Selection, and Implementation Phases). An important assumption for these measures of ER/D&D/C&T performance is that — *everything is considered waste.* Performance incentives or targets for increasing recoverable materials from

primary waste streams can be developed and progress can be measured across dissimilar ER/D&D/C&T operations by employing a recoverable materials ratio. The formula is defined as:

*Recoverable Materials Ratio rm% = (rm ÷ pw) * 100*

Note: Total Waste is divided into recoverable materials to include recovered materials from secondary waste.

*Recoverable Materials % ' = (rm ÷ tw) * 100*

Definitions

- Total waste (tw) includes: "all waste" primary, recoverable, reusable, secondary.
- Primary waste (pw) includes: waste from remediation (e.g., contaminated process equipment, etc.).
- Secondary waste (sw) includes: waste generated as a result of ER/D&D/C&T operations (e.g., samples, etc.).
- Recoverable materials (rm) includes: materials that still have useful economical, physical or chemical properties after serving their original purpose.
- Planning phase: actual waste reduction opportunities for both primary and secondary wastes are non quantitative since this phase requires no physical work; however qualitative measures could be applicable to action plan documentation specifying WMin/P2.
- Assessment and selection phase: the project is characterized (how big; how far; how wide; etc.), expected waste types, quantities, and disposal costs are projected, schedules and budgets are established, and options of how to remediate are generated. Opportunities to implement WMin/P2 to secondary wastes and the limited primary waste can be quantitatively measured. These measurements include establishing the baselines for both primary and secondary wastes to quantify against actual performance.
- Implementation phase: physical work is underway (e.g., dirt gets dug-up, process equipment is removed, etc.)

EXAMPLE: *Recoverable Materials Ratio*

	Project Planning	Assessment & Selection	Implementation Phase
Recovery of materials requirement	10%	10%	10%
Primary waste (m^3)	17.35	145	503.5
Amount of recovered materials (m^3)	2.5	25.5	104.2
Ratio (rm ÷ pw) * 100	14.41	17.59	20.70

Waste Minimization performance incentives can also be developed and progress measured across dissimilar ER/D&D/C&T operations by employing a secondary waste ratio. Targets or incentives for reducing this ratio can be established for each WMin/P2 opportunity. It is defined as:

$$Secondary\ Waste\ Ratio\ sw\% = (sw \div tw) * 100$$

EXAMPLE: *Secondary Waste Ratio*

	Project Planning	Assessment & Selection	Implementation Phase
Recovery of materials goal	10%	10%	10%
Primary waste (m^3)	17.35	145	503.5
Secondary waste (m^3)	4.5	98.57	102.5
Total waste(m^3) (sw + pw)	21.85	243.57	606.00
Secondary Waste Ratio (sw ÷ tw) * 100	20.60	40.47	16.91

3.3.6 PPOA Measure. Pollution Prevention Opportunity Assessments (PPOAs) are recognized as an important part of an ongoing P2 Program; the objective of a PPOA is to document a facility's processes, projects, operating procedures and waste streams in a manner that will permit identification of improvements to avoid or minimize waste generation. The PPOA report can provide a summary of material usage, project size, process by-products, and waste generated; it is an important tool to identify those projects and processes which can contribute to meeting the reduction requirement. By use of the PPOA process, sites can identify projects to reduce waste from their waste generating sources which are not meeting the reduction requirement or other priority wastes such as CFC/Halon and Toxic Release Inventory Chemicals. These targets would support funding for PPOAs at each site, within each waste type (radioactive, mixed, hazardous, and sanitary) and for air/water emissions and for toxic materials which are not meeting the reduction requirement.

Tracking the number of PPOAs completed versus the number of PPOAs required (identified and scheduled) provides a means to measure and evaluate potential P2 opportunities. The formula for the PPOA measurement is:

$$PPOA\ Measure = A \div B$$

Definitions

- Completed PPOAs (A): Σ (all PPOAs which are "final" i.e., P2 opportunities identified and report written).

- Total PPOAs (B): Σ (all identified PPOAs: completed, PPOAs in progress, planned, to review, etc.).
- In-Progress PPOA: the PPOA is in progress at this time and the completion date is a reasonable estimate.
- Planned PPOA: Process has been identified for PPOA but no firm schedule has been established. A tentative date may be dependent upon funding.

To determine the total number of PPOAs required, count the number of all PPOAs (completed, PPOAs in progress, planned, to review, etc.). The total number is compared to the number of PPOAs actually completed; the number of completed divided by the total will establish the PPOA measure. Variations of the PPOA Measure, such as by waste type can also be useful when comparing reduction requirements of different waste types. The waste type PPOA measure could support corrective actions decisions or reallocation of resources. The basic calculation steps are demonstrated in the following example:

EXAMPLE: *PPOA MEASURE*

PPOA NUMBER	PROCESS	WASTE GEN. (kg/year)	WASTE TYPE	PPOA STATUS	SCHEDULE
001	Project A	100	RCRA	Review	4/95
002	Project B	1000	RCRA	Complete	8/93
003	Project C	200	RCRA	Complete	6/94
004	Project D_1	1200	Sanitary	Complete	8/94
005	Project D_2	4500	RCRA	Complete	9/94
006	Project E	3750	Sanitary	In-Progress	6/95
007	Project F	550	Industrial	In-Progress	7/95
008	Project G	3675	Industrial	Planned	8/95
009	Project H	95	RCRA	Planned	12/95
010	Project I	300	LLW	Planned	12/95
Σ (B) = 10				Σ (A) = 4	

PPOA measure = (A ÷ B) = 4/10 or 40%

3.3.7 Milestone Completion Measure. The Milestone Completion Measure provides a measure of progress of authorized projects. The measurement can be useful for managing successful P2 projects. The measure supports decisions for allocating resources, detecting departures from planned levels of performance and restoring performance to planned levels. To calculate the Milestone Completion Measure, the sum of the total weighted score is divided by the sum of the potential weighted score. The formula is defined as:

$$\Sigma\,(Actual\ Weighted\ Score) \div \Sigma\,(Potential\ Score)$$

Definitions

- Milestone Completion Measure: the P2 approved project milestone is assigned a priority weight and the project progress is scored proportionate to completion. The sum of the weighted score is divided by the potential score to determine P2 performance to achieving the P2 requirement.
- Milestone Priority: an assigned weight factor (table below) designating the priority of completing the milestone.
- Completion Score: the project progress score proportionate to completion (completion score table below).

The importance of meeting each milestone, as shown in the table below, is defined by three priority levels and assigned a weight (higher being more important); the percent project completion is also assigned an appropriate completion score. The weighted priority is multiplied by the completion score and can be compared to the potential score for evaluating P2 milestone completion performance.

Milestone Weight Table

Priority	Weight	Description
High	9	A critical milestone — if not achieved then P2 requirement will not be met.
Medium	3	An important milestone to ensure P2 requirement is met.
Low	1	P2 Program enhancement; no major significance to meeting milestone.

P2 Project Completion Score Table

Completion Score	Description
100	Milestone complete
75	Milestone almost complete
50	Milestone 50% complete
25	Milestone started
0	Not started

To establish the P2 project priority weight, consideration of a number of factors, in addition to meeting the P2 reduction requirement, could be used. One example is to include an additional weight factor for distinguishing reduction in environmental, health, and safety impacts of selected chemicals (suggested source: *Hazard Levels of TRI Chemicals,* EPA/600/R-94/177). Other examples include: economic impacts of regulatory fines, materials or wastes without approved disposal methods (e.g., mixed waste), or other less tangible benefits (such as improved public image or employee morale). The table below provides a simple example of the Milestone Completion Measure calculation:

EXAMPLE: *Milestone Completion Measure*

Milestone	Waste Type	(a) Milestone Weight	(b) Completion Score	(a * b) Weighted Score	(a * 100) Potential Score
1. Project A	RCRA	9	75	675	900
2. Project B	RCRA	3	100	300	300
3. Project C	Sanitary	1	25	25	100
			Total	1000	1300

$$\Sigma (a * b) \div \Sigma (a * 100) = 1000 \div 1300, \text{ or } 0.77$$

3.3.8 Return on Investment Return on investment (ROI) is one of many measurements to compare and evaluate P2 projects for economic and requirement achievement benefits. The measurement can be useful for establishing priorities of planned, but unfunded P2 projects necessary to meet the P2 reduction requirement. The measure supports decisions for allocating resources, detecting departures from planned levels of performance and restoring performance to planned levels. The Return on Investment Measure uses the current DOE calculation. To calculate the Return on Investment, the formula is defined as:

$$ROI\% = [\,[(b-a) - d]/(c + e)\,] * 100$$

Definitions

- Annual operating costs after P2 project (a) includes: materials, supplies, operation, maintenance, transportation, training, waste management costs, etc.
- Annual operating costs before P2 project (b) includes: materials, supplies, operation, maintenance, transportation, ongoing training, waste management costs, etc.
- Initial capital investment (c) includes: all capital equipment purchases.
- Depreciation (d) or [(c + e) / useful life]: if project's useful life is less than ten years, than depreciation calculation is used.
- the installation expense (e) includes: facility preparation, equipment installation, etc.

An example of the ROI% calculation is provided using the P2 project information in the following table; all three projects are targeted to reduce the same waste type and all three projects have a projected useful life greater than ten years, therefore deprecation is ignored.

Planned, Unfunded P2 Projects Summary

Project	(b) Operating Costs Before ($K)	(a) Operating Cost After ($K)	(c) Capital Investment ($K)	(e) Installation Cost ($K)	Expected PP (kg)	Percent of Reduction Requirement (%)
Project 1	50	25	70	30	2500	25%
Project 2	200	50	50	50	700	7%
Project 3	8	4	20	40	1500	15%

EXAMPLE: *ROI% Calculation*

Project	(b - a)	(c + e)	$\frac{(b - a)}{(c + e)}$ * 100	ROI%
Project 1	50 - 25 = 25	70 + 30 = 100	(25 ÷ 100) * 100	25%
Project 2	200 - 50 = 150	50 + 50 = 100	(150 ÷ 100) * 100	150%
Project 3	8 - 4 = 4	20 + 40 = 60	(4 ÷ 60) * 100	6.7%

Using the example ROI% calculation, Project 2 has a significant return on investment and would be a likely project to target for funding. However, if Project 2's reduction results in 700 kg or contributes 7% of the P2RA%, will the waste reduction requirement for the waste type be achieved? If both the ROI% and the contribution to P2RA% are considered, Project 1 could be a better use of resources. Other considerations, such as those discussed for the Milestone Completion Measure, could be included in the planning and resource allocation process.

