



Pollution Prevention (P2) for Indiana Businesses



**Indiana Department of Environmental Management
Office of Program Support
Pollution Prevention and Technical Assistance Section
Compliance and Technical Assistance Program**

Chapter 1 Understanding Pollution Prevention (P2)

What is Pollution Prevention?	4
What is Sustainability?	12
Pollution Prevention Policy and Environmental Regulation	15
The Pollution Prevention Act of 1990 and U.S. EPA	16
The Toxics Release Inventory (TRI)	19
Indiana P2 Law	20

Chapter 2 Exploring the Potential Benefits of P2

Why Practice Pollution Prevention?	21
Planet	21
People	22
Profits	24

Chapter 3 Bird's-eye View of Business P2

Pollution Prevention Program and P2 Process Overview	27
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Chapter 4 Initiating and Developing a P2 Program

Initiating and Developing a P2 Program	29
Obtain Management Support / Company Commitment	30
Create a Mission Statement and Formal P2 Policy	31
Construct a P2 Management Plan	33
Obtain P2 Program Resources	43

Chapter 5 Facility Preliminary Assessment

Conduct Preliminary Assessment of Facility	44
--	----

Chapter 6 12 Steps to P2 Success - The P2 Project Process

The P2 Project Process	56
Step 1 – Prepare the P2 Process Plan	58
Step 2 – P2 Process Plan Approval / Obtain Management Support	60
Step 3 – Detailed Assessment Phase - Analyze Process / Develop Baselines	61
Step 4 – Identify P2 Opportunities	69

Step 5 – Evaluate Alternatives	73
Step 6 – P2 Project Proposal	86
Step 7 – Obtain Approval and Resources	87
Step 8 – Implement P2 Alternatives	88
Step 9 – Measure Progress	88
Step 10 – Review Projects / Make Adjustments	93
Step 11 – Reward and Publicize	94
Step 12 – Move to the Next P2 Project	94

Chapter 7 P2 Strategies

P2 Strategies	96
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Chapter 8 Valuable P2 Resources

Indiana P2 Assistance and Resources.....	109
State Government Agencies	109
Indiana Universities	112
Utility Companies	113
Federal and Regional P2 Resources	114
Federal Agencies.....	114
Regional P2 Organizations	117
Other State Agencies (in U.S. EPA Region 5)	118
Recommended P2 Publications	118

Appendices

Appendix A – Option Rating Weighted Sum Method.....	121
Appendix B – Total Cost Accounting Economic Analysis of Pollution Prevention Projects.....	123

P2 Reference Materials

P2 Reference Materials – Works Cited.....	129
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Foreword

The Indiana Department of Environmental Management (IDEM) encourages Indiana businesses to implement pollution prevention (P2) practices whenever and wherever feasible. This document is intended as advisory guidance to develop approaches for pollution prevention implementation. Compliance with environmental and occupational safety and health laws is the responsibility of each individual business and is not the focus of this training document.

This guide is written for individuals responsible for implementing P2 in their facilities. It is intended to help businesses and production facilities of all sizes and types to develop broad-based multimedia P2 programs. This document is not intended to be a prescriptive guide. Rather it provides a generalized overview and approach to P2 implementation. Users are encouraged to duplicate portions of this publication as needed to implement a P2 program and P2 practices.



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What is Pollution Prevention?

In the past, when waste or pollution was generated, businesses looked for ways to dispose of it or control it after production. Waste can be solid, liquid, gas, or a combination released into the air, land, surface water, or ground water. Waste is defined as any nonproductive output from an activity or production process. Common wastes from manufacturing processes include scrap materials, byproducts, off-specification materials or products, obsolete materials or products, surplus “virgin” materials, packaging, process losses like excess energy use, or any material not being used efficiently. A waste stream is the complete flow of waste from a process through to recovery, recycling, or final disposal. Waste streams vary in the commercial and industrial sectors depending on the type of business, but all wastes require management. Treating wastewater, filtering air emissions, disposing of solid or hazardous waste in landfills or incinerators, and even recycling, are all methods of waste management. Although, pollution controls often reduce the concentration of various contaminants that are emitted from a particular process, the overall environmental impact remains negative because wastes have been created and continue to require management.

Pollution prevention (P2) is any practice that reduces, eliminates, or prevents pollution and waste at its source or point of origin. By working to implement changes at the source of pollutants, such as a piece of equipment or a process line, resources can be conserved and waste generation can be prevented or reduced.

Pollution Prevention (P2) includes:

- Source reduction, which is any practice that:
 - Reduces the amount of any hazardous¹ substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and
 - Reduces the hazards to public health and the environment associated with the release of substances, pollutants, or contaminants.
- Equipment or technology modifications; process or procedure modifications; product reformulation or redesign; substitution of raw materials (including substituting less harmful substances for hazardous ones); and improvements in housekeeping, maintenance, training, or inventory control. ([Ref. 26](#))

¹ Hazardous is used in a broad sense to include federally or state regulated pollutants, including Clean Air Act criteria pollutants and Clean Water Act toxic and priority pollutants, but excludes items generally considered of low hazard and frequently recyclable or divertible, such as paper products, cans, iron and steel scrap, and construction waste.

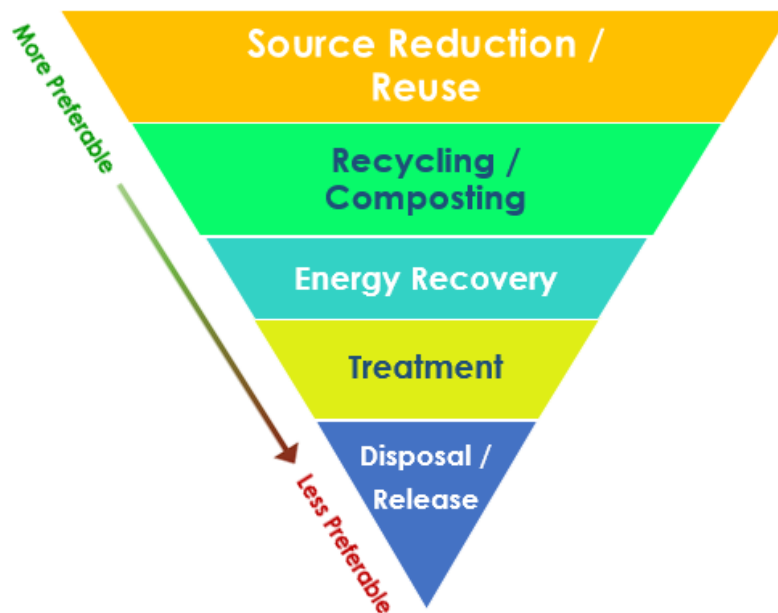
- Other practices that reduce or eliminate the creation of pollutants through:
 - Increased efficiency in the use of supplies, raw materials, energy, water, or other resources (includes some “in-process” recycling or energy recovery methods);
 - Reuse of products in their original forms, which can include the development of new uses for existing chemical and process wastes;
 - Use of repairable, refillable, and durable products resulting in a longer useful life; and
 - Protection of natural resources by conservation.

Although some of the following practices can be beneficial for businesses to employ, pollution prevention does NOT include:

- Recycling (unless “in process”/closed-loop);
- Energy recovery (unless “in process”/closed-loop) or waste-to-energy incineration;
- Treatment of a waste stream;
- Disposal, incineration, or release;
- Any practice that alters a hazardous substance, pollutant or contaminant once it is generated;
- A practice that is unnecessary for production; or
- Practices that create new risks to human health or the environment.

The focus of P2 is conservation and waste minimization or elimination, not pollution control. Actions taken after waste has been generated, including recycling, composting, treatment, concentration, or dilution, is not considered P2. The “Waste Management Hierarchy” illustration (next page) puts the most desirable waste reduction priorities—source reduction and reuse—at the top, followed by environmentally sound recycling and composting; energy recovery; treatment; and as a last resort, disposal or release (including unintended spills). Since source reduction and reuse both result in the prevention of waste, the amount of waste requiring management is reduced overall. Waste reduction of these types are given the highest priority in solid waste management plans because they reduce the demand placed on the management system.

Illustration 1: Waste Management Hierarchy



Source Reduction is any activity that prevents the creation of solid or hazardous waste at the point of generation or minimizes the volume and toxicity of waste entering the waste stream. Source reduction is one of the primary components of P2, and sometimes the term is used synonymously with P2. In the waste-management hierarchy, source reduction is at the top because avoiding waste creation is the best way to limit the environmental and financial impacts of waste management. Examples of source reduction activities include substitution of nontoxic materials for toxic ones, process efficiency improvements, or process changes that reduce manufacturing waste (scraps).

The term "source reduction" does not include any practice that alters the physical, chemical, or biological characteristics or the volume of a hazardous substance, pollutant, or contaminant through a process or activity that is not integral to the production of a product or the providing of a service.

Source reduction strategies are often inexpensive to implement, and by reducing the volume of waste materials that must be managed, the costs of the other management methods are lowered. Therefore, source reduction is the most desirable alternative and should be the cornerstone of any business's waste management program.

Reuse means putting an output item to use again after it has fulfilled its original function. Reuse of an item or material can either serve its original function again or a different use. While reuse doesn't completely prevent the generation of discarded materials, it does prolong their useful life. True reuse does not change the original form of the product or materials (requires no alterations prior to reintroduction into a manufacturing process), does not harm the environment in any way, and inherently

saves energy (as no new energy is consumed in order for reuse). It is an eco-friendly technique of saving money, time, and resources.

By extending the useful life of materials, fewer total products are used, which indirectly prevents waste generation. This often makes it difficult to distinguish between the concepts of source reduction and reuse. For instance, returnable packaging is an example of reuse because a durable container is returned to a business or industry for redistribution. This reusable container replaces single-use or disposable packaging and reduces raw material use and waste generation. However, a better source reduction option for packaging would be to forgo it altogether to eliminate the raw material use and waste generation completely. Ultimately, both packaging methods are forms of pollution prevention, but the former is considered reuse and the latter is source reduction.

Recycling is the process whereby materials that would have become waste (destined for disposal) are collected, reprocessed, and remanufactured into new materials or products, or are modified for reuse in a process (e.g., filtered process chemicals). The term 'recycle' is described as a process in which waste material is transformed into new or usable materials.

In the waste management hierarchy, recycling includes material reclamation and composting. Municipal solid waste **composting** is a controlled process that creates a useful material through the biological decay of organic waste. To obtain the highest grade of compost, non-compostable materials such as glass, plastic, metal, and hazardous materials must be removed by either hand-sorting or mechanical means. Modern solid waste composting facilities use complex systems to speed up the natural process of decay. Composting is considered a form of recycling because the original waste material (e.g., yard waste, food waste) is altered by the decay process and transformed into a new material, such as enriched soil products.

One may conclude that materials sent to the recycler represent lost revenues for a business because they are not becoming part of a product or service that generates profits. In addition, recycling is dependent on the availability of markets for the collected recyclable materials. While recycling can be beneficial because it can create jobs, the economic development potential should be balanced against the benefits of source reduction alternatives. While some materials such as aluminum or steel command good prices in the recycling market, most materials do not provide enough sales value to cover the collection and recovery costs.

However, if markets are available, it makes economic and environmental sense to recycle a material rather than dispose of it. A quality recycling program can complement a P2 program by finding uses for waste materials that have already been produced. Recycling conducted in an environmentally sound manner shares many of the advantages of P2, such as energy and resource conservation compared to

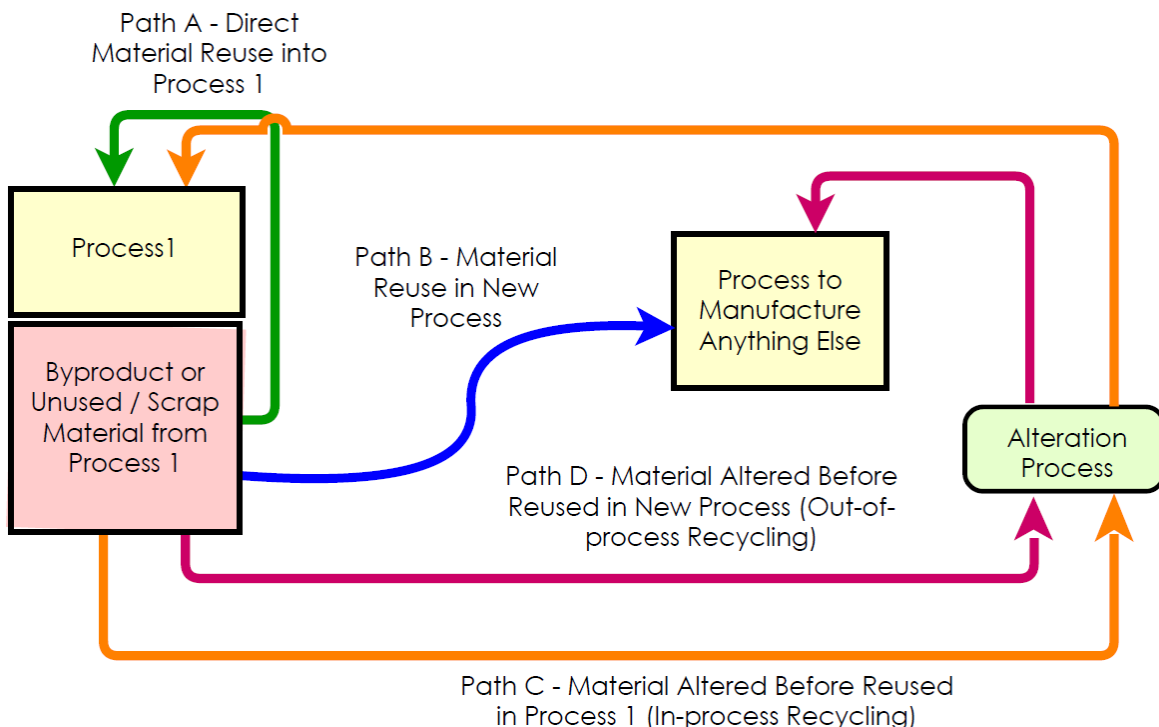
manufacturing similar products from virgin materials, and the reduced need for end-of-pipe treatment or waste containment. Still, the recycling process requires material handling, energy use, and processing operations that could result in the production of harmful discharges that may damage the environment and carry risks of worker exposure.

Distinguishing between pollution prevention (P2) and recycling can sometimes be difficult. General recycling can be thought of as "out-of-process recycling" and is not considered a form of P2. However, P2 does include "closed-loop" recycling, which is commonly called "in-process" recycling. In order to consider "in-process" recycling a pollution prevention activity, it must serve a productive function in the making of the commercial product and must be an integral part of that process (i.e., the production process cannot function without the recycling process).

This example P2 project included in-process recycling:

A manufacturing plant making Freon eliminated hydrochloric acid waste by installing a conversion unit to change anhydrous hydrogen chloride into chlorine. The chlorine was then recycled back into the process as a raw material. By using this integral recycling process, the plant saw a significant reduction in raw material inputs, waste outputs, and associated costs. The following illustration shows the pathways of reuse and recycling.

Illustration 2: Material Pathways - Reuse and Recycling



- Path A (green line) is the direct reuse of the byproduct or scrap material from Process 1 in its original form, by returning it directly into the same process. Path A represents a flow of material reuse that is considered source reduction/reuse and meets the definition of pollution prevention for Process 1.
- Path B (blue line) is the reuse of the byproduct or scrap material from Process 1 in its original form as an input material to a new process to manufacture anything else. Path B represents a flow of material reuse that is considered waste and does not meet the definition of pollution prevention for Process 1. However, Path B does meet the definition of pollution prevention for the manufacturing process for anything else because the amount of raw input materials used to make another product has been reduced.
- Path C (orange line) is the reuse of the byproduct or scrap material from Process 1 after it goes through an alteration of some kind and then is put back into the same process as input material. This is a form of “in-process” or “closed-loop” recycling. Path C represents a flow of material reuse that is considered source reduction, and meets the definition of pollution prevention for Process 1.
- Path D (pink line) is the reuse of the byproduct or scrap material from Process 1 in an altered form as an input material to a new process to manufacture anything else. This is a form of out-of-process recycling. Path D represents a flow of material reuse that does not meet the definition of pollution prevention for Process 1.

Energy recovery is a waste treatment process that generates energy in the form of electricity, heat, or fuel. Energy recovery is a preferable waste handling method over landfill disposal. However, it only should be considered as a waste management option if reuse or recycling is not feasible, unless it is “closed loop” or “in-process” recovery.

There are four types of energy recovery technologies:

- Energy transfer: the conversion of one form of energy into another, or the movement of energy from one place to another. An energy transfer or 'energy exchange' from one system to another occurs when an amount of energy crosses the boundary between them. This increases the energy content of one system while decreasing the energy content of the other system by the same amount.
- Thermo-chemical: a conversion process that extracts energy from waste through high temperatures. Types of thermo-chemical energy recovery include combustion, gasification, and several types of pyrolysis. Combustion energy, also known as “waste-to-energy”, is produced when heat is released from burning waste that converts water to steam. The steam is then sent to a turbine

generator to produce electricity. Gasification is the process of converting any carbon-containing material into a synthesis gas that can be combusted. Pyrolysis is the thermal degradation of waste in an oxygen-free environment, or in an environment in which the oxygen content is too low for combustion or gasification to take place. Pyrolysis liquefaction is a non-combustion heat treatment that chemically decomposes waste material by applying heat (directly or indirectly) to the waste material in an oxygen-free environment. Pyrolysis is an endothermic reaction (unlike gasification and combustion, which are usually exothermic reactions) and requires an input of energy that is typically applied indirectly through the walls of the reactor in which the waste material is placed for treatment. The process generally produces char, oil and syngas. ([Ref. 18](#))

- Chemical: a conversion process that extracts energy through esterification, the creation of esters due to a chemical reaction between alcohols and acids, which can be used in a variety of ways, including blending with other fuels to increase performance.
- Bio-chemical: a conversion process that extracts energy using bio-decomposition of waste. Types of bio-chemical energy recovery include biogas from anaerobic digesters or landfills, and bio-hydrogen and bio-ethanol from fermentation and microbial fuel cells.

If energy recovery is implemented through a closed-loop (in-process) system that allows for the direct capture and reuse of energy without adding additional waste streams to convert energy from waste products, then it qualifies as a form of P2. Examples of in-process energy recovery are building ventilation systems with recovery devices that transfer outgoing heat and humidity to incoming outdoor air to warm its temperature for building use without additional energy drawn from a power source.

Treatment includes the destruction or removal of pollutants from a waste stream through the use of control devices (flares, baghouses, etc.) or chemical or biological conversions that are implemented into or at the end of manufacturing processes. Example treatment activities are scrubbing, incineration, evaporation, precipitation, detoxification, decomposition, stabilization, solidification, encapsulation, and neutralization. Treatment of waste streams is often required by permits that limit the allowable discharges of regulated pollutants by a business. Pollution control and treatment often move pollution from one media (air, water, land) to another media. This relocation of pollution is what is known as the cross-media transfer of waste. For example, air pollution treatment devices called scrubbers are used to strip sulfur from air emissions. The sulfur is not released into the air, but it is contained in the form of a hazardous slurry that must be disposed of in a landfill. Therefore, the sulfur is simply transferred from the air to the land and is still capable of harming the environment. The following illustration depicts the cross-media transfer concept.

Illustration 3: Cross-Media Transfer of Waste

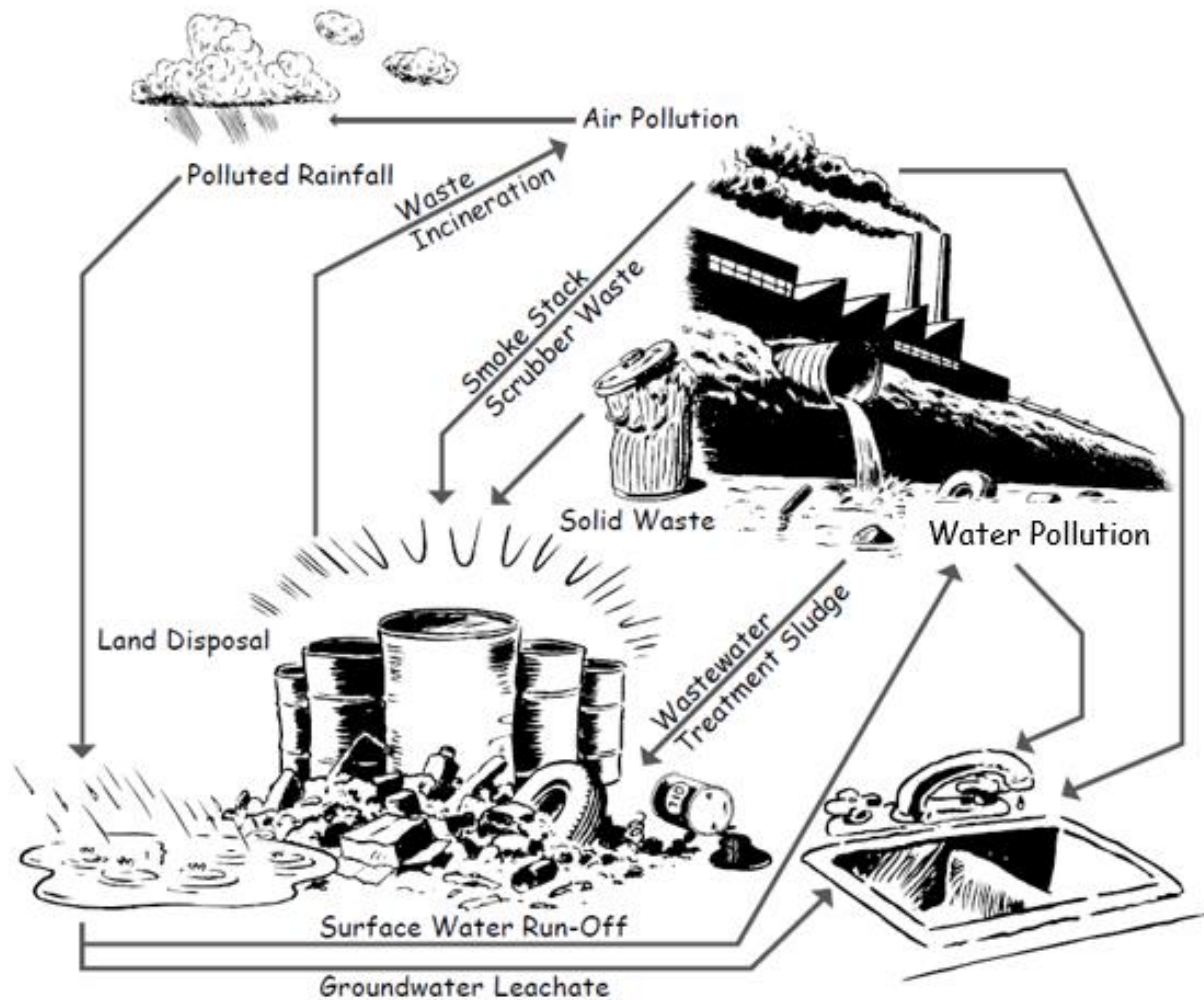


Illustration 3 used with permission of Ohio EPA

In some cases the volume or toxicity of the waste has been reduced, or the movement of the waste in the environment has limited the potential exposure to humans or animals. However, the same amount of waste is generated at the source. The treated pollution still can cause environmental damage and require money, time, and labor hours to manage.

Control and treatment are not forms of P2 because the same amount of waste is created and is simply moved from one place in the environment to another, while P2 aims to reduce the total amount of waste and pollution created.

Disposal or Other Releases includes approved disposals to landfills or incinerators, permitted releases, and unintended releases such as spills where waste ultimately enters the environment.

Pollution prevention is fundamentally different and more desirable than waste management and pollution control. Not only does it cost less to avoid waste than to

dispose of it or treat it in any fashion, but avoiding the generation of pollution is the most effective way to protect the environment and promote sustainability. The adage "an ounce of prevention is worth a pound of cure" is as true in reference to waste and pollution as it is to human health.

What is Sustainability?

Sustainability is based on a simple principle:

"Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment." ([Ref. 19](#))

Very little in nature is wasted, and waste from one organism almost always is useful to another. One can say that nature is self-sustaining. Humanity, however, has historically chosen a non-sustainable approach. Many lifestyles depend on a constant flow of new natural resources from the earth that cannot be regenerated or renewed at the pace at which they are used.

Population growth has historically led to a greater and more concentrated use of energy, water, and materials. Concurrently, population growth is associated with increases in waste creation and environmental pollution, which results in harm to ecosystems and human health. Similarly, economic growth requires increased quantities of energy, materials, and natural resources. This too leads to more waste creation, toxic substance releases, and other forms of environmental pollution. Consumption is typically seen as being good for the economy. In such an atmosphere, pollution prevention may be criticized as anti-prosperity or anti-progress because it encourages source reduction. However, making better use of resources is really a test of ingenuity and is more likely to result in sustained economic growth through the creation of better products. Businesses can become more competitive and individual consumers more prosperous by using resources more efficiently and creating less waste. Eventually, resources and disposal options will be limited if a more sustainable approach is not adopted by manufacturers and consumers alike.

Sustainability is about finding the balance point among population, consumption, and waste assimilation. The flow chart illustration below relates the consumption rate of natural resources to the state of the environment, and the degree of sustainability that results.

Illustration 4: Relationship of Consumption Rate and Sustainability

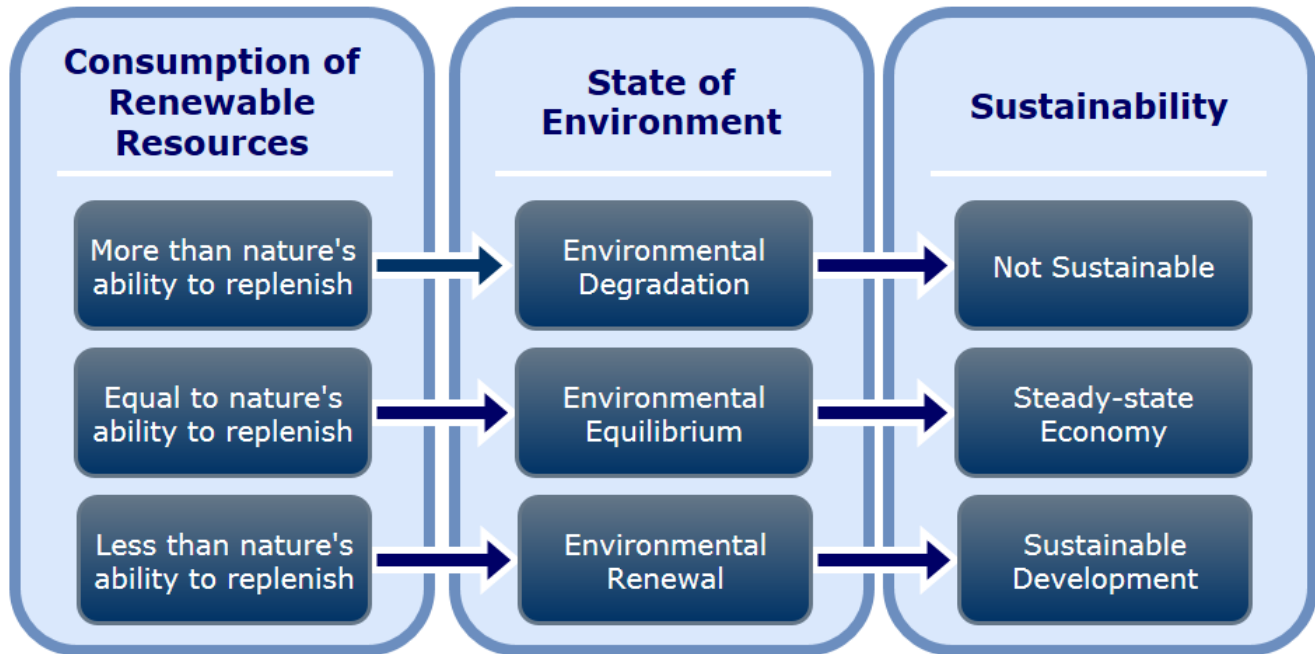


Illustration 4: Adapted from Source [Ref.20](#)

Note to businesses: When supply of resources decreases and demand stays the same or increases, costs rise and the economy will be impacted significantly in all sectors.

The root word, *sustain*, means to keep in existence without diminishing, to provide sustenance and nourishment. Many forms of the word sustainable are used in various situations today:

- Ecological Sustainability
- Sustainable Development
- Sustainable Growth
- Sustainable Economies
- Sustainable Communities
- Sustainable Practices
- Sustainable Societies
- Sustainable Business
- Sustainable Agriculture
- Sustainable Food Systems

Environmental sustainability encompasses all of these terms, as the environment is essential to life and communities are interrelated webs of many overlapping variables. Communities are complex systems, interconnecting in ways that allow changes in one area to affect other areas, and all members are stakeholders. [\(Ref. 20\)](#)

Sustainability implies responsible and proactive decision-making and innovation that minimizes negative impact and maintains balance between ecological resilience, economic prosperity, political justice, and cultural vibrancy.

Illustration 5: Variables Affecting the Sustainability of Communities



The concept of environmental sustainability was introduced into public policy in the United States through the [National Environmental Policy Act \(NEPA\) of 1969](#), signed into law on January 1, 1970. NEPA was one of the first laws ever written that establishes a broad national framework for protecting our environment and promoting efforts that will prevent or eliminate damage to the environment and biosphere. Title I of this policy committed our nation to sustainability by requiring the federal government, in cooperation with state and local governments, to use all practicable means “to create and maintain conditions under which humans and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.”(Ref. 21)

Although traditional pollution control will remain an important part of societal practices, the paradigm shift in favor of P2 must occur in order to increase sustainability in all communities, as P2 is a cornerstone of the sustainability movement. This sentiment is reflected in the strategic plan for the U.S. Environmental Protection

Agency's Pollution Prevention (P2) Program, which declares that its broad mission is to "prevent pollution at the source, promote the use of greener substances, and conserve natural resources, which are critical steps towards achieving a sustainable society." ([Ref. 22](#))

Pollution Prevention Policy and Environmental Regulation

In the 1960s and 70s, Americans became increasingly aware of the ways pollution was destroying the country's air, water, and land. As a result, a series of landmark environmental statutes including the Clean Water Act, the Clean Air Act, and the Resource Conservation and Recovery Act (RCRA) were established to regulate and control pollution releases to the environment.

Major Environmental Legislation*			
Year	Law	Year	Law
1899	Refuse Act	1976	Toxic Substances Control Act
1948	Federal Water Pollution Control Act	1977	Clean Air Act Amendments
1955	Air Pollution Control Act	1977	Clean Water Act Amendments
1963	Clean Air Act (1963)	1980	CERCLA (Superfund)
1965	Solid Waste Disposal Act	1984	Hazardous and Solid Waste Amendments
1969	National Environmental Policy Act	1986	Safe Drinking Water Act Amendments
1970	Clean Air Act (1970 Amendments)	1986	Superfund Amendments and Reauthorization Act
1972	Federal Insecticide, Fungicide, and Rodenticide Act	1986	Emergency Wetlands Resources Act
1972	Clean Water Act	1987	Water Quality Act
1973	Endangered Species Act	1990	Oil Pollution Act
1974	Safe Drinking Water Act	1990	Pollution Prevention Act
1975	Hazardous Materials Transportation Act	1990	Clean Air Act (1990 Amendments)
1976	Resource Conservation and Recovery Act	1993	North American Free Trade Agreement
1976	Solid Waste Disposal Act	1996	Safe Drinking Water Act Amendments
* This is not a comprehensive list of U.S. environmental legislation.			

The gains from these regulations have been notable, as air and water quality have improved dramatically through the prescribed “end-of-pipe” or “end-of-stack” technologies and permissible amounts of emissions and discharges. However, the costs of removing pollutants from a waste stream increase exponentially as greater efficiencies are achieved. Industries often approach the economic and technical limits of waste treatment feasibility.

After 20 years of attempts at control and managing substances that had already been sacrificed as waste, attention has shifted to the elimination of potential pollution at its source, and spawned the concept of pollution prevention. Part of the attractiveness of pollution prevention rests on the perception that it allows all interested parties to achieve their separate goals. “Environmentally friendly moves by industry, on one hand, and government’s willingness to employ non-coercive pollution prevention methods, on the other, have created the perception of a new cooperative approach to environmental protection.”(Ref. 23) Industry benefits because pollution prevention means elimination of waste, profitable innovation, and avoidance of command-and-control regulation. Government and the public benefit from businesses’ enthusiasm for pollution prevention, as employing P2 practices reduces the [cross-media](#) pollution that old-style regulation often produced.

The Pollution Prevention Act of 1990 and U.S. EPA

In 1990, the Pollution Prevention Act (P2 Act) was enacted to increase interest and awareness in pollution prevention and the primary focus of source reduction. The [Pollution Prevention Act](#) is in Title 42 (Public Health and Welfare) of the United States Code, Chapter 133 (Pollution Prevention). In clear terms, the P2 Act calls for industry, government, and the public to look upstream in manufacturing processes and to prevent sources of pollution rather than use end-of-pipe reduction or cleanup strategies.

According to the P2 Act findings, it is “the national policy of the United States that all pollution be prevented or reduced at the source whenever feasible. If the pollution cannot be prevented it should be recycled in an environmentally safe manner whenever feasible. If the pollution cannot be prevented or recycled that pollution should be treated in an environmentally safe manner whenever feasible; and disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.” This established hierarchy is intended to guide current and future national policy decisions.

The P2 Act further states that the U.S. Environmental Protection Agency must develop and implement a strategy to promote source reduction, collect and disseminate P2 information, provide financial assistance to states to promote the use of source reduction techniques by businesses, and create an office within the agency to carry out these and other functions established by the Act. Currently, the Office of Pollution

Prevention and Toxics (OPPT) implements the [Toxic Substances Control Act \(TSCA\)](#), the [Pollution Prevention Act](#) and [Section 313](#) of the [Emergency Planning and Community Right-to-Know Act](#). OPPT is housed within U.S. EPA's Office of Chemical Safety and Pollution Prevention (OCSP), which includes the [Office of Pesticide Programs](#), the [Office of Pollution Prevention and Toxics](#), and the [Office of Science Coordination and Policy](#).

The Office of Pollution Prevention and Toxics currently manages these programs and projects, many of which contribute to the fulfillment of the P2 Act provisions and objectives:

- [Acute Exposure Guideline Levels](#)
- [Assessing and Managing Chemicals under the Toxic Substances Control Act \(TSCA\)](#)
- [Biotechnology under TSCA](#)
- [Chemical Data Reporting under TSCA](#)
- [Confidential Business Information Provisions under TSCA](#)
- [E3: Economy, Energy and Environment](#)
- [Green Chemistry](#)
- [Green Engineering](#)
- [Green Sports](#)
- [Importing or Exporting Chemical Substances under TSCA](#)
- [Pollution Prevention](#)
- [Predictive Models and Tools for Assessing Chemicals under TSCA](#)
- [Reviewing New Chemicals under TSCA](#)
- [Safer Choice](#) (formerly Design for the Environment)
- [Sustainable Futures](#)
- [Sustainable Marketplace Greener Products and Services](#)
- [Toxics Release Inventory \(TRI\) Program](#)
- [TSCA Chemical Substance Inventory](#)

The P2 Act defines “source reduction” [Ref. 26](#) and establishes the activities outlining U.S. EPA's authorities and functions related to P2. The U.S. EPA is directed to establish federal grants for P2, establish a Source Reduction Clearinghouse, collect source reduction and recycling data, and create and submit biennial reports. The OPPT is required to develop and coordinate a pollution prevention strategy and develop source reduction models (see [U.S. Environmental Protection Agency 2010-2014 Pollution Prevention \(P2\) Program Strategic Plan](#) which is supported by the [FY 2014-2018 EPA Strategic Plan](#) (see Strategic Goal 4 and the Cross-Agency Strategies). The most current pollution prevention strategy identifies a number of opportunities to

reduce the emissions of greenhouse gases, the use of hazardous materials, and the use of natural resources while contributing to a more sustainable economy. The strategy further identifies goals, resources required, organizational responsibilities, and the established criteria to evaluate program progress. Outlined within the P2 Act are specific functions of the U.S. EPA strategies related to P2:

- Establish standard methods of measurement of source reduction
- Coordinate and promote source reduction activities and techniques in federal agencies and businesses
- Improve coordination of, streamline, and assure public access to data collected under federal environmental statutes
- Establish a training program on multimedia source reduction opportunities
- Make recommendations to Congress to eliminate barriers to source reduction including the use of incentives and disincentives
- Develop and disseminate model source reduction auditing procedures designed to highlight source reduction opportunities
- Establish an advisory panel of technical experts comprised of representatives from industry, the states, and public interest groups, to advise the U.S. EPA on ways to improve collection and dissemination of data
- Establish an annual award program to recognize companies operating outstanding or innovative source reduction programs
- Make matching grants to states for programs to promote source reduction by businesses
- Establish a source reduction clearinghouse [the [Pollution Prevention Information Clearinghouse](#) (PPIC)] to compile information including a computer database that contains information on management, technical, and operational approaches to source reduction
- Make clearinghouse information available to the public
- Direct owners and operators of facilities who report annually on releases of toxic chemicals to the environment [currently through the use of the [Toxics Release Inventory](#) (TRI)] to include with each annual filing a toxic chemical source reduction and recycling report for the proceeding calendar year
- Facilitate the adoption of source reduction techniques by businesses (strategy includes the use of the source reduction clearinghouse and state matching grants)

The Pollution Prevention Act has focused industry, government, and public attention on reducing the amount of pollution at the source through cost-effective changes in production, operation, and raw materials use. It is the responsibility of federal and state

agencies to promote a multimedia approach to P2 with a focus on source reduction and advise businesses of all types. Federal and state agencies do this by conducting trainings, workshops, and developing and disseminating guidance documents that identify P2 opportunities and share successful case studies (see [Federal and Regional P2 Resources](#)). These recommendations by U.S. EPA and the states are meant to mitigate or eliminate barriers to source reduction. This point is important because many opportunities for source reduction are often not realized because of the focus on treatment and disposal in existing regulations.

Unlike other command-and-control regulations applied to industry, the P2 Act serves mostly as a directive to U.S. EPA to create resources, measures, and strategies that can be voluntarily applied by industry, with or without additional incentives. However, while government's role in pollution prevention through the P2 Act currently emphasizes awards, university courses, research programs, and voluntary goals and deadlines, "regulatory" pollution prevention has been applied in more traditional terms of command and control through substance bans, technology specifications, and the incorporation of pollution prevention obligations in actions related to permits and enforcement of other environmental protection laws.

The Toxics Release Inventory (TRI)

The [Toxics Release Inventory](#) (TRI) is a publicly available database that contains information on toxic chemical releases by covered industry groups as well as many federal facilities. This inventory was established under a federal law called the [Emergency Planning and Community Right-to-Know Act of 1986 \(EPCRA\)](#) and was expanded by the Pollution Prevention Act of 1990 to include other waste management

Pollution Prevention Act of 1990 Data Reporting Requirements for TRI Chemicals:

- Amount entering any waste stream (or otherwise released into the environment) before recycling, treatment, or disposal, and the percent change from the previous year.
- Amount recycled on-site or off-site during each calendar year, the percent change for the previous year, and the recycling process used.
- Source reduction practices used during each year.
- Amount expected to be reported under the first two data items above for the two calendar years right after the reporting year (reported as percent change).
- Ratio of reporting year's production to previous year's production.
- Techniques used to identify source reduction opportunities.
- Amount released into the environment from a catastrophic event, remedial action, or other one-time event and not associated with the production process.

activities and P2 information. TRI requires facilities in certain industries that manufacture, process, or use significant amounts of toxic chemicals over specific thresholds to report annually on their releases of these chemicals. The reports contain information about the types and amounts of toxic chemicals that are released each year to the air, water, land, and underground through injection. Reports also contain information on the quantities of toxic chemicals sent to other facilities for further waste management. When providing this information, many facilities choose to describe the measures they have taken to prevent pollution and reduce the amount of toxic chemicals entering the environment. This information can be used to track industry progress in reducing waste generation and moving towards safer waste management alternatives. As a result, TRI serves as a tool for identifying effective environmental practices and highlighting pollution prevention successes that can be shared with other businesses for possible implementation.

Indiana P2 Law

By 1996, almost every state in the U.S.—including Indiana—had a pollution prevention program to assist companies in reducing waste. Like most state-developed P2 programs, Indiana's P2 program provides outreach and develops technical resources that promote multimedia pollution prevention and waste minimization. The establishment of Indiana's Division of Pollution Prevention and Technical Assistance Program within the Indiana Department of Environmental Management (IDEM) and the functions it serves are outlined in the Indiana Code under Title 13, Article 27, Industrial Pollution Prevention and Safe Materials ([IC 13-27](#)). Similar to the federal P2 Act, the majority of the law outlines directives for IDEM to facilitate P2 practices and ensure public access to relative information. Programs developed under this article are to be implemented based on voluntary participation by businesses (see [Indiana P2 Assistance and Resources](#)).

Why Practice Pollution Prevention?

Pollution prevention is a business strategy that can benefit any company, regardless of size or type, along with the communities in which they operate. P2 is about increasing operational efficiencies, reducing risk, and effectively meeting environmental responsibilities. Unlike most pollution control strategies, P2 offers important environmental, social, regulatory, and economic benefits that can often result in a more competitive business. A facility that commits to an effective, ongoing P2 program that is dedicated to source reduction efforts and reuse practices can benefit the planet, people, and company profits.

Planet

Practicing pollution prevention promotes innovation in the fields of waste minimization and resource conservation to more effectively ensure a clean and sustainable environment. Successful P2 efforts result in positive environmental impacts that are beneficial immediately and in the long run.

- **Conserved landfill space / disposal capacity:** Landfill space is finite and keeping valuable materials out of costly landfills maximizes the use of both. Landfills are also a source of significant environmental damage, including air (methane gas production), soil, and ground water pollution. These contaminants can cause harm to humans, animals, and plant life. By reducing the use of hazardous materials and the generation of waste, disposal capacity is conserved in existing landfills, extending their lifespans and reducing the need for new ones. By maximizing the size of the region served by a disposal facility, more people are available to pay for the facility operating costs, which can directly decrease the costs per person. Additionally, fuel and labor costs decrease because waste haulers can service more accounts before tipping and make fewer round trips on roadways.
- **Conserved energy:** Energy generation processes often require the use of limited natural resources and create a variety of wastes that end up in the air, land, and water. By reducing energy use through P2 efforts, businesses help to minimize the negative environmental impacts of energy generation and the consumption of valuable resources.
- **Conserved natural resources:** Reducing production wastes provides upstream benefits because it reduces ecological damage due to raw material extraction and refining operations. The conservation and wise use of an assortment of limited natural resources supports sustainability and helps ensure that the needs of future generations can be met.

- **Decreased pollution:** In general, reducing raw material use and the generation of process wastes decreases the potential for environmental pollution from spills, transport, disposal, resource extraction, and conversion processes. P2 allows for the greatest and quickest improvements in environmental protection.

People

A facility that commits to an effective P2 policy can positively impact workers, consumers, neighbors, and community residents in a variety of ways and help ensure the quality of life for all people.

Workers

- **Improved health, safety, and operational conditions for workers:** Chemicals used in the workplace have resulted in serious health impacts on workers within companies, persons associated with the chemical manufacturing upstream, and those responsible for the handling, disposal, transport, cleanup, and remediation of hazardous wastes downstream. Workers often experience negative health impacts ranging from skin rashes and headaches to cancer, organ damage, and death. These and other health effects can be immediate or experienced decades after exposure to certain chemicals. For some of the most toxic of these chemicals and wastes, the only adequate protection is a transition to safer alternatives. By reducing the use and disposal of hazardous materials, a business effectively reduces future liabilities related to health problems. Businesses may also experience lower worker compensation rates, lower health care payments, and reduced Occupational Safety and Health Administration (OSHA) regulatory oversight. Additionally, businesses can reduce monetary losses related to employee illness, associated productivity decreases, and missed workdays. ([Ref. 9](#))
- **Improved employee morale:** Implementing a P2 program at a business can directly improve the morale of employees at all levels because it sends a message of concern for the well-being of people and the planet. Many employees take pride in working for a socially and environmentally responsible company. Environmental stewardship and commitment to the long-term health of employees has proven to be a powerful talent retention tool, minimizing personnel turnover rates, and maintaining institutional knowledge.
- **Improved productivity and innovation:** P2 programs and the P2 process enhance employee awareness of business operations, stimulate employee enthusiasm and involvement, and improve staff productivity. Many small and large innovations have been the result of P2 efforts that encourage team building, brainstorming, and employee empowerment.
- **Receive and give recognition:** It is rewarding to have a company and management team recognized in the news because of proactive P2 efforts. It

provides free marketing and instills pride in the workforce. P2 programs may be eligible for one of the Indiana [Governor's Awards for Environmental Excellence](#), P2 or toxics reduction grants, or recognition programs at the federal, state or local level. Earning and displaying these awards will establish a precedent and serve as a constant reminder of the company values. By also offering awards and incentives to staff for P2 involvement, project development or implementation, a company can spur continuous improvement in environmental stewardship among employees.

Consumers

- **Reduced risk to consumers:** Sometimes, a toxic substance such as lead or mercury is used in a product in a way that can directly harm people, particularly sensitive populations like infants and young children. P2 strategies can reduce the potential transfer of hazardous materials to consumers. Keeping customers safe and enjoying the products of a business are crucial elements of maintained success.
- **Improved public relations, enhanced public image, and new market-based potentials:** Trends show customer preference for environmentally friendly or “green” products and environmentally responsible companies that avoid excessive consumption of resources and discharge of waste materials. A commitment to P2 can enhance a company's image, which is often directly linked to market acceptance of its products. If a company has previously had negative publicity related to environmental issues, P2 involvement can bolster a business's environmental reputation and ensure consumer retention. Citizen consumers are not the only ones partial to environmentally benign products. Many institutions and manufacturers are also interested in “greening” their supply chains. By meeting the demand for “green” production, a business can reach new market bases, increase sales, and enable more consumers to enjoy the use of their products.

Surrounding Communities

- **Improved public health:** Process changes resulting from the implementation of a P2 program can help a business reduce permitted and fugitive emissions, or accidental releases or spills. Reduced emissions positively impact the quality of the local community's air, water, and land resources, making surrounding areas safer and healthier places to live, work, and play. A cleaner environment can reduce the adverse health impacts to local populations from illnesses, diseases, and cancer risk associated with pollution exposure. U.S. EPA considers pollution prevention to be an equivalent form of disease prevention. ([Ref. 24](#))
- **Supported economic development potential:** Everyone wants to live next to a good neighbor. Businesses are no exception. By proactively protecting the local

community's quality of air, water, and land resources through P2 practices, a community can become more desirable to prospective businesses and new development. Preventing waste generation reduces the need for a community to allocate resources for waste handling, and preserves the integrity and capacity of local waste management facilities. Decreased degradation of existing infrastructure helps ensure its longevity and ability to provide services for all members of the community. Implementation of P2 practices can also help communities avoid the negative attention of the media and decreased land values related to toxic spills, site contamination, and federal or state enforcement issues.

- **Improved societal and cultural development:** The local community, environmental regulators, environmental organizations, and other businesses see P2 practices as an indication of a company's willingness to be a responsible corporate citizen and go beyond compliance. This perception by external groups gives credibility to environmental programs and promotes similar actions by others. When businesses allow communities to have more than an indirect influence on industry's production through participation in the P2 development process, P2 activities can lead to significant reductions in local pollution exposures, cooperative community development, and economic sustainability for the area. It is important for businesses to be established as community leaders, operate as environmental stewards, and offer community inclusion. Doing so sends a powerful message of social responsibility that fuels societal and cultural development related to environmental awareness and protection.

Profits

One of the greatest benefits of implementing P2 strategies at a business is the associated financial gains. The practice of P2 can directly save businesses money by reducing potential regulatory permit delays, labor costs from cradle-to-grave material handling, liability costs, and raw material usage. P2 also offers potential monetary gains through new market development and production improvements.

- **Improved regulatory compliance and reduced regulation:** It costs time and money to be regulated. There are expenses related to permitting and compliance, including permitting fees; required emission control technologies; emission rate fees (\$/ton rates); staff time related to permit applications, recordkeeping, and reporting requirements; and potential fines for noncompliance. If the wastes a business aims to reduce or eliminate through P2 are regulated under state or federal laws and the reductions are significant enough, costly permits and government approvals can potentially be avoided. At the very least, P2 efforts can minimize regulatory compliance issues and the liability costs associated with regulated waste management including permitted emissions. The adoption of P2 procedures, work instructions, and additional

training will add consistency and stability to environmental programs, lead to improved control of potential environmental impacts, and help a business anticipate and control upsets.

Pollution prevention also provides an opportunity to act cautiously with imperfect information, scientific uncertainty, and high risk. [\(Ref. 2\)](#) As science progresses, the stringency of environmental regulations continues to increase for contaminant discharges into all environmental media. P2 projects have the ability to position a company to meet or surpass projected future usage and discharge limits resulting from unknown factors such as purchase prices, disposal costs, or new health issues that accompany the use of substances known to be environmentally damaging. [\(Ref. 9\)](#)

- **Reduced waste generation, storage, treatment, and disposal costs:** Every business generates waste that is costly to manage at any stage in the process. The costs associated with the following areas are escalating:
 - 1) Handling – both in-house and external custodial and collection services
 - 2) Storage – vessel cost, maintenance, labeling, and secondary containment for safety and spill prevention
 - 3) Transport – waste loading/unloading and hauling
 - 4) Treatment – additional control equipment to meet regulatory requirements
 - 5) Disposal of excess or spent materials

Burying waste management costs into general overhead can lead to the illusion that disposal is free. The expenses are significant whether the waste is recycled, landfilled, or it is hazardous waste that requires special transport, treatment, and disposal practices.

Furthermore, some businesses are currently complying with regulatory restrictions by treating total plant effluents, which can be complex mixtures of process waste materials that involve large volumes of dilute wastes. These aggregated waste streams often require a great deal of attention because it is difficult to effectively destroy or to remove a high percentage of all regulated contaminants. [\(Ref. 6\)](#)

The potential for cost reductions associated with reduced waste generation is substantial. Managing something as simple as food waste through composting, for instance, is currently at least 10 times more costly than preventing food waste in the first place. By moving back “up the pipe” to identify and segregate waste streams through P2 implementation, businesses can reduce or avoid expensive treatments; equipment and maintenance expenses; the number of overall waste pickups; and all other associated storage and disposal costs.

- **Reduced present and future liability costs:** The financial liability from using and disposing of hazardous substances is potentially unlimited, and can be associated with civil actions, tort suits, real property damage, fines, and many other costs related to accidental releases or exposures during handling, storage, transportation, and disposal processes.[Ref.10](#) By reducing the use and disposal of toxic or hazardous wastes through P2, some facilities have been given lower liability insurance rates and lower loan rates. These lower rates are the result of reduced legal liability concerns, decreased likelihood of catastrophic occurrences, and reduced exposure risk to workers, communities, and the environment.
- **Reduced raw material consumption / material costs:** Gone are the days when resources were inexpensive and energy costs were low. As the demand for resources increases and supplies remain limited, operating costs for businesses rise. Conservation is one of the most lucrative investments a company can make. By using P2 to reduce raw material and resource use (e.g., energy and water), a company can experience immediate and long-term savings. Even when utilizing renewable resources (e.g., solar or wind power), a company should strive for efficiency through conservation, as prevention is less costly than renewables. Additionally, by improving inventory control through P2 practices, businesses can avoid material costs related to overbuying, spoilage or expiration, and necessary storage or transfer. Further, material reuse and interchangeability can be optimized through P2 efforts, which can result in significant savings through reduced purchasing costs.
- **Improved process efficiency, expanded production, and improved company profits:** Companies can gain a competitive advantage and revenues by implementing P2 process or operational improvements. P2 efforts result in efficient use of resources, optimized production methods or processes, and reduced waste generation. Some businesses have been able to expand production without additional regulation because of material substitutions, in-process recycling, or better material application methods. Many P2 efforts have resulted in reduced downtime, reduced rework or operational losses, and improved product quality. Often, these changes lead to increased sales and company profits.

Expanded markets: It is common for P2 efforts to result in new market development for businesses. Sometimes, previously untapped markets are opened for a company as a result of new or modified product development from P2 process changes, new sales or uses of byproducts or recovered products through material exchanges or sales of recyclables, or by reaching new consumers that value “green” production. Market shares that were previously lost can be regained and those left unexplored can become a viable source of new sales.

Pollution Prevention Program and P2 Process Overview

In order to realize the many benefits of P2 practices, an organization must be committed to creating and maintaining an effective P2 program, conducting necessary facility assessments, and implementing P2 projects. Preparing for P2 will be different for every company. Business practices and philosophies, finances, logistical needs, and abilities will differ for each company, which will shape the P2 process. One common component of successful P2 execution, however, is good planning. As illustrated below, good planning at the onset of program development and/or project implementation results in time savings, fewer complications, and less work overall than poorly planned efforts. Conversely, poor planning results in extended time frames and progressive increases in the work efforts required for project completion.

Illustration 6: Planning for Program Development and Project Implementation

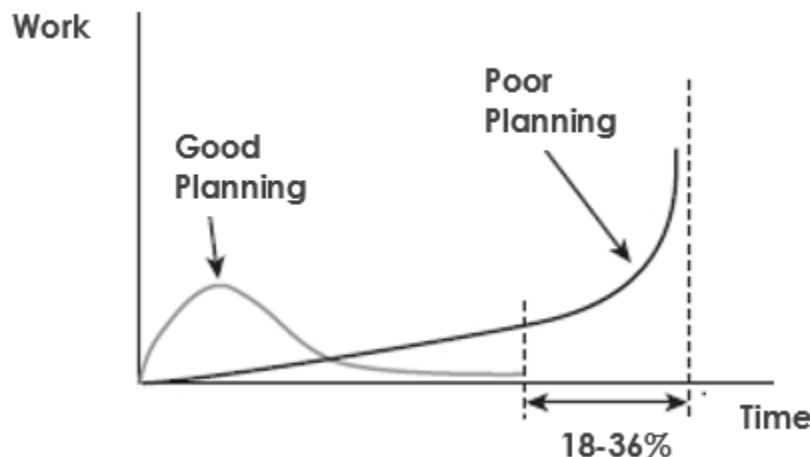
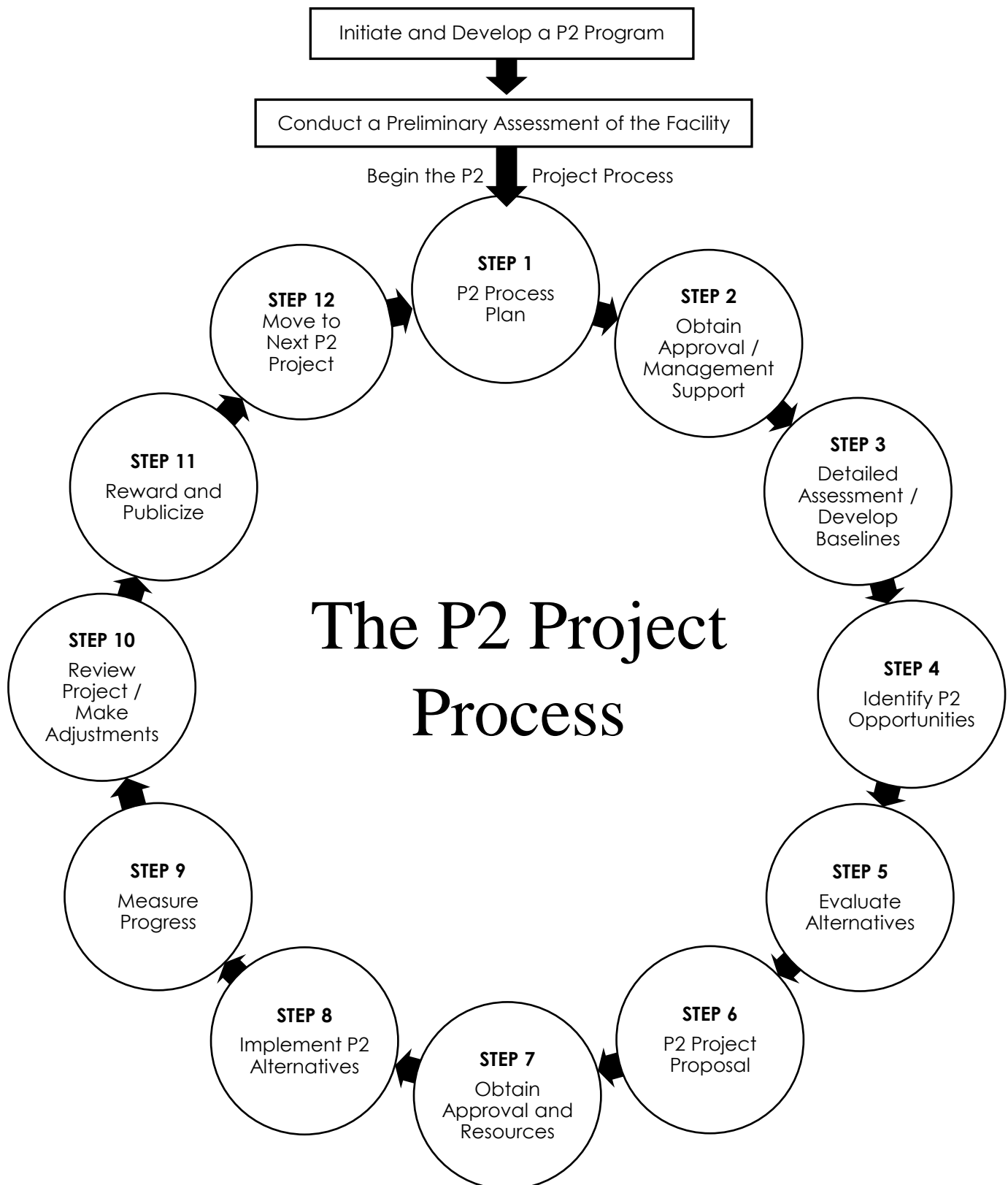


Illustration 7 (next page) provides an overview of the P2 process recommended in this manual. This bird's-eye view can enable planners, managers, and executives to understand the stages of the process and help gain consensus on company P2 planning efforts. The illustration begins with initiating and developing a P2 Program, followed by conducting a preliminary assessment of the facility. Once these two foundational elements have been completed, the company begins the 12-step P2 Project Process. Once all steps for project development and implementation are completed, they are meant to be repeated for each new P2 project.

Illustration 7: Pollution Prevention (P2) Process Overview

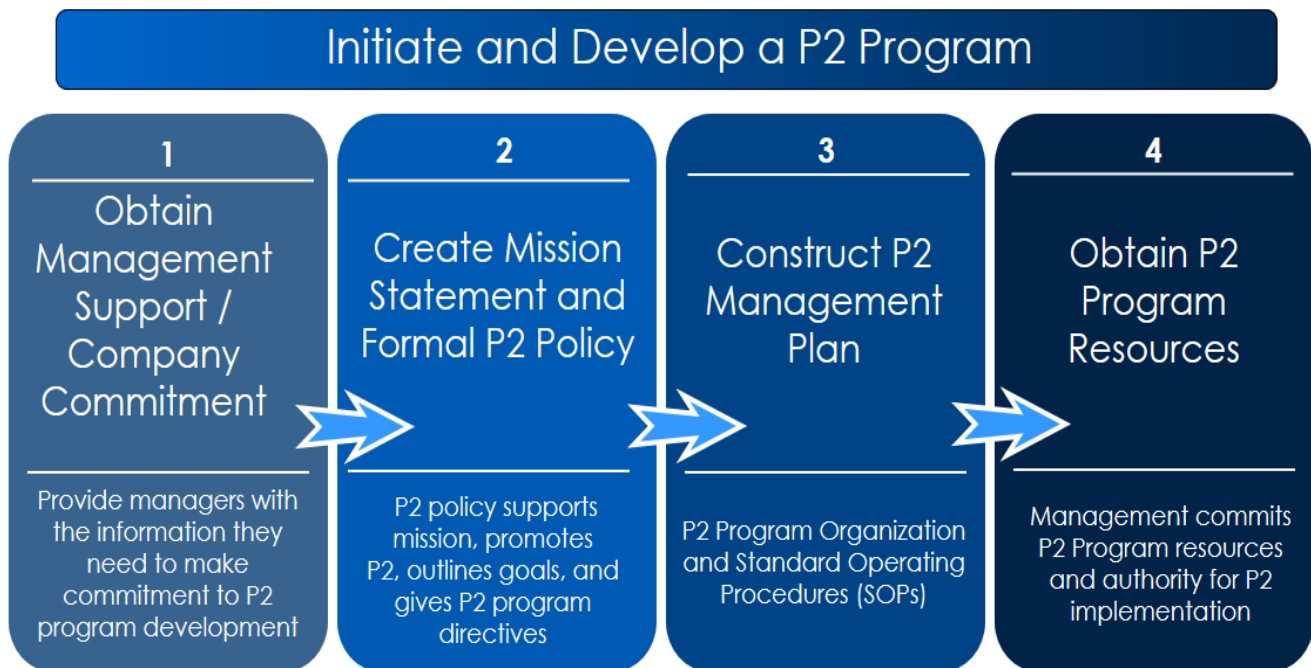


Initiating and Developing a P2 Program

An effective P2 program is the key to reducing negative environmental impacts from business operations and realizing the many benefits of P2 efforts. A P2 program facilitates an ongoing and comprehensive examination of the operations at a company or facility with the goals of minimizing raw material usage, waste products, and hazards associated with production. Developing and implementing a P2 program doesn't have to be a complicated endeavor, but it does require management and staff support, strategic planning, and dedicated resources. Building a basic P2 program requires four steps:

- 1) Obtain management support / company commitment
- 2) Create a mission statement and formal P2 policy
- 3) Construct a P2 management plan [program and process organization and standard operating procedures (SOPs)]
- 4) Obtain P2 program resources

Illustration 8: Steps for Initiating and Developing a P2 Program



Obtain Management Support / Company Commitment

The support of upper management is essential to acquire the necessary resources to conduct all P2 activities and to ensure that employees understand that P2 is a priority for the company. Upper management is very influential in creating a culture where P2 is accepted, successful, and celebrated in its applications. In some companies, the initiative to develop a P2 program may come from the executive level. In others, employees or lower-level managers may be the catalyst. [\(Ref. 3\)](#) In either case, senior management must be educated about P2 in order to commit to program development. This involves providing managers with the information they need to make informed decisions.