3.3.9 Gross P2 $$ Savings. Cost is yet another principal measurement used to evaluate the success of a project. The purpose of cost performance measures are to demonstrate accomplishing the objective — *to improve the cost/benefit ratio (to include cost, liability, and risk savings) to DOE through P2 efforts associated with operations, pollution control, and waste management.* [6] The Gross P2 $$ Saving Measure is one of two economic measures presented in this workbook to track the monetary savings of pollution prevention efforts. The Gross P2 $$ Savings Measure formula is:

$$\textit{Gross P2 \$\$ Savings} = \Sigma\,(\textit{avoided waste management costs} + \textit{avoided purchases} + \textit{revenues from recoverables} + \textit{etc.}).$$

[6]Unfortunately, cost management of P2 projects is a complex topic and there is uncertainty about the availability of data; the difficulties associated with cost determination include tracking the total project implementation cost and estimating cost avoidance. This topic is continuing to be investigated, but in the interim, the information summarizes the present deliberations on P2 cost management measures

Definitions

- $$ Avoided/Saved includes: avoided treatment, storage, disposal or release (TSDR) waste management costs,[7] $ value of material reduced, reused, recovered, or recycled in process; $ value of reapplication of used equipment or the dollar value of recoverable materials; $ saved from reduced purchases; $ saved from reduced legal liabilities; risk reduction savings; reduced environmental compliance, or energy savings.

Avoided waste disposal costs can be calculated differently depending on the type of waste and the units (weight, volume, or container) used to determine disposal costs. Additional savings can be revenues collected from recoverable or exchanged materials as well as avoided purchase costs. Using the information in the P2 Projects Pollution Prevented Summary table below, an example of calculating the Gross P2 $$ Savings measure is demonstrated.

P2 Project Pollution Prevented (PP) Summary

P2 PROJECT	WASTE TYPE	AMOUNT PREVENTED units/time	ANNUAL AMOUNT PREVENTED (x annual multiplier)
Paper recycling	Sanitary	2 tons/month	24 tons/year
Reuse wood pallets	Sanitary	10 pallets/wk	520 pallets/year
Reapplication of property	LLW	100,000 lbs/yr	100,000 lbs/year
Batteries recycled	Hazardous	3 ea/month	36 ea/year
Rechargeable batteries	Hazardous	50 ea /month	600 ea/year
Toner cartridge	Hazardous	5 ea/month	60 ea/year

Step A. Avoided Costs of Waste Management (WM)

PROJECT	AMOUNT OF WASTE REDUCED (annual)	CONVERSION TO WM UNITS (kg, m^3, etc.)	WM COSTS (per unit)	AVOIDED WM COSTS ($)
Paper recycling	24 tons/year	(800 lbs/yd^3)	$8/yd3	480
Reuse wood pallets	520 pallets/year	(3 ea/yd^3)	$8/$yd^3$	870
Reapplication of property	100,000 lbs/year (1600 ft^3)	(.028 ft^3/m^3)	$1742/$m^3$	78,042
Batteries recycled	36 ea/year	(2.5 kg/each)	$32/kg	2,880
Rechargeable batteries	600 ea/year (150 lbs/year)	(0.454 lbs/kg)	$32/kg	2,180
Toner cartridge	60 ea/year	(1 kg/each)	$32/kg	1,920
			Total Annual Avoided Costs of Waste Management	$$ 86,372

[7] [(quantity of wastes by type diverted from TSDR) * (disposal $ from DOE Model) = (estimated avoided $)].

Step B. Savings From Materials Not Purchased

PROJECT	AMOUNT MATERIAL NOT PURCHASED (annual)	PURCHASE COST (per unit)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)	ANNUAL AVOIDED $$ PURCHASE ($)
Toner cartridge	60 ea/year	$30 each	----	1,800
Wood pallets	520 ea/year	$20 each	----	10,400
Recharge batteries	600 ea/year	$2 each	----	1,200
Total Annual Savings From Materials Not Purchased				$$ 13,400

Step C. Revenues Generated From the Sale of Recoverables

PROJECT	AMOUNT OF RECOVERED MATERIAL (annual)	REVENUE GENERATED (per unit)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)	ANNUAL REVENUES ($)
Paper recycling	24 tons/year	$140/ton	----	3,360
Battery recycling	36 ea/year	$5 each	----	180
Total Annual Revenues Generated From the Sale of Recoverables				$$ 3,540

GROSS POLLUTION PREVENTED SAVINGS

Avoided waste management costs (step A)		Amount of savings from materials not purchased (step B)		Revenues from recoverables (step C)		*GROSS P2 $$ SAVING*
$$ 86,372	+	$$ 13,400	+	$$ 3,540.00	=	*$$ 103,312.00*

3.3.10 Net P2 $$ Benefit The second economic P2 measure is called the Net P2 $$ Benefit Measure. This measurement considers the cumulative dollar saving benefits over the life of the P2 project. The Net P2 $$ benefit provides a defensible basis for budgeting and implementation of P2 projects similar to the return on investment measure. The Net P2 $$ Benefit measure is defined as:

$$\textit{Net P2 \$\$ Benefit} = [(b * L_y)] - [(c + e) + (a * L_y)]$$

Definitions

- Life of P2 Project (L_y): the expected life of the P2 Project in years.
- Annual operating costs after P2 project (a) includes: materials, supplies, operation, maintenance, transportation, training, waste management costs, etc.

- Annual operating costs before P2 project (b) includes: materials, supplies, operation, maintenance, transportation, ongoing training, waste management costs, etc.
- Initial capital investment (c) includes: all capital equipment purchases (i.e., capital equipment budget items of $5,000 - $5,000,000).
- the installation expense (e) includes: facility preparation, equipment installation, etc.
- Payback Period in years: is the amount of time when the cumulative savings equal the initial capital equipment and installation costs.
- Δ $$ savings from implementing P2 project: is the difference in the operation expenses before and after P2 implementation.

The Net P2 $$ Benefit formula estimates the P2 dollar benefit over the life of the project. The formula uses constant dollars over the life of the P2 project; conservatism is used to avoid debate over appropriate inflation factors (e.g., additional operation costs due to changing environmental regulations, etc.). This measure includes those activities that are specifically funded for implementation as part of the pollution prevention program. As tracking P2 project implementation costs improve, all activities that are considered pollution prevention related (even those funded out of overhead, or non-pollution prevention accounts) could also be measured. The following example demonstrates calculating the Net P2 $ Benefit Measure using a simple P2 project with a life of 12 years:

EXAMPLE: *Net P2 $ Benefit Calculation*

Initial Capital Investment & Installation Expense for P2 Project (c + e) :

1. Equipment	
a. baler	$ 30,000
b. containers	$ 2,000
	$
2. Facility preparation (grading site)	$ 5,000
3. Installation (install compactor)	$ 5,000
4. Other	$ 0
5. Other	$ 0

$ 42,000
Total Capital Costs

Annual Operating Costs of P2 Project	(b) Before $$	(a) After $$	(b-a) Δ $$
1. Materials & Supplies	5,000	2,000	3,000
2. Operation & Maintenance	20,000	10,000	10,000
3. Transportation	5,000	1,000	4,000
4. Ongoing training	1,000	1,000	0
5. Other	0	0	0
6. Other	0	0	0
Total	31,000	14,000	17,000

Net P2 $$ Benefit $= [(b * L_y)] - [(c + e) + (a * L_y)]$

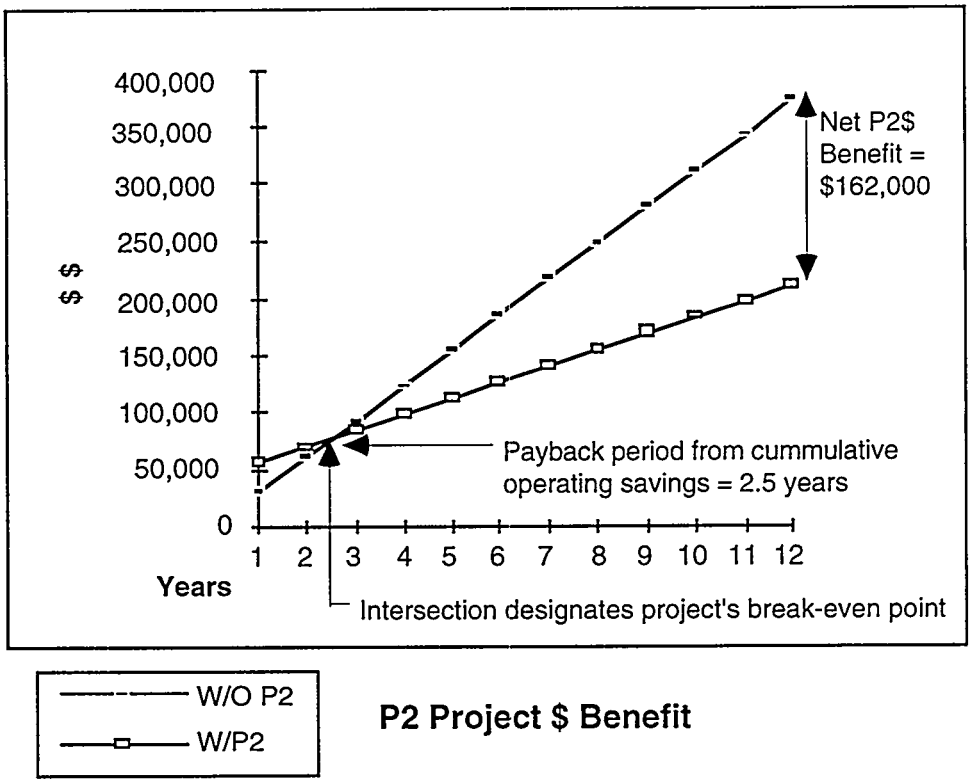
$= [(31{,}000 * 12) - (42{,}000 + (14{,}000 * 12))]$

$= (372{,}000) - (210{,}000) = \$\ 162{,}000$

Using the results from the Net P2 $$ Benefit calculations, another method to measure the economic benefits of the P2 project is to calculate the payback period for the P2 project. The payback period measures the amount of time required for the *cumulative savings to equal the initial capital equipment and installation costs.*

Payback period in years $= (c + e) \div (\Delta$ *savings from P2 project)*

Using the data from the example above, the payback period is [($42,000) ÷ ($17,000)] = 2.5 years. The economic analysis information can be plotted, to illustrate the P2 $ benefits.



P2 Project $ Benefit

SECTION 3.0 Notes.

Comments for the P2RA% measure include:

- A conscious effort will be necessary for each site to obtain data at the project or process level. Completing pollution prevention opportunity assessments (PPOAs) and implementing P2 options are frequently at a process or project level. By use of the PPOAs process, sites can identify projects that will result in waste avoided. The Environmental Restoration/Decontamination & Decommissioning program can also use the PPOA and remediation planning processes to project waste avoidance. Until actual data can be gathered at the process or project level, site–level will be the principal measure.