- **Reasons for a P2 program and Potential Benefits to the Business:** In order to justify a P2 program, it is helpful to demonstrate that P2 opportunities exist and should be explored. The process begins by gathering information that can be used by management to weigh the potential value of P2 for the business. Focus on presenting potential P2 benefits that align with the company's current missions and values. Provide detailed examples of source reduction and P2 accomplishments of other organizations. Identify specific and attainable reduction goals envisioned for the facility's P2 program. Note areas where losses are suspected to be occurring and possible opportunities for cost savings. Consider concentrating on areas that offer low-cost and quick-payoff P2 techniques that can be readily implemented. If those opportunities are difficult to identify, consider areas that generate wastes that are easy to reduce, costly to dispose of, generated in large volumes, have negative impacts (environmental or health), are generated from expensive raw materials, require specialized handling methods, or are considered to be hazardous or regulated. Of course, the hard data needed to back up these ideas can only be obtained by carrying out the P2 assessments described in this manual. In many cases, however, projections can be enough to convince management to allocate the resources needed for P2 activities.
- **Detailed Elements of the P2 Process:** It is important for management to understand the elements of a P2 program and how the P2 Project Process works. Sharing the content outlined in this manual may prove effective. Additionally, many of the references listed at the end of this document can be used for resource use/waste generation audits and P2 assessment methods. Note that the P2 program structure can be tailored to meet the specific needs of the company and suggested processes can be adapted accordingly.
- **Required Resources for a Sustainable P2 Program and P2 Process Implementation:** It costs a company money to conduct P2 efforts. There are expenditures associated with P2 program supplies, staff salaries, and any necessary external consultation services. There are also capital costs, and potentially lost profits due to production downtime during P2 Project Process

implementation. The number of staff and the time they spend related to P2 work naturally depends on the complexity of the facility. Some companies may need staff specifically dedicated to continuous improvement and P2 efforts, while other P2 programs will be built and sustained by the work of existing personnel. In the latter case, if the program work is well distributed, none of the required tasks should interfere with employees' regular jobs. However, it is important to acknowledge that these individuals have taken on more work and additional compensation or recognition may be warranted. Emphasize to company directors that when the company reduces the amount of money spent on managing waste, those monies become available for research and development, facility improvements, and social programs. Many of the resulting P2 financial gains can more than sustain a P2 program; however, the initial costs must be allocated from existing budgets.

Create a Mission Statement and Formal P2 Policy

Once senior management has decided to establish a P2 program, they should convey this commitment to all employees clearly through the creation of a company P2 mission statement and a formal P2 policy.

A mission statement is most effective when prepared in cooperation with staff and built upon consensus among management and employees. It gives importance to the P2 program and helps define the new company P2 policy. A company can develop one or more P2 related mission statements, which can range from simple and generalized to specific and comprehensive.

Example Mission Statements:

"We make a commitment to proactively protect the environment by reducing the wastes we generate through our use and disposal of products."

"At Subaru of America we are committed to the vitality of our people, to the health of our planet, and to enhancing the communities where we live and work. Our corporate responsibility efforts and philanthropic commitments address the issues our employees, customers and communities are passionate about and we strive to address these issues in ways that allow us to create positive change – within our operations and beyond our four walls."

Patagonia's Mission Statement – "Build the best product, cause no unnecessary harm, use business to inspire and implement solutions to the environmental crisis."

Establishing a formal P2 policy is a way to integrate P2 into corporate planning because programs will falter if support from senior management is not visible, strong, and subject to accountability. The P2 policy supports the established mission

statement(s), promotes a common understanding of the company's philosophy toward P2 practices, outlines specific goals for the organization, and gives concise directives for the P2 program. The policy should clearly state:

- 1) Why a P2 program is being established (i.e., to fulfill the mission statement[s])
- 2) What is to be accomplished (i.e., company goals)
- 3) Who will do it (i.e., all company staff)
- 4) How it will be accomplished (i.e., through SOPs outlined in the [P2 management plan](#)).

The goals identified within the P2 policy need to be both challenging and obtainable. Goals can be qualitative, such as, "achieve a significant reduction of toxic emissions to the environment," or they can be specific target objectives that are quantifiable with established measurement units and set time frames. Quantitative goals are more difficult to develop but are worth the extra effort if a company already has some baseline data available on waste generation or raw material use. Quantitative goals may include specific percentages, volumes, or weights of waste prevented; stated reductions in contracted waste management services or materials used; or a target number of implemented P2 ideas. There may be some existing corporate P2 directives or goals that have been established through prior P2 planning conducted in response to requirements of state or federal laws. If so, these ideas should be carried forward and recognized as continued objectives for the company. Goals can encompass institution-wide and/or departmental objectives, and they can be both short- and long-term in nature. These outlined goals can also help determine which P2 projects get priority and funding for implementation. It is important to understand that goals should be flexible and adaptable. Periodic status review and goal adjustment is strongly recommended. As pollution-specific aspects of operations become better known and lessons are learned, the goals can be refined.

Example company goals:

- Reduce halogenated solvent use on the parts cleaning line by 25% by the end of the fiscal year.
- Identify five pollution prevention projects for implementation by December 31, 2018.
- Reduce our company's carbon emissions by 50% in comparison with base year 2009.
- Expand our use of green electricity to 40% by 2020.
- Purchase and use paper products in our offices that are sourced from sustainably managed forests only.

Once established, the company P2 mission statement and P2 policy should be publicized so that all employees know the program goals, how they are expected to

participate, and the company priority assigned to P2 efforts. Announcing authorization for the P2 program development and associated P2 activities is an extremely important step, regardless of the size of the facility.

Construct a P2 Management Plan

Once a P2 policy is established, a P2 management plan must be developed to outline the functional elements of the P2 program and the P2 process. This will include a detailed program description, standard operating procedures (SOPs), and any other appropriate details or practices. The following is a suggested outline for the P2 management plan:

- Determine the P2 Program Scope
- Establish P2 Teams, Roles, and Responsibilities
- Determine Facility / Process Assessments and P2 Project Process Steps
- Establish Measurement Guidelines
- Establish Reporting Requirements
- Establish Prioritized Methods of Data Collection and Management, Approved Calculations/Conversions, Records and Tracking Preferences
- Determine P2 Financial Approval Process
- Establish Evaluation Timelines, Performance Measures, and Continuous Improvement Mechanisms
- Outline Employee Education and Involvement Standards
- Establish Employee Incentive Mechanisms
- Determine P2 Promotions/Outreach Mechanisms and Procedures

Consider the SOPs within the P2 management plan as quality assurance measures. They are used for the organization, monitoring, and evaluation of the various aspects of a P2 program and P2 projects to ensure that standards of quality are being met.

If a company has an environmental management system (EMS), many of these program elements may have been identified and established already. If no EMS is in place, the P2 management plan will be important to complete in order to obtain a thorough view of P2 program functions. As with any management document, the SOPs developed now can be revised as necessary when the document is due for periodic review and updates.

Determine the P2 Program Scope

The scope, or workable parameters of the program, must be clearly established. As guided by the company mission and P2 policy, the scope of the program describes how all groups within a company (i.e., production, laboratory, maintenance, shipping, marketing, engineering, and others) will work together to reduce waste production

and resource use. The viable scope of a P2 program is affected by company size, available resources, and products or services provided. Lack of clarity on the scope of a program can stop or hinder progress. For example, are employees only to assess the impacts of resources used and wastes generated through the use of products within the organization, or are they to include the impacts for the entire life cycle of manufactured products, which includes the company's supply chain, consumers, and the products' ultimate fate? Should the program focus on company-specific economic and immediate environmental impacts, or will it span economic, environmental, and social impacts in a greater context? Properly identifying the latitude of the program will affect the procedures for the program and better enable its success.

Establish P2 Teams, Roles, and Responsibilities

The P2 management plan should include thorough descriptions of the company's P2 teams, their makeup, authority, and responsibilities. Small businesses may not need formal teams if coordinated "teamwork" can take place without them. If personnel resources are limited, then having P2 teams is not a direct requirement for implementing P2 efforts at a facility. However, if appropriate for the size of the business, it is strongly recommended to establish a P2 program team or task force to direct and oversee the P2 program on a continual basis. Also, designate P2 assessment teams that temporarily assist the P2 program team during detailed process assessments and whose focus is relatively specific (see Chapter 6, [Step 3](#) – Detailed Assessment Phase - Analyze Process / Develop Baselines).

Outlining the general job duties for these roles does not require identifying specific people in the SOP. In some cases, the staff selected to fill these roles will not necessarily be static. Different personnel may be needed as the P2 teams progress through the P2 Project Process for one or more operations.

The P2 program team will have the responsibility as the overall force to lead the P2 program, facilitate P2 implementation, and help integrate P2 principles throughout all phases of corporate planning. The size of the P2 program team will depend on the size and complexity of the business, but it should be cross-functional and multidisciplinary, composed of individuals with a wide variety of skill sets. The people who will direct the P2 program should be selected carefully, as they will be responsible for developing the P2 project plans and directing P2 implementations. The capabilities of this team's members and their attitudes toward the company P2 efforts could be very influential toward P2 outcomes. Successful P2 program execution will require integration and continuity of the planning, implementation, modification, and maintenance stages. This is why some of these team members serve in permanent positions related to the P2 program even if this is not the sole role of these individuals within the company staffing matrix. Individuals named to this P2 program team should have substantial technical, business, and communication skills as well as thorough knowledge of the company.

The position title, authority, and responsibilities of each P2 program team member should be established within the P2 management plan SOPs. These descriptions will vary based on the team size. It is recommended to have a minimum of three permanent roles identified, such as P2 program leader or captain, P2 program facilitator, and P2 champions. Furthermore, the P2 program team should have at least one voluntary role description available to allow for additional employee participation, such as P2 stewards.

Recommendations for crucial P2 program team member roles:

The **P2 program leader/captain** should be named from the highest corporate level practical. The leader must have the authority and the influence necessary to keep the program on track and to ensure that P2 becomes an integral part of the overall corporate plan. The roles of the leader are to facilitate the flow of information among all levels in the company, serve as the spokesperson for the P2 program team, review and approve all P2 reports, and establish the P2 related training programs for staff. Therefore, the leader should possess the skills and abilities necessary to elicit broad-based support from the company's executives, employees, and the other P2 program team members.

The **P2 program facilitator** has a key role as a designated link to all things P2 and must possess strong organizational and team-building skills. The facilitator serves as a liaison to other organizations and agencies, coordinates the P2 teams' job assignments, is the centralized recipient of P2 assessment data and summary reports, and may post agendas and minutes for P2 related meetings.

P2 champions are typically selected for their specific technical or business expertise. Environmental and plant process engineers, production supervisors, and experienced line workers are good candidates. Other potential sources include purchasing and quality assurance staff. The tasks of champions are to assist with P2 planning, research, P2 evaluation, data organization, and report writing. They also serve as the department's P2 contact to facilitate the flow of information from management to staff in their areas and to help overcome possible resistance to proposed changes in operations. Part of a champion's job is to provide an immediate contact for others in their departments, be a nonthreatening sounding board, encourage brainstorming, provide educational information to staff, and identify how ideas are to be gathered. In a medium-sized company, several champions may be assigned according to production area. If possible, including one representative from each department as a champion gives invaluable perspective to the program. Champions will be the team members who are the most visible within the production areas and should be respected and trusted at all levels in order to perform this liaison role well.

P2 stewards are existing staff that volunteer to assist the company P2 efforts. Individuals who have a personal interest in the P2 program work best in this role, and other personnel in the organization are typically receptive to them because they are peers.

P2 stewards help support the rest of the team members' functions and can be an integral part of P2 marketing, publicizing, and employee reward strategies.

The P2 program team should include employees and management at every level and from all areas of the organization if possible. This could include employees that work as legal representatives, finance/accounting/purchasing staff, research and development scientists, environmental and process engineers, production supervisors/personnel, line workers, quality assurance managers, clerical assistants, custodial professionals, and maintenance staff, etc. Once the P2 program team has been established, they will be a valuable resource within the company. When plans are being made to expand the facility, to design new products, or to redesign existing products, the team can review the plans to determine whether waste generation has been evaluated thoroughly and if potential P2 measures have been considered.

The P2 Assessment Team members should be people with knowledge of and direct responsibility for the waste streams and/or areas of the facility under consideration for P2 projects. These teams will be assembled in the detailed assessment phase of the P2 Project Process (see chapter 6, [Step 3](#)). The focus of each P2 assessment team will be unique to the operations of interest, but general guidelines for their roles should be established here. Assessment team members are responsible for assisting the P2 program team with review of specific process sites and data, writing assessment reports, conducting feasibility analyses of P2 options, and other work necessary to fulfill the P2 Project Process. It should be noted within the SOP that Human Resources should be notified to update the job profile for staff selected to be on a P2 assessment team to include these work requirements.

Whether or not a company chooses to organize P2 teams, it is important to establish the duties of those persons working on P2 projects. Outlining the general job duties for these roles in the P2 management plan enhances efficiency, establishes individual work priorities, and minimizes the risk of duplicated efforts.

Pollution prevention should be considered as a job responsibility subject to review. As with any work expectations, it is suggested to establish performance reviews to delineate staff responsibility for maintaining and enhancing the P2 program. Progress in P2 can be stated as an objective of job performance evaluations, particularly at the management level. An annual performance report to recognize efforts in this area raises the importance and visibility of P2 and serves as a mechanism of accountability for staff involvement.

Determine Facility / Process Assessments and P2 Project Process Steps

The types of assessments needed and the P2 Project Process steps that will be utilized will depend on the status and goals of the company, as well as the current information available. For instance, a small company with few processes may not need to conduct a [preliminary assessment](#) of the facility prior to performing the [P2 Project Process](#). This is also true of any company that already has a sound understanding of their facility's operations, a general or detailed facility flow diagram, has identified the data sources available for evaluations, and has general process information compiled. It is important to outline the specific assessment needs of the company and the agreed-upon steps for the P2 Project Process that P2 program will employ.

Establish Measurement Guidelines

It is important to determine the criteria in terms of the program's goals and constraints. By pre-establishing some standards for measurement and ranking methodology, data collection, analysis, and decision-making will be more efficient and accurate throughout the P2 processes. When performing any type of comparisons, care should be taken to use the same unit of measure for all types of materials used in the analysis. List evaluation methods that are preferred in order to meet the company objectives. For example, the Interstate Chemicals Clearinghouse (in their Alternatives Assessment Guide, Version 1.1 ([Ref. 7](#)), suggests that for most alternative assessments aimed to replace chemicals of concern used in products or processes with safer alternatives, a standardized evaluation process should be implemented. This standardization is achieved by conducting several evaluations for each process under review, including four primary assessments and three optional assessments. The primary evaluations include assessing hazard, performance, cost, availability, and exposure. The optional assessments include materials management, social impact, and life cycle analysis. Further, it is valuable to establish the ranking systems and the weighted criteria used for decision-making purposes.

Establish Reporting Requirements

The creation of several reports and other documents are recommended to summarize, present, and evaluate information during various stages of the P2 processes. It is important to identify the reporting expectations, requirements, and the procedures for their review, approval, and publication.

Regular reporting cycles, report contents, and any known specialized reports that can be valuable to P2 processes, along with detailed summary reports, should also have SOPs to ensure reports are properly prepared at meaningful intervals. Quality reports are the basis for evaluating and maintaining P2 programs and they may also be needed to secure funding for projects that require capital investment. Adequate reports can help to focus current and subsequent P2 efforts, serve as a historical reference and baseline data source, and assist with recognition activities.

Establish Prioritized Methods of Data Collection and Management, Approved Calculations / Conversions, Records and Tracking Preferences

All published goals that are quantitative in nature should set numeric objectives, measurement units, and a mechanism to track progress. The extent and complexity of the systems for collecting, measuring, and recording P2 data should be consistent with the needs of the company and the P2 policy goals. The least complicated systems available that meet the P2 program's needs should be used.

Numerous data sources typically already exist, and if data is currently collected as a normal part of facility operations, it should be documented as one of the primary methods of collection whenever possible. Historical data, if documented appropriately, can be an excellent source for establishing baseline values. It is important to address record retention in the data management SOPs for this purpose. Also outline how various program areas within a company will coordinate data acquisition and sharing.

If new data procurement is necessary, the scope, methods, and schedule should be identified. For instance, if a goal is to reduce annual air emissions from an entire facility, this may require gathering new data from several individual process units on a monthly basis (or other appropriate time frame). It may also involve installation of new data acquisition systems. Data can be gathered from many sources, including field notes, records of observations or test results, inventory and purchase records, drawings, photographs, computer generated or electronically recorded information, maps, charts, graphs, and surveys. Therefore, if there are preferred template worksheets, questionnaires, or checklists for data collection they should be identified or developed. Establishing how various formats of data will be managed is crucial and should be addressed in the SOPs.

How data is measured and translated is equally important for P2 program success, and should be consistent throughout the company. Measurement SOPs should be written on the different methods used to evaluate the published goals. Measurements can be assessed on a product-by-product basis, process-by-process basis, facility-wide basis, or an expanded level, such as life cycle basis. If it is known, normalization requirements should be described to compensate for external factors affecting values that are not related to P2 efforts. Uniform formulas for conversions and comparisons that are acceptable should be established. When these and other necessary standards are confirmed for measurement, the frequency of errors is reduced and interpretation for reporting is more consistent.

Finally, SOPs should outline how individuals gathering and measuring data know how to record, organize, and share this important information. If there are preferred forms, databases, or programs that should be used for these purposes, those systems should be identified and included for reference.

Determine P2 Financial Approval Process

Every company has a procedure for the procurement of funding for capital investments or facility improvements. This process should be followed within the P2 program as well. The only differences may be the chain of approving members that will now include P2 program members, the potential investment options from outside sources such as lower rate loans based on potential liability reductions, and opportunities for receipt of grant monies. If a company is interested in utilizing grant or other external programs for funding options, it is imperative to understand the grant requirements to ensure eligibility. Therefore, establishing the procedures for identifying and applying for these sources of funding is important. The correlation of these goals with other practices and parameters within the SOPs is equally important. For instance, many grants establish expectations for quantification methods that must be used and the submittal criteria of estimated P2 results in order to be eligible for funds.

Establish Evaluation Timelines, Performance Measures, and Continuous Improvement Mechanisms

P2 is about continuous improvement. It encourages businesses to set reasonable goals, and after meeting them, to reestablish the goals for further improvements. All published goals should have associated time limits. The lack of planning and organization can lead to low performance and higher costs to implement P2 opportunities. In order to ensure continuous improvement for the P2 program efforts, a schedule should be established in the P2 management plan for project reviews and report submittals. This can be accomplished by listing the milestones within each of the P2 Project Process stages, from systematic assessments (process mapping) to P2 opportunity implementation. Realistic target dates or time frames for review (e.g., within 1 month after stage completion) should be assigned. This process allows the P2 teams to make adjustments quickly if obstacles are identified anytime during the P2 Project Process. Adherence to the schedule will also help control the implementation costs of the program and each project.

Once a P2 project is complete, the performance should also be periodically assessed against the expected environmental outcomes, technical improvements, and financial returns. Another way for facilities to evaluate performance is by developing, implementing, and maintaining an environmental management system (EMS). An EMS is a mechanism for tracking, assessing, and continually improving environmental performance. The EMS model encourages companies to go beyond basic regulatory requirements and track their performance improvements (e.g., International Organization for Standardization (ISO) 14001 standard). The schedules outlined in the company EMS for assessment can be the basis for the P2 program performance measures.

Aside from tracking and evaluating performance, it is crucial to keep information current even when P2 projects are not underway. Facility and process data (including

maps and descriptions) should be reviewed and updated whenever major changes occur (e.g., material variations and costs, applicable regulations, or disposal methods and costs, etc.). At the very least, these items should be targeted for updates during an annual P2 program evaluation that is performed at the corporate level, to keep information accurate and the program operations efficient. Continuous improvement hinges on maintaining accurate information, adhering to target schedules, and establishing valuable performance measures.

Outline Employee Education and Involvement

Employee Education

Training is one of the most important elements of the P2 program. As with any other new program, general resistance to change and friction within the organization may arise. These obstacles can result from many factors, such as lack of awareness of corporate goals and objectives, individual or organizational resistance to change, lack of commitment, poor internal communication, requirements of existing labor contracts, or an inflexible organizational structure. These institutional barriers can be overcome with education and outreach programs. It is vital to gain the support of staff at all levels early in the P2 effort. By establishing education standards in the P2 management plan and ongoing staff education programs, employee engagement and support can be achieved and maintained. The P2 training program should include all levels of personnel within the company. The goal is to make each employee aware of P2 efforts and understand why they are important. The P2 training program should be developed by the P2 program team. Modules should be included that are designed for different participants. The training content will teach employees about various environmental topics at the company, including management practices and environmental goals. Consider incorporating and developing the following suggested P2 trainings:

New Employee Orientation – Valuable ideas can come from new people, and early involvement in P2 practices can increase participation. Make sure Human Resources has P2 training materials ready for new employees. P2 awareness can be incorporated into the employee orientation program to impart the importance of P2 to the company. The economic, social, and environmental benefits of P2 should be explained, as well as the incentives for employee contribution.

Annual Employee Training – A more detailed P2 training should be provided to employees on an annual basis. This training will provide staff with the skills needed to participate in P2 efforts, keep current on policy and procedure changes, and provide updates on P2 project successes and activities. This training also emphasizes the company's commitment to P2 and incorporates management procedure review. Examples of specific P2 related management practices that might be incorporated into this training are:

- Proper materials handling practices to reduce waste and spills

- Proper equipment operation to minimize resource use (energy, water, and materials) and waste generation
- Detection methods for operational problems (checking for leaks, spikes, etc. to minimize material losses)
- Maintenance schedules (avoiding equipment deterioration and malfunctions to reduce potential losses)
- Emergency procedures (minimize material losses during accidents)
- The importance of P2 by explaining the economic and environmental ramifications of waste generation and disposal, and the benefits of alternative P2 practices

Advanced Training – The P2 program team should be provided with additional education about P2 strategies and equipped with educational materials from governments, other businesses, associations, universities, and independent groups. Building on information from these sources saves valuable time, helps keep the members focused, and allows the members to identify new P2 opportunities through technological advances. Specialized training sessions on P2 policy, procedures, and techniques should be provided to staff when their job scope is expanded or when they transfer to other areas in the company. For instance, new procurement staff might benefit from understanding the full costs of hazardous and unused chemicals. Also, persons moved to areas that require the handling of chemicals should be trained on minimizing chemical hazards, spill prevention, and preventive maintenance related to P2.

Employee Involvement

Staff involvement is crucial to a P2 program's longevity and success. Establishing standard methods to engage staff is recommended to facilitate staff commitment to P2. Employees often feel dedicated to P2 when they are encouraged to:

- Help define company goals and objectives
- Participate in process assessments (operations review)
- Provide suggestions (suggestions are acknowledged and given feedback, even if not used)
- Design or modify forms and records to monitor materials used and waste generated
- Find ways to involve suppliers and customers

Employees also feel involved in P2 efforts when they receive regular P2 updates and information communicated through a P2 newsletter, departmental meetings, memos, seminars, presentations, and brochures. Finding the methods that are most suitable for the company to engage staff and increase their involvement is important and should be outlined within this plan.

Establish Employee Incentive Mechanisms

Think of ways to acknowledge and reward employee (individual and group) contributions to the P2 efforts to keep motivation alive and innovative thinking robust. Establish the approved mechanisms and how they will be supported within this document. Some suggested ideas for recognizing P2 involvement are:

- Grant material rewards (cash or merchandise) – Cash value can be a set percentage of the estimated annual savings (or new profits) to be realized by the company or production unit. Company merchandise may be desirable to employees and cost-effective for the company to provide as a reward.
- Recognition among peers – Give written recognition in company publications (e.g., newsletters), on bulletin boards, and in media blasts. Post employee pictures and their P2 profiles on websites, banners, or in common areas like cafeterias, breakrooms, or company entrances.
- Formal awards – Give plaques, trophies, or certificates at staff meetings or ceremonies.
- Cite accomplishments in performance reviews.

Determine P2 Promotions/Outreach Mechanisms and Procedures

Sharing P2 success stories can be a valuable way to sustain the P2 efforts of a company and help to achieve some of the additional P2 benefits associated with promotions. Setting guidelines for when and how P2 efforts should be shared with external parties can eliminate barriers or resistance to promotional activities. Some ideas for how to share P2 activities include:

- Submit press releases on innovations to local media and to industry journals read by prospective clients.
- Arrange for employees to speak publicly about P2 measures in schools and civic organizations.
- Generate publicly accessible reports and post on company website.
- Include P2 projects in public relations/marketing efforts such as commercials, social media, or flyers.

Make sure the structure for recognizing additional P2 activities is developed and able to be sustained. If this structure is not in place to promote all of the P2 ideas implemented to the entire staff, some may go without note and enthusiasm can fade. Effective programs are self-perpetuating to the degree that management supports and promotes them.

In summary, a P2 management plan serves as a roadmap to sustaining an integrated and coherent P2 program that supplements other important facility programs (e.g.,

safety and health, environmental compliance, training, and development). It is a framework for the P2 processes to be conducted consistently and efficiently.

Obtain P2 Program Resources

Management must be willing to commit the resources necessary to support the P2 program. Formal authority for the staff to conduct the necessary assessments and implement the P2 Project Process must be provided. This can be in the form of creating permanent positions for some of the P2 program team members, allocating a certain number of staff hours for the roles of other members, or procuring consulting services to serve those functions.

Conduct Preliminary Assessment of Facility

A preliminary assessment provides an overall evaluation of the facility's operations to understand the relationships between the operations, the materials used, the wastes generated, and the management of waste streams. For the purposes of this analysis, the approach should consider both inputs and outputs so that the overall flow of materials or throughput can be evaluated. P2 concerns all resource use and all waste generated including emissions and releases into all media (air, water, and land). An approach that focuses only on inputs or outputs may not account for all potential P2 opportunities available to the various operations. Even though a preliminary assessment may have been previously completed as a tool to develop a P2 program, a deeper examination is needed to determine what background information is available, its value for P2 efforts, and how it should be processed in order to quantify the true costs of waste management.

Before starting, it is important to notify facility staff about the assessment, explain why it is important, and encourage them to help by providing expertise when questions arise. Employee involvement and cooperation is crucial, so they should be assured that they will not be punished if poor operating practices are found in their departments.

This preliminary assessment is a wise use of employee time and company money because it can enable the P2 program team to prioritize and select areas for more detailed evaluations in the next assessment phase and assist with baseline development for those processes. The results of each step of the preliminary assessment are important, but each step may not be necessary depending on the facility. Businesses should perform the appropriate steps in the order that makes the most sense for the facility being assessed and at the level of detail deemed sufficient by the company objectives.

- Tour Facility
- Identify Data Sources for the Facility
- List Unit Processes, Create Facility Flow Diagram, and Write Facility Description
- Create Unit Process Descriptions and Unit Process Maps
- Collect and Analyze Data on Unit Processes / Expand Unit Process Maps
- Establish Preliminary Measurements
- Rank Process Unit Areas for Further Evaluation
- Construct a Preliminary Assessment Report

Tour Facility – The P2 program team should conduct a tour to acquaint themselves with the processes in the facility and bring all team members equally up-to-date on the plant operations. Sometimes the best ideas to reduce waste come from a fresh

perspective. It is important that the entire P2 program team participate during the tour and view the processes of each area of the facility. If there are representatives from every department on the team, they should each lead the tour of their specific areas.

If possible, schedule the initial walk-around when the majority of the production units are in operation. Subsequent tours will be necessary to fully examine process activities. However, an initial cursory review of the layout and operations of the facility will help familiarize the P2 program team with the organizational structure. The review will identify the major products produced or services provided by the facility and determine the level of coordination of environmental activities between various departments. Additionally, this plant tour will help the P2 program team decide how to describe plant production in terms of unit processes.

Identify Data Sources for the Facility – Depending on the type of facility operations, there may be several existing sources of data that can be used in the P2 assessments. Determine what potential sources of data are available and how they can be accessed (see [Facility Data Sources](#) on next page).

List Unit Processes, Create Facility Flow Diagram, and Write Facility Description – The P2 program team should identify and list all the unit processes within the facility. A unit process can be defined as an area of the facility, a specific process, or a piece of equipment. For the sake of keeping records, assign a name to each unit process.

A general flow diagram needs to be created to outline the flow of production activities and serve as a visual representation of the interconnection between individual unit processes. This diagram is not a floor plan for the facility. Rather, it will indicate the sequence of operations and the relationships of process elements to each other. This diagram will be helpful in determining measurement points and the logistics of potential P2 opportunities. Make sure that all unit processes that were identified and listed are included on the facility flow diagram. It is also important to include areas used for materials storage and handling operations as well as equipment maintenance and repair. These areas can be linked by broken lines and labeled in the diagram. Once the facility flow diagram is completed, it is easy to see where processes can be measured in relation to quantity, quality, timeliness, and cost.

The P2 program team should collect basic information that will give them the big picture for the facility. In order to provide a scale of operation and comparison for material use, energy consumption, and waste generation versus production, a facility description should be written. It should include basic items such as annual business volume, annual business sales, number of employees, operational schedule, previous energy conservation and pollution prevention efforts, and general characteristics of the company facilities. [\(Ref. 5\)](#)

Facility Data Sources

Process Engineering and Operating Information:

- Plant design documents and process descriptions (architect's facility plans, piping and equipment layouts, organization charts, process/workflow diagrams)
- Equipment information (lists, operating manuals, manufacture specifications)
- Plot and elevation plans
- Standard operating procedures (SOPs)

Regulatory Information:

- Permits and/or permit applications
- Waste shipment manifests
- Regulatory reports (biennial hazardous waste reports, NPDES reports, EPCRA Form R, spill reports, etc.)
- Environmental audit reports
- Emission inventories (waste, wastewater, and air emissions analyses - including intermediate streams)

Raw Material/Production Information:

- Product composition and batch sheets
- Safety Data Sheets (SDS) / Environmental data sheets
- Material application diagrams
- Product and raw material inventory records
- Operator data logs and production schedules
- Lab reports/characterization data

Plant Business Records and Accounting Information:

- Invoices / bills (utility fees - including surcharges, waste management fees, consulting or specialized services)
- Department cost accounting reports (including operations and maintenance (O&M))
- Internal tracking reports (material and waste handling, storage, and losses)
- Purchasing records (raw materials, products, equipment)
- Other inventory records

Figure 1: Example Facility Layout – Screen Printing Facility

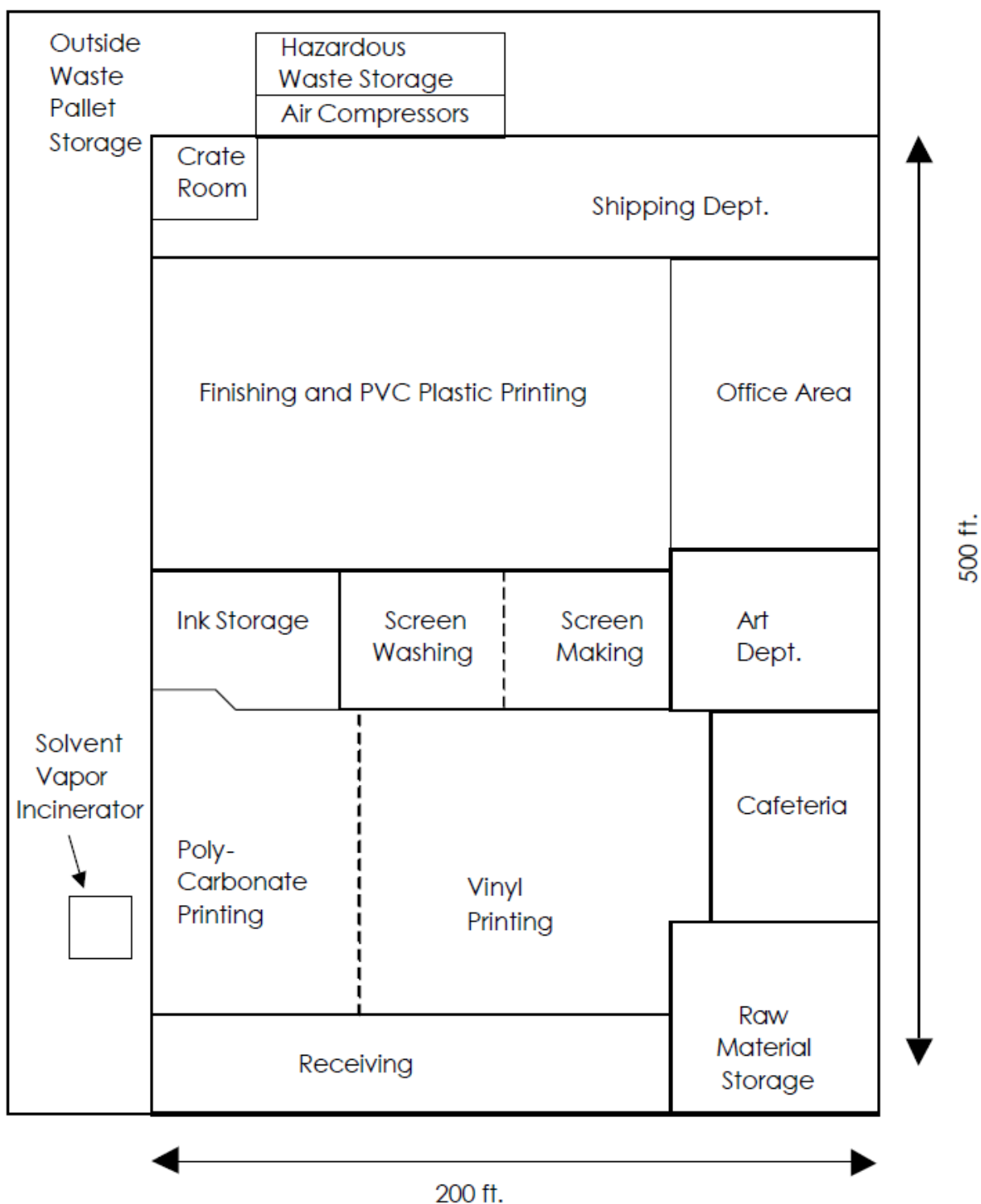


Figure 1 - Copied from Source [Ref. 5](#)

A simplified layout of the facility provides orientation and scale of operations. This can be useful for creating a facility flow diagram and logistical aspects of potential P2 opportunities.

Figure 2: Example Facility Flow Diagram – Paints Manufacturing

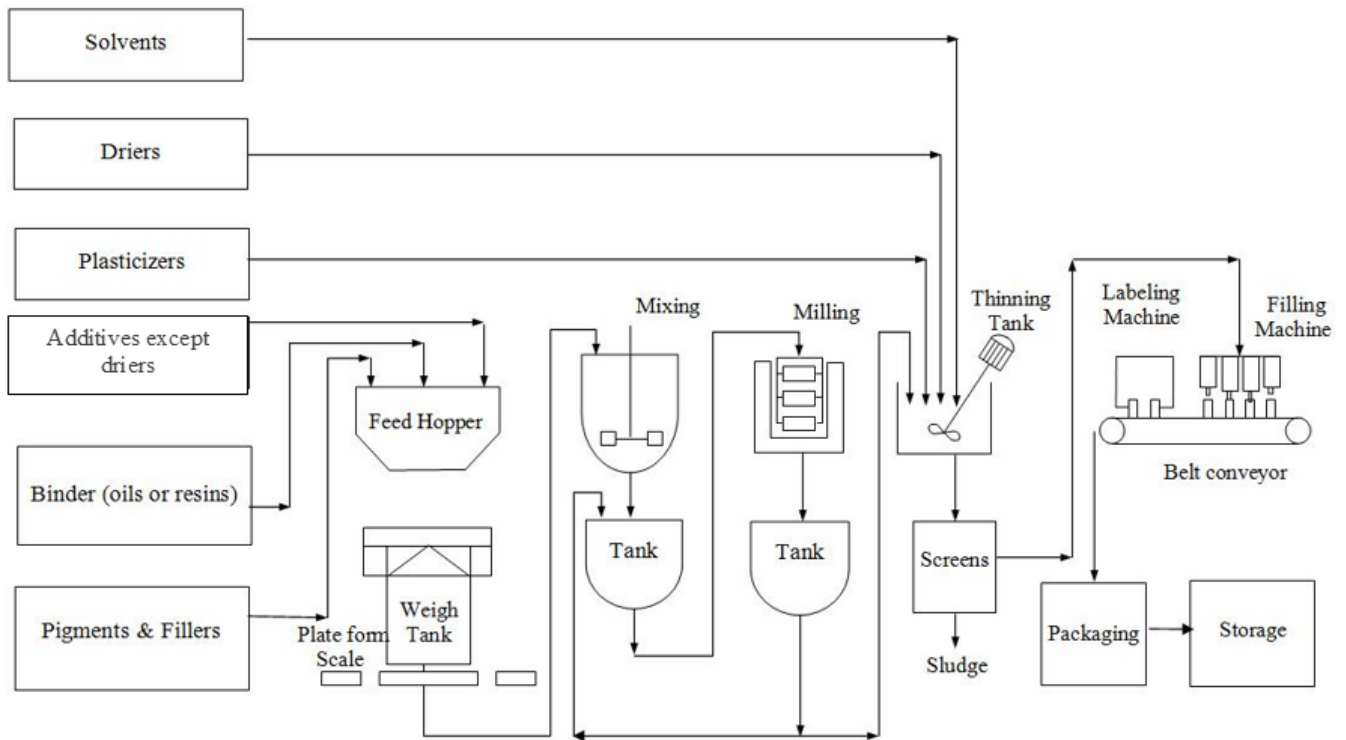


Figure 2 - By William361905663 [CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/>)], from Wikimedia Commons

Create Unit Process Descriptions and Unit Process Maps – Using the unit process list and the facility flow diagram as guides, develop unit process descriptions and a process map for each unit process. The process description is a very important part of the information collection process because it provides the basic information needed to generate process maps and for opportunity analysis later. A process description should include the main products produced, a brief list of raw materials, and the step-by-step description of unit operations from the beginning of the product manufacture to the finished product. (Ref. 5)

Map out all of the steps in each process and include intermittent operations such as cleaning, make-up, or tank dumping as well as any known direct releases to the environment such as fugitive emissions, spills or leaks. This schematic depiction of the unit processes shows the series of steps through which materials and other inputs pass. Such a map shows the system boundaries, all streams entering and leaving the process, points at which products or wastes are generated, and where losses occur.

Most unit processes have numerous process streams, many of which affect various environmental media. Identify and characterize as many of these process streams as is feasible. It is important to clearly distinguish between products, byproducts, processes, and production units. If possible, denote when there are regular or periodic process changes that may affect input and output fluctuations or introduce new materials,

byproducts, or wastes. It can also be helpful to list all related treatment, disposal, transport, and recycling facilities that are currently used by each unit process to clarify specific pathways and disposal practices.

Figure 3: Process Map – Block Diagram Model

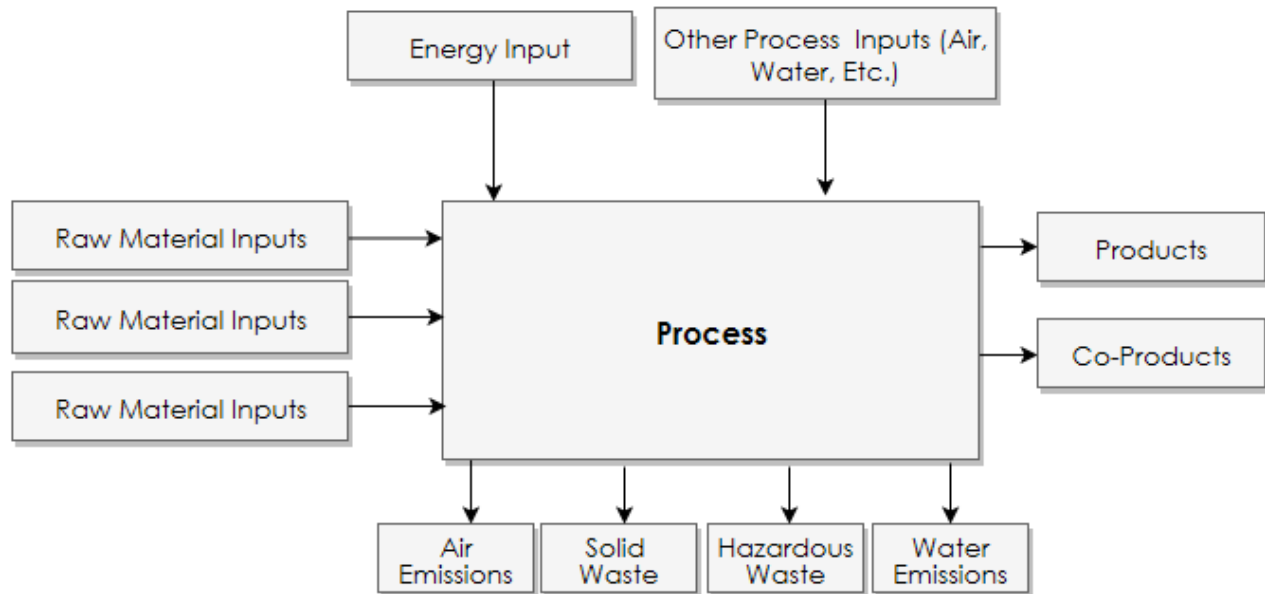


Figure 3 - Adapted from Source [Ref. 3](#)

Figure 4: Process Flow Map – Screen Making Operation

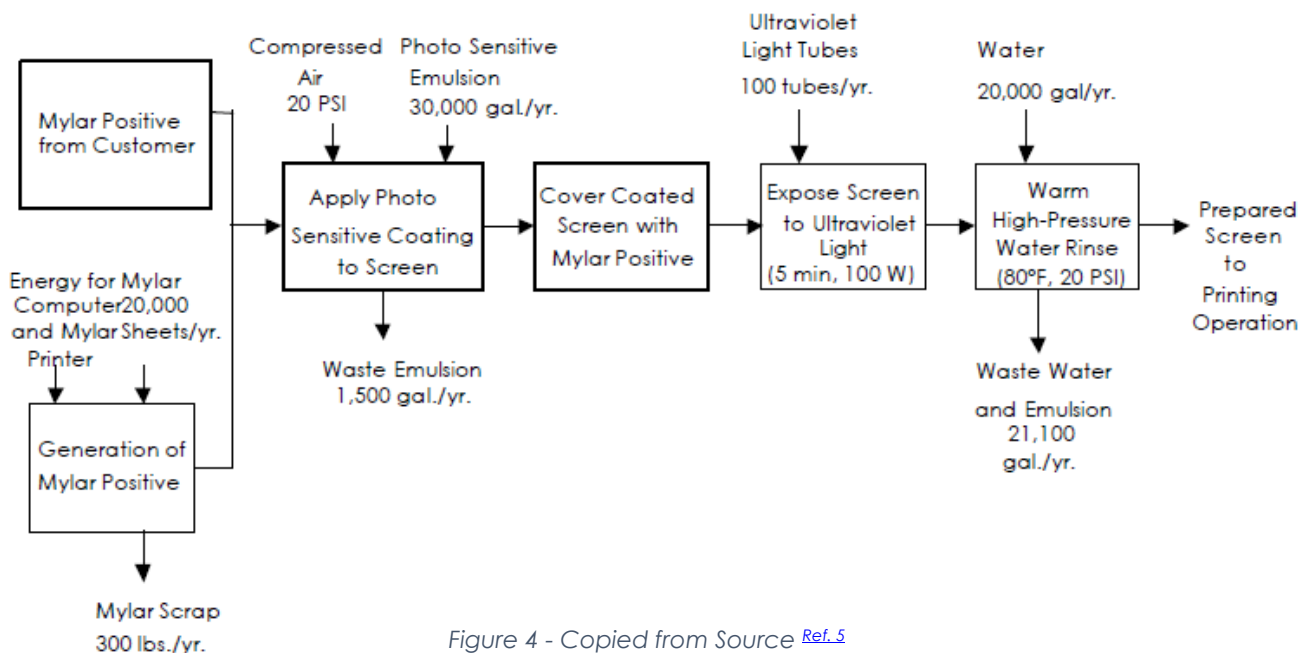


Figure 4 - Copied from Source [Ref. 5](#)

Figure 5: Process Flow Map – Printing Operation

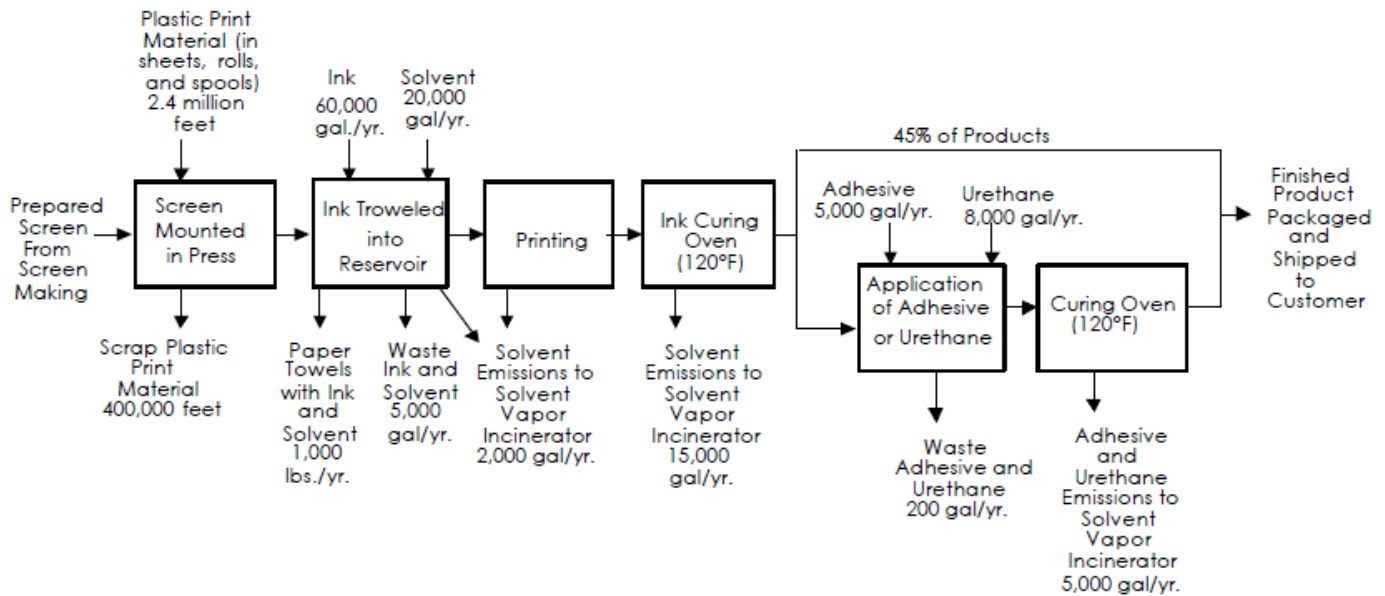


Figure 5 - Copied from Source [Ref. 5](#)

Figure 6: Process Flow Map – Cleaning Operations

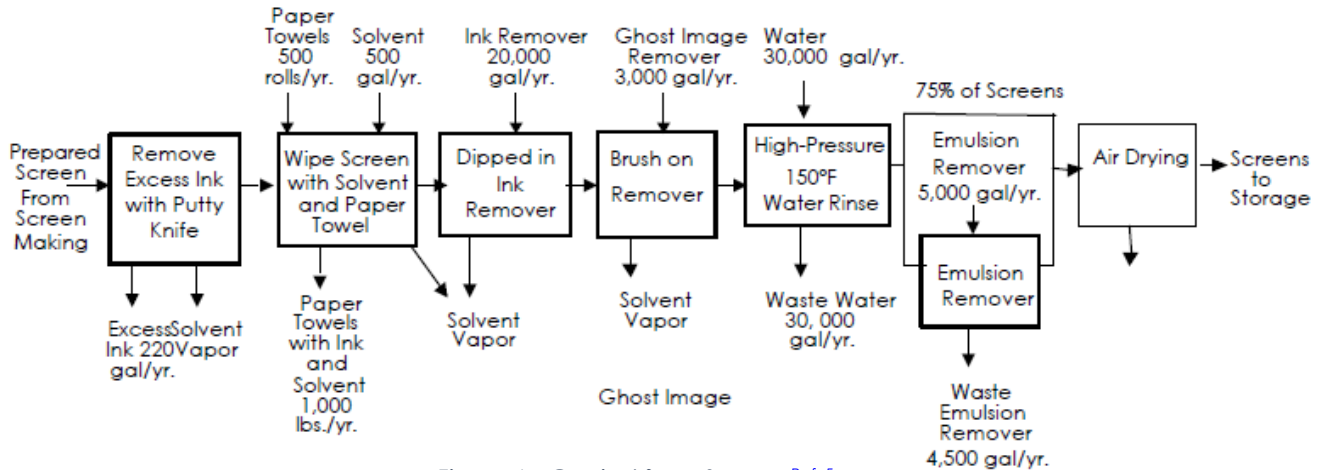


Figure 6 - Copied from Source [Ref. 5](#)

Collect and Analyze Data on Unit Processes / Expand Unit Process Maps – It is now necessary to assemble as much readily available information about how each of the unit processes operates as possible and how the units are connected. Use the current and historical data sources identified for the facility to gather specific unit process information. Itemize and analyze all of the unit process input and output information and further define each of the substances, materials, and products involved. At a minimum, the P2 program team should try to obtain data including: equipment specifics, raw material input (including utilities), waste stream output, products and services, and byproducts. Organize and record this information in quantifiable terms including weights, volumes, costs (including regulatory), labor or time

allocated (if appropriate), and the amounts of products created or services rendered. All data should be based on the same time unit (e.g., annual, quarterly, or monthly).

Products and Services

- Products and service quantities, associated profits
- Byproduct(s) amounts (note if any are recycled back into the process)

Raw Materials

- Weight and/or volume of procured raw materials (routine and non-routine) along with purchase costs and inventory practices
- Utility (water and energy) consumption and costs

Waste Streams (routine and non-routine) and Environmental Releases

- Volume and characteristics of hazardous wastes generated
- Volume and characteristics of air emissions
- Volume and characteristics of wastewater discharges
- Other releases and environmental impacts
- Waste management costs for each of the above waste streams

Equipment and Operations

- Equipment list, all units
- Equipment specifics (including pollution control devices) such as equipment ratings, average loads, energy/fuel source, hours of operation, temperature, pressure, etc.
- Equipment maintenance and operating costs (e.g., emergency generators)[Ref. 5](#)

It is also helpful to document qualitative information about each process if it is relative to the ranking criteria that will be used to evaluate priority areas for further evaluation (e.g., hazardous waste from the process unit identified as “A” is regulated under RCRA).

Compile the information for each category on a worksheet for each process or unit. Once compiled, the P2 project team should review the data and compare the information available to the process maps to identify any areas where data gaps or conflicts exist. It may be necessary to make estimates if the missing information cannot be easily obtained. The quantifiable information can be added to expand the process maps, making them a more valuable tool for subsequent evaluation efforts. Each process unit should have a unique record or file, and all appropriate data and process maps should be stored together.

If a business is small and has few unit processes, this step may not require an unreasonable amount of time and resources to complete. Larger companies may decide to limit this preliminary assessment step and those that follow to specific unit processes that have already been identified as potential focus areas, or they may encourage additional staff participation to assist with the completion of these steps.

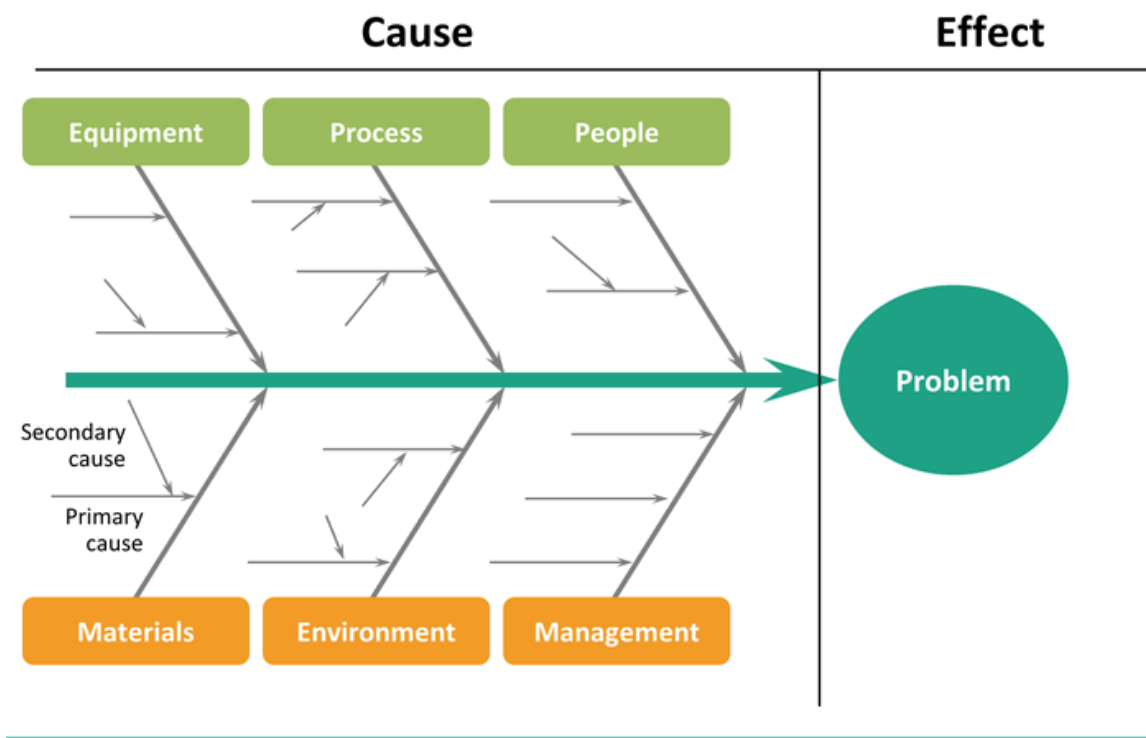
Establish Preliminary Measurements – Preparing preliminary measurements can be useful for ranking unit processes for further evaluation, helping identify data gaps, and determining sampling requirements that may be needed during detailed assessments.

The P2 program team can use simple methods of measurement and assessment, such as cause and effect (fishbone) diagrams, material balance accounting, or basic cost analysis to facilitate and support prioritization. The most appropriate evaluation techniques will depend on the nature of the processes being assessed and the company P2 goals. Each of these methods can be used during the preliminary assessment phase for initial estimations, and again during the detailed assessment phase once complete and accurate data is available for producing refined estimations.

- Cause and Effect Diagrams

Cause and effect (also known as fishbone) diagrams can be useful to identify causes for problems identified and for sorting information or ideas into useful categories. This visual means of depicting cause and effect scenarios can be valuable if problems are identified at the facility level, but the contributing factors within the processes are unclear. Illustration 9 depicts an example fishbone diagram template.

Illustration 9: Cause and Effect (Fishbone) Diagram



- Material Balance Accounting

A material balance shows all the materials that enter and leave a process. This is an organized system of accounting for the flow, generation, consumption, and accumulation of resources in a process. Material balance can help calculate concentrations of waste constituents where quantitative composition data are limited. This method is particularly useful if there are points in the production process where it is difficult or uneconomical to collect or analyze samples. In its simplest form, a material balance is drawn up according to the mass conservation principle:

$$\text{Mass in} = (\text{Mass out} - \text{Generation} + \text{Consumption} + \text{Accumulation})$$

If no chemical reactions occur and the process progresses in a steady state, the material balance for any specific compound or constituent is as follows:

$$\text{Mass in} = \text{Mass out}$$

Data collection problems, such as an inaccurate reading or an unmeasured release, can be revealed when “mass in” fails to equal “mass out.” Such an imbalance can also indicate that fugitive emissions are occurring, which could be a qualifying factor when considering the area for further evaluation. For example, solvent evaporation from a parts cleaning tank can be estimated as the difference between solvent put into the tank and solvent removed by disposal, recycling, or dragout (solvent carried out of tank on parts). If it is determined that large amounts of solvent losses are occurring, this may be justification for further evaluation of that process.

- Basic Cost Analysis

A basic estimation of the costs associated with a process can be useful for process evaluation prioritization. If the material costs and/or waste management costs are high, this can indicate a need to further evaluate the process on the basis that potential financial savings opportunities exist. Note that this basic cost estimation may not accurately reflect true process costs because it may not account for all variables that affect these values. True cost analysis for the processes that are selected for further evaluation can be determined as part of the detailed assessment phase.

Basic material costs for each process can be gathered from purchase and utility records. Typically, a year's worth of data is sufficient. True material costs (determined in the detailed assessment phase) will include cleanup, ancillary operations, and labor for material management. Basic waste management costs can be estimated by identifying treatment expenses (including operating costs for control devices), disposal fees, and waste transportation fees.

Again, true waste costs will include other factors such as in-house labor for managing waste and equipment expenditures.

Rank Process Unit Areas for Further Evaluation – Ideally, all process units would be evaluated in further detail to identify P2 opportunities; however, this is usually not practical for many facilities, especially those with limited resources. Therefore, it is recommended to rank all the process units and select those that should be prioritized for detailed assessments to identify P2 opportunities. Follow the P2 management plan guidelines for priority ranking if they have been established.

If not, consider using a decision matrix such as the *Option Rating Weighted Sum Method* (illustrated in [Appendix A](#)), which quantifies important criteria by assigning values for screening and ranking purposes. Values can be set using professional judgement or team consensus. This approach can be used if there is insufficient information for performing a quantitative ranking by other means, or it can be used in conjunction with the basic cost estimation data collected to supplement the ranking process. Both the Option Rating Weighted Sum Method and forms of economic evaluations can be used during the pre-assessment as well as during the detailed assessment phase.

Typical considerations for prioritizing processes for further study include:

- Potential to meet specific company goals established in the company P2 policy and mission statement(s) (e.g., minimizing wastewater discharges, reducing energy use, reducing toxic substance use)
- Compliance with current and anticipated environmental regulations
- Occupational health and safety considerations (regulation compliance, employee hazards, liability concerns)
- The type, quantity, or volume of wastes produced (hazardous, difficult to manage, etc.)
- Specific hazardous properties of the material used or wastes produced (including toxicity, flammability, corrosivity, and reactivity)
- Estimated costs of waste management practices (pollution control, treatment, and disposal)
- Costs of materials and resources
- Potential for P2 options, ease of implementation, or P2 project payback time (if known)
- Available budget for the P2 assessments and/or project implementation
- Opportunity to perform process improvement/optimization

- Opportunity for product or service quality improvements
- Potential recovery of valuable byproducts
- Obvious opportunities for economic savings

Construct a Preliminary Assessment Report – The results of the preliminary assessment should be summarized in a report. All identified process units should be listed in the order of priority ranking and accompanied by a brief description of the input/output analysis. The ranking method(s) and criteria used should be explained, and detailed justifications should support the top selections for further evaluation. Typically, the report will identify the top 3 to 5 process units to be considered for P2 projects. The list of facility data sources, the general facility flow diagram, and the unit process maps for the top selections should be attached to the report.

The P2 Project Process

Once the P2 program team has conducted a preliminary assessment of the facility, it is time to begin the P2 Project Process for one or more areas being recommended for further evaluation. Each step of the P2 Project Process expands upon the framework established by the company's P2 policy and mission statement(s) and the P2 management plan. Depending on the nature of each P2 project, steps in the process may take varying degrees of resources. Many P2 efforts involve only a change in attitude or work procedures, while others require research, testing, and financial investments. Therefore, the P2 Project Process outline serves as a guide for P2 project implementation and can be adjusted according to specific company and project needs.

At the beginning the P2 Project Process, it is important to determine if community or other external stakeholder involvement is recommended for the creation of the [P2 process plan](#) and/or the [P2 project proposal](#). The P2 program team should consult with upper management and discuss the results of the preliminary assessment to see if involving community or other external stakeholders is warranted based on the areas identified for further evaluation, goals of the company, and potential impacts of P2 efforts to the external parties. Input from many perspectives can be used to inform and shape the project scope, identify alternatives, and facilitate manufacturer and user adoption of process alternatives such as safer chemicals. If the company considers the full life cycle of a process or product, a list of potential stakeholders are drawn from the entire supply chain and could include those associated with manufacturing, transport, storage, and product use or disposal. Involvement throughout the project helps to ensure that stakeholders understand and support the outcome, and promote adoption of the P2 projects. Including the surrounding community in the P2 planning process can create a new forum for communication, build credibility, and help focus P2 efforts on the areas that most concern neighbors. Assistance with narrowing the P2 focus can be useful if multiple competing processes have been identified for further evaluation. Positive community involvement can be encouraged through holding open meetings, granting interviews to the media, advertising, direct-mail surveys, and opinion polls.

Typical stakeholders include:

- Chemical manufacturers
- Product manufacturers
- Nonprofit organizations
- Neighborhood and community leaders
- Waste and recycling companies
- Government agencies
- Retailers
- Consumers
- Innovators
- Academics

Illustration 10: The 12 Steps of the P2 Project Process



Step 1 – Prepare the P2 Process Plan

If this is the company's very first P2 project endeavor, the scope may include all facility operations, but the objective may be limited to creating a facility process map and gathering general data for future P2 project use. If a specific department or process is targeted for the P2 project, the scope may be narrowed, but it may include greater detail about the appropriate data collection or reviews necessary for the assessment and possible project implementation. Any clarifications or procedural requirements that are not identified in the P2 management plan should be established within the P2 process plan if possible. It is also important to set or review specific goals for the processes under review, including general or specific reduction targets. This information, combined with results of the preliminary assessment, can be used by the P2 program team to develop a detailed P2 process plan to outline and address:

- The scope and assessment objectives including the results from environmental stakeholder / community input (if applicable)
- Schedule development
- Data collection needs and format
- Potential obstacles and solutions

Define Scope and Objectives

During the preliminary assessment phase, the P2 program team will have identified and prioritized processes with potential P2 opportunities and generated a preliminary assessment report. Combined with the resulting information from environmental stakeholder / community involvement, this information will be the starting point for defining the scope and objectives for the current P2 process plan. Objectives should be stated in both quantitative and qualitative terms. They should determine, list and describe each stage of the P2 Project Process that is required for each process being evaluated, such as completion of process assessments or additional research efforts. These two attributes make objectives effective tools for directing effort and measuring progress.