- Sites must track the waste types in the Annual Report and air/waster emissions for the Toxic Release Inventory (TRI) goals, as well as the procurement/use of toxic materials for both the TRI and affirmative procurement program goals.

- From the planned activities, a yearly requirement can be established for waste generation reductions (percent reduction) in each waste type, as well as targets for waste avoidance for air/water/solid emissions based on projects to be implemented. Sites would report actual waste avoided data by waste type and for air/water/toxic materials in their Annual Report submission. The actual versus the requirement would be used to compute a percentage measure or performance measure on how successful the site was meeting their requirements, including the waste avoided requirement based on their pollution prevention projects. This approach gives a score for each site on conformance with their requirement and includes any ER/D&D projects that are completed by the site. The individual scores for each waste type can be aggregated to an overall score for the site. Where site overall generation totals increase, sites could still show progress on waste avoided.

- Under many conditions the pollutant reduction attributable to P2 may be a combination of discontinuation and cutbacks in production. It is hoped that the optional normalization index (see glossary - normalization) adjustment will capture these effects.

- Often segregation by activity type is necessary to accommodate the cases where short–term waste generation activities like environmental restoration, intermittent tasks, and level-of-effort projects can increase waste generations. An example is personal protective equipment routinely generated from D&D activities which in the near-term increases waste generation.

- Some initial work is required to set up the requirement tables and key indicators for various CSOs and DOE activity types. Once they are established, they should be adjusted annually. A major benefit of the effort is an awareness of DOE's effectiveness in carrying out its P2 responsibility.

Notes for the cost management measures:

- The program requirements to achieve requirements must be integrated into the DOE budgeting and planning system as a distinct budget category for each line organization. This is essential to both ensure P2 implementation and cost tracking.

- Implementation of P2 typically requires non recurring capital equipment and installation cost that benefit DOE in the future, but are charged to operations in the current year. These P2 expenses are over and above the routine operation needs of the site and are strategic to the extent they are used to achieve DOE and site pollution prevention requirements. For purposes of calculating

return on investment of P2 projects, longer payback periods may be used to justify implementation.

- Other suggested economic measures and their definition are:

1. Actual versus forecasted costs for pollution prevention.

    - Forecasted costs for pollution prevention (costs estimates prior to implementation) including: labor, materials, construction, equipment, training, energy, overhead, and procedural development.

    - Actual costs for pollution prevention (total cost of implementation) including: labor, materials, construction, equipment, training, energy, institution overhead, and procedural development.

2. $\frac{\text{Saving (\$) from waste avoided + energy (\$) saved + materials (\$) saved + etc.}}{\text{Total implementation costs}}$[8]

    - The benefits of pollution prevention (i.e., waste cost avoided plus operating cost savings plus material cost savings) divided by the implementation costs for pollution prevention must be greater than one for all projects/sites.

3. Project Life-Cycle Costs: includes potential costs avoided that could have been achieved had implementation dollars been received.[9]

Comments for the ER/D&D/C&T measures includes:

- Although the greatest opportunities for performing and measuring WMin/P2 are when physical work takes place (e.g., when dirt gets dug up, when process equipment is removed, etc.) consideration and inclusion of WMin/P2 requirements and incentives into the planning, assessment and selection phases, are also possible; opportunities include specifying WMin/P2 requirements and incentives in (1) the design package, (2) the detailed plan/schedule, and (3) the contracts for procurement and or services. Qualitative WMin/P2 measures comparing work performed to a WMin/P2 Checklist of Best Management Practices could also be useful. Quantitative data demonstrating a project's WMin/P2 progress for both primary and secondary wastes can be taken from manifests, receipts, checklists, and the project's final report.

- Common definitions or lack of clear definitions are often encountered in the field.

- Waste Management requirements need to be considered and coordinated with ER/D&D/C&T operations.

- Waste disposal should be a factor in total life cycle of project.

- A checklist (Yes or No) of Best Management Practices for ER/D&D/C&T operations should be developed.

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[8]The numerator for this metric is under investigation to identify and define elements for determining cost saving.

[9][($ spent which could have been avoided) - (implementation $s requested) = (net savings $)].

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GLOSSARY

To ensure the validity (data collection) and usefulness of interpretation (analysis) of information, it is necessary to establishing some common understanding of measurement terms and elements; the following terms and measurement system elements as presented here are specific to the P2 measurement evaluation process.

Activities: Actions that change resources from one form to another.

Baseline: The baseline is a quantity of pollutant released during a specific year. It serves as a comparison or control reference for determining actual progress toward source reduction and recycling requirements. At present, DOE evaluates P2 progress by measuring the difference in annual generation rates between the current year and the baseline years. DOE's baseline pollutant release reference is 1993. When setting requirements from an established baseline, frequency of waste generation must be considered. There are both routine and discontinuous operations within the DOE.

Discontinuous activity types: Discontinuous activity types include such operations as surveillance and monitoring and one–time environmental remediation activities. They also include infrequently occurring level-of-effort projects. The following activity types may not have a fixed 1993 waste generation baseline from which to evaluate P2 progress. The establishment of a BL or a reduction requirement in terms of the BL may have little meaning. Specific throughput-based pollutant reduction values are needed as requirements for these activity types. Once requirements are set, achievement toward P2 efforts can be measured.

Goal: A specific result toward which processes are directed.

Indexing: In the process of normalizing waste generation measurements, an index is used to relate the waste generation quantity (a dependent variable) to an independent variable that reflects changes in waste generation quantities. Several alternatives exist for accounting changes in the level of production or activity. They can be either output or input measures. Output measures — such as mass of the product, units produced, or value of the product can be used as an index. Likewise, input measures — such as mass or value of input materials can be used. However, these choices have some inherent disadvantages:

1) they do not necessarily correlate,
2) they are not necessarily applicable to non-manufacturing operations,
3) they are not directly comparable across waste types,
4) data is not always available,
5) sensitive or proprietary information may restrict use or dissemination.

Indexing (con't): Based on currently available studies, (see Dependent And Independent Variables And Correlation Coefficients table at end of Glossary) the most reliable normalization factor for waste generation is the number of employees or work hours. Historically, the work hours adjustment has had widespread acceptability, has been widely understood and its advantages and limitations are well known to site managers. In addition, work hour information is readily available at many facilities, is widely applicable to different processes and facilities, and is not likely to be restricted information. It is also easy to aggregate from the process level to higher levels. For example, industrial accident and injuries are reported per 200,000 work hours.

By using work hours as the index, an appropriate method for scaling the waste generation quantities to the site population can be calculated; for the different waste types, the activity index is used to normalize the waste generation for newly-generated waste from routine site-wide activities for that calendar year. To calculate the index, the population for the baseline year, is divided by the current site population. (ALSO SEE NORMALIZING)

Intermittent projects: Intermittent projects are activities that occur regularly but not on a predictable schedule, or during which the amount of waste generated is unpredictable. Examples may include facility construction or remodeling and some ground water monitoring operations.

Level–of–effort projects: Level-of-effort projects are short-term activities that introduce a waste stream for a period of time and then cease. Research and development activities are often a level-of-effort project. The waste generated from the research exists during the length of project funding.

Metric: Metrics are standards of measurement (such as length, area, frequency, etc.).

Non-routine operations: Non routine operations are activities that are lengthy but not routine, e.g., decontamination and decommissioning projects, environmental restoration projects, etc. These activities produce a waste stream for a period of time and then cease, or it may be uncertain if the activity, and therefore the wastes produced, will ever occur again. Examples include D&D, pond waste management project activities, some long-term R&D laboratory activities, remedial investigation/site characterization, and site environmental restoration activities.

Normalizing: To present an accurate picture of waste generation data, it is necessary to normalize the data — that is, to present the waste generation data relative to changes in production or activity level. This will prevent inclusion of waste generation reductions that result solely from reductions in production or activity levels at a particular facility. More importantly, it will allow comparisons of data from facilities that may have differing levels of production or activity (i.e., standard waste measurement units allow data collection, roll-up, and summary despite differences in waste types).
Normalization Index (N_I) = ($a^b \div a^y$)
a^b = baseline year work hours
a^y = current year work hours
(ALSO SEE INDEXING)

Objective: A statement of the general condition to be achieved.

Performance indicators: Performance indicators are pointers comprised of related performance measures that reveal changes compared to a reference; that is, an indicator is composed of one or more measures.

Performance measure: Performance measures are quantitative evaluations of the products or services of a process or system. A performance measure is comprised of a number and a unit of measure. The number gives us a magnitude (how much) and the unit gives the number a meaning (what). Performance measures are tied to a goal or an objective (target). Performance measures may be represented by single dimensional units, (attributes: things that get counted or sorted) such as minutes, hours, dollars, the number of reports, number of errors, number of employees completing required training, etc. They can show the variation in a process or deviation from specifications. Single dimensional units of measure often represent basic and fundamental measures of product or process. More often, multi-dimensional units of measure are used (variables). These performance measures are expressed as a ratio of two or more fundamental units. Some examples are: miles per gallon (a measure of fuel economy); number of accidents per 200,000 hours worked (a performance measure of the safety program's effectiveness); or the number of on-time vendor deliveries per total number of vendor deliveries (a performance measure of both the vendor's delivery capability and procurement process). Performance measures expressed this way usually convey more information than do single dimensional performance measures.

Process: A set of activities that produce products or services and has inputs and outputs.

Product: A tangible output of a process or system.

Project: An activity that is planned or devised involving budget, personnel, time and equipment.

Recoverable Materials: Materials that still have useful economical, physical or chemical properties after serving their original purpose.

Routine operations: Routine operations are ongoing activities that occur year-in, year-out. Their inputs and outputs are easily identifiable and predictable. A baseline of waste generation (BL) can be established, and a reduction goal can be expressed in terms of the BL. Many facility infrastructure operations, such as vehicle maintenance and photo processing have routinely generated waste streams.

Service: Work done for others

Surveillance and monitoring operations: Surveillance and monitoring operations are activities during which no product is being generated currently but generation is projected during future actions. Wastes are generated during the monitoring and surveillance.

System: A logical, interconnected set of processes.

Waste Reduction: Preventing and or decreasing the amount of waste being generated either through prevention or recovery.

Dependent And Independent Variables And Correlation Coefficients[10]

Dependent Variables	Independent	Correlation Coefficient[11]
Generation	Time	.35
Disposal	Time	.00
Generation	Employment	.70
Disposal	Employment	.00
Generation	Budget[12]	not available[13]

[10]Table source from Measuring Pollution Prevention Progress, May 1994, EPA

[11]All correlation coefficients report here are "adjusted r^2" values. This is a standard statistical measure; it is the usual correlation coefficient, adjusted downward to correct for spurious correlation which can appear due to a small sample.

[12]The reader is warned, in order to utilize budget data, this data must be adjusted so that the information is expressed in constant year dollars.

[13]The correlation coefficient is not available, however the coefficient of variation from the same study is equal to 0.059.

APPENDIX D. P2 MEASUREMENT WORKSHEETS

WORKSHEET 1: P2 WASTE REDUCTION REQUIREMENT (R)

The first step of the evaluation process is to identify and quantify the requirement; this provides a numeric target as the basis to evaluate progress in P2 activities. To establish the numeric requirement, the following information is required:

- (BL) the baseline waste generation quantity, and
- (G) the quantitative waste reduction goal.

The quantified requirement equals the specified baseline quantity times the goal (expressed as a fraction); for example, using the RCRA hazardous waste type reduction goal of 50% by the year 1999 means that the baseline RCRA waste quantity is multiplied by 0.5 to determine the required quantity of prevented waste. The formula to determine the P2 Waste Reduction Requirement is:

$$R = BL * (G/100)$$

P2 Waste Reduction Requirement

Waste Types	Sanitary	RCRA	TSCA	State-Reg	Mixed TRU	Transuranic
Goal (G) Target date Reduction goal						
Baseline (BL) CY Amount (units)						
Requirement (R) Quantity required to meet reduction goal						

Waste Types	Mixed LL	LL	HW	Industrial		TOTAL
Goal (G) Target date Reduction goal						
Baseline (BL) CY Amount (units)						
Requirement (R) Quantity required to meet reduction goal						

WORKSHEET 2: POLLUTION PREVENTED (PP) PERFORMANCE

Use the following table to quantify the annual amount of pollution prevented (waste reduced) as a result of your site's P2 activities. When recording the quantities of waste prevented, keep in mind the time frame of the measurement and if necessary multiply those measures by an appropriate[15] multiplier to get an annual quantity. Finally, if required, use the last column to convert the units of measure to the appropriate units (e.g., weight in tons to kilograms, etc.) A separate table could be used for each waste type (e.g., RCRA, sanitary, etc.) To calculate the total amount of pollution prevented annually, add the quantities (per waste type with same units) in the last column.

Amount of Pollution Prevented (PP)

COMPLETED P2 PROJECT	WASTE TYPE	AMOUNT PREVENTED (units/time)	ANNUAL AMOUNT PREVENTED (x annual multiplier)	CONVERSION TO PROPER UNITS (kg, m^3, etc.)
		TOTAL AMOUNT OF WASTE REDUCED:		

[15]The appropriate multiplier is the number of months, weeks, days, that the P2 project has resulted in the reduction of targeted waste generation (i.e., actual P2 implementation time). If the quantity of pollution prevented is from an intermittent or discontinuous activity, then the annual amount prevented is the calculated by summation of the known quantities.

WORKSHEET 3: POLLUTION PREVENTION REQUIREMENT ACHIEVEMENT (P2RA%)

The P2RA% is a key indication of performance. The extent of achievement is measured by comparison against a standard P2 requirement. P2RA% can also be used as a standard of comparison to estimate or judge progress toward requirements across dissimilar operations and within specific CSOs. The P2RA% formula is defined as:

*Pollution Prevention Requirement Achievement (P2RA%) = (PP ÷ R) * 100*

- P2 Waste Reduction Requirement (R): the quantity of waste to be avoided/reduced to meet the reduction requirement from the specified baseline amount (further definition may be per waste type and year).
- Pollution Prevented Measure (PP): the quantity of pollution prevented from completed P2 projects.

The quantity of pollution prevented from completed projects is divided by the waste reduction requirement quantity and then multiplied by 100 to determine the percent achievement towards the requirement. The table below can be used to show the annual targets for the waste types and the accumulated progress towards meeting the reduction requirement. To forecast long-term performance, projections of pollution prevented can be included; these estimated quantities are from approved or planned P2 projects.

Pollution Prevention Requirement Achievement (P2RA%)

	1994	1995	1996	1997	1998	1999
Cumulative P2 Requirement (R)						
Completed P2 Projects (PP)						
Approved P2 Projects[16]						
Planned P2 Projects[17]						
Remaining P2 Requirement						
(PP ÷ R) * 100 = P2RA%						

[16] Approved P2 project must be completed in the current CY to be included in next CY cumulative sum of completed projects.

[17] Planned P2 projects must be approved and completed in next CY to be included in cumulative sum of completed projects.

WORKSHEET 4: RECOVERABLE MATERIALS & ER/D&D/C&T RATIO

These measures include establishing recoverable material goals, the baselines for total waste quantities, the quantity of recovered materials, and for the ER/D&D/C&T measures primary and secondary waste quantities to calculate performance. An important assumption for these measures of performance is that *"everything is considered waste."* The formulas are defined as:

*Recoverable Materials Ratio rm% = (rm ÷ tw) * 100*

*ER/D&D and C/T Recoverable Materials Ratio rm% = (rm ÷ pw) * 100*

*ER/D&D and C/T Recoverable Materials % ' = (rm ÷ tw) * 100*

*Secondary Waste Ratio sw% = (sw ÷ tw) * 100*

Recoverable Materials Ratio

Waste Stream	A_1	A_2	A_3	$\Sigma (A_n)$
Recovery of materials goal				
Total waste (units)				
Amount of recovered materials (units)				
Ratio (rm ÷ tw) * 100				

ER/D&D/C&T Recoverable Materials Ratio

	Project Planning	Assessment & Selection	Implementation Phase
Recovery of materials requirement			
Primary waste (units)			
Amount of recovered materials (units)			
Ratio (rm ÷ pw) * 100			

Secondary Waste Ratio

	Project Planning	Assessment & Selection	Implementation Phase
Recovery of materials goal			
Primary waste (units)			
Secondary waste (units)			
Total waste(units) (sw + pw)			
Secondary Waste Ratio (sw ÷ tw) * 100			

WORKSHEET 5: PPOA MEASUREMENT

Tracking the number of PPOAs completed versus the number of PPOAs (identified and scheduled) provides a means to measure and evaluate potential P2 opportunities. The formula for the PPOA measurement is:

$$PPOA\ Measure = A \div B$$

To determine the total number of PPOAs required, identify all PPOAs (i.e., PPOAs completed, in progress, planned, to review, etc.) The total number is compared to the number of PPOAs actually completed; the number of completed divided by the total will establish the PPOA measure. Variations of the PPOA Measure, such as by waste type can also be useful when comparing reduction performance of waste types.

		PPOA MEASURE			
PPOA NUMBER	PROCESS	WASTE GEN. (units)	WASTE TYPE	PPOA STATUS	SCHEDULE
Σ (B) =				Σ (A) =	

PPOA measure = A ÷ B =

WORKSHEET 6: P2 PROJECT MILESTONE COMPLETION MEASURE

The P2 Milestone Completion Measurement can be useful for establishing milestone priorities of P2 projects necessary to meet the P2 reduction requirement. The measure supports decisions for allocating resources, detecting departures from planned levels of performance and restoring performance to planned levels. The importance of meeting each milestone, is defined by one of three weights (higher represents more important) described in the table below; the percent project completion is also assigned an appropriate completion score. To calculate the Milestone Completion Measure, the sum of the total weighted score is divided by the sum of the potential weighted score. The formula is defined as:

$$\Sigma(\textit{Actual Weighted Score}) \div \Sigma(\textit{Potential Weighted Score})$$

Milestone Priority Table

Priority	Weight	Description
High	9	A critical milestone — if not achieved then P2 requirement will not be met.
Medium	3	An important milestone to ensure P2 requirement is met.
Low	1	P2 Program enhancement; no major significance to meeting milestone.

P2 Project Completion Score Table

Completion Score	Description
100	Milestone complete
75	Milestone almost complete
50	Milestone 50% complete
25	Milestone started
0	Not started

Approved P2 Projects Summary[18]

P2 Project	(b) Operating Costs Before ($K)	(a) Operating Cost After ($K)	(b-a) Δ $$ ($K)	(c + e) Capital Cost ($K)	Expected PP (units)	Percent of Reduction Requirement (%)

[18]where: a = the annual operating costs after P2 project,
b = the annual operating costs before P2 project,
(c + e) = the initial capital investment + installation expense
Δ $$ = (b-a)

WORKSHEET 6 (con't): PROJECT MILESTONE COMPLETION

		Milestone Completion Measure			
Milestone Project	Waste Type	(a) Milestone Weight	(b) Project Completion Score	(a * b) Weighted Score	(a * 100) Potential Score
			Total Σ		

$\Sigma (a * b) \div \Sigma (a * 100) =$

WORKSHEET 7: RETURN ON INVESTMENT (ROI%)

The Return on Investment (ROI) Measure uses the current DOE calculation to compare and evaluate P2 projects for economic and requirement achievement benefits. The measurement can be useful for establishing priorities of planned, but unfunded P2 projects necessary to meet the P2 reduction requirement. The measure supports decisions for allocating resources, detecting departures from planned levels of performance and restoring performance to planned levels. To calculate the Return On Investment the formula is defined as:

$$ROI\% = [\,[(b-a) - d]/(c + e)\,] * 100$$

where: a = the annual operating costs after P2 project,
b = the annual operating costs before P2 project,
c = the initial capital investment,
d = adjustment for depreciation[19] [(c + e) / useful life], and
e = the installation expense.

Planned, Unfunded P2 Projects Summary

Project	(b) Operating Costs Before ($K)	(a) Operating Cost After ($K)	(c) Capital Investment ($K)	(e) Installation Cost ($K)	Expected PP (units)	**Percent of Reduction Requirement (%)**

ROI% Calculation

Project	d	(b - a)	(c + e)	$\frac{(b - a) - d}{(c + e)}$ * 100	**ROI%**

[19]Depreciation is used only for calculation purposes; it can be ignored for projects with a useful life of more than 10 years.

WORKSHEET 8: GROSS POLLUTION PREVENTED $$ SAVINGS

Avoided waste disposal costs can be calculated differently depending on the type of waste and the units (weight, volume, or container) used to determine disposal costs. Additional savings can be revenues collected from recoverable or exchanged materials as well as avoided purchase costs. $$ Avoided/Saved includes: avoided treatment, storage, disposal or release (TSDR) waste management costs,[20] $ value of material reduced, reused, recovered, or recycled in process; $ value of reapplication of used equipment or the dollar value of recoverable materials; $ saved from reduced purchases; $ saved from reduced legal liabilities; risk reduction savings; reduced environmental compliance, or energy savings. Use the following tables to determine the total gross Pollution Prevented Savings. Using the information in each table, the Gross Pollution Prevention Saving formula is:

$$\Sigma \textit{ [avoided waste disposal costs (step A) + avoided purchases (step B) + revenues from recoverables (step C) + etc.]}$$

Step A. Avoided Costs of Waste Management(WM)

COMPLETED P2 PROJECT	AMOUNT OF WASTE REDUCED (annual)	CONVERSION TO WM UNITS (kg, m^3, etc.)	WM COSTS (per unit)	AVOIDED WM COSTS ($)
Total Annual Avoided Costs of Waste Management				$$

[20] [(quantity of wastes by type diverted from TSDR) * (disposal $ from DOE Model) = (estimated avoided $)].