Develop Schedules

The final aspect of preparing the P2 process plan is to list the milestones—from detailed assessment through implementation—within each of the stages. Realistic target dates should then be assigned. The execution of these stages should follow this schedule closely if possible. Significant deviations may cause difficulties if certain steps are not completed. Adherence to the schedules will also help control the startup or implementation costs of the program.

Define Data Collection Needs and Format

The P2 program team should decide on a data collection format for the assessment (if not outlined in the P2 management plan). The format can be a standard format, such as the worksheets provided in U.S. EPA's Facility Pollution Prevention Guide (EPA/600/R-92/088) ([Ref. 4](#)) or elsewhere. Alternatively, the team may want to develop their own assessment worksheets, questionnaires, or checklists for data collection and to record observations during the assessment site visit(s). The P2 program team should also identify and obtain P2 case studies and other resources that can provide P2 ideas for processes that are similar to the one(s) being assessed. ([Ref. 5](#))

Identify Potential Obstacles and Solutions

As the P2 program team begins to implement a P2 project process, they are likely to encounter a number of factors that will complicate the process. These factors need to be recognized and the means for overcoming them need to be defined. Apparent obstacles will be less likely to impede progress if everyone understands that there is a mechanism for addressing them in a later stage. The mix of factors and the relative degree of difficulty each presents will vary from company to company and process to process. Examples include:

- Limited financial resources for capital and other improvements may become a problem even for P2 options that will be profitable. The P2 program team should investigate the availability for funding assistance or low-interest loans from state or local agencies if they know that financing might be an issue for the P2 project proposal.
- Technical obstacles may arise related to the possible disruption of production, product quality changes, and availability of quality information. A proposed P2 option may involve modifying the work flow, material, or product, or require installation of new equipment. Alternative procedures and how to integrate them into the production process(es) should be considered for minimizing disruptions, production shutdown, and lost production time. It is important to identify potential side effects, measures to avoid them, and ways for adaption. Estimation methods or additional data procurement options such as submetering for areas that lack quality information sources need to be considered.
- Limited flexibility in the manufacturing process may pose other technical barriers if the new P2 operation does not work as expected, creates a production bottleneck, or the production facility lacks adequate space for new equipment. These technical barriers can be overcome by having the appropriate design and production personnel take part in the planning process and by using tested technology or setting up pilot operations in advance.

- Product quality or customer acceptance concerns might cause resistance to change, reduced sales, or loss of customer support. Some substitutions of material inputs can reduce waste and costs, but compromise product quality. Plan to avoid potential product quality degradation by verifying customer needs, preliminarily testing the new process or product, and increasing quality control during manufacture.
- Regulatory obstacles may be a barrier to some P2 options that require material substitutions, significant process changes, or new equipment. Even when the changes result in decreased emissions, regulatory permits may require modification to incorporate the new process operation details, obtain construction approval, or update the applicable regulations for the proposed alternative input materials. Recognizing and researching these possibilities in advance can allow the company to work with the appropriate regulatory entities early in the planning process to avoid delays, noncompliance, or negative regulatory surprises. U.S. EPA and state environmental agencies, including IDEM, have developed and posted online a number of free documents to facilitate P2 efforts by industry.

The preliminary assessment report and any addendums should be attached to the plan for reference. Any other details that are warranted by the processes being evaluated, company policies, or management directives should be incorporated into the plan as well. Once the P2 process plan is complete, it should be peer reviewed and submitted to upper management for consideration and approval.

Step 2 – P2 Process Plan Approval / Obtain Management Support

If the formal P2 process plan review guidelines are outlined in the P2 management plan, they should be followed to obtain management approval and support. The approval process may include revisions or corrections to the P2 process plan, which should be completed in a timely manner to ensure steady progress. Once management has approved the plan, resources can be allocated for implementation, even if it is only staff time initially, and work may commence.

It is important for management and supervisors at each process location to understand and support the P2 process plan objectives for the identified processes to be assessed. Their support will increase the probability of success, staff cooperation, and efficiency of evaluations and project implementations. Therefore, it is recommended that the approving bodies forward the finalized plan and attachments to the appropriate personnel.

Step 3 – Detailed Assessment Phase - Analyze Process / Develop Baselines

If conducted, the preliminary assessment of the facility identified areas for further evaluation where P2 implementation may be possible. At this point, a detailed assessment will focus on those units of process that were targeted by the preliminary assessment and outlined in the P2 project plan. Overall, the detailed assessment is intended to provide more comprehensive information and data on the targeted areas. Detailed assessments vary from process to process depending on the types of operations conducted. The assessment procedures will be the same for each process but will vary in the details. This section will describe the basic concepts and organization of an industrial assessment.

Establish P2 Assessment Teams

P2 assessment teams will be assigned to each operational area of the facility to gather data for additional analysis. As was the case during the preliminary assessment, they will use existing data sources such as written materials and site evaluations. They will examine each production process in greater detail by interviewing workers and compiling necessary data that may not have been collected before. During this process, the team(s) may identify some options that can be implemented quickly and with little cost or risk. It is likely, however, that many options will be more complex and will require in-depth analysis later.

Unless the company is small enough that the P2 program team and the P2 assessment team members are the same, additional staff should be named to comprise one or more P2 assessment teams. Ideally, at least one member of the P2 program team will be included on each P2 assessment team to facilitate communication, maintain team focus, and provide oversight. A multidisciplinary team is likely to be more successful in achieving a comprehensive assessment and providing the best input possible in subsequent stages of the process. It is also recommended that some of the staff responsible for implementing the selected P2 options later in the process be involved in assessment and planning stages of the process. Core team members will include those who are involved with the operation or process (e.g., line workers with day-to-day operational responsibility and experience), both supervisors and staff, as well as energy or waste management and environmental staff. Other areas of expertise which may benefit the core P2 assessment team include:

- Engineering
- Quality Control
- Production and Maintenance
- Accounting and Finance
- Legal
- Health and Safety
- Research and Development
- Purchasing and Contracting

Approximately three to six people will prove to be a workable number for an assessment team, but this can vary depending on the complexity of the unit process. Each member of the P2 assessment team provides key pieces of information necessary to get the entire picture of the operation. Aside from field of expertise, consider a candidate's ability to work on a team, commitment to the program, capacity for looking at situations from new perspectives, and creative thinking skills. It is important to keep in mind that the assessment is meant to provide constructive criticism for the improvement of the entire operation. In some cases, outside consultants or engineers may be retained to work with the in-house teams.

Review Data and Process Operations (Site Review)

Numerous data sources exist for a given process operation and many of these may have been identified during the preliminary assessment. The P2 assessment team for this area will search for additional sources of data that will be useful in studying the targeted process operations. However, the team should limit this information collection phase to only information that will be necessary for the assessment. If the team has chosen to focus on a specific part of the operation or on one target objective (e.g., energy conservation) only information for those areas should be collected.

Most of the team's efforts will be directed toward becoming as familiar with the process as possible by performing one or more thorough site reviews and interviewing workers. This will help them understand the data already being collected, and identify gaps in data that will then need to be collected. If consultants are on the assessment team, the site review(s) enable them to become familiar enough with the operations to utilize their expertise effectively.

The P2 assessment team should review operations with facility personnel. This should include review of all data collected prior to the assessment (preliminary assessment results), a step-by-step verbal walk-through of the process, and review of the process flow map(s). This will allow the team to ask questions and receive answers without the distractions of the site tour (e.g., noise, etc.). If preferred, the team may wish to include a brief walk-through of the area prior to these discussions. If possible, conclude this discussion with scheduling of a detailed site review.

Site reviews should be well planned and efficiently executed to ensure that maximum benefit is obtained without excessive expenditures of time. While multiple visits to check or supplement data will usually be required, good planning can minimize such repetitions. With this in mind, the P2 assessment team should:

- **Prepare an agenda** in advance that covers all points that still require clarification. Make sure that all team members, supervisors at the site, and staff contacts in the area being assessed receive the agenda several days before the site review.

- **Schedule** the assessment walk-through to coincide with the particular operation that is of interest (e.g., makeup chemical addition, bath sampling, bath dumping, startup, shutdown, etc.).
- **Follow the process from beginning to end** from the point where input materials enter the work site to the point where products and wastes exit. This will help identify any unsuspected sources of waste and assist with material accounting. Waste sources to inspect include the production process, piping, maintenance operations, storage areas for raw materials, finished products, work in process, associated waste treatment areas, and even trash cans or dumpsters.
- **Monitor the operation at different times** during all shifts, especially when waste generation is highly dependent on human involvement (e.g., in painting or parts cleaning operations). Also, monitor during different days of the week or month because many products may appear frequently but not daily. In addition to the direct production operations, cleaning, maintenance, or repair procedures can possibly be observed. Operations, as they are actually performed (by separate shifts and under various circumstances), may be different from the methods described in their operating manuals. Equipment may have been modified without being documented in the flow diagrams or equipment lists, all of which can cause variations in production.
- **Interview** the operators, shift supervisors, and work leaders in the assessed area. Typically, they are the most knowledgeable staff about the actual operations. Their experience and opinions concerning P2 opportunities can be quite valuable. Employees often have ideas or information that can be highly useful in properly characterizing production units or identifying options to reduce risk. Seek information about the length of time materials are in stockrooms or storage areas. Discuss the waste generation aspects of the operation and note their familiarity with the impacts their operations may have on other operations. Verify the actual operating procedures and try to answer any questions that may have

Sample Questionnaire

- What are specific wastes that are generated by this department?
- What comments do employees in the department have about their waste (i.e., quantity, toxicity, or necessity)?
- Is the area free of easily avoidable waste such as spills, drips, or inefficient use of materials?
- Are there strong odors, perhaps indicating leaks, overuse, or spills?
- What are the waste materials found in the department's trash cans/ dumpsters?

arisen during the preliminary assessment. If appropriate, use a questionnaire for obtaining more detailed information.

- **Photograph or digitally record** the area of interest, if warranted. Pictures and videos are excellent methods of capturing extensive detail quickly and accurately.
- **Observe the “housekeeping”** aspects of the operation. Check for signs of spills or leaks. If appropriate, visit the maintenance shop and ask about problems in keeping the equipment leak-free or functioning properly. Assess the overall cleanliness of the site; look for previously unidentified wastes; pay attention to odors and fumes; and take note of problems that arise within the operation.
- **Assess administrative controls** such as cost accounting procedures, material purchasing procedures, and waste collection procedures.
- **Verify the accuracy of the process flow map** by carefully checking it against the actual layout and functioning of the equipment. Observe how materials and products are transported in and out of the operation. Update the process map if inconsistencies are found.
- **Take notes** of employee suggestions or ideas that arise for material or energy efficiencies and other source reduction opportunities.

It will likely be necessary to schedule and make follow-up site visits once the data collected is analyzed, found to have flaws, or is unclear. The site review should not be performed superficially, even though the assessment team members who are employed at the facility will be familiar to some extent with the work site being reviewed. Those members who are not involved in the day-to-day operations in that area may see opportunities that otherwise would be overlooked. Furthermore, personnel assigned to that specific site will often see it in a new light when performing a P2 assessment.

Organize, Document, and Analyze Process Information

After making real-time observations, the team should compare written procedures with the observations and then, refine and update process information. Detailed itemizations should be created to clarify processes and establish baselines for:

- **Work Practices** – Moment-by-moment actions, routes, interrelated activities, and dependencies between applications
- **Materials and Resource Inputs** – Raw materials used (natural and process), source(s) and procurement practices, inventory practices, material storage and handling, resource usage (water, energy, fuel), and input material characteristics

- **Process Outputs** – Products/services; coproducts; all waste streams (including process waste, quality control waste, cleanup waste, and office waste if appropriate); spills and releases; output material characteristics; and output handling, storage, and transport practices
- **Waste Management** – Mixing, handling, storage, transport, treatment, recycling, final disposal methods, and waste reuse

Quantify all available input and output data for the unit process. A new material balance or an updated one from the preliminary assessment should be calculated for each component entering and leaving the process. The limitations of material and energy balances should be understood. They are useful for organizing and extending pollution prevention data and should be used whenever possible. The user should recognize, however, that most balance diagrams will be incomplete, approximate, or both.

- The exact composition of many process streams is unknown and cannot be easily analyzed.
- Phase changes may occur within the process, requiring multimedia analysis and correlation.
- Plant operations or product mix change frequently, so the material and energy flows cannot be accurately characterized by a single balance diagram.
- Many sites lack sufficient historical data to characterize all streams.

These are examples of some of the complexities that might occur when analyzing real world processes. Judgement will be required to determine what accuracy is acceptable. Despite the limitations, material balances are essential to organize data, identify gaps, and enable estimations for missing information. Use the material balance results to determine if there is a need to investigate raw material storage and handling losses, perform sampling or testing, or conduct a waste composition audit. A waste audit is a process where waste from a department or process is separated, cataloged, and weighed over a period of time to evaluate the volume and characteristics of the waste from that area. Perform any of these needed analyses if possible to acquire accurate and detailed information.

Describe the Current Practices

Once the material balance for each unit process has been completed for the total amount of raw material inputs and waste outputs, it might be necessary to repeat the evaluation with respect to each contaminant of concern. Material balances for individual contaminants can be done for those contaminants that pose a specific problem, such as high costs, environmental impact, or health and safety issues. The

material balance approach should be performed at the level of detail appropriate for the process being studied. The resulting values can effectively be used as baselines for that process. If more accurate baselines are important for the company goals, additional tools and methods for evaluation—such as life cycle assessments and total cost accounting—can be applied to describe the current practices. Update process unit descriptions, process maps, and the process plan (stages, timelines, etc.)

Consider Current Process Life Cycle and Total Costs

Consideration of the life cycle of the current process can help to establish better baseline values and evaluate the impacts and costs of additional criteria. The term “life cycle” refers to the notion that a fair, holistic assessment requires the consideration of raw material extraction and production, manufacture, distribution, use, and disposal, including all intervening transportation steps necessary or caused by the product’s existence.[\(Ref. 13\)](#)

Life Cycle Assessments

In 1990, U.S. EPA sponsored an international pollution prevention conference on “clean” technologies and products. The introduction to the published proceedings provides the following overview. “Life cycle assessment is a snapshot of inputs and outputs. It can be used as an objective technical tool to identify and evaluate opportunities to reduce the environmental impacts associated with a specific product, process, or activity. This tool can also be used to evaluate the effects of various resource management options designed to create sustainable systems.

The three components of a life cycle assessment include (1) the identification and quantification of energy and resource use and waste emissions (inventory analysis); (2) the assessment of the consequences those wastes have on the environment

Three Phases of a Life Cycle Assessment

Inventory Analysis
Impact Analysis
Improvement Analysis

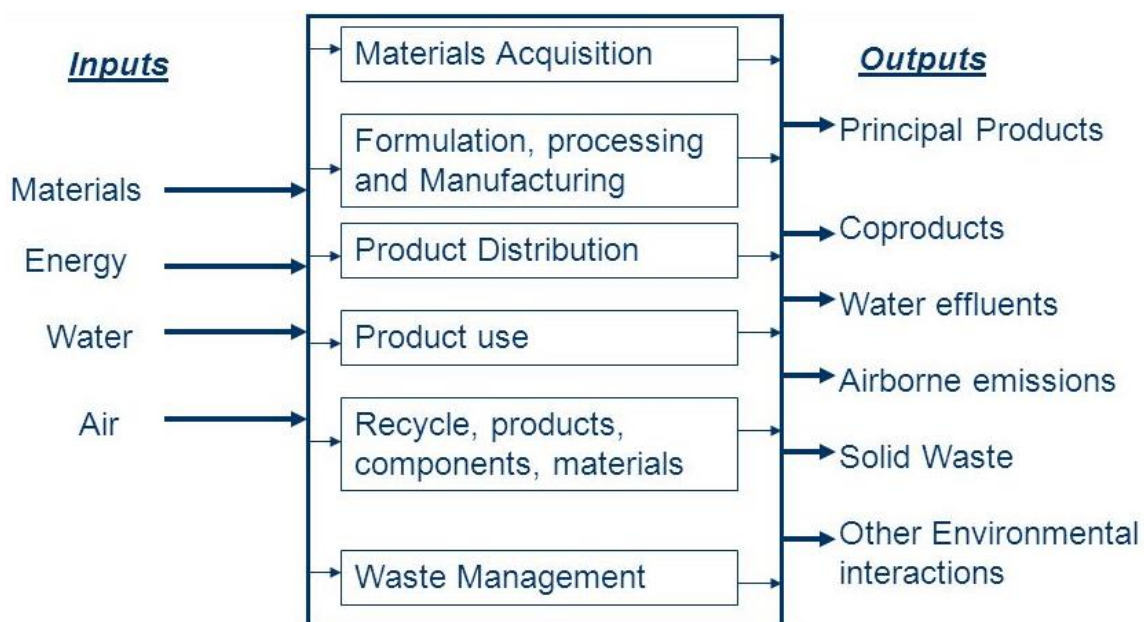
(impact analysis); and (3) the evaluation and implementation of opportunities to effect environmental improvements (improvement analysis). The life cycle assessment is not necessarily a linear or stepwise process. Rather, information from any of the components can complement information from the other two. Environmental benefits can be realized from each component of the assessment process. For example, the inventory alone may be used to identify opportunities for reducing emissions, energy consumption, or material use. Impact analysis typically identifies the activities with greater and lesser environmental effects, while the improvement analysis helps ensure that any potential reduction strategies are optimized and that improvement programs do not produce additional, unanticipated adverse impacts to human health and the environment.”[\(Ref. 11\)](#)

If the P2 program objectives for the company (outlined in the P2 management plan) have determined the scope to include “total cost accounting” and the use of a holistic approach to analyzing the entire life cycle of products, processes, and activities, the P2 teams should consider conducting the life cycle inventory and impact analyses, and a total cost assessment for the current operations. These analyses can be utilized again and expanded to their full potential during the P2 opportunity assessment phase.

- Use the quantifications established for all inputs and outputs (include airborne emissions, wastewater flows and concentrations) of material flows for the process or product. Include the material balance data for the unit processes (to determine losses), evaluate imbalances, and make estimations.
- Account for the environmental loads during the product's life cycle. It is intended to be a “cradle-to-grave” approach to assessing the full range of environmental impacts from the product manufacturing (material flows from raw material extraction through final disposal).
- Associate a “full or total cost accounting” from the product manufacturing (material flows from raw material extraction through final disposal).

This information is used to evaluate and improve processes by providing a sound basis for informed decisions.

Illustration 11: Life Cycle Assessment Outline



Life cycle assessment looks at all inputs and outputs of a product during its life cycle

Total Cost Accounting

The total cost accounting (TCA) tool (developed by the Tellus Institute for U.S. EPA) employs both economic and environmental criteria. The TCA study is usually focused on a particular process as it affects the bottom-line costs to the user. TCA tracks direct costs (e.g., capital expenditures and operating expenses), indirect costs (e.g., compliance and liability costs), and less tangible benefits (e.g., enhanced company image, improved supplier-customer relationships) when used for P2 opportunity assessments. By factoring in these indirect environmental costs, TCA helps to assess the economics associated with environmental impacts.^(Ref. 5) (see [Appendix B](#) for more on TCA).

The estimation of the current costs associated with a process determined earlier can now be expanded to associate the “true” costs of materials (including cleanup, ancillary operations, and labor for material management) and wastes (including labor, equipment expenditures, permitting fees, etc.). This information can be expanded even further during the P2 opportunity assessment and the project evaluation phases.

Total Cost Accounting – Cost Categories for Current Operations		
Direct Costs	Indirect or Hidden Costs	Liability Costs
<ul style="list-style-type: none"> – Capital Expenditures <ul style="list-style-type: none"> · Buildings · Equipment · Utility connections · Equipment installation · Engineering – Operations and Maintenance – Expenses/Revenues <ul style="list-style-type: none"> · Raw materials · Labor · Waste disposal · Utilities · Value of recovered materials 	<ul style="list-style-type: none"> – Administrative Costs – Compliance Costs <ul style="list-style-type: none"> · Permitting · Recordkeeping and Reporting · Monitoring · Manifesting – Insurance – Workers' Compensation – On-Site Waste Management – On-Site Pollution Control Equipment Operations <i>Note: Can be expanded to include product environmental life cycle costs - “externalities” that may become “internalized”</i> 	<ul style="list-style-type: none"> – Penalties and Fines – Personal Injury – Property Damage – Natural Resources Damage / Cleanup Costs (Corrective Action)

Record Baseline Values

Document all baseline values for the unit process (or areas of concern), as these values are directly linked to project design and will be crucial for measuring project impacts. A baseline value (or measurement) is needed to determine the exact starting point for each project, otherwise known as the "before" value. The result of the same measurement taken after implementation of the final project is called the "after" value. Understanding the past performance of the unit process is a prerequisite for setting P2 project targets, which is difficult to accomplish without baseline data. Establishing baseline and target values are an integral part of project design.

$$\text{Baseline Value} + \text{Desired Level of Improvement} = \text{Target Performance}$$

Step 4 – Identify P2 Opportunities

Once the data collection and process assessment is complete, the creative phase of the P2 Project Process—exploring the universe of P2 opportunities—begins. The objective is to generate a comprehensive set of P2 options by researching the widest range of possible alternatives, including emerging technologies. If the P2 teams are developing a list of P2 options for more than one process, each process should be considered separately and may warrant several brainstorming sessions.

If the entire process is being targeted for P2, begin developing a list of options for the most problematic areas of the process that have been identified in the assessments, such as:

- Leaks or losses
- Resource inefficiencies (materials, energy, water)
- Large volumes of waste
- Highly toxic waste streams
- Operational inconsistencies
- Straying from best management practices or other written procedures
- Poor housekeeping efforts
- Lack of environmental ethics within the process

It may be useful to evaluate each of these problem areas individually, and then look for holistic opportunities for the entire process. If only one issue or area of the process is the focus of P2 efforts, holistic changes to the process can still be considered.

Brainstorming

There are numerous sources of information available to help identify general and industry-specific P2 opportunities. The very first source consulted, however, should be individuals from within the organization. The P2 team(s) should plan and conduct one or more brainstorming sessions. Assemble members of the P2 assessment team and P2 program team (if they are different), in-line employees, operators, supervisors, engineers, plant managers, purchasing agents, and others with firsthand knowledge of the process operation. A broad collaborative effort is encouraged, and if desirable, can also include other members of the company (to achieve representation from all levels of the organization).

Group brainstorming sessions that allow the free flow of ideas are often very productive. The best results will be achieved in an environment that encourages creativity and independent thinking by each participant. Brainstorming sessions are useful for encouraging creative thought because they provide a nonjudgmental atmosphere where ideas can be shared without fear of criticism. The participants should begin developing a list of ideas, without regard to cost or feasibility. Then, these ideas can be developed by means of group decision-making techniques. All ideas in brainstorming should be

considered. Even though an idea may appear unworkable at first, it may lead to another more feasible idea. It is important to emphasize that this portion of the process has only questions, not answers.

“Would it work if we reused our solvent?” is a question. If people give approval or disapproval of ideas too soon, those suggestions have no chance to evolve, which may curtail the flow of ideas.

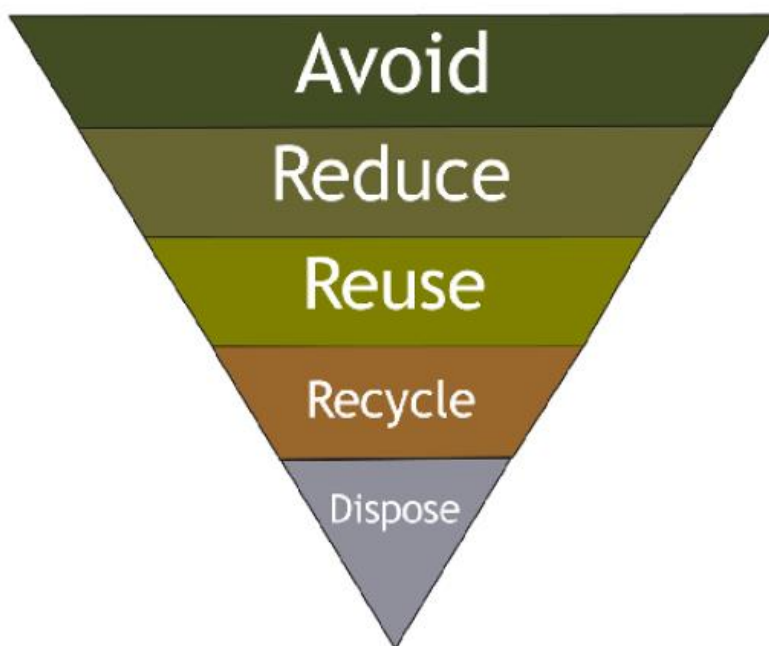
Sometimes providing a little direction can prompt the flow of solutions. The group is encouraged to list obvious P2 options that have likely been identified during the assessments—known as “low hanging fruit”—which usually are easy to implement with little or no cost or risk. These may include simple process changes, better management practices, and maintenance efforts (like fixing air or water leaks), etc. Although pollution prevention is the ultimate goal, if the process can stand to be improved by other methods (such as recycling), those ideas should be identified as alternate means of improvement in case P2 options are determined to be infeasible later. It may also be helpful to encourage the group to think in terms of

Effective Brainstorming

- Consider all ideas
- Address problematic areas of the process
- Identify obvious and easy-to-implement opportunities – “low hanging fruit”
- Follow the P2 hierarchy when drafting ideas for process improvements
- Develop long-term waste reduction alternatives
- Use established information sources to generate ideas

following the P2 hierarchy by trying to identify true source reduction options, such as improved operating procedures and changes in technology or materials. Then, list options that involve reuse or closed-loop recycling methods. Finally, any offline and off-site recycling strategies, and alternative treatment and disposal methods, should be identified.

Illustration 12: The Pollution Prevention Hierarchy



Other Employees' Suggestions

The P2 program's structure must make it easy for ideas to come from as many people as possible, and keep communication flowing between management and staff. Employees' ideas for P2 projects should be actively sought. Employees take their P2 roles more seriously when management keeps them informed and encourages them to participate by sharing their ideas. Forums such as breakfasts or informal P2 review meetings promote the exchange of information that will help generate new ideas. Suggestion boxes, surveys, contests, rewards, and recognition mechanisms are all ways to gather employee input.

Research and Technical Resources

Along with brainstorming sessions and the gathering of other employee suggestions, the P2 teams should contact and research other information sources:

- **Trade associations** generally provide assistance and information about environmental regulations and various available techniques for complying with these regulations. Their information is especially valuable because it is tailored to the specific industry.

- **Published literature** can be a valuable resource. Articles in technical journals, trade magazines, government reports, and research briefs describe pollution prevention technologies and applications.
- **Case studies and success stories** can be found through P2 clearinghouses, the TRI database, internet resources, and technical support groups.
- **Federal (U.S. EPA), state, and local environmental agencies** are expanding their pollution prevention publications and technical assistance programs. These programs disseminate information on industry-specific pollution prevention techniques and can often assist with site reviews and audit processes. U.S. EPA has numerous P2 related publications, case studies, and success stories online.
- **University engineering departments** often provide free waste and energy assessments, workshops, on-site training, and consulting services.
- **Equipment vendors and suppliers** provide sales literature and specification documents that are helpful in identifying and analyzing potential equipment-oriented options.
- **Consultants** with experience in pollution prevention in the specific industry can usually be located (see IDEM's guidance on how to [Find an Environmental Consultant](#)).
- **Other Companies** can be a source of information on technical issues and suppliers, either because they are in the same geographic area or because they have similar technical areas of interest. Local business groups are a good way of procuring resources in the immediate area, while trade and professional associations can provide contacts in other parts of the county or the world. Of course, the companies with the most similar interests may be competitors, but it should be possible to interact without risking disclosure of business-sensitive information. Consider involvement in local programs where there is a "business helping business" approach for reducing waste, such as the [Indiana Partners for Pollution Prevention](#) or the [Green Business Network](#). These programs involve business volunteers who tour participating businesses and offer advice on implementation of P2 practices. The strength of these programs comes from the fact that they operate via peer matching to offer nonthreatening, nonregulatory assistance, networking, and P2 information sharing.
- **P2 Resources** from [Chapter 8](#) of this manual provide a number of suggested technical assistance resources, tools, and publications.

At a minimum, the P2 teams should consider the following opportunities for each targeted area:

- Input changes or material substitutions
- Operational improvements or improved housekeeping
- Production process changes / process optimization
- Product redesign or reformulation
- Waste stream segregation
- Inventory control
- Closed-loop recycling, direct reuse, or reclamation systems
- Best management practices and training
- Waste stream segregation
- Inventory control

Many more P2 options are listed in Chapter 7, [P2 Strategies](#).

Step 5 – Evaluate Alternatives

A variety of proposed P2 opportunities have been identified, and now the range of alternatives must be narrowed for comprehensive evaluation by the P2 teams.

Screen and Prioritize Identified P2 Opportunities

Because of time and resource constraints, most facilities have to set priorities among their resource conservation and P2 options based on the original goals and criteria specific to the processes evaluated. It is recommended to screen and prioritize the listed options since detailed technical, economic, and environmental feasibility analyses can be time-consuming and costly.

The P2 teams should start by screening the options to separate ideas into three categories:

- 1) Options that qualify as “low hanging fruit” (those that can be easily executed and have low costs and risks).
- 2) Options that are found to have marginal value or are impractical due to obvious company technical and resource limitations.
- 3) The remaining options that will require feasibility assessment.

Ideas that fall into the first category should be kept and targeted for immediate implementation. Those ideas that fall into the second category should be dropped from further consideration at this time and removed from the list. Those ideas that fall into the third category should be ranked to determine their priority for detailed evaluation efforts.

If prioritization methods have been determined in the P2 management plan, the P2 teams should follow them. Otherwise, the ranking process can range from an informal review (such as a P2 program team vote) to the use of quantitative decision-making tools.

The informal review is a procedure by which the P2 teams employ group decision-making techniques by selecting the options that appear best after discussing and examining each one. In more complicated situations, the team may decide to use the weighted sum method (see [Appendix A](#)) again or another similar technique.

Option screening should consider these questions:

- Which options will best achieve the goal of waste reduction?
- What are the main benefits to be gained by implementing this option (e.g., financial, compliance, liability, workplace safety, etc.)?
- Does the necessary technology exist to develop the option?
- How much does it cost? Does it appear to be cost-effective, meriting in-depth economic feasibility assessment?
- Can the option be implemented within a reasonable amount of time without disrupting production?
- Does the option have a good “track record”? If not, is there convincing evidence that the option will work as required?
- What other areas will be affected?