WORKSHEET 8 (con't): GROSS POLLUTION PREVENTED $$ SAVINGS

Step B. Savings From Materials Not Purchased

COMPLETED P2 PROJECT	AMOUNT MATERIAL NOT PURCHASED (annual)	PURCHASE COST (per unit)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)	ANNUAL AVOIDED $$ PURCHASE ($)
Total Annual Savings From Materials Not Purchased				$$

Step C. Revenues Generated From the Sale of Recoverables

COMPLETED P2 PROJECT	AMOUNT OF RECOVERED MATERIAL (annual)	REVENUE GENERATED (per unit)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)	ANNUAL REVENUES ($)
Total Annual Revenues Generated From the Sale of Recoverables				$$

Gross Pollution Prevented $$ Savings =

Avoided waste management costs (step A)		Amount of savings from materials not purchased (step B)		Revenues from recoverables (step C)		*GROSS P2 $$ SAVING*
$$	+	$$	+	$$	=	*$$*

WORKSHEET 9: NET POLLUTION PREVENTION $ BENEFIT

This measurement considers the cumulative dollar saving benefits over the life of the P2 project. The Net P2 $$ benefit provides a defensible basis for budgeting and implementation of P2 projects using the data elements of the return on investment measure. The Net P2 $$ Benefit measure is defined as:

$$\textit{Net P2 \$\$ Benefit} = [(b * L_y)] - [(c + e) + (a * L_y)]$$

where: a = the annual operating costs after P2 project,
b = the annual operating costs before P2 project,
c = the initial capital investment,
e = the installation expense, and
L_y = the expected life of the P2 Project in years.

The Net P2 $$ Benefit formula estimates the P2 dollar benefit over the life of the project; the formula uses constant dollars over the life of the P2 project.[21] This measure includes those activities that are specifically funded for implementation as part of the pollution prevention program. As tracking P2 project implementation costs improve, all activities that are considered pollution prevention related (even those funded out of overhead, or non-pollution prevention accounts) could also be measured.

Using Net P2 $$ Benefit results, another method to measure the economic benefits of the P2 project is to calculate the payback period for the P2 project. The payback period is the amount of time required for the *cumulative savings to equal the initial capital equipment and installation costs.* Δ $$ savings from implementing P2 project is the difference in the operation expenses before and after P2.

$$\textit{Payback period in years} = (c + e) \div (\Delta \textit{ savings from P2 project})$$

Net P2 $ Benefit Calculation

Initial Capital Investment & Installation Expense for P2 Project (c + e):

1. Equipment	
a)	$
b)	$
c)	$
2. Facility preparation	$
3. Installation	$
4. Other	$
5. Other	$

$ _____
Total Capital Costs

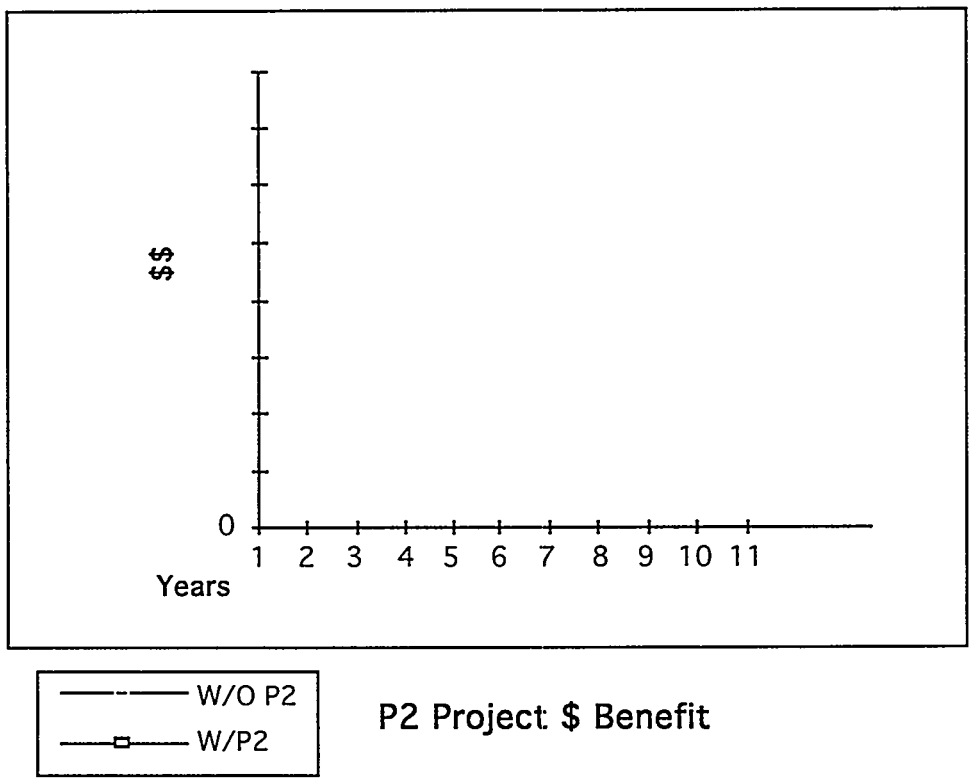
[21] To calculate a cumulative total for all P2 projects, then: Σ *[Net P2 $$ Benefit]*

WORKSHEET 9 (con't): NET POLLUTION PREVENTION $ BENEFIT

Annual Operating Costs of P2 Project	L_y	(b) Before $$	(a) After $$	(b-a) Δ $$
1. Materials & Supplies				
2. Operation & Maintenance				
3. Transportation				
4. Ongoing training				
5. Other				
6. Other				
7.				
8.				
Total				

Net P2 $$ Benefit = $[(b * L_y)] - [(c + e) + (a * L_y)]$

Payback period in years = $(c + e) \div (\Delta$ savings from P2 project)



P2 Project $ Benefit

APPENDIX E.

EXAMPLE P2 MEASURES PROBLEM

As the Waste Minimization coordinator, you have been asked to prepare a presentation for the company president. The request was to answer the following questions:

1. Is the company on track to meet their 50% waste reduction requirement by 1999 (using 1993 as the baseline)?
2. If not, what are we doing to get on track to meet the requirement?
3. What other projects do we need to fund to help meet our waste reduction requirement with a $150K budget?
4. Is there any economic benefit/cost in meeting the waste reduction requirement?

Review the attached P2 data file:

1. Company goals and baseline waste generation data taken from the Company's 1994 Waste Minimization Plan.
2. PPOA status report.
3. Completed RCRA Hazardous Waste P2 projects from CY94.
4. Approved RCRA Hazardous Waste P2 projects with estimated or actual start and completion dates.
5. Planned RCRA Hazardous Waste ROI project proposals.

Then using the workbook definitions and example calculations, develop answers to the above questions. Answer worksheets are provided following the P2 file information.

Waste Minimization Plan P2 Goals[22] -- Cumulative Schedule

Waste Type	CY93	CY94	CY95	CY96	CY97	CY98	CY99
RCRA	0%	8%	17%	25%	33%	42%	50%
Industrial	0%	8%	17%	25%	33%	42%	50%
Sanitary	0%	8%	17%	25%	33%	42%	50%

Waste Generation Baseline (1993) Quantities

Waste Type	Disposition	1993 (actual)
RCRA	TSDR	45,000 kg
Industrial	TSDR	100,000 kg
Sanitary	Landfill	12,000 kg

PPOA STATUS REPORT SUMMARY

PROCESS	WASTE GEN[23]. (kg)	WASTE TYPE	PPOA STATUS[24]	SCHEDULE
Milling	100	RCRA	Complete	6/91
Milling	1200	Sanitary	Complete	8/94
Machining	4500	RCRA	Complete	12/94
Machining	3750	Sanitary	Complete	12/94
Micro-electronics	550	Industrial	In Progress	8/95
Motor Pool	1300	RCRA	In Progress	9/95
Plating	4500	RCRA	In Progress	12/95
Photo Voltaic Ops	100	RCRA	Planned	6/96
Electromagnetic-	3675	Industrial	Planned	6/96
Fire Test	95	RCRA	Planned	8/96

[22]The company has set a corporate goal of 50% reduction in all waste by the end of CY99.

[23] The waste generation quantity is the amount of waste the process generated in CY94.

[24]NOTE:

Complete: PPOA has been completed and opportunities identified. A review of PPOAs occurs every three years.

In-Progress: The PPOA is in progress at this time. The completion date is reasonable and tied to milestone completion date.

Planned: PPOA is in the Q but no firm schedule has been established. A tentative date has been agreed upon but is dependent on funding in the next fiscal year.

COMPLETED P2 PROJECTS

RCRA Hazardous Waste

Project A: Recycling Machine A cutting fluid solution recycling machine was procured for an initial investment (including equipment and installation) of $15K. This machine allowed 550 gallons[25] of cutting fluid to be recycled and reused rather than sent out as hazardous waste[26]; this project also avoids purchasing cost of $50/lb for the 20/1 concentrate to make the cutting fluid. The new operating costs for managing the cutting fluid solution were reduced from $5K/yr to $4K/yr. The machine is expected to have a useful life of 15 years.

Project B: Material Substitution A material substitution was implemented, substituting Methylene Chloride with D-Limonine. This substitution reduced employee exposure to dangerous VOCs and also reduced the volume of hazardous waste generated. Now only 500 kg of hazardous waste is produced rather than 1000 kg. The operating costs have changed from $3000/yr to $2500/yr. Start up costs were $3000.

Sanitary Waste

Project C: Metal Recycling A recycling program was developed to recycle the scrap metal and fines from the machining operation. In CY94, 1000 kg of metal were recycled[27] rather than sent to disposal.[28] The operating costs increased by $2000/yr. Start up costs for this project were $1000.

APPROVED RCRA HAZARDOUS WASTE P2 PROJECTS

The following projects have approved project plans and are funded; these projects are scheduled for completion in CY95.

Project 1: Materials Substitution Filter cleaning systems that utilize TCE will be substituted with a non-hazardous material. The initial capital expense will be $100K. Operating costs before implementation were $24K; after implementation operating costs will be $30K. Implementation of this program will reduce the TCE waste by 2500 kg. The project is almost complete. If TCE is not eliminated, the company is subject to a $25K per day fine beginning January 1, 1996. The useful life of the new equipment is 20 years.

Project 2: Heavy Metal Extraction An ion exchange unit will be used to remove heavy metals from the sludge residue at the materials maintenance area. The unit will require an initial capital expenditure of $100K. Operating costs before implementation were $15K; after implementation operating costs will be $5K. The project will eliminate the generation of 400 kg of RCRA hazardous waste. The unit is on-line and ready to begin operating after the final inspection is complete. The useful life of the new equipment is 5 years.

Project 3: Nitrogen Fixation The parts cleaning unit in the maintenance department will utilize high pressure steam in place of chlorinated solvent. The system will require an initial capital expenditure of

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[25]Cutting solution weight is 8 lbs/gal. There are 2.2 lbs per kg.
[26]$32/kg hazardous waste management costs.
[27]Mixed metal scrap recovery value is $15/lb.
[28]$8/yd^3 for sanitary waste management costs.

$40K. Operating costs before implementation were $20K; after implementation operating costs will be $4K. This project will eliminate the generation of 1500 kg of hazardous waste. The project has just been started; the waste reduction will contribute to reaching the waste reduction goal. The useful life of the equipment is expected to be 10 years.

PLANNED RCRA HAZARDOUS WASTE ROI PROJECTS

The following planned projects will be completed by the end of CY96 if funded through the Company's Return on Investment program.

Project Proposal -- Ion Exchange Currently, machining in the machine shop produces 4500 kg of hazardous waste. The annual operating cost is $30K. With the addition of an Ion Exchange machine, the annual operating costs will be lowered to $12K. The initial capital investment is $50K with an installation cost of $25K. The project will last 15 years and 1500 kg of waste will be avoided the first year.

Project Proposal -- Material Substitution (MSUB) Methyethyl-death (MED) is currently in use at the machine shop for degreasing. The annual cost is $112K and produces 7000 kg of waste per year. If ethylenecoma (EC) is used instead of MED, the new annual operating cost will be reduced to $29.5K and 1000 kg of waste will be avoided. Furthermore, the capital investment for an EC degreasing machine is $35K with an installation cost of $40K. The machine has a useful life of 20 years.

Project Proposal -- Filtration A waste water filtration unit was proposed for the machine shop. It now cost $19K/year to manage waste water produced by the machine shop. After installation of a $25K unit with an installation fee of $50K, the new annual operating cost will go down to $7K. Ultimately 3750 kg of waste will be avoided the first year. The life expectancy of the unit is 12 years.

Answers to the Example Problem

The first question of whether the Company is on track to met the waste reduction requirement can be answered by determining the P2RA%. But first, the reduction requirement must be identified and quantified; this provides a numeric target as the basis to evaluate progress in P2 activities. The data from the P2 Goals Schedule and the baseline quantities table is used to calculate the reduction requirement.

Waste Minimization Plan P2 Waste Generation Baseline & P2 Goals Cumulative Schedule

Waste Type	1993 BL	CY93	CY94	CY95	CY96	CY97	CY98	CY99
RCRA	45,000 kg	0%	8%	17%	25%	33%	42%	50%
Industrial	100,000 kg	0%	8%	17%	25%	33%	42%	50%
Sanitary	12,000 kg	0%	8%	17%	25%	33%	42%	50%

The Company's waste reduction requirements are calculated using the formula: $R = BL * (G/100)$

Cumulative P2 Waste Reduction Requirement

Waste Type	CY93	CY94	CY95	CY96	CY97	CY98	CY99
RCRA	0	3,750 kg	7,500 kg	11,250 kg	15,000 kg	18,750 kg	22,500 kg
Industrial	0	8,333 kg	16,667 kg	25,000 kg	33,333 kg	41,667 kg	50,000 kg
Sanitary	0	1,000 kg	2,000 kg	3,000 kg	4,000 kg	5,000 kg	6,000 kg

Answer to Worksheet 1:

P2 Waste Reduction Requirement

Waste Types	RCRA	Industrial	Sanitary		Overall
Goal (G) Target date Reduction goal	1999 50%	1999 50%	1999 50%		1999 50%
Baseline (BL) CY Amount (units)	1993 45,000 kg	1993 100,000 kg	1993 12,000 kg		1993 157,000 kg
Requirement (R) Quantity required to meet reduction goal	**22,500 kg**	**50,000 kg**	**6,000 kg**		**78,500 kg**

After establishing the numeric target, the next step is to collect information regarding pollution prevented (actual waste reduced) as a result the Company's P2 projects. The data from approved and planned projects is also collected (expected pollution prevented can be based on PPOA information, engineering estimate, etc.) and summarized in separate tables for use in projecting near-term performance. This information is summarized in the following tables:

Completed P2 Projects Summary

P2 Project	Waste Type	Amount P2 Prevented	Conversion To Uniform Units (kg, m^3, etc.)
A - Recycling Machine	RCRA	550 gal	550 * 8 lbs/gal * 0.453 kg/lbs = 1,993 kg
B - Material Sub	RCRA	500 kg	500 kg
C - Metal Recycling	Sanitary	1,000 kg	1,000 kg

Approved P2 Projects Summary

Project	Useful Life (years)	Operating Costs Before ($K)	Operating Cost After ($K)	Δ $$	Capital Cost ($K)	Expected PP (kg)
1	20	24	30	(-6)	100	2,500
2	5	15	5	10	100	400
3	10	20	4	16	40	1,500

Planned/Unfunded Projects Summary

P2 Project	Useful Life (years)	Existing cost ($K)	New cost ($K)	Capital investment ($K)	Installation cost ($K)	Expected PP (kg)
Ion Exchange	20	30	12	50	25	1500
MSUB	20	112	29.5	35	40	1000
Filtration	12	19	7	25	40	3750

Using the completed P2 projects information, Worksheet 2 is completed for each separate waste type (e.g., RCRA, sanitary, etc.).

Answers to Worksheet 2:

Annual Amount of RCRA Pollution Prevented (PP)

P2 PROJECT	WASTE TYPE	AMOUNT PREVENTED (units/time)	ANNUAL AMOUNT PREVENTED (x annual multiplier)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)
A - Recycling Machine	RCRA	550 gal/yr	550 gal	550 * 8 * 0.453 = 1,993 kg
B - Material Sub	RCRA	500 kg/yr	500 kg	500 kg
TOTAL AMOUNT OF RCRA WASTE REDUCED:				**2,493 kg**

Annual Amount of Sanitary Pollution Prevented (PP)

P2 PROJECT	WASTE TYPE	AMOUNT PREVENTED (units/time)	ANNUAL AMOUNT PREVENTED (x annual multiplier)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)
C - Metal Recycling	Sanitary	1,000 kg/yr	1,000 kg	1,000 kg
TOTAL AMOUNT OF SANITARY WASTE REDUCED:				**1,000 kg**

Annual Amount Industrial of Pollution Prevented (PP)

P2 PROJECT	WASTE TYPE	AMOUNT PREVENTED (units/time)	ANNUAL AMOUNT PREVENTED (x annual multiplier)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)
TOTAL AMOUNT OF INDUSTRIAL WASTE REDUCED:				**0.0**

Total Annual Amount of Pollution Prevented (PP)

P2 PROJECT	WASTE TYPE	AMOUNT PREVENTED units/time	ANNUAL AMOUNT PREVENTED (x annual multiplier)	CONVERSION TO UNIFORM UNITS (kg, m^3, etc.)
A - Recycling Machine	RCRA	550 gal/yr	550 gal	550 * 8 * 0.453 = 1,993 kg
B - Material Sub	RCRA	500 kg/yr	500 kg	500 kg
C - Metal Recycling	Sanitary	1,000 kg/yr	1,000 kg	1,000 kg
TOTAL AMOUNT OF WASTE REDUCED:				**3,493 kg**

Using the Completed P2 Projects pollution prevented data from Worksheet 2 and the waste reduction requirement quantity from Worksheet 1, the percent achievement towards the requirement is determined. These results provide a measurement of the Company's P2 performance; this information answers the first question.

Pollution Prevention Requirement Achievement (P2RA%) **= (PP ÷ R) * 100**

P2RA% $RCRA_{1994}$ = (2,493 ÷ 3,750) * 100 = 66.5%
P2RA% $Sanitary_{1994}$ = (1000 ÷ 1,000) * 100 = 100%
P2RA% $Industrial_{1994}$ = (0 ÷ 0) * 100 = 0%
P2RA% $Overall_{1994}$ = (3,493 ÷ 12,560) = 27.8%

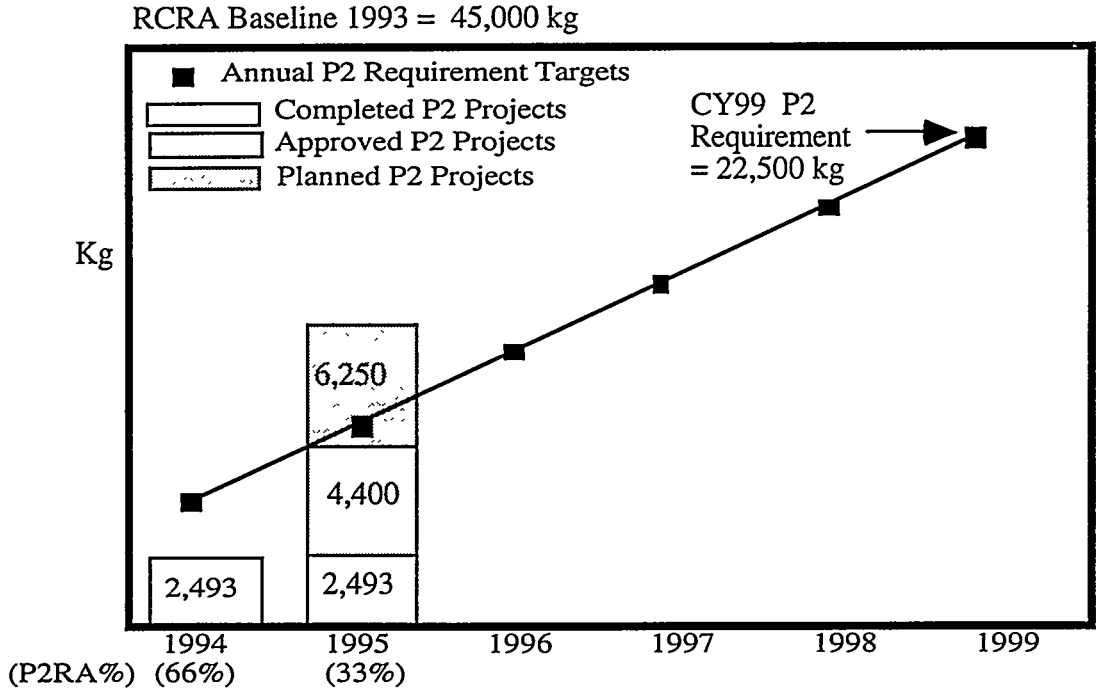
The results of calculating the P2RA% shows that the Company's reduction requirement for the RCRA and Industrial waste types (as well as overall) are not on track to meet the Company's 50% reduction requirement. It is important to establish if there are current projects underway or planned that will correct these deficiencies or if a corrective action plan is needed. To address this part of the problem,

forecasts using the expected pollution prevented quantities from the approved P2 projects are included in the P2RA% calculation to consider next year's performance towards the reduction requirement; this information is needed to support decisions (e.g., allocating resources, priorities, etc.) if corrective actions are determined to be necessary. (Longer-term performance could be calculated using the planned P2 Project information.) In the example problem, the Approved P2 projects are scheduled to be completed in CY95. Using the estimated pollution prevented quantity of 4,400 kg of RCRA waste (and the 2,493 kgs from the completed projects) the P2RA% for the $RCRA_{1995}$ Waste type is = **[(2,493 + 4,400) ÷ 7,500] = 91.9%.**