Facility Pollution Prevention Guide, U.S. EPA - [Ref. 3](#)

Feasibility Analysis

Once a prioritized list of P2 opportunities has been established, these options now need to be examined for implementation feasibility to refine their priority and assess potential effectiveness. A general feasibility analysis involves assessing the technical, economic, and environmental aspects of each proposed project to isolate those opportunities that have the greatest potential to be viable options in a holistic manner.

Technical Feasibility

Some technical evaluations will be straightforward, such as procedural or housekeeping changes, which may require minimal review, approval, and training of selected staff. Other technical evaluations will require the expertise of a variety of people. Significant coordination may be required with the process operators, related product vendors, and external engineering consultants before deciding whether a proposed P2 solution is feasible. ([Ref. 3](#))

Feasibility Analysis

- **Technical** – Determines if P2 projects will work in application and screens out options that are not technically feasible.
- **Economic** – Financial cost, revenues, and savings are evaluated for each individual project to determine advantages of competing projects and allocation of resources.
- **Environmental** – Considers both human and environmental health factors and options that permanently reduce/eliminate a facility's negative environmental impacts.

Equipment-related options or process changes can be expensive and may affect production rates or product quality. Therefore, such options require more study to determine whether the alternative will perform in the field under conditions similar to the planned application. Sometimes, arrangements can be made with equipment vendors or other industry contacts to visit existing installations. Although some equipment vendors may be willing to validate their applicability to the process prior to purchase of the equipment, experienced operators' comments are especially important and should be compared with vendors' claims. In some cases, demonstration tests—such as bench-scale or pilot-scale projects—may be necessary in a laboratory or as a field demonstration to adequately determine technical feasibility. Some vendors will install equipment on a trial basis, with acceptance and payment after a prescribed time, or it may be possible to obtain scale-up data using a rental test unit. ([Ref. 3](#))

It is important to remember that the P2 teams and all groups affected should contribute to the technical evaluation. This might include additional people from within the facility who are not on the P2 teams (people from production, maintenance, QC/QA), and customers may need to be consulted to ensure the viability and acceptance of an option. If the option includes changes in production methods or input materials, the likely effects on the quality of the final product need to be carefully assessed. New technology or material substitutions could produce "disbenefits" for the process and the products, such as some loss in safety, efficiency, reliability, durability, convenience, attractiveness, or price. If after the technical evaluation the option appears impractical or can be expected to lower product quality, it is not recommended for further consideration. ([Ref. 15](#))

Consider potential technical factors:

- Results from applications in similar operations
- Availability of new equipment or materials
- Impacts on current process operations (operating procedures, workflow, and production rates); include advantages and disadvantages
- Impacts on other facility operations (production steps eliminated, bottlenecks removed, requires changes up or downstream of the process)
- Impacts on the safety and quality of the product; maintained or improved?
- Impacts on customer needs (compatibility, schedules, price, etc.)
- Downtime requirements and effects
- Functionality for current facility design (space availability, transport and installation factors, utility requirements and availability, new construction requirements and effects on capital costs)
- Impacts on employees (labor required, safety concerns, special skills or worker expertise required to operate or maintain the new system)
- Impact on annual operating and maintenance costs
- Potential of new hazards or negative environmental impacts. ([References 15 and 16](#))

Depending on the facility requirements there may be other criteria that should be included for technical evaluation.

Economic Feasibility

Assessing the economic impacts for some P2 project proposals can be simple and straightforward. Others prove to be complex and require extensive analysis. The types of tools and techniques used for economic evaluations may vary from one process to the next in order for the results to be valuable. The easiest economic evaluation, the “payback period,” compares the up-front purchase price of competing project alternatives and the time frame required to recoup these costs, but this method does not measure a project’s total cost or the financial benefits.

Payback Period – The purpose of the payback analysis is to determine the length of time it will take before the costs of a new project are recovered. The payback period calculations are normally used as a “rough” financial indicator in a decision matrix and best used for low risk projects.

The formula to calculate the payback period is:

$$\text{Payback Period} = \frac{I}{(N - C)}$$

Where:

I = initial investment, startup costs (in dollars)

C = annual cost of current practice (in dollars/year)

N = annual cost of new practice (in dollars/year)

Although the payback period indicator is the simplest to calculate, there are certain limitations to the accuracy for evaluating the project economics. One limitation is that the payback period indicator does not account for all of the cash flows of a project. It considers the cash flows that take place before the investment costs are paid back, but ignores all cash flows after this threshold is met. Ignoring these cash flows can skew the true profitability of implementing a proposed project.

Example:

When comparing two projects, "A" and "B", each requires an initial start-up cost or investment of \$50,000. Project "A" generates \$25,000 in revenues (or annual savings) for the next three years and project "B" generates \$20,000 in annual revenues for the next 20 years. Using the principles of payback period, project "A" is more profitable than project "B" because start-up costs (or initial investment costs) are recouped earlier with project "A" (2 vs. 2.5 year payback). However, project "A" generates revenues for only three years (totaling \$75,000) whereas project "B" continues to earn revenues for 20 years (\$400,000).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total \$
Project A	25K	25K	25K	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	\$75K
Project B	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	20K	\$400K

This example illustrates that a project's payback period does not necessarily reflect its overall profitability because it only measures the time it takes to reach the break-even point for implementing a project. For P2 projects, this can be an especially significant limitation because many annual operating costs may occur several years after the initial startup costs have been incurred. A second limitation is that complex scenarios can have multiple paybacks when annual operating costs vary significantly from year to year, or when there are startup costs in multiple years. ([Ref. 5](#))

Many other financial factors must be included to calculate other instrumental values for economic feasibility now, and project measurement after implementation.

Commonly considered financial factors:

- Capital cost / process modification cost changes
- Utility, operation, and maintenance cost changes
- Raw material and waste cost changes
- Changes in overhead costs – include labor costs
- Insurance, liability, and regulatory compliance rates / savings
- Cost changes associated with product quality

Some factors are difficult to accurately account for, such as indiscernible current costs or future costs that are probabilistic. Choosing the most appropriate financial performance indicators for the situation allows valuable comparisons to be made between competing project alternatives.

Three common financial performance indicators are used to determine the economic viability of P2 projects: net present value, internal rate of return, and profitability index calculations. These calculations are detailed financial indicators based on the value of money over a specified period of time. Additional data about the proposed projects may be necessary in order to accurately determine the economic viability.

Net Present Value (NPV) – NPV (also called a cost-benefit analysis) is a value method that is based upon the concept that a dollar today is worth more than a dollar in the future (a concept known as the time value of money). This decreased value is both because of earnings that could potentially be made using the money during the intervening time (investments) and because of inflation. The NPV concept captures the cost of a given project, taking into consideration discounted future monetary values. The discount rate, similar to an interest rate, is the mechanism that equates today's dollar with its value in the future.

A simple interest rate illustration considers what the value of a dollar invested today will be worth in a year. At a simple interest rate of five percent (5%), a dollar today is worth \$1.05 one year from now. This is referred to as the “present value” of one dollar one year from now at an interest rate of five percent (5%).

The selection of an appropriate discount rate is one of the most difficult aspects of a cost-benefit analysis, but it is also one of the most important. Companies often have different ways of identifying the discount rate. Common methods for determining the discount rate include:

- Using the expected return of other investment choices with a similar level of risk (rates of return investors will expect)
- Using the costs associated with borrowing the money needed to finance the project (borrowing interest rates)
- Using a combination of these factors

The discount rate is a function of what a business must pay to borrow money and what rate of return it must earn to satisfy a company's financial requirements. For evaluating multi-year and long-term projects, the identification of an accurate discount rate is crucial. This is because the NPV method progressively reduces (discounts) the value of costs and revenues occurring in future years. For example, a long-term project that looks favorable using a 5 percent (5%) discount rate may look very unattractive at a 10 percent (10%) rate. Even for short-term projects, the NPV is very sensitive to changes in the discount rate and even small percentage changes can change the outlook for the project feasibility. Therefore, the prudent investor will test a range of reasonable discount rates to get a sense of the range of possible results.

Although the results are the same, there are several ways to express the formula for NPV:

1)
$$\text{NPV} = \text{PV future cash inflows} - \text{PV cash outflows (initial investment)}$$

Where: PV = present value

2)
$$\text{NPV} = \left[\frac{\text{CF}_1}{(1+r)^1} + \frac{\text{CF}_2}{(1+r)^2} + \frac{\text{CF}_3}{(1+r)^3} + \dots \right] - \text{Initial Investment}$$

Where:

r = internal rate of return (a percentage expressed as a decimal)

CF_1 = period 1 net cash inflow (cash inflows – cash outflows)

CF_2 = period 2 net cash inflow

CF_3 = period 3 net cash inflow, and so on ...

3) $NPV = I + [(AS - CE)_1(PVIF)_1 + (AS - CE)_2(PVIF)_2 + \dots + (AS - CE)_n(PVIF)_n]$

Where:

I = initial investment, startup cost (expressed as a negative number)

AS = annual savings (cash inflows)

CE = capital expenses (cash outflows)

$(AS - CE)_1$ = net cash flow year 1

$(AS - CE)_2$ = net cash flow year 2

$(AS - CE)_n$ = net cash flow year n

$PVIF = 1/(1 + r)^t$ = present value interest factor

r = discount rate of money

t = incremental time period, 0 thru n, normally expressed in years

The initial investment required is only the cash flow required at the start of the project. All other outlays may occur at any point in the project's life, and these are factored into the calculation through the use of discounting in the numerator.

For an investment to be cost beneficial, it must return more relative dollars in the future than the amount of dollars spent in the present (the cost of the investment). A project is deemed profitable if its NPV is greater than zero, because the returns are sufficient to:

- Pay off the initial startup costs
- Pay off interest payments to lenders (for investment costs)
- Provide the required return to shareholders (company's financial requirements)
- Increase economic value in the company

Consider this example with an investment cost of \$30,000 and a discount rate of 10%:

Example 1

Investment Cost	\$30,000	Discount Rate
Year 1 Net Cash Flow:	\$10,000	10%
Year 2 Net Cash Flow:	\$20,000	10%
Year 3 Net Cash Flow:	\$25,000	10%

$$NPV = \left[\frac{\$10,000}{(1 + 0.10)^1} + \frac{\$20,000}{(1 + 0.10)^2} + \frac{\$25,000}{(1 + 0.10)^3} \right] - \$30,000$$

Year 1 - Discounted Value:	\$9,091
Year 2 - Discounted Value:	\$16,529
Year 3 - Discounted Value:	\$18,783
Total Discounted Values (PV of future cash flow)	\$44,403

Now subtract the initial investment from the present value of all the future cash flows to calculate the NPV.

$$\text{NPV} = \$44,403 - \$30,000 = \$14,403$$

Now consider this equation using different discount values:

$$\text{NPV at } 9\% = \$15,312$$

$$\text{NPV at } 11\% = \$13,521$$

$$\text{NPV at } 15\% = \$10,256$$

Net present value is a very useful indicator because it measures a project's profitability relative to the company's value of money. However, gauging an investment's profitability with NPV relies heavily upon multiple assumptions and estimates, so there can be substantial room for error. Estimated factors include investment costs, discount rate, and projected returns. A project may require unforeseen expenditures to get off the ground or additional expenditure at the project's end. Additionally, discount rates and cash inflow estimates may not account for risk associated with the project, and may assume the maximum possible cash inflows over an investment period. In order to maximize the use of NPV, these factors need to be accounted for and values adjusted accordingly. Further, NPV is a useful tool for determining the profitability of one project, but it is limited in its use as a comparison tool for project alternatives. To have some kind of meaningful comparison, the range of time (at a minimum) must be the same for each project. ([Ref. 5](#) and [Ref. 12](#))

Internal Rate of Return – The internal rate of return (IRR) is another technique used in decision-making. The purpose of determining the IRR is to accurately describe the relationship between future cash flows and current investment costs. The IRR is the discount rate (r) within the formula for calculating NPV. Therefore, the same equation is used, but solving for a different unknown variable, the IRR (discount rate) at which NPV is equal to zero. When the discount rate is found that makes the present value of the future cash flows equal to initial investment costs, that value is the IRR.

If that rate (IRR) exceeds the target rate of return (defined as the minimum acceptable rate of return on a project to meet company goals), the investment is deemed worthy of funding.

The formula for IRR is:

NPV = 0; or PV of future cash flows – Initial Investment = 0; or

$$\underbrace{\left[\frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \dots \right]}_{\text{NPV}} - \text{Initial Investment} = 0$$

Where:

r = internal rate of return (a percentage expressed as a decimal)

CF_1 = period 1 net cash inflow (cash inflows – cash outflows)

CF_2 = period 2 net cash inflow

CF_3 = period 3 net cash inflow, and so on ...

In practice, IRR is usually calculated by trying different interest rates until the IRR is found, or by using available electronic calculator tools. Using the IRR financial performance indicator, projects are ranked according to their IRRs, and projects with IRRs in excess of the appropriate discount factor are accepted.

For the previous example used to calculate NPV, the IRR is approximately 30.184%, which is much greater than the accepted discount factor of 10%. Therefore, this investment promises to be financially successful.

IRR is the measurement of choice for many investors because it takes into account both the timing and the magnitude of cash flows. Consider this example:

Example 2

Project A		Project B	
Investment Cost	\$30,000	Investment Cost	\$30,000
Year 1 Net Cash Flow:	\$10,000	Year 1 Net Cash Flow:	\$25,000
Year 2 Net Cash Flow:	\$20,000	Year 2 Net Cash Flow:	\$20,000
Year 3 Net Cash Flow:	\$25,000	Year 3 Net Cash Flow:	\$10,000
Total Net Cash Flow:	\$55,000	Total Net Cash Flow:	\$55,000
IRR = 30.184%		IRR = 45.106%	

Both projects have identical investment costs and the same total net cash flows over a three year period, but the second project shows a greater return on investment (IRR).

This is because the earliest intervening cash flows are larger in project “B”. This is a better alternative for the company because returns happen faster and, therefore, those values don’t have to be discounted so greatly.

Something to consider when comparing mutually exclusive projects using both IRRs and NPVs is that sometimes the values for these methods can give contradictory signals. For instance, a given project might have a higher IRR but a lower NPV than an alternative project. This problem can arise when the discount rate (IRR) is set at an implied reinvestment rate for cash flows when calculating for IRR, and the discount rate (IRR) used in the NPV method is a company's interest rate on loans for investment (cost of capital). If the IRR for a project uses differing reinvestment / capital cost rates, this can lead to discrepancies in project ranking. In most situations, reinvestment of cash flows at a rate close to the cost of capital is more realistic. ([Ref. 5](#))

Profitability Index (PI) – The profitability index (also called the benefit-cost ratio) is an appraisal technique used to determine the potential profitability of a project, and to compare different projects to one another. While the NPV is the difference between the “present value” of future cash flows and the investment amount necessary to acquire them, “profitability index” is the ratio. It doesn’t calculate the number of dollars, rather it estimates the value of the return in proportion to the size of the investment. The PI ratio is calculated by dividing the projected capital inflow (future profits) by the projected capital outflow (initial investment costs).

$$PI = \frac{\text{Present Value of Future Cash Flows}}{\text{Initial Investment}}$$

Guideline for PI interpretation: If $PI > 1$ then project is expected to be profitable
 If $PI < 1$ then project is expected to lose money

A ratio of 1.0 is the lowest acceptable measure on the index, indicating that any gains or losses from a project are minimal (or equivalent). Any value lower than 1.0 would indicate that the project would result in a deficit, where initial investment costs are greater than the projected returns. As the value of the profitability index increases, so does the financial attractiveness of the proposed P2 project, which is a good way to compare alternative investment options.

So where the NPV in Example 1 was equal to \$44,403 – \$30,000, the profitability index looks like this:

$$\frac{\$44,403}{\$30,000} = 1.48$$

If, quite improbably, an alternative project expects the exact same cash flows but requires an investment amount of \$40,000, the profitability index would be less favorable:

$$\frac{\$44,403}{\$40,000} = 1.11$$

When projects are mutually exclusive and limited capital is available, the project with the highest profitability index is to be accepted, as it indicates the project with the most productive use of limited capital.

Additional Economic Analysis Tools

Additionally, life cycle assessment (LCA) and total cost accounting (TCA) (also see [Appendix B](#)) used earlier can be expanded to be used as economic analysis tools to evaluate alternatives and justify P2 projects. Life cycle costing is an economic application based on life cycle. TCA describes internal costs and savings, including environmental criteria, while the life cycle costs include all internal costs and the external costs incurred throughout the entire life cycle of a product, process, or activity.

Life Cycle Cost Analysis (LCCA) – The LCCA associates economic criteria and societal (external) costs with individual P2 opportunities. The purpose of LCC is to quantify a series of time-varying costs for a given opportunity over an extended time horizon, and to represent these costs as a single value. These time-varying costs usually include:

- *Capital Expenditures* – Costs for large, infrequent investments with long economic lives (e.g., new structures, major renovations, and equipment replacements).
- *Nonrecurring Operations and Maintenance (O&M)* – Costs reflecting items that occur on a less frequent than annual basis that are not capital expenditures (e.g., repair or replacement of parts in a solvent distillation unit).
- *Recurring O&M* – Costs for items that occur on an annual or more frequent basis (e.g., oil and hydraulic fluid changes).
- *Evaluation of Energy Conservation* – All energy or power generation related costs. Although energy costs can be included as a recurring O&M cost, they are usually itemized because of their economic magnitude and sensitivity to both market prices and building utilization.
- *Residual Value* – Costs reflecting the value of equipment at the end of the life cycle cost analysis (LCCA) period. Considers the effects of depreciation and service improvements.

By considering all costs, an LCCA can quantify relationships that exist between cost categories. For example, certain types of capital improvements will reduce operations,

maintenance, and energy costs while increasing the equipment's residual value at the end of the analysis period. When energy costs are broken out from recurring O&M costs, there is the potential for the application of environmental criteria, but this is generally not the focus of traditional LCCA. Societal (external) costs including those resulting from health and ecological damages—such as those related to unregulated air emissions, wetland loss, or deforestation—can also be reflected in a LCCA, either in a quantitative or qualitative manner. LCCA includes the following cost components:

- *Extraction of Natural Resources* – The cost of extracting the material for use and any direct or indirect environmental cost for the process.
- *Production of Raw Materials* – All of the costs of processing the raw materials.
- *Making the Basic Components and Product* – The total cost of material fabrication and product manufacturing.
- *Internal Storage* – The cost of storage of the product before it is shipped to distributors and/or retail stores.
- *Distribution and Retail Storage* – The cost of distributing the products to retail stores including transportation costs, and the cost of retail storage before purchase by the consumer.
- *Product Use* – The cost of consumer use of the product. This could include any fuels, oils, maintenance, and repairs that must be made to the equipment.
- *Product Disposal or Recycling* – The cost of disposal or recycling of the product. ([Ref. 5](#))

Environmental Feasibility

Specifically evaluates feasibility by the P2 project impacts on the environment/human health within the facility and within the surrounding community. Including this analysis in a feasibility study is essential in finding the project option that permanently eliminates or reduces a facility's environmental impacts most effectively. Often the environmental advantage(s) of a P2 option are obvious, such as when the toxicity of a waste stream will be reduced without generating a new waste stream, and the environmental situation in the company improves without new environmental problems arising. Unfortunately, the environmental evaluation is not always so clear cut, as some options require a thorough environmental evaluation, especially if they involve product or process changes or the substitution of raw materials.

Commonly considered environmental factors:

- Effect on the number, volume, and toxicity of waste streams
- Risk and acceptability of transfer of pollutants to other media

- Impact of the P2 option on other processes or procedures (including disposal methods)
- Raw materials requirements and sourcing (are they renewable?)
- Overall associated resource (water and energy) consumption
- Hazard impact on safety and health

The feasibility screening is meant to isolate those opportunities that are viable options for P2 implementation and eliminate those that do not meet feasibility requirements. Although a P2 opportunity may be feasible, it does not necessarily mean that it must be implemented, as there may be more than one P2 opportunity available for the process. It may not be possible to implement all feasible opportunities at once. Therefore, the feasible options must be prioritized again to determine the most effective P2 options using the ranking methods outlined previously.

Generate an Assessment Report

In a company that has several assessment teams, the P2 program team will need to evaluate the results and resolve any conflicts that might exist among the teams about the approach and resources required for the project(s) they intend to propose. As input to this integration effort, each assessment team should prepare a summary report, presenting the results of their investigations and listing the options they screened and determined are feasible in order of priority. All appropriate information should be carried over into a complete assessment report, including the methodology used. Finally, the best P2 projects are selected for potential implementation (immediate and future) and incorporation into a P2 project proposal, which will be used to seek management review and approval.

Step 6 – P2 Project Proposal

After the prioritization and evaluation of the identified P2 opportunities is complete, the P2 teams should generate a P2 project proposal describing in detail the option(s) recommended for implementation. The proposal should contain all the information needed to present the recommended opportunities to facility managers for possible implementation, including the following items:

- General process information (as described in the assessment activities above)
- Executive summary with a listing of the P2 measure(s) recommended and the estimated effectiveness (P2 potential)
- Target values for reductions
- Advantages and disadvantages of the P2 project
- Potential implementation obstacles
- The maturity of the technology and a discussion of successful applications

- The overall project economics (including profitability under both optimistic and pessimistic assumptions)
- A qualitative evaluation of the indirect and intangible costs and benefits
- The required resources and how they will be obtained
- The proposed schedule for implementation (estimated time for installation and startup)
- A plan for adjusting and fine-tuning the initial project(s) as knowledge and experience increases, or to overcome unforeseen challenges
- Possible performance measures to allow the project to be evaluated after it is implemented
- Review P2 team functions and refine roles and responsibilities based on project implementation decisions

The proposal should be submitted to upper management using the outlined approval process from the P2 management plan. If the company executives question aspects of some projects, the P2 teams may be asked to produce additional data or revise the proposal. Team members should be flexible enough to develop alternatives or modifications, and be willing to do background or support work if necessary.

Step 7 – Obtain Approval and Resources

Management support is the single most important element in successfully implementing P2 opportunities. Regardless of the size or nature of the organization, top management must exhibit active and continuing leadership and interest in P2 efforts. Once management has approved the proposal, the P2 program team will need to secure resources (staff time with documented approval for individual staff participation) and financial support. The P2 program team will seek to secure funding for those projects that will require expenditures. There will probably be other company projects that will compete with the P2 program for funding, such as expanding production capacity or moving into new product lines. If the P2 program team is part of the overall budget decision-making procedure, they can help make an informed decision that a given P2 project should be implemented right away or wait until the next capital budgeting period (ensure reconsideration at that time).

Some companies will have difficulty raising funds internally for capital investment and may need to look into outside financing options, such as private sector lending (including bank loans and other conventional sources). Financial institutions and private investors are increasingly aware of the sound business aspects of P2 practices, and they are willing to supplement them financially (some investors even require P2 efforts to help guard a company from environmental risks and liabilities). Additionally, public financial assistance is available in some cases, including pollution prevention and toxics reduction grants from state and local governments.

Step 8 – Implement P2 Alternatives

This stage is where the selected P2 projects begin to take shape. Actions taken to implement P2 measures vary greatly from project to project and company to company. Some actions will be undertaken immediately with few resources, while others involve significant preparatory work before actual process changes can be started. These may require substantial expertise to implement. Some projects require new or repeat pilot tests at this stage to analyze / critique elements of the project and re-evaluate the cost-benefit analysis. Exploring and adopting P2 measures in laboratory settings or in pilot tests carries a tremendous potential for reducing pollution in current and future industrial processes. Once refined, the P2 project can be scaled up to full potential slowly to allow for continuous monitoring of the progress.

For projects that involve equipment modification or new equipment, the installation of the P2 project is essentially the same as any other capital improvement project. The phases of the project include planning, design, procurement, construction, and operator training. Some facilities may decide to use in-house expertise to implement projects while others may find it beneficial to contract the work to an outside organization.

Whatever the course of action, it is important to document the implementation process by taking “before and after” photographs for project review, as well as promotional activities later. Keep data logs current and have point people assigned for project oversight as much as possible during early stages of implementation.

Many P2 projects will result in more than process changes, as they also impact company standard operating procedures, purchasing methods, or inventory management practices. Company policies, procedural documents, and employee training programs will also be affected and require updates. It can take time for plant personnel to feel comfortable with a new way of thinking, acting, or doing. It is a good idea to allow everyone sufficient time to adapt to these and other changes by implementing P2 approaches slowly but consistently. Ultimately, it may require training and incentive programs to get employees used to the new P2 procedures and equipment.

Step 9 – Measure Progress

It is important to track and measure the progress of P2 projects and the benefits realized. Tracking implementation and operational progress will prevent expensive equipment from being purchased but never installed. It will also help identify opportunities for improvement. Equipment or programs may need to be modified to fully realize the project payback and other environmental savings. Progress should be measured against the expected technical, environmental, and financial returns and

established company goals. Measurable results are normally available within six months of startup, depending on the complexity of the project.

P2 Project Measurement Overview

- **Monitor process and waste production changes** – Track things such as the volume of waste produced, how often it is hauled away, and reductions in raw material (including water and energy) use.
- **Calculate the savings** – Consider the full costs of the generation of waste and calculate the total savings. This can be gauged by looking at savings in handling, treating, storage, and disposal costs as well as savings from reduced raw material use; then comparing the actual cost of purchasing raw material, the cost of storage and inventory of materials, and the cost of solid waste collection and air/water emissions.
- **Look at the indirect benefits** – Try to gauge the value of less obvious benefits such as improved public image, reaching new markets, improving or expanding production processes, employee morale and safety, improved product quality, reduced liability or regulatory concerns, better relationships with the community and regulatory agencies, and other possible advantages.

Selecting and Acquiring Data

Although the process is simple in theory, there are a number of factors to consider when defining what data to track, how to collect it, and how to use it.

- 1) **Select a quantity** (e.g., waste volume or toxicity) – The selected quantity must accurately reflect the waste(s) of interest (it is helpful if the units easily correlate to previously established baseline values).
- 2) **Measure that quantity** – Even when the criteria being used for comparisons is qualitative, it must be measurable in some way using the company resources currently available.
- 3) **Normalize the data as necessary** – Quantity comparisons can be useful for P2 review; however, the data may have to be normalized to account for influential factors not related to the P2 method being reviewed.

Data Sources, Comparisons, and Considerations

If the criteria for performance evaluation is predominately qualitative, the P2 process measurement method relies primarily on text supplemented by a limited amount of numerical data. However, the lack of quantitative data makes evaluating achievement of specific goals difficult and typically, less valuable. For instance, without quantitative data, comparing similar processes for potential technology

transfer opportunities is not easy. Therefore, whenever possible, evaluation of performance should include quantitative measures.

Depending on the nature of the processes being evaluated and the quality of the established baselines for the units, determining P2 progress can be complex. Typically, progress cannot be gauged and summarized by a single measure. Rather, a combination of variables will be necessary to account for data availability, facility and process characteristics, and corporate goals.

Using Established Baselines

If baselines have been established from historical performance for an existing process, these values can be used for comparison. If the P2 efforts involve incremental changes to the process, new baselines can be established as changes are implemented, and used to evaluate continual progress. If the P2 efforts involve new processes or units, historical data will not exist for the application. If similar process have been utilized in other facilities or other companies, estimates from those applications may be used as baseline values. Sometimes, baselines may be projected amounts of pollution that will never be generated. In general, baselines can be used effectively for comparison and P2 performance evaluation.

- **Material Input** – Changes in the quantities of materials used in a process can be used to measure P2 progress. However, some considerations need to be taken into account when using material input data. For instance, factors such as the quantity of material input that is destroyed during the process or input that is acquired from other production units in the facility should be identified and accounted for in the comparisons.
- **Waste Shipped Off-site or Treated On-site** – The amount of solid wastes can be estimated based on shipment costs and tipping fees for a facility, but it may be difficult to isolate and account for contributions made from the specific process unit. If it is possible, measure by weight or volume the solid waste resulting directly from the process prior to loading into aggregate waste collection receptacles (especially if baselines for the process were established this way). Quantities of hazardous waste shipped off-site are likely to be accurately recorded in manifests, although some inaccuracy may be introduced when partial barrels are shipped. If possible, keep records whenever barrel counts need to be adjusted. Again, try to record the amounts of the hazardous waste coming directly from the process by labeling barrels with process unit names, and by avoiding mixing wastes from multiple production processes. In the same way, the amounts of waste going to on-site waste treatment plants should be measured or estimated by process unit.
- **Quantity of Waste Generated or Used** – Using the mass balance data for each material and waste component as baselines, conduct new mass balance to get

an overall picture of input and output flows for the process. Be sure to track and account for fugitive emissions, material destruction and byproduct generation in the production process, and discharges to waste treatment and disposal. It is also important to consider any wastes that are related, but not generated directly from the specific process. Some types of waste that can often be missed (or not attributed to the specific processes) include construction debris related to P2 implementation, area lighting and utility support, process wastewater, and material waste resulting from inventory management practices (expired materials).

- **Change in Amount of Toxic Constituents** – P2 efforts related to hazardous or toxic material use and waste generation can be measured by the change in the total amounts reported on SARA Title 313 Form R. Toxics input quantities for specific processes should be recorded separately if possible. Additionally, process streams contributing to the plant waste effluents may need to be partitioned into separate phases to account for specific process unit generation of wastes.
- **Change in Material Toxicity** – In addition to the quantity of toxics used or produced, the level of toxicity of material inputs and outputs should also be assessed. Reducing the sheer volume of a given material or waste while increasing its per-unit toxicity is a treatment option, but it is not P2. For example, adding lime to a waste stream to precipitate metals reduces the volume of waste but does not prevent pollution since the total quantity of metal in sludge is not changed. [\(Ref. 27\)](#) Toxicity is not frequently measured as part of production reporting, so procedures may need to be established for doing so. Again, process streams contributing to the plant waste effluents may need to be partitioned into separate phases to account for specific process unit generation. These phased effluents (often stored in holding tanks) can then be sampled to determine actual toxicity resulting from the process. Toxicity testing requires sophisticated testing and data handling, however, and may not be feasible for all applications.

When comparing baseline values, it is important to assess if any wastes have been shifted. Transferring a given pollutant to another medium or replacing it with a different pollutant is, in P2 principle, to be avoided. If the P2 efforts have eliminated part of the target material but shifted some of it to another process stream, another environmental medium, or into the process product, the relative impact must be evaluated very carefully. All outputs of the process should be considered—not just the primary process stream originally associated with the waste—to account for pollutant medium shifts. It can be difficult to track or to determine what new pollutants may be created by the new procedure (especially when the scope of evaluation is centered on one unit process). Therefore, it can be worthwhile to evaluate inputs and outputs of downstream units to ensure that process stream transfers have not occurred.

Normalizing for External Factors

Changes in quantity are straightforward and can be useful input to a P2 project review. Nonetheless, there are a number of external factors that can cause the quantities and/or mix of products and byproducts to change. If there were major factors unrelated to P2 efforts that influenced the quantities produced, the data will have to be normalized. Normalizing data is a process of structuring data so as to reduce or eliminate data redundancy and properly attribute impact values to derivations.