Answers and Graphs to Worksheet 3:

Pollution Prevention Requirement Achievement (P2RA%) for RCRA

	1994	1995	1996	1997	1998	1999
Cumulative P2 Requirement (R)	8% 3,750 kg	17% 7,500 kg	25% 11,250 kg	33% 15,000 kg	42% 18,750 kg	50% 22,500 kg
Completed P2 Projects (PP)	2,493 kg	2,493 kg				
Approved P2 Projects[29]		4,400 kg				
Planned P2 Projects[30]		6,250 kg				
Remaining P2 Requirement	1,257 kg	5,007 kg				
(PP ÷ R) * 100 = P2RA% **(2,493 ÷ 3,750) * 100**	**66.5%**	**33.2%**				



Requirement Achievement for RCRA Hazardous Waste (January 1, 1995)

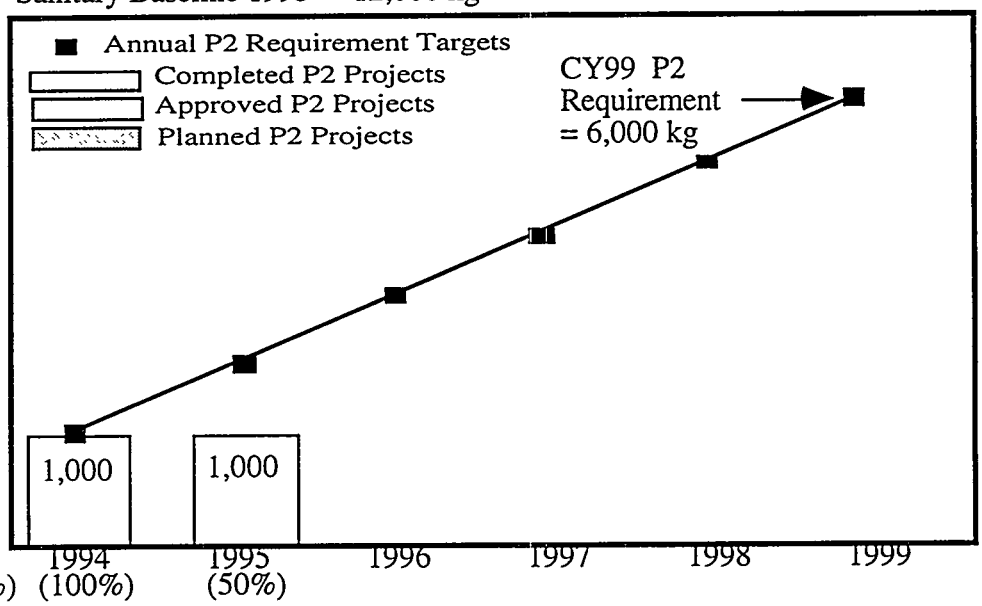
[29] Approved P2 project must be completed in the current CY to be included in next CY cumulative sum of completed projects.

[30] Planned P2 projects must be approved and completed in next CY to be included in cumulative sum of completed projects.

Pollution Prevention Requirement Achievement (P2RA%) for Sanitary

	1994	1995	1996	1997	1998	1999
Cumulative P2 Requirement (R)	8% 1,000 kg	17% 2,000 kg	25% 3,000 kg	33% 4,000 kg	42% 5,000 kg	50% 6,000 kg
Completed P2 Projects (PP)	1,000 kg	1,000 kg				
Approved P2 Projects						
Planned P2 Projects						
Remaining P2 Requirement	0	1,000 kg				
(PP ÷ R) * 100 = P2RA% **(2,493 ÷ 3,750) * 100**	**100%**	**50%**				

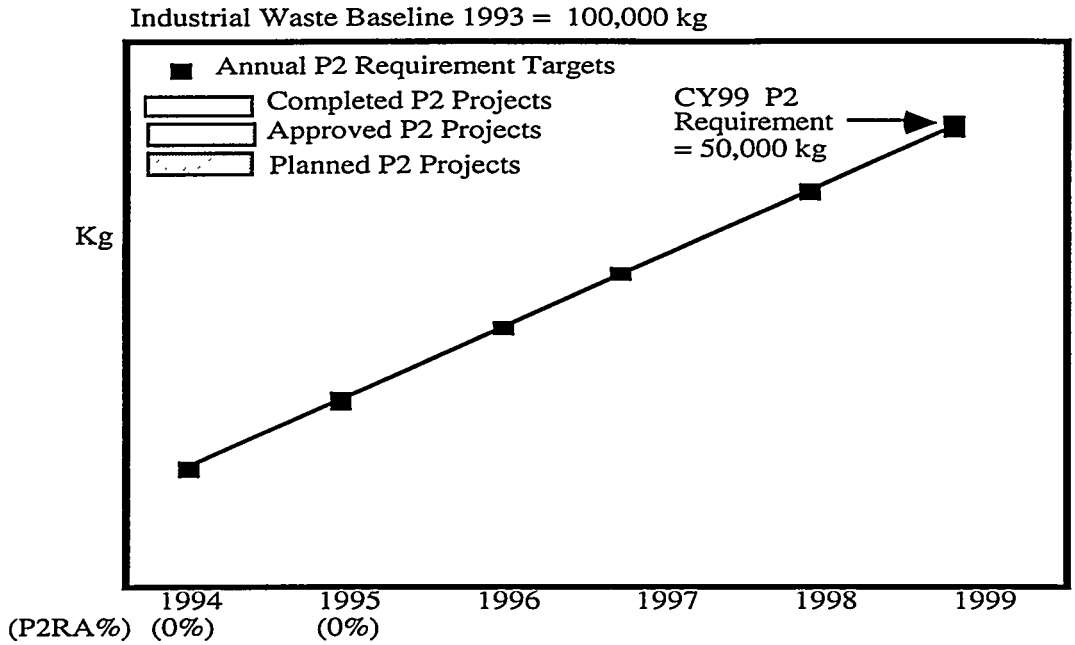
Sanitary Baseline 1993 = 12,000 kg



Requirement Achievement for Sanitary Waste (January 1, 1995)

Pollution Prevention Requirement Achievement (P2RA%) for Industrial

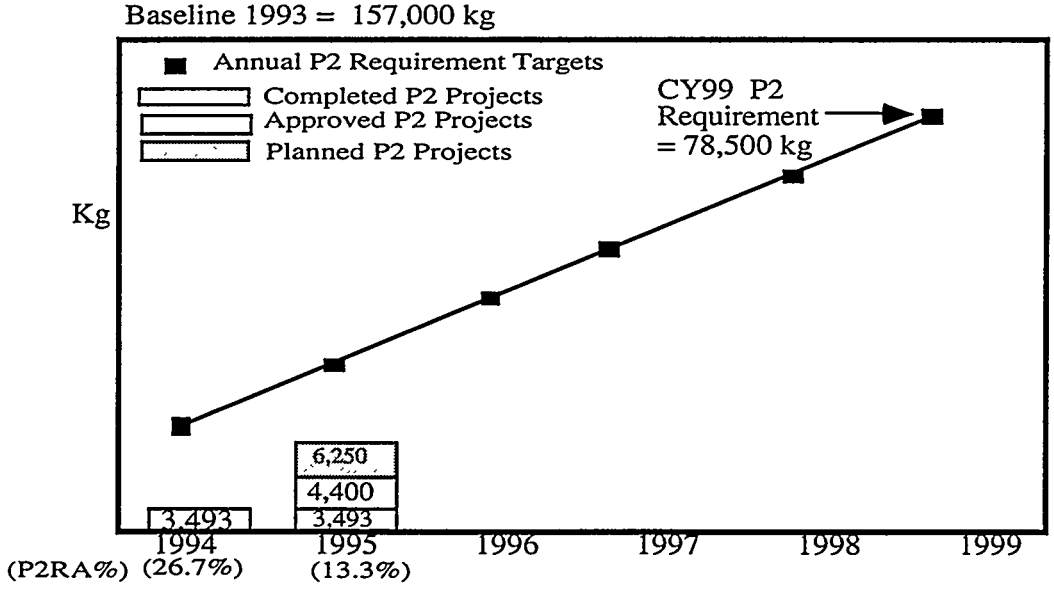
	1994	1995	1996	1997	1998	1999
Cumulative P2 Requirement (R)	8% 8,333 kg	17% 16,667 kg	25% 25,000 kg	33% 33,333 kg	42% 41,667 kg	50% 50,000 kg
Completed P2 Projects (PP)	0					
Approved P2 Projects						
Planned P2 Projects						
Remaining P2 Requirement	8,333 kg	16,667 kg				
(PP ÷ R) * 100 = P2RA% **(0 ÷ 0) * 100**	**0%**	**0%**				



Requirement Achievement for Industrial Waste (January 1, 1995)

Pollution Prevention Requirement Achievement (P2RA%) Overall Prevention Program

	1994	1995	1996	1997	1998	1999
Cumulative P2 Requirement (R)	8% 13,083 kg	17% 26,167 kg	25% 39,250 kg	33% 52,333 kg	42% 65,417 kg	50% 78,500 kg
Completed P2 Projects (PP)	3,493 kg	3,493 kg				
Approved P2 Projects	4,400 kg	4,400 kg				
Planned P2 Projects	6,250 kg	6,250 kg				
Remaining P2 Requirement	9,590 kg	22,674 kg				
(PP ÷ R) * 100 = P2RA% **(0 ÷ 0) * 100**	**26.7%**	**13.3%**				



Requirement Achievement Overall Prevention Program (January 1, 1995)

These results demonstrates that even if the approved P2 projects are completed, the reduction requirement will still fall short of the targeted reduction amount. Additional reduction projects, such as the RCRA planned P2 projects would contribute to meeting the reduction requirement, however, since there are no Industrial waste approved or planned projects, the Company needs to take corrective action if the waste reduction requirement is to be successfully achieved. This is the essence of question two, "what are we doing (or can we do) to get on track to meet the reduction requirement?"

An understanding of how the current approved or planned projects and any other P2 opportunities that can correct the deficiency is needed. One means of getting back on track is to identify potential P2 opportunities (such as PPOAs) with particular interest in the deficient waste types; the PPOA status is reviewed for information. Worksheet 4 is used to determine the PPOA Measures and the results will support corrective actions (i.e., what can be done to get back on track to meeting the reduction requirement). The usefulness of these results can support directing resources where and when they will be most effective.

Answers to Worksheet 4:

PPOA MEASURE

PPOA Number	Process	Waste Gen. (CY94)	Waste Type	PPOA Status	Schedule
001	Milling	100 kg	RCRA	To Review	6/91
002	Milling	1200 kg	Sanitary	Complete	8/94
003	Machining	4500 kg	RCRA	Complete	12/94
004	Machining	3750 kg	Sanitary	Complete	12/94
004	Micro-electronics	550 kg	Industrial	In Progress	8/95
006	Motor Pool	1300 kg	RCRA	In Progress	9/95
007	Plating	4500 kg	RCRA	In Progress	12/95
008	Photo Voltaic Operations	100 kg	RCRA	Planned	6/96
009	Electromagnetic	3675 kg	Industrial	Planned	6/96
010	Fire Test	95 kg	RCRA	Planned	8/96
Σ (B) = 10				Σ (A) = 3	

PPOA measure = A ÷ B = 3/10 = 30%

$PPOA_{RCRA}$:	**B= 6, A = 1**	**A ÷ B = 1/6 = 0.167**	**=**	**16.7%**
$PPOA_{Sanitary}$:	**B = 2, A = 2**	**A ÷ B = 2/2 = 1**	**=**	**100%**
$PPOA_{Industrial}$:	**B = 2, A = 0**	**A ÷ B = 0/2 = 0**	**=**	**0%**

First, the industrial waste type PPOA measure shows that zero industrial PPOAs have been completed; furthermore only two PPOAs are even identified (one in progress, the other scheduled). Although six

RCRA PPOAs were identified, only one has been completed. Given limited resources to conduct PPOAs, this information should be useful in targeting and scheduling PPOAs particularly at deficiencies in meeting the reduction requirement.

The next measure, the Milestone Completion Measure, provides another means to support decisions and can be used to establish milestone priorities of P2 projects necessary to meet the P2 reduction requirement. The importance of meeting each milestone is defined by one of three weights (higher represents more important); in the Company's case, consideration of the penalty of $25K a day is an important factor in determining the priority milestone weight. The percent project completion score is assigned to reflect the status of completing the project. To calculate the Milestone Completion Measure, the sum of the total weighted score is divided by the sum of the potential weighted score. The formula is defined as: Σ *(Actual Weighted Score)* $\div \Sigma$ *(Potential Weighted Score).*

Approved P2 Projects Summary

Project	Operating Costs Before ($K)	Operating Cost After ($K)	Δ $$	Capital Cost ($K)	Expected PP (kg)	Percent of Reduction Requirement (%)
1	24[31]	30	(-6)	100	2,500	11.1%
2	15	5	10	100	400	1.7%
3	20	4	16	40	1,500	6.7%
					Σ = 4,400	

Answers to Worksheet 6

Milestone Completion Measure

Milestone Project	Waste Type	(a) Milestone Weight	(b) Project Completion Score	(a * b) Weighted Score	(a * 100) Potential Score
1- Material Sub	RCRA	9	75	675	900
2- Heavy Metal	RCRA	3	75	225	300
3- Nitrogen Fix	RCRA	9	25	225	900
			Total Σ	1125	2100
Σ (a * b) $\div$ Σ (a * 100) = 1125/2100 = 0.54 or 54%					

The results of the Milestone Completion Measure reflects that more attention to the higher priority P2 projects could be more closely monitored to ensure timely implementation (e.g., if possible, reallocating the resources from project 2 to project 3 would result in achieving higher percent of reduction requirement).

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[31] If is not eliminated, then subject to fine of $25K/day beginning Jan 1, 1996.

The Return on Investment (ROI) Measure uses the current DOE calculation to compare and evaluate P2 projects for the obvious economic benefits as well as requirement achievement. This measure also supports decisions for directing resources towards deficient performance. To calculate the Return On Investment the formula is defined as: $ROI\% = [\,[(b-a) - d]/(c + e)\,] * 100$[32]

Answers to Worksheet 7:

Planned, Unfunded P2 Projects Summary

P2 Project	(b) Operating Costs Before ($K)	(a) Operating Cost After ($K)	(c) Capital Investment ($K)	(e) Installation Cost ($K)	Expected PP (kg)	Percent of Reduction Requirement (%)
Ion Exchange	30	12	50	25	1,500	6.7%
MSUB	112	29.5	35	40	1,000	4.4%
Filtration	19	7	25	50	3,750	16.7%

ROI% Calculation

P2 Project	d[33]	(b - a)	(c + e)	$\frac{(b-a)}{(c+e)} - d * 100$	ROI%
Ion Exchange	0	18	75	18/75 * 100	24%
MSUB	0	82.5	75	82.5/75 * 100	110%
Filtration	0	12	75	12/75 * 100	16%

The results of the ROI% calculation demonstrate that the Material Substitution Project (MSUB) has a significant return on investment and would be a likely project to target for funding. However, if Material Substitution Project's reduction results in 1,000 kg or contributes only 4.4% of the P2RA%, will the waste reduction requirement for the waste type be achieved? If both the ROI% and the contribution to P2RA% are considered, the Ion Exchange Project could be a better use of resources. Other considerations, such as those discussed for the Milestone Completion Measure, could be included in the planning and resource allocation process.

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[32]where: a = the annual operating costs after P2 project,
b = the annual operating costs before P2 project,
c = the initial capital investment,
d = adjustment for depreciation [(c + e) / useful life], and
e = the installation expense.

[33]Depreciation is used only for calculation purposes; it can be ignored for projects with a useful life of more than 10 years.

Using the information from the completed P2 Projects, the Gross Pollution Prevention Saving formula is calculated to determine the economic benefit of these P2 activities. The formula is: Σ *[(avoided waste disposal costs (step A) + avoided purchases (step B) + revenues from recoverables (step C) + etc.]* The results from Worksheets 8 & 9 will address the question concerning the cost/benefit of the P2 projects.

Answers to Worksheet 8

Step A. Avoided Costs of Waste Management(WM)

Completed P2 Project	Amount Of Waste Reduced (annual)	Conversion To WM Units (kg, m^3, etc.)	WM Costs (per unit)	Avoided WM Costs ($)
A - Recycling Machine	550 gal	550 * 8 lbs/gal * 0.453 kg/lbs = 1,993 kg	$32/kg	63,782
B - Material Sub	500 kg	500 kg	$32/kg	16,000
C - Metal Recycling	1,000 kg	1,000 kg * 2.2lbs/kg * 800 lbs/yd^3 = 27.5 yd^3	$ 8/yd^3	220
Total Annual Avoided Costs of Waste Management				$$ **80,002**

Step B. Savings From Materials Not Purchased

Completed P2 Project	Amount Material Not Purchased (annual)	Purchase Cost (per unit)	Conversion To Uniform Units (kg, m^3, etc.)	Annual Avoided $$ Purchase ($)
A - Recycling Machine	550 gal of 20/1 conc. solution = 27.5 gal	$ 50/lb	27.5 gal * 8 lbs/gal = 220 lbs	11,000
Total Annual Savings From Materials Not Purchased				$$ **11,000**

Step C. Revenues Generated From the Sale of Recoverables

Completed P2 Project	Amount of Recovered Material	Revenue Generated (per unit)	Conversion To Uniform Units (kg, m^3, etc.)	Annual Revenues ($)
C - Metal Recycling	1,000 kg	$ 15/lb	1,000 kg * 2.2lbs/kg = 2200 lbs	33,000
Total Annual Revenues Generated From the Sale of Recoverables				$$ **33,000**

Gross Pollution Prevented $$ Savings =

Avoided waste management costs (step A)		Amount of savings from materials not purchased (step B)		Revenues from recoverables (step C)		*GROSS P2 $$ SAVING*
$$ **80,002**	+	$$ **11,000**	+	$$ **33,000**	=	*$$ 124,002*

The next measurement considers the net dollar saving benefits over the life of the P2 project. The Net P2 $$ benefit is defined as: *Net P2 $$ Benefit = $[(b * L_y)] - [(c + e) + (a * L_y)]$*

Project A Net P2 $ Benefit = (5K * 15 yr) - [(15K) + (4K * 15 yr)] = (75K - 75K) = 0
Project B Net P2 $ Benefit = (3K * 20 yr) - [(3K) + (2.5K * 20 yr)] = (60K - 53K) = 7K
Project C Net P2 $ Benefit = (1K * 20 yr) - [(1K) + ((-30K) * 20 yr)] = (20 K- (-599K) = 619K

The payback period is the amount of time required for the *cumulative savings to equal the initial capital equipment and installation costs. Payback period in years = (c + e) ÷ (Δ savings from P2 project)*
Δ $$ savings from implementing P2 project is the difference in the operation expenses before and after P2.

Project A Payback = (15 yr ÷ 1K) = 15 yr
Project B Payback = (3 yr ÷ 0.5K) = 6 yr
Project C Payback = (1 yr ÷ 31K) = 0.03 yr or 12 days

Answer to Worksheet 9 (Summary of Projects A, B, & C):

Net P2 $ Benefit Calculation

Initial Capital Investment & Installation Expense for P2 Project (c + e):

Project A	$ 15,000
Project B	$ 3,000
Project C	$ 1,000
Total Capital Costs	$ 19,000

Annual Operating Costs of P2 Project	L_y	(b) Before $$	(a) After $$	(b-a) Δ $$
Project A	15	5,000	4,000	1,000
Project B[34]	20	3,000	2,500	500
Project C	20	1,000	(-30,000)[35]	31,000
Total				
Net P2 $$ Benefit = $[(b * L_y)] - [(c + e) + (a * L_y)]$				
Payback period in years = (c + e) ÷ (Δ savings from P2 project)				

34 Life of project is infinite; for calculation purpose a value of 20 years is assigned.

35 Includes $33K revenue from sale of recoverable materials.

Net P2 $ Benefit (all Completed P2 Projects) = 0 + 7K + 619K = $626,000

Payback (all Completed P2 Projects) = (19K ÷ 32.5K) = 0.6 yr or 7 months