Some of the common factors that may affect the process quantities (including costs and savings) are:

- Total hours the process operated
- Number of batches processed
- Input material changes
- Total employee hours
- Area, weight, or volume of product produced
- Area, weight, or volume of raw material purchased
- Profit from product

Normalization factors will be different depending on the type of process being evaluated. For instance, continuous processes can often use the product output or raw material input as factors for standardization. Some flow processes may be best measured by volume or weight, whereas others may be better normalized by area. In batch processes, production volume is usually relative to waste production, but it may not always be a linear relationship if production processes are not consistent for each product produced. For example, printing processes use solvents at varied rates depending on the total volume of stock printed and ink used. However, usage is also significantly influenced by the number of color changes required for the unique prints.

Comparing quantities is further complicated by inverse relationships that may occur between production amounts and waste generation (waste is generated at a higher rate than production volumes). Contrary correlations can occur due to things like the startup and shutdown of equipment or when purchased materials expire before they can be used in a process.

When normalizing data, it is important to determine what factors are affecting values and identify reliable indicators for accurate measurement. Because many businesses are focused on the line items of expenditures and profits, it may require a shift of thinking to account for market forces that can affect those material costs or the sales profits (due price changes). Monetary factors such as revenues and earnings can be indicative of business activity, but they can only be dependable indicators in extremely stable markets. Therefore, these important financial values may need to be adjusted to be useful when evaluating P2 performance. ([Ref. 3](#))

P2 Economic Impacts

Once the effectiveness of a P2 project to prevent pollution is assessed, it is time to add in the associated financial values to determine the economic standing of the project. Like any other new process or capital investment, the installation and operation estimates should be compared to the actual construction and operating costs. The baseline costs for material usage and waste management should be compared to the newly derived values for these factors. The economic impacts of the P2 project can be assessed using any of the financial performance indicators discussed previously in [Step 3 - Detailed Assessment Phase](#) and [Step 5 - Evaluate Alternatives](#). Total cost accounting and life cycle costing can be fully exercised with the information available at this stage, and are considered to be the superior economic evaluation techniques for P2 performance.

Step 10 – Review Projects / Make Adjustments

The P2 process does not end with project implementation. The performance of implemented P2 projects should continue to be periodically assessed against the expected technical, environmental, and financial returns and established company goals. Quantitative evaluation also enables comparison of the process unit with similar units in the company and with data from other companies. The information systems utilized should track and retain the data necessary to measure and review P2 program results, and allow for reports to be generated at meaningful intervals. The results of these evaluations should not be expressed just in terms of successes or shortfalls, but also in terms of lessons learned and future opportunities identified. Options that do not meet the original performance expectations may require rework or modifications to be effective. Above all, reuse the knowledge gained by continuing to evaluate and fine-tune P2 projects, as reiteration of the process will yield maximum success.

Consider these questions during project review:

- Were goals met? Have target goals changed?
- What obstacles were realized?
- Were estimations accurate?
- What lessons were learned?
- What can be improved?
- How can changes or corrective actions be implemented?
- What future opportunities have been realized?

It is also recommended to regularly re-evaluate P2 efforts and the P2 program as a whole. Then, program enhancements can be planned and implemented. Upper management can demonstrate continuing commitment to P2 by conducting annual

reviews of the program. Managers at all levels can assess the degree to which P2 goals at the facility and production unit levels are being met. The comparison identifies P2 techniques that work well and those that do not, and helps to select technologies for transfer to or from other operations. The results of these annual reviews should be communicated to all employees through written announcements and meetings.

Objectives and approaches to achieve them may need to be adjusted to maintain the same high profile the P2 program had initially. It is also necessary to update and/or redefine the P2 goals, policies, and standard operating procedures periodically to keep them current and in alignment with the company's sustainability aspirations. Program successes should be recognized and any changes to the objectives or policies should be announced and explained to staff, if not coordinated with them directly.

Finally, conduct regular assessments of the business to determine whether P2 efforts are effective for the entire facility. As new raw materials and processes are introduced, waste streams and operations change. It is important to maintain data, facility flow diagrams, and process maps to keep them current and accurate. This will ensure P2 process efficiency, identify additional P2 opportunities, and help guide future P2 assessment and implementation cycles.

Continual improvement can be built into the P2 planning process and sustained by:

- Building and maintaining a strong P2 program team
- Scheduling periodic reviews of unit processes, the P2 program, and the facility
- Building in methods to evaluate and re-evaluate performance

Step 11 – Reward and Publicize

A great way to sustain the P2 program is to create and publicize success stories that exemplify the effectiveness of the program and demonstrate the benefits that have been realized. It is also extremely important to establish ways to acknowledge and reward employee contributions to the P2 efforts. This will keep enthusiasm high and innovative thinking persistent. Follow the P2 management plan guidelines for employee recognition practices and P2 publication strategies (see *Establish Employee Incentive Mechanisms* and *P2 Promotions / Outreach* sections in [Chapter 4](#)).

Step 12 – Move to the Next P2 Project

Armed with increased P2 awareness, knowledge, and experience, repeat the P2 Project Process. Start again at Step 1, developing a P2 process plan for the next P2 project, and follow the appropriate steps to P2 success. It is recommended to conduct regular assessments of the business to identify additional P2 opportunities, and to view

P2 as a continuous cycle of improvement. Remember, as long as materials are used and waste generated, there will be opportunities to reduce or eliminate it.

P2 Strategies

There are numerous ways to increase efficiency and prevent waste in all aspects of a business, regardless of the types of products or services provided. Many P2 options are inexpensive and simple to implement. By taking advantage of several easy and low-cost P2 opportunities, a company can experience immediate and sizable benefits. Other P2 alternatives require additional resources and extended time periods for returns. Taking the extra time and effort to implement these project types can dramatically improve a company's long-term outlook by sustainably reducing waste and lowering operating costs. Indiana businesses, both large and small scale, can make P2 a routine part of daily business. The following is a brief review of some of the most common P2 opportunities and techniques a business can use to achieve P2 goals.

1) Integrate Environmental Considerations into the Business Planning Process

Implement Cost Accounting – Experience has shown that the most successful P2 programs account for the true cost of wastes through cost accounting. In order to implement cost accounting, a business must allocate and charge for the direct and indirect costs of all air, land, and water discharges to specific processes, products, or departments. This includes expenses for lost raw materials, staffing, paperwork and insurance, sample analyses, utilities, material management, and waste management (handling, storage, treatment, and disposal).

Implement an Environmental Management System (EMS) – An EMS is a set of processes and practices that enable a business to reduce environmental impacts and increase operating efficiency. An EMS helps a business identify and implement P2 opportunities. It also provides the framework needed to track, measure, and continually improve environmental performance. The EMS provides a cost-effective, convenient, and systematic way to demonstrate environmental stewardship and accountability. The most commonly used schema for defining criteria of an EMS is the International Organization for Standardization (ISO) 14001 standards. ISO 14001 is known as a generic management system standard that is relevant to any organization seeking to improve and manage resources more effectively. ISO 14001, like other ISO 14000 standards, is voluntary. The goal is to assist companies in continually improving their environmental performance and complying with any applicable legislation.

Provide Support for the P2 Program – In order to effectively implement P2, facility P2 goals need to be considered as part of the company bottom line through cost accounting and allocation of company resources. Access to corporate resources, such as engineering, marketing, research, and laboratories services,

must be available to aid P2 efforts. The company should utilize quality tools for program development and management, such as team-based quality culture, ISO 9000/14000, total quality control, Six Sigma techniques, etc.

Best Management Practices – A facility must update standard operating procedures (SOPs) to incorporate P2 and assist with total cost accounting practices. These updates should document waste stream segregation, utility metering for individual unit processes, recordkeeping, and communication practices for purchasing, receiving, and regulatory compliance.

2) Process and Equipment Optimization, Redesign, Modification, or Modernization

Process design techniques can be used in new or existing facilities to improve operating and material use efficiency. These system designs or upgrades can also reduce the frequency of off-spec production, reduce other waste generation, and isolate waste streams for better management. New processes can be designed using modern technology and engineering practices, or existing units can be retrofitted or replaced to increase precision. Examples include:

Process and Equipment Optimization

- Make system adjustments to existing processes such as flow rates, temperature, pressure, or residence times to optimize functions.
- Change equipment or infrastructure (i.e., plumbing) location or layout to minimize material transfers, pressure losses, and slowed flow rates.
- Adjust equipment and process operations to optimize cleaner (solvent) concentrations and cleaning times.
- Keep lids and covers closed to reduce evaporation losses from cleaning and dip tanks.
- Remove sludge and surface oils/scum from cleaning and dip tanks to extend solution life.
- Make sure that parts being cleaned in a degreaser/defluxer are positioned in a manner that permits maximum drainage and minimizes dragout (whether contained in baskets, suspended from hooks or racks, or conveyed on a belt).
- Implement water conservation practices to reduce the use of water and chemical inputs to water.

Equipment Modification and Modernization

- Buy and maintain durable equipment / upgrade tool and equipment quality.
- Install high-performance nozzles and applicators.
- Install or make better use of automation equipment and process controls such as thermostats, shut-off valves, or flow meters.
- Install mechanical alarms to notify of leakages and process bypasses.
- Replace high-volume hoses with high-pressure, low-volume systems.
- Use devices such as blower-powered air knives to contain or remove free-standing materials to reduce chemical cleaning practices.
- Install splash guards and drip boards to minimize solvent and chemical losses.
- Install floating covers on heated baths to extend solution life by reducing evaporative losses.

Process and Equipment Redesign

- Design continuous closed systems to replace batch processes.
- Install holding tanks or other equipment to segregate waste streams.
- Design or retrofit units to use energy / fuel sources that are renewable or cause fewer emissions.
- Redesign refrigeration units to use non-ozone depleting refrigerants.
- Redesign or implement alternative cleaning processes to reduce solvent and toxic chemical usage in the manufacturing process by:
 - Determining the true degree of cleanliness needed for equipment or process materials to eliminate redundant cleaning practices that are deemed unnecessary.
 - Reviewing upstream and downstream processes / practices and accurately determine how they influence the cleaning practices in the process.
 - Modifying employee practices to improve solvent handling and storage procedures to reduce waste generation.
 - Researching and studying the chemistry, mechanics, and other fundamentals of cleaning and understanding the pros and cons of potential alternatives or if experimentation is needed.
 - Utilizing alternative cleaning technologies or chemical solutions such as:

- Aqueous and semi-aqueous cleaning processes
 - Thermal and steam cleaning processes
 - Abrasive blasting using bead, dry ice, baking soda, starch, plastic, and other media
 - Supercritical carbon dioxide solvent cleaning
 - Less hazardous solvents with low vapor pressure, low toxicity, and non-ozone depleting characteristics (i.e., lactic acid, dimethyl esters, dimethyl sulfoxide, n-methyl pyrrolidone, glycol ethers, terpenes, soybean, and other bio-based solvents)
 - Implementing in-process recycling by installing equipment or methods that become integral to production through hard-piped or closed-loop systems
- Using distillation, filtration, or vapor recovery (i.e., refrigerated condensation) equipment to capture and reclaim cleaning or process chemicals such as solvents, oils, and toxics.
 - Installing counter-current rinsing systems and using spray nozzles as part of a rinse system instead of single rinse tanks.
 - Utilizing regeneration processes (chemical or mechanic).
 - Installing efficient condensers, regenerative heat exchangers, heat pumps, or similar equipment to recover and reuse heat.
 - Recycling and reusing spent water through grey water use (when appropriate), ultrafiltration / nanofiltration systems, reverse osmosis purification, filter presses, high capacity angled plate clarifiers, or batch treatment systems.

3) Product Design, Product Reformulation or Redesign, Product Stewardship, and Sustainable Development

Product design, reformulation, or redesign for P2 incorporates environmental objectives with minimal loss to the product's performance, useful life, or functionality. The product's initial composition or reformulation should be nontoxic, or less toxic, to ensure environmental protection and consumer safety. Designs should consider the feasibility of the final product to be reused, recycled, and disposed of in environmentally sound manners. Examples include:

Product Design, Stewardship, and Sustainable Development

- Integrate P2 into pre-manufacturing decisions by beginning P2 at research, development, and design phases of the product. Also include P2 into equipment and materials procurement for the production of the product.
- Design and create products or services that are ecologically safe throughout their life cycle,
- Introduce new product lines specifically designed to eliminate or reduce the use of toxic chemicals,
- Design durable products (extend product life span),
- Design products that allow for resale, reuse, or are conducive to recycling (i.e., plastic parts are marked to aid recycling) instead of immediate disposal,
- Use modular and upgradeable designs allowing for easy repair, replacement of component parts, and upgrades (thus lengthening the useful life of the product),
- Produce combined, condensed, or concentrated products that require less packaging,
- Minimize the use of product fillers.
- Utilize materials and parts that can be reused or recycled during production.
- Use natural, renewable, or recycled materials in manufacturing processes.

Product Reformulation or Redesign

- Eliminate raw materials that are not incorporated into final products or services.
- Substitute raw materials by:
 - Using organic or aqueous-based materials instead of petroleum, solvent, or toxic chemical-based inputs / ingredients.
 - When toxics are required, use the least toxic alternative available.

4) Purchasing and Inventory Management

An efficient and coordinated material-purchasing program can be achieved through monitoring of all requests for products throughout the company or plant. Improved inventory control and judicious purchasing can significantly reduce the disposal volume of raw materials because they become outdated.

- Implement “just in time” purchasing (in quantities matching process demand), as the cost associated with the disposal of surplus hazardous materials often exceeds the purchase price of the items.
- Purchase frequently or commonly used products in bulk or in concentrated form.
- Prioritize purchasing locally to reduce transportation and storage needs.
- Purchase durable, long-lasting materials.
- Implement a computerized inventory control program that:
 - Promotes sharing of materials between common users
 - Provides data on what processes use hazardous products
 - Identifies large volume users
 - Locates unused caches of materials
 - Identifies where waste reduction / material substitution options are viable
 - Rotates stock on a first-in, first-out basis and monitors expiration of materials
- Avoid unnecessary purchasing by reusing materials / equipment (i.e., drums, pallets, boxes) or by participating in a material exchange program (allows the movement of unwanted materials between companies).

5) Improved Maintenance, Preventative Maintenance, and Housekeeping

Equipment components start to wear over time. By maintaining equipment in optimum working condition, a facility can reduce off-spec production and prevent unplanned downtime resulting from breakdowns. Preventing operational problems from occurring through repair, replacement, or adjustments will almost always cost less than the potential consequences of actual failures while in service.

- Establish schedules and procedures for routine inspections.
- Regularly conduct key maintenance activities and system adjustments (i.e., calibration, air to fuel ratios).
- Identify equipment or systems that frequently malfunction and implement preventative measures.
- Repair equipment instead of purchasing new whenever possible.
- Maintain a supply of spare parts for equipment that needs frequent repair.
- When repair is not possible or economically beneficial, replace defective equipment promptly.

- Update system maintenance and monitoring software regularly.
- Modify existing equipment or methods through improved housekeeping or process / product inspections.
- Implement spill prevention training and procedures.

6) Improved Receiving and Distribution Practices

A second look at the transportation and product packaging that companies send and receive often leads to waste reduction without sacrificing product safety or quality.

- Work with suppliers and transporters to implement the use of lightweight, returnable, and reusable containers for shipping and receiving.
- Reduce or eliminate excess product packaging.
- Increase the use of recycled or recyclable packaging.
- Ship products in bulk or in concentrated form.

7) Green Building, Infrastructure, and Sustainable Grounds Management

The green building practice (also known as green construction or sustainable building) expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life cycle. A structure's life cycle takes into account the following: planning, design, construction, operation, maintenance, renovation, and demolition. Green infrastructure is a P2 approach to managing wet weather impacts (i.e., flooding) and provides many property and community benefits. Green infrastructure uses vegetation, soils, and other elements to restore some of the natural processes required to reduce and treat stormwater at its source while delivering environmental, social, and economic benefits. When installing new buildings and infrastructure, or when remodeling existing structures, green design practices should be utilized. This often requires close cooperation of the contractor, architects, engineers, and the company representatives.

Green Building

- Use life cycle thinking in all engineering activities and ensure that all material and energy inputs and outputs are as inherently safe and benign as possible.
- Install a skylight system and design window placement to provide more natural light and lessen the need for electric lighting during the day.

- Orient windows, walls, and awnings with trees to shade windows and roofs during the summer while maximizing solar gain in the winter.
- Reduce heat gain by tinting windows.
- Reduce infiltration / exfiltration (air leakage) by insulating the building envelop, installing high-performance windows, and adding extra insulation in walls, ceilings, and floors.
- Generate renewable energy for building use through solar power, wind power, geothermal power, or hydropower.
- Install solar water heating units where feasible.
- Install personal temperature and airflow controls over the HVAC system.
- Design systems to collect, purify, and reuse water on-site (e.g., dual plumbing that recycles water into toilets (flushing) or for use of non-sewage and grey water for site irrigation).
- Utilize water conserving fixtures such as ultra-low flush toilets and low-flow faucets.
- Install “point of use” water treatment and heating (improves water quality /energy efficiency).
- Install a hybrid central chilled water system (cools floor-by-floor with steam instead of water).
- Use zero or low VOC-emitting construction materials and interior finish products.
- During the construction phase, reduce the amount of material going to landfills.

Green Infrastructure

- Reroute rooftop drainage pipes from draining rainwater into the storm sewer to draining it into rainwater harvesting systems, cisterns, or permeable areas.
- Install bioretention or bioinfiltration cells (shallow, vegetated basins that collect and absorb run-off from rooftops, sidewalks, and streets).
- Install vegetated swales to slow, infiltrate, and filter stormwater flows along streets and parking lots.
- Use permeable pavements made of pervious concrete, porous asphalt, or permeable interlocking pavers to infiltrate, treat, and/or store rainwater where it falls.
- Create green parking by using permeable pavements in sections of a lot and adding rain gardens and bioswales in medians and along the perimeter.

- Install green roofs that are covered with growing media and vegetation that enable rainfall infiltration and evapotranspiration of stored water. They are particularly cost-effective on large industrial or office buildings where stormwater management costs are likely to be high.
- Plant trees on-site to reduce and slow stormwater by intercepting precipitation in their leaves and branches.

Sustainable Grounds Management

- Convert lawns to natural areas (e.g., prairies) with a diversity of native plants (e.g., wildflowers, groundcovers, and grasses). This practice helps prevent pollution from mowers and lawn chemicals, reduces maintenance costs, promotes biodiversity, and provides a sanctuary for flora and fauna. These areas can help manage stormwater run-off and alleviate flooding, while simultaneously providing recreation and/or aesthetic amenities that can beautify company grounds and improve the surrounding community's quality of life.
- Monitor the growth of remaining lawns and only mow when necessary. For example, a church² in Indianapolis avoided 15 mows in 2016 via its "mow-upon-call" system, saved over \$2,000 in mowing costs, and reduced the church's carbon emissions.
- Leave grass clippings where they fall to facilitate recycling nutrients back into the soil. If clippings are collected, compost them with garden waste, raked leaves, and organic cafeteria waste (if appropriate).
- Use native plants in garden areas, as they tend to naturally resist insects, infections and fungus and can withstand local weather conditions such as extreme heat, cold or drought.
- Use organic pesticides and mulches.
- Irrigate higher grounds first to provide run-off to lower areas, use timers, and direct nozzles away from concrete areas.
- Reduce watering cycles when weather appropriate.
- Use rakes or blowers to remove leaves and debris from walkways instead of water hoses.
- Harvest and reuse rainwater whenever possible.

² Unitarian Universalist Church of Indianapolis

8) Energy Usage, Conservation, and Efficiency

Energy use is a key area where increased efficiency can result in significant cost savings. Energy savings can be achieved by simple changes in daily operations, maintenance practices, and employee habits. Most energy conservation efforts can be implemented at little or no cost. Although more significant energy savings may involve investment in new/upgraded equipment, these simple changes typically have excellent financial returns.

Examples of energy efficiency activities include:

- Conducting a facility-wide energy assessment.
- Submetering energy usage for detailed information on how and where energy is used within a facility and within processes.
- Maintaining equipment and the facility through an ongoing maintenance program (see subsequent tables).

Free and Confidential Energy Assessments

The Industrial Assessment Center (IAC) at Indiana University-Purdue University provides free energy assessments to qualifying small to medium sized companies. A team of highly skilled engineering faculty and students conducts on-site energy audits for eligible companies. They help establish baselines, provide a comprehensive report that identifies opportunities to save energy and reduce cost, and explain the recommendations. The report provides the potential savings with detailed calculations, estimates of implementation costs, and computes payback times. To learn how a company qualifies for a free and confidential energy assessment that does not interrupt production, visit www.engr.iupui.edu/IAC or contact IAC at iupuiiac@iupui.edu.

Maintenance Activities that Increase Energy Efficiency	
Furnaces	<ul style="list-style-type: none"> • Analyze burners and flue gas; adjust fuel-air ratio • Convert from atmospheric to oxygen burners • Replace electric furnaces with natural gas or geothermal • Improve or increase insulation on heating or cooling lines • Improve thermodynamics by recapturing heat using condensers, regenerative heat exchangers, heat pumps, or similar equipment

Maintenance Activities that Increase Energy Efficiency	
Process Heat Containment and Recovery	<ul style="list-style-type: none"> • Enhance sensitivity of temperature control and cutoffs • Use flue gas waste heat to preheat combustion air or process loads • Insulate hot surfaces to reduce wall losses • Use cogeneration of electricity and steam • Use condensers, heat pumps, or regenerative heat exchanger to recapture heat
Process Cooling: Cooling Towers and Chillers/Refrigeration	<ul style="list-style-type: none"> • Use a cooling tower instead of refrigeration when outside temperature allows • Use waste heat for absorption refrigeration • Use variable-frequency drives (VFDs) on cooling tower fans • Use higher efficiency chiller models • Use highest temperature for chilling or cold storage • Stage chillers to optimize part-load efficiency
Motors and Drives	<ul style="list-style-type: none"> • Upgrade existing motors to high efficiency motors; choose replacement motors with high power factor • Use variable speed drives to control motor speeds • Turn off idle motors • Improve lubrication practices for motor-driven equipment • Use energy-efficient power transfer belts and use notch belts instead of smooth belts to lower friction loss • Measure and avoid / reduce motor vibration
Office Equipment	<ul style="list-style-type: none"> • When purchasing new equipment, buy higher-efficiency models with the U.S. EPA Energy Star label, and check the Energy Guide label included on many major appliances • Put computers, printers, and other equipment into energy saver / sleep mode.

Maintenance Activities that Increase Energy Efficiency	
Compressed Air Systems	<ul style="list-style-type: none"> • Compressed air should only be used when essential • Keep air hose lengths as short as possible to reduce pressure drops • Keep air compressors at lowest possible pressure settings for demand requirements • Check for and eliminate leaks in compressed air supply lines often • Use outside air for intake when the weather is cold • Recover heat or direct heat for heating space • Use variable-frequency drives (VFDs) to control compressor if is not used at full load all the time • Use more efficient air nozzle to reduce energy consumption
Heating, Ventilation, and Air Conditioning (HVAC) Equipment	<ul style="list-style-type: none"> • Develop an optimal start / stop schedule for the HVAC system • Use a 7-day, programmable thermostat to coordinate system operations with loads • Seal heating and cooling ducts • Install a variable air volume system where practical • Install an airside, rooftop, central, or waterside economizer to use outside air to cool the space • Place cool air intakes and air-conditioning units in cool, shaded locations • Be prudent on opening of overhead doors resulting in significant heat or cooling loss • Replace old units with newer, energy-efficient units • Change air filters regularly • Use air curtains in shipping and receiving areas to reduce energy loss • Reduce building ventilation air to minimum safe levels in areas unfrequented • Install VFD on air handler motors

Maintenance Activities that Increase Energy Efficiency	
Electrical Power	<ul style="list-style-type: none"> • De-energize excess transformer capacity and increase power factor for facilities and equipment by installing the proper combination of fixed and variable capacitance • Store heated / cooled water for use during peak demand periods • Reschedule plant operations or reduce load to avoid peaks • Use fossil fuel-powered generators during peak demand periods
Lighting	<ul style="list-style-type: none"> • Use LED lighting (lower energy consumption / increased life) • Install low-mercury T-8 or similar triphosphor fluorescent systems with electronic ballasts • Remove two out of four tubes in fluorescent fixtures where lower light levels are acceptable; disconnect the ballast that operates these tubes; install reflectors or higher output lamps so more light is utilized • Install low-wattage, long-life, light-emitting, diode exit signs • Use high-efficiency halogen, low-voltage halogen, and quartz lamps where lighting quality is critical (e.g., retail displays) • Replace mercury vapor or other inefficient, high-intensity, discharge lighting systems with an efficient metal halide, sodium, or other high-output fluorescent systems • Do not over-light areas; tailor lighting levels to the task and occupants, and increase the use of task lighting • Rewire fixtures or use dimming controls to turn lighting off or down • Install occupancy sensors in areas of sporadic use • Turn off equipment and lights when not in use
Alternative Energy Usage	<ul style="list-style-type: none"> • Use solar heat for heating process • Install wind powered electric generators • Install a solar photovoltaic system to generate electricity • Utilize water level difference by installing water turbines

Indiana P2 Assistance and Resources

An excellent way to start any P2 effort is to draw upon the many services and resources available through Indiana State Government agencies, universities, utility companies, nonprofit organizations, consultants and other associations. Some of these local Indiana P2 resources are highlighted below.

State Government Agencies

Indiana Department of Environmental Management (IDEM)

The mission of the [Indiana Department of Environmental Management \(IDEM\)](#) is to implement federal and state regulations to protect human health and the environment while allowing the environmentally sound operations of industrial, agricultural, commercial, and governmental activities vital to a prosperous economy. In order to fulfill this mission, IDEM complements the regulatory programs within the agency through the [Office of Program Support \(OPS\)](#), which offers assistance programs, incentive programs, and industry partnerships to promote pollution prevention.

- The [Compliance and Technical Assistance Program \(CTAP\)](#) is Indiana's business assistance program, statutorily authorized to operate under Indiana Code (IC) 13-28-1, 13-28-3, and 13-28-5-4. CTAP is a non-regulatory program that provides free, confidential compliance and technical assistance to regulated entities. CTAP was established to help Indiana businesses understand and achieve compliance with environmental regulations by providing guidance on air, water, and waste regulations. CTAP also offers pollution prevention assistance to businesses by helping them identify P2 opportunities during site assessment visits, and by helping them conduct and review a P2 self-assessment using the [Pollution Prevention Opportunity Self-Assessment Checklist](#). CTAP also provides in-person classroom training and pollution prevention resource materials online, including guidance documents, success stories, P2 sector guides, and other resources that can be used to become more knowledgeable about P2 or prepare and/or implement a P2 program.

IDEM's [sector-specific P2 guides](#) cover P2 opportunities for these industries that are ranked by cost and amount of waste and emission reductions:

- Chemical Manufacturing
- Fabricated Metal Products
- Foundry Core Production
- Metal Degreasing
- Paint Manufacturing
- Paper and Pulp Processing
- Plastic Processing and Manufacturing

- The [Indiana Partners for Pollution Prevention \(P2\)](#) is an organization comprised of Indiana industries, businesses, nonprofit organizations, and governmental entities that are interested in pollution prevention and the resulting financial and environmental benefits of P2 project implementation. The partners provide a forum where Indiana businesses can network and exchange ideas about P2 experiences and discuss how P2 fits into current and future IDEM policies and programs. The Partners for P2 champion pollution prevention and environmental stewardship programs in businesses and organizations by promoting successful practices and approaches to achieve measurable reduction of pollution in Indiana. Their vision is that Indiana becomes a place where people embrace pollution prevention as a means to live and prosper in a clean environment, while enjoying and preserving Indiana's natural resources. Through the Partners for P2, an organization can be recognized as a pollution prevention leader in Indiana, learn how other businesses have implemented successful P2 technologies, share improvements in P2 business practices, and stay informed about P2 technology development. The Indiana Partners for P2 sponsor quarterly meetings and the annual [Pollution Prevention Conference and Trade Show](#), which showcases how award-winning companies have used P2 to improve their businesses. Past topics have included new and emerging pollution prevention technologies, options for successful and profitable product substitutions, and sustainability practices for businesses and the environment.
- The [Environmental Stewardship Program \(ESP\)](#) is a statewide, performance-based, voluntary leadership program designed to provide incentives and recognition for Indiana regulated entities who work to minimize waste generation and go above and beyond current environmental regulations for preventing air, land, and water pollution. In return for participating organizations' exemplary performance, these establishments will receive program incentives including regulatory flexibility, public recognition, and networking opportunities. The ESP focuses on improving Indiana's environment and business climate through innovation and efficient resource allocation. Participating organizations achieve environmental objectives through creating and implementing an environmental management system (EMS), which is an excellent component of a well-rounded P2 program. Together, the EMS and the member's commitment to continual environmental improvement allow a company to increase its efficiency, decrease environmental impacts, and may save the business time, money, and resources. Regulatory flexibility incentives earned by members are designed to provide business value, reduce regulatory oversight, allow a shift in resources from compliance driven to achieving results, and provide the member with increased operational flexibility. Any IDEM regulated entity is eligible to apply to Indiana's Environmental Stewardship Program regardless of type, size, or complexity.

- The [Indiana Governor's Awards for Environmental Excellence](#) are the state's most prestigious environmental recognition awards. Given annually, they are reserved for the most innovative, sustainable, and exemplary programs or projects that positively impact Indiana's environment and demonstrate measurable environmental, economic, and social benefits. Each year, any Indiana citizen, business, nonprofit organization, school, university, or government agency may submit a nomination or be nominated for an award. These awards recognize Indiana's leaders who have implemented outstanding environmental strategies into their operations and decision-making processes. By seeking out and utilizing innovative environmental practices, these facilities and programs reduce waste, save money, and contribute greatly to Indiana's environmental protection efforts, as well as benefit the health and welfare of Indiana's communities and the state as a whole.

The most recent awards categories (2018) are:

- Energy/Renewable Resources
 - Greening the Government
 - Land Use/Conservation
 - Environmental Education and Outreach
 - Pollution Prevention
 - Recycling/Reuse
 - Five Year Continuous Improvement.
- IDEM's [Comprehensive Local Environmental Action Network \(CLEAN\) Community Challenge](#) is a free and voluntary statewide program aimed at challenging and rewarding Indiana communities for proactively managing environmental and health impacts associated with governmental operations. The challenge put forth to Indiana communities is to implement projects with the goal of making Indiana a cleaner, healthier place to live to ensure a better quality of life for present and future Hoosiers. The challenge is designed to be flexible, allowing communities and their municipalities to choose projects that fit their long-term sustainability goals. The CLEAN Community Challenge can potentially help communities cut operating costs; improve their ability to meet compliance requirements; attract quality businesses; and improve environmental awareness, communication, and involvement within the community. Through CLEAN, the relationships between regulators, businesses, and residents can improve as they conduct a coordinated effort to improve the quality of life for all community members.
- The [Indiana Clean Marina Program](#) and the [Clean Vessel Act \(CVA\) Grant Program](#) offer pollution prevention opportunities to boaters and marinas throughout the state. The voluntary Indiana Clean Marina Program provides technical assistance to marinas and boaters to aid them in protecting Indiana's

inland and coastal waterways from pollutants that can be generated at marinas and in the course of recreational boating. The program recognizes marinas for environmental stewardship practices. The CVA Grant Program provides grant funds for the construction, renovation, operation, and maintenance of pumpout stations and waste reception facilities for recreational boaters. Grant funds are also available to assist in the development of educational programs that inform boaters of the importance of proper disposal of their sewage.

Indiana Office of Energy Development (OED)

- The [Indiana Office of Energy Development \(OED\)](#) focuses on the development and implementation of comprehensive energy planning for Indiana businesses, municipalities, and residents. OED coordinates state energy policy with executive branch agencies, houses energy-related programs, and works to support a strong, comprehensive, and coordinated energy plan for Indiana. The office also administers grant programs, mostly funded by the U.S. Department of Energy. These grants promote the use of alternative power and fuels, energy efficiency, and public education on energy issues in Indiana. For example, the [Community Conservation Challenge \(CCC\)](#) is a grant program in which OED offers approximately \$250,000 to eligible Indiana entities involved in community energy conservation projects. CCC offers financial assistance to non-residential entities for projects that reduce an organization's energy consumption or displaces the use of traditional energy sources by diversifying energy supplies. Eligible grantees include local units of government, school corporations, businesses, universities, and nonprofit agencies in Indiana. Grant rounds are subject to funding availability.

Indiana Universities

- The [Indiana University Environmental Resilience Institute](#) predicts impacts of environmental change (like extreme and unpredictable weather patterns) and develops solutions for businesses, farmers, communities, and individuals to prepare for and respond to these changes. It brings together a broad, bipartisan coalition of government, business, nonprofit, and community leaders to help Indiana better prepare for the challenges that environmental change brings to our economy, health, and livelihoods.
- The [Industrial Assessment Center \(IAC\)](#) at Indiana University-Purdue University of Indianapolis provides free energy, productivity, and waste assessments to small and medium sized industrial facilities through funding provided by the U.S. Department of Energy. IAC is part of the School of Engineering and Technology and uses trained energy-efficiency experts to help manufacturing companies reduce energy costs.

- Purdue University's [Manufacturing Extension Partnership \(MEP\)](#) provides innovation and growth services to small and medium sized companies. MEP focuses on small, rural, and emerging manufacturers to increase competitiveness by identifying areas for improvement and streamlining processes. MEP provides high value, affordable solutions for manufacturing challenges and offers these services through on-site training/analysis projects and workshops:
 - Energy Efficiency & Sustainability
 - Faculty Projects
 - Leadership Development
 - Lean Manufacturing
 - Lean Office
 - Quality Improvement
 - Quality Systems (ISO)
 - Six Sigma
 - Supply Chain Services
 - Top Line Business Growth Solutions
 - Training Within Industry (TWI)
 - Assistance in developing an Environmental Management System (EMS)
- The mission of Purdue University's [Technical Assistance Program \(TAP\)](#) is to advance economic prosperity, health, and quality of life in Indiana and beyond. Purdue TAP provides up to 40 hours a year (per business) of assistance to businesses throughout the state of Indiana on a broad range of challenges and opportunities including business growth, cost reduction, energy efficiency and sustainability, engineering challenges, and systems implementation.

Utility Companies

- Many Indiana utilities offer free energy audit programs and efficiency training for commercial and industrial customers and offer utility rebates for energy efficiency.
 - [Citizens Energy Group](#)
 - [Duke Energy Indiana](#)
 - [Hoosier Energy](#) member co-ops
 - [Indiana Michigan Power](#)
 - [Indiana Municipal Power Agency](#)
 - [Indianapolis Power and Light](#)
 - [NIPSCO](#)
 - [Vectren](#)
 - [Wabash Valley Power](#) member co-ops

The [Indiana Utility Regulatory Commission's](#) Energy Division provides additional information about Indiana municipal, investor-owned, and wholesale utilities.

Federal and Regional P2 Resources

Federal Agencies

U.S. Economic Development Administration (EDA)

- [EDA Funding Opportunities](#) - EDA grants support a range of business and industrial development activities—including infrastructure development—that create or retain jobs. EDA-capitalized revolving loan funds encourage new business development in economically distressed communities.

U.S. Department of Energy (DOE)

- The [U.S. Department of Energy](#) offers [funding opportunities](#) that support a range of business and industrial development activities (including infrastructure development) that create or retain jobs. EDA-capitalized revolving loan funds encourage new business development in economically distressed communities.
- The Energy Department offers [energy efficiency tax credits, rebates, and savings](#). Green infrastructure can be integrated into project design to claim tax incentives and rebates. For example, in Eugene, Oregon, a new biofuel station built on an abandoned gas station site included a green roof, bioswales and rain gardens. Nearly \$250,000 worth of tax credits reduced income and sales tax for the private company that built and operated the project.

U.S. Environmental Protection Agency (U.S. EPA)

- U.S. EPA's [Pollution Prevention Resources](#) offers access to the agency's information and outreach materials on pollution prevention:
 - The [Pollution Prevention Information Clearinghouse \(PPIC\)](#) is a free information service dedicated to reducing and eliminating industrial pollutants through education and public awareness. PPIC provides reference and referral via telephone/voicemail at (202) 566-0799, or via U.S. Mail, email, or an online form.
 - The [Pollution Prevention Calendar](#) lists conferences, webinars, events, and training opportunities related to pollution prevention and sustainability.
 - The [Pollution Prevention Resource Exchange \(P2Rx\)](#) is a national partnership of regional centers that advance pollution prevention as a cornerstone of sustainability. U.S. EPA created the grant program that supports P2Rx in 1997. The centers ensure easy access to high-quality information on how to prevent and reduce pollution through source reduction and conservation of natural resources. The centers also build communities of practice, provide technical assistance, and measure P2 program results.

- The [Newsletters](#) link leads to technical magazines, bulletins, abstracts, and stories on P2 and sustainability.
- [EPA P2 publications](#) is the current publication inventory that includes over 7,000 publication titles on P2 and related technical assistance.
- The [A-Z Pollution Prevention Subject Index](#) is an alphabetical listing of P2 and sustainability subjects with definitions and links to more information.
- [Case Studies](#) on pollution prevention; E3: Economy, Energy, and Environment; and Green Suppliers Network are searchable by keyword, title, year, sector, and process used to achieve results.
- [U.S. EPA, Pollution Prevention \(P2\) Small Business Guide](#) outlines P2 for small businesses and includes success stories.
- [Green Engineering](#) offers basic information, training, case studies, program information, and computer-based tools for the design, commercialization, and use of processes and products that minimize pollution, promote sustainability, and protect human health without sacrificing economic viability and efficiency.
- U.S. EPA's green engineering textbook "[Green Engineering: Environmentally Conscious Design of Chemical Processes](#)" is a college senior-to-graduate-level engineering textbook. The agency's Green Engineering Program offers chapter summaries, example problems, and sample homework problems.
- [Green Chemistry](#) covers U.S. EPA's efforts to speed the adoption and design of chemical products and processes that reduce or eliminate the generation of hazardous substances.
- [Greener Cleanups](#) details U.S. EPA's "Principles for Greener Cleanups," which provide a foundation for planning and implementing cleanups that protect human health and the environment while minimizing the environmental footprint of cleanup activities.
- [Energy and the Environment](#) provides resources for renewable energy and energy efficiency programs.
- [E3: Economy, Energy and Environment](#) is a federal technical assistance framework helping communities, manufacturers, and manufacturing supply chains adapt and thrive in today's green economy. U.S. EPA and five other federal agencies have pooled their resources to support small and medium-sized manufacturers with customized assessments.
- [ENERGY STAR®](#) is a U.S. EPA program helping organizations and individuals fight climate change through superior energy efficiency. Resources include energy savings plans, financing for energy efficiency investments, a cash flow

opportunity calculator to calculate returns on energy investments, rebates, and incentives.

Commercial Buildings:

- [ENERGY STAR Portfolio Manager®](#) is a U.S. EPA-created online tool that measures and tracks energy and water consumption, as well as greenhouse gas emissions. Use it to benchmark the performance of one building or a whole portfolio of buildings, all in a secure online environment. Portfolio Manager uses an automated benchmarking tool that can award ENERGY STAR certification to buildings that have uploaded 12 months of consecutive energy usage data and received scores of 75 or above.
- [Target Finder](#) helps predict the ENERGY STAR score of new construction. Enter the estimated energy use of a commercial building design, and this tool will calculate its projected ENERGY STAR score on a scale of 1 to 100. For existing buildings, enter either an ENERGY STAR score or an energy reduction target and it will calculate the annual energy use to aim for to achieve goals.

Industrial Facilities:

- [Energy Performance Indicators \(EPIs\)](#) are industry-specific benchmarking tools that score a plant's energy performance and compare it to that of similar plants in its industry. Example industries include automobile assembly and cement manufacturing.
- [Industrial Energy Tracking Tool](#) allows facilities to track energy performance over time.
- [Environmental Management Systems \(EMS\)](#) provides U.S. EPA information and resources related to EMS for small businesses and private industry, as well as local, state, and federal agencies.
- [RE-Powering America's Land](#) offers resources for siting renewable energy sources on potentially contaminated lands, landfills, and mine sites.
- [Safer Choice](#) helps consumers, businesses, and purchasers find products that perform and are safer for human health and the environment.
- [Safer Chemical Ingredients](#) lists chemicals that are safer alternatives, grouped by their functional-use class.
- [Sustainable Marketplace: Greener Products and Services](#) is a comprehensive green purchasing resource for manufacturers, institutions, and consumers.
- [Toxics Release Inventory \(TRI\) Program Pollution Prevention \(P2\) Resources](#) are available to assist industrial facilities with reporting P2 information, accessing and

analyzing P2 data, promoting P2 best practices, and understanding TRI P2 data. The [TRI P2 Search Tool](#) now helps identify P2 successes and compare P2 performance at both the facility and corporate level.

- [WasteWise](#) encourages organizations and businesses to achieve sustainability in their practices and reduce select industrial wastes. WasteWise is part of U.S. EPA's sustainable materials management efforts, which promote the use and reuse of materials more productively over their entire life cycles.
- [WaterSense](#) is a voluntary partnership program sponsored by U.S. EPA. It is both a label for water-efficient products and a resource for water saving strategies. The website offers best management practices, commercial and institutional facility [water assessment tools](#) (including a water assessment checklist and water assessment worksheets), case studies, webinars, other tools, and products.

Regional P2 Organizations

- The [Toxics Use Reduction Institute](#), through the University of Massachusetts Lowell, provides resources and tools to help businesses, municipalities, and communities find safer alternatives to toxic chemicals.
- The [Interstate Chemicals Clearinghouse](#) is an association of state, local, and tribal governments that promotes a clean environment, healthy communities, and a vital economy through the development and use of safer chemicals and products.
- The [University Library](#) at the University of Illinois at Urbana-Champaign offers [Pollution Prevention 101](#), a guide for P2 technical assistance providers who are new to P2. It includes resources, case studies, software tools and databases, sector/subject specific guidance, compliance resources, statistics and data sets, methods and standard information, news, and other P2 tools.
- The [National Pollution Prevention Roundtable](#) (NPPR) is a membership organization comprised of the country's preeminent P2 experts that promotes the development, implementation, and evaluation of efforts to avoid, eliminate, or reduce waste generated to air, land, and water.
- The [Global Development Research Center](#) is an independent nonprofit think tank that carries out effective initiatives in the strategic spheres of environment, urban, community, economy, and information.
- [Leadership in Energy and Environmental Design \(LEED\)](#) is a rating system for the design, construction, operation, and maintenance of green buildings, which was developed by the [U.S. Green Building Council](#). LEED certification is a globally recognized symbol of sustainability achievement.

Other State Agencies (in U.S. EPA Region 5)

- [Illinois Environmental Protection Agency](#)
- [Michigan Department of Environmental Quality](#) – P2 resources
- [Minnesota Pollution Control Agency](#) – Pollution Prevention
- [Ohio Environmental Protection Agency](#) – Office of Compliance Assistance and Pollution Prevention
- [Wisconsin Department of Natural Resources – Pollution Prevention Information](#)

Recommended P2 Publications

These “essential” P2-related publications contain useful information about implementing pollution prevention in today's industrial facilities.

- [Pollution Prevention: A Guide to Project and Program Implementation](#) (Illinois Hazardous Waste Research and Information Center, 1993). This manual serves as an overview for Illinois businesses of all sizes that have chosen to learn more about developing a pollution prevention program.
- [The Industrial Green Game: Implications for Environmental Design and Management](#) (National Academies Press, 1997). This volume examines industrial circulation of materials, energy efficiency strategies, “green” accounting, life cycle analysis, and other approaches for preventing pollution and improving performance. Corporate leaders report firsthand on “green” efforts at Ciba-Geigy, Volvo, Kennecott, and Norsk Hydro.
- *Industrial Waste Audit and Reduction Manual: A Practical Guide to Developing and Conducting a Manufacturing Process Survey for Waste Minimization Opportunities*, Ontario Waste Management Corporation, Ontario, Canada, October 1993, 3rd edition. This manual outlines the steps for a facility to conduct an in-depth waste audit, implement P2 opportunities, and offers case studies of P2 implementation.
- [Interstate Chemicals Clearinghouse Alternatives Assessment Guide](#), Interstate Chemicals Clearinghouse, January 2017, version 1.1. The guide is a comprehensive look at the developing science of alternatives assessments and provides assessors with three potential frameworks and sufficient flexibility to allow a wide range of users to conduct an alternatives assessment to replace toxic chemicals in products or processes with safer alternatives.
- [Source Reduction Now, How to Implement a Source Reduction Program in your Organization](#), Minnesota Office of Environmental Assistance, Saint Paul, MN, January 1996. This manual complements “Source Reduction Now,” a training video, and is arranged in sections that follow the changing needs of an ongoing

program. The sections can be distributed individually to address specific needs as they arise.

- [Toxics Use Reduction to Achieve Enhanced Pollution Prevention Success](#), Massachusetts Toxics Use Reduction Institute, University of Massachusetts Lowell, Lowell, MA, September 2016. This manual provides information on reducing toxics in manufacturing through P2.
- D. Raymond Martin, [ISO 14001 Guidance Manual](#), Technical Report NCEDR/98-06, National Center for Environmental Decision-Making Research, 1998. This manual has been developed and organized to assist all interested organizations in the development of an environmental management system (EMS) that is consistent with the ISO 14001 standard.
- U.S. EPA P2 publications – The [National Service Center for Environmental Publications \(NSCEP\)](#) maintains and distributes U.S. EPA publications in hard copy, CD ROM and other multimedia formats. The current publication inventory includes over 7,000 titles. NSCEP also develops and distributes the annual U.S. EPA National Publications Catalog.
 - [EPA Sector Notebooks](#) (U.S. EPA, late 1990s)
U.S. EPA's Office of Enforcement and Compliance Assurance (OECA) developed the EPA Sector Notebooks to provide chemical profiles of selected industries. Each profile includes information about the processes conducted in the industry, chemical releases and transfers of chemicals, opportunities for pollution prevention, pertinent federal statutes and regulations, and compliance initiatives associated with the sector. Although these notebooks were published in the late 1990s, they still contain a wealth of information about the production processes, environmental impacts, and pollution prevention options for these sectors.
 - [Facility Pollution Prevention Guide](#) (U.S. EPA, 1992) EPA/600/R-92/088
For those who are interested in and responsible for pollution prevention in industrial or service facilities. Summarizes the benefits of a company-wide pollution prevention program and suggests ways to incorporate pollution prevention in company policies and practices.
 - [Guide to Industrial Assessments for Pollution Prevention and Energy Efficiency](#) (U.S. EPA, 1990), EPA/625/R-99/003
Presents an overview of industrial assessments and the general framework for conducting them. It describes combined assessments for pollution prevention and energy and provides guidance for performing them at industrial or other commercial facilities.
 - [Searching for the Profit in Pollution Prevention: Case Studies in the Corporate Evaluation of Environmental Opportunities](#) (U.S. EPA, 1998), EPA 742-R98-005
This research was initiated to more fully illuminate the challenges facing industry in the adoption of pollution prevention (P2) opportunities, and to

identify issue areas that can be studied and addressed by policymakers and industry. The case studies in this paper describe three P2 projects that were chosen for analysis precisely because they were in some way unsuccessful. This analysis, based on a small and non-random sampling, is not necessarily representative of the experiences of all companies or all P2 investment possibilities.

- [Organizational Guide to Pollution Prevention](#) (U.S. EPA, 2001) EPA/625/R-01/003
This P2 guide provides information to help organizations get P2 programs started or to re-evaluate existing P2 programs. It presents an alternative method for working on P2 projects and four approaches to implementing a P2 program in an organization.
- [Lean and Green Supply Chain: A Practical Guide for Materials Managers and Supply Chain Managers to Reduce Costs and Improve Environmental Performance](#) EPA-742-R-00-001, January 2000. This guidebook provides a four-step framework for identifying and using environmental information to improve financial performance
- [Integrating Green Purchasing Into Your Environmental Management System \(EMS\)](#) (70 pp, 608 K, April 2005, EPA 742-R-05-001). The goal of this report is to help federal facilities integrate green purchasing into their environmental management system. The intended audience includes those tasked with implementing an EMS, reducing environmental impacts, meeting green purchasing requirements, and/or buying products and services in a federal facility.

Appendix A – Option Rating Weighted Sum Method [\(Ref.3\)](#)

The Weighted Sum Method is a quantitative method for screening and ranking pollution prevention options. This method provides a means of quantifying the important criteria that affect waste management in a particular facility.

This method involves three steps.

1. Determine what the important criteria are in terms of the program goals and constraints and the overall corporate goals and constraints. Example criteria are:
 - Reduction in waste quantity
 - Reduction in waste hazard (e.g., toxicity, flammability, reactivity)
 - Reduction in waste treatment/disposal costs
 - Reduction in raw material costs
 - Reduction in liability and insurance costs
 - Previous successful use within the company
 - Previous successful use in industry
 - Not detrimental to product quality
 - Low capital cost
 - Low operating and maintenance costs
 - Short implementation period with minimal disruption of plant operations

The weights (on a scale of 0 to 10, for example) are determined for each of the criteria in relation to their importance. For example, if reduction in waste treatment and disposal costs are very important, while previous successful use within the company is of minor importance, then the reduction in waste costs is given a weight of 10 and the previous use within the company is given a weight of either 1 or 2. Criteria that are not important are not included or are given a weight of 0.

2. Each option is then rated on each criterion. Again a scale of 0 to 10 can be used (0 for low and 10 for high).
3. Finally, the rating of each option for a particular criterion is multiplied by the weight of the criterion. An option's overall rating is the sum of the products of rating times the weight of the criterion. The options with the best overall ratings are then selected for the technical and economic feasibility analyses. Table A-I presents an example using the Weighted Sum Method for screening and ranking options.

Table A-I. Sample Calculation Using the Weighted Sum Method

ABC Corporation has determined that reduction in waste treatment costs is the most important criterion, with a weight factor of 10. Other significant criteria include reduction in safety hazard (weight of 8), reduction in liability (weight of 7), and ease of implementation (weight of 5).

Options X, Y, and Z are then each assigned effectiveness factors. For example, option X is expected to reduce waste by nearly 80%, and is given a rating of 8. It is given a rating of 6 for reducing safety hazards, 4 for reducing liability, and because it is somewhat difficult to implement, 2 for ease of implementation.

The table below shows how the options are rated overall, with effectiveness factors estimated for options Y and Z.

<u>Rating Criteria</u>	<u>Weight (W)</u>	Ratings for each option (R)		
		<u>X</u>	<u>Y</u>	<u>Z</u>
Reduce treatment costs	10	8	6	3
Reduce safety hazards	8	6	3	8
Reduce liability	7	4	4	5
Ease of implementation	5	2	2	8
Sum of weight times ratings $\sum (W \times R)$		166	122	169

From this screening, option Z rates the highest with a score of 169. Option X's score is 166 and option Y's score is 122. In this case, both option Z and option X should be selected for further evaluation because their scores are high and close to each other.

Appendix B – Total Cost Accounting

Economic Analysis of Pollution Prevention Projects (Adapted from [Ref. 3](#))

In recognition of opportunities to accelerate pollution prevention, U.S. EPA has funded several studies to demonstrate how economic assessments and accounting systems can be modified to improve the competitiveness of prevention-oriented investments. U.S. EPA calls this analysis Total Cost Assessment (TCA). There are four elements of Total Cost Assessment: expanded cost inventory, extended time horizon, use of long-term financial indicators, and direct allocation of costs to processes and products. The first three apply to feasibility assessment while the fourth applies to cost accounting. Together these four elements will help you to demonstrate the true costs of pollution to your firm as well as the net benefits of prevention. In addition, they help you show how prevention-oriented investments compete with company defined standards of profitability. In sum, TCA provides substantial benefits for pre-implementation feasibility assessments and for post-implementation project evaluation.

1. **Expanded Cost Inventory:** TCA includes not only the direct cost factors that are part of most project cost analyses but also indirect costs, many of which do not apply to other types of projects. Besides direct and indirect costs, TCA includes cost factors related to liability and to certain “less-tangible” benefits. TCA is a flexible tool that can be adapted to specific needs and circumstances. A full-blown TCA will make more sense for some businesses than for others. In either case it is important to remember that TCA can happen incrementally by gradually bringing each of its elements to the investment evaluation process. For example, while it may be quite easy to obtain information on direct costs, estimating some of the future liabilities and less tangible costs can be difficult. Perhaps a first effort should incorporate all direct costs and as many indirect costs as possible. Then add those costs that are more difficult to estimate as increments to the initial analysis, thereby highlighting to management both their uncertainty and their importance.
- Direct Costs – are those costs that are directly attributable to a source (process, product, and department). These can be classified as net savings or net cost depending on which category the pollution prevention project includes them in. Examples of direct cost include: capital expenditures (building, equipment, and installations; utility connections; and project engineering), and operation and maintenance expenses or revenues (raw materials, labor, waste disposal, water and energy usage/reductions, and value of recovered material). This can provide clarity on whether or not a pollution prevention project is a sound investment for the company. For most capital investments, the direct cost factors are the only ones considered when project costs are being estimated. For pollution prevention projects, this category may be a net cost, even though a number of the components of the calculation will represent savings. Therefore, confining the cost analysis to direct costs may lead to the incorrect conclusion that pollution prevention is not a sound business investment.

- Indirect Costs – These costs are usually allocated to overhead rather than to their source (production process or product) or are altogether omitted from the financial analysis process. Indirect cost are likely to represent a significant net savings. For example, administrative costs, regulatory compliance cost (permitting, recordkeeping/reporting, monitoring, manifesting), insurance costs, workers' compensation, on-site waste management cost, and on-site pollution control equipment operations are significant cases where saving can be incurred. An essential first step in including these costs in a Total Cost Accounting system is to estimate and allocate them to their source (process, products, and departments). See the section below on Direct Cost Allocation for several ways to accomplish this.
- Liability Costs – These costs depend on a company's ability to predict future regulatory and environmental costs of its current or proposed operations. Reduced liability associated with pollution prevention investments may also offer significant net savings to a company. Potential reductions in penalties, fines, cleanup costs (superfund/corrective actions), and personal injury and damage claims can make prevention investments more profitable, particularly in the long run. The assessment of liability, however, is subject to a high degree of uncertainty. For example, it may be difficult to estimate liabilities from actions beyond company control, such as an accidental spill by a waste hauler. It may also be difficult to estimate future penalties and fines that might arise from noncompliance with regulatory standards that do not yet exist. Similarly, personal injury and property damage claims that may result from consumer misuse, from disposal of waste later classified as hazardous, or from claims of accidental release of hazardous waste after disposal are difficult to estimate. Allocation of future liabilities to the products or production processes also presents practical difficulties in a cost assessment. Uncertainty, therefore, is a significant aspect of a cost assessment and one that top management may be unaccustomed to or unwilling to accept.
- Less Tangible Benefits – These benefits include those that may prove difficult to apply an accurate dollar value. Examples of less tangible benefits from pollution prevention investments include: increased sales (due to improved product quality, enhanced company image, consumers' interest in environmentally safe products), improved supplier-customer relationship, reduced health maintenance cost, increased productivity due to improved employee relations, and improved relationships with regulators. Although they are often difficult to measure, they should be incorporated into the assessment whenever feasible. Highlighting and adding these factors in the analysis of a pollution prevention

investment can improve profitability as well as gain the attention of management.

Expanding a facility's cost inventory brings a wide array of environmental cost and benefits to a company's assessment of pollution prevention investments.

2. **Extended Time Horizons:** Requires companies to allow longer periods for financial benefits to be achieved for some pollution prevention projects. This additional time is necessary since many of the liability and less-tangible benefits of pollution prevention projects occur over a long period of time. Extending the time horizon can improve the profitability of the pollution prevention investment and strengthen competitiveness, since these investments tend to have longer payback schedules than other investment options.
3. **Use of Long-term Financial Indicators:** Long-term financial indicators are used when making pollution prevention decisions. Financial indicators are financial evaluation tools that account for all cash flows during the project and the time value of money. The result is a characterization of a pollution prevention project's profitability in a concise, understandable form. Three common measures of profitability are used to assist decision-makers in a financial analysis to determine if a pollution prevention project will add economic value to a company. The three measures include:
 - Net Present Value (NPV) – This analysis relies heavily on the concept of the time value of money and is the most powerful tool for assessing profitability over the life of a project. The time value of money recognizes that receiving \$100 today is not equivalent to receiving \$100 at some point in the future, because the \$100 today can be invested to earn a return. Net Present Value is the present value of the future cash flows of an investment, minus the investment's current cost (Tellus, 1995).

Net Present Value is calculated by: $NPV = PV \text{ (cash inflows)} - PV \text{ (cash outflows)}$

 - If NPV is greater than zero, the project should be accepted.
 - If NPV is less than zero, the project should be rejected.
 - If NPV equals zero, the project generates exactly the return that is required.
 - Internal Rate of Return (IRR) – This is a metric measuring the profitability of potential investments, expressed in percentage terms, that is analogous to an average rate of return from an investment. IRR is the discount rate that will yield a net present value of zero for a given stream of cash flows. This method allows a comparison between the IRR of a project and a company's self-determined discount rate. A financial calculator or computer spreadsheet should be used to

determine IRR. In general, if the IRR is greater than the discount rate, the project will be accepted. If the IRR is less than the discount rate, the project will be rejected (Tellus, 1995). The IRR is a convenient way of examining the return a project will generate.

The following is the formula for calculating IRR:

where:

C_t = net cash inflow during the period t

C_0 = total initial investment costs

r = discount rate, and

n = number of time periods

$$NPV = \sum_{n=0}^N \frac{C_n}{(1+r)^n} = 0$$

- Profitability Index (PI) – The profitability index is a measure that attempts to identify the relationship between the cost and benefits of a proposed project. This measure evaluates the feasibility of pollution prevention projects by comparing the ratio calculated as: PV of Future Cash Flows / Initial Investment

Rules for selection or rejection of a project:

If $PI > 1$ then accept the project

If $PI < 1$ then reject the project

A ratio of 1.0 is the lowest acceptable measure on the index, as any value lower than 1.0 would indicate that the project's PV is less than the initial investment. As values on the profitability index increase, so does the financial attractiveness of the proposed pollution prevention project.

The use of long term financial indicators provide managers with accurate and comparable financial data that allows prevention oriented investments to successfully compete with other investment options.

4. Direct allocation of cost to processes and products: In general, few companies allocate environmental costs to products and processes that generate these costs. Without the direct allocation of cost, most businesses tend to lump these expenses into a single overhead account or simply add them to other budget lines where they cannot be segregated easily. This leads to accounting systems that are incapable of the following:

- Identifying the products or processes most responsible for environmental cost

- Assessing an investment in the pollution prevention opportunity in relation to the environmental cost of products and processes
- Tracking the financial savings of a selected pollution prevention alternative

Like much of the TCA method, implementation of direct cost allocation should be flexible and tailored to the specific needs of your company. To help you evaluate the options available to you, the discussion below introduces three ways of thinking about allocating your costs: single pooling, multiple pooling, and service centers. The discussion is meant as general guidance and explains some of the advantages and disadvantages of each approach.

Single Pool Concept

With the single pool method, the company distributes the benefits and costs of pollution prevention across all of its products or services. A general overhead or administrative cost is included in all transactions.

Advantages – This is the easiest accounting method to put into use. All pollution costs are included in the general or administrative overhead costs that most companies already have, even though they may not be itemized as pollution costs. It may therefore not be a change in accounting methods but rather an adjustment in the overhead rate. No detailed accounting or tracking of goods is needed. Little additional administrative burden is incurred to report the benefits of pollution prevention.

Disadvantages – If the company has a diverse product or service line, pollution costs may be recovered from products or services that do not contribute to the pollution. This has the effect of inflating the costs of those products or services unnecessarily. It also obscures the benefits of pollution prevention to the people who have the opportunity to make it successful—the line manager will not see the effect of preventing or failing to prevent pollution in his area of responsibility.

Multiple Pool Concept

The next level of detail in the accounting process is the multiple pool concept, wherein pollution prevention benefits or costs are recovered at the department or other operating unit level.

Advantages – This approach ties the cost of pollution more closely to the responsible activity and to the people responsible for daily implementation. It is also easy to apply within an accounting system that is already set up for departmentalized accounting.

Disadvantages – A disparity may still exist between responsible activities and the cost of pollution. For example, consider a department that produces parts for many outside companies. Some customers need standard parts, while others require some special preparation of the parts. This special preparation produces pollution. Is it reasonable to allocate the benefit or cost for this pollution prevention project across all of the parts produced?

Service Center Concept

A much more detailed level of accounting is the service center concept. Here, the benefits or costs of pollution prevention are allocated to only those activities that are directly responsible.

Advantages – Pollution costs are accurately tied to the generator. Theoretically, this is the most equitable to all products or services produced. Pollution costs can be identified as direct costs on the appropriate contracts and not buried in the indirect costs, affecting competitiveness on other contracts. Pollution costs are more accurately identified, monitored, and managed. The direct benefits of pollution prevention are more easily identified and emphasized at the operational level.

Disadvantages – Considerable effort may be required to track each product, service, job, or contract and to recover the applicable pollution surcharges. Added administrative costs may be incurred to implement and maintain the system. It may be difficult to identify the costs of pollution when pricing an order or bidding on a new contract. It may be difficult to identify responsible activities under certain circumstances such as laboratory services where many small volumes of waste are generated on a seemingly continual basis.

Expanding cost inventory pulls a much wider array of environmental costs and benefits into an assessment. Extending the time horizon, even slightly, can improve the profitability of prevention investments substantially since these investments tend to have somewhat longer payback schedules. Choosing long-term financial indicators, which consistently provide managers with accurate and comparable project financial assessments, allows prevention oriented investments to compete successfully with other investment options. Finally, directly allocating costs to processes and products enhances the ability to target prevention investments to high environmental cost areas, routinely provides the information needed to do TCA analysis, and allows managers to track the success of prevention investments. Overall, the TCA method is a flexible tool, to be applied incrementally, as your company's needs dictate.

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