ENGS 171
INDUSTRIAL ECOLOGY

Pollution Prevention

The 3M story
"Pollution Prevention Pays"
&
Extracting Principles

Benoit Cushman-Roisin
23 January 2020

Primary goal:
SUSTAINABILITY
(responsibility toward future generations)

Basic approach:
INDUSTRIAL ECOLOGY
(imitation of nature)

Imitation of ecosystem:
ECO-INDUSTRIAL PARKS
(closing material loops, energy efficiency)

In addition:
GREEN TECHNOLOGIES
(pollution avoidance rather than pollution treatment)

POLLUTION PREVENTION
(green processes)
Design for Environment

Process changes

Product changes

Improved operating practices
- Maintenance
- Efficient management
- Stream segregation
- Better material handling
- Inventory control
- Training

Technology changes
- Layout changes
- Increased automation
- Improved equipment
- New technology

Change of materials
- Material purification
- Less material variety
- Avoidance of toxics

Realm of Pollution Prevention (P2)

1 → 4 in order of difficulty and commitment on the part of the company

Testimony to U.S. Congress in 1993 by Dr. Robert P. Bringer, then VP at 3M:

“We believe that environmental interests and our business interests have merged.”
The 3M company has pioneered the way

Pollution Prevention Pays (3P)
The 3P program helps prevent pollution at the source – in products and manufacturing processes – rather than removing it after it has been created. The 3P program is predicated on the belief that prevention is more environmentally effective, technically sound and economical than conventional pollution controls.

Back in 1975 when the program was launched, the concept of applying pollution prevention on a companywide basis and documenting the results was an industry first.

3P seeks to eliminate pollution at the source through:

- Process modification
- Equipment redesign
- Product reformulation
- Recycling and reuse of waste materials.

The 3P program depends directly on the voluntary participation of 3M employees. Innovative projects are recognized with 3P Awards. A 3P Coordinating Committee representing 3M's engineering, manufacturing and laboratory organizations - and the Environmental, Health and Safety group - administers the program.
Projects must meet these criteria to receive formal recognition:

- Eliminate or reduce a pollutant;
- Benefit the environment through reduced energy use or more efficient use of manufacturing materials and resources;
- Save money through avoidance or deferral of pollution control equipment costs, reduced operating and materials expenses, or increased sales of an existing or new product.

3P results in 2008 alone:
- 616 projects completed
- > 122 million lbs of pollution prevented
- almost $91 million saved.

In 2010 on the 35th anniversary of the Pollution Prevention Pays program, 3M issued a major report on its achievements. The company determined that the company:
- Carried out more than 8,000 projects,
- Prevented more than 3 billion pounds of pollutants,
- Saved nearly $1.4 billion, and
- Had become a model for pollution prevention around the world.

Example from 3M: The manufacture of Scotch® tape

4 layers, each using a solvent for its application!

One of 3M’s primary strategies for continuing to reduce air emissions has been the development of solventless technologies, for a variety of products including tapes.

Some new processes are hot-melt technology, ultraviolet curing, and caustic wash materials.

https://news.3m.com/press-release/company/3m-marks-35-years-pollution-prevention-pays
Reduction in Solvent Emissions from Tape Production

In 2005, a 3P team from 3M Brazil’s Itapetininga facility replaced the solvent-based paper treatment process the plant used to manufacture packaging, medical and masking tapes with a new, water-based process.

As a result of this change, the facility reduced solvent emissions by over 45 tons per year. By preventing solvent emissions at the source, the plant also eliminated the need for pollution control equipment, reducing the plant’s energy use and eliminating over 125 metric tons of CO\textsubscript{2} emissions annually.

The project is expected to save the facility over $850,000 in its first year of implementation.

Waste Reduction by Electrode Redesign

A 3P project team from 3M’s Valley, Nebraska facility reduced the waste from adhesive electrodes used in electrocardiogram (EKG) applications, by redesigning the electrode.

The team changed the configuration of the electrodes on the card which reduced silver coating weight, adhesive coating weight, and the overall size of the electrode.

The project prevented nearly 11 tons of waste and saved nearly $1,000,000 in its first year of implementation.
Dental Product Waste Becomes a Source of Revenue

The 3M facility in Irvine CA manufactures dental products. As part of its operations, the facility generates platinum catalyst waste.

In 2006, the facility implemented a 3P project which turned this waste into a raw material by working with a recycler to recover and process the waste so that it can be reused.

Through this new process, the facility saves over $100,000 and prevent over 1,000 tons of platinum waste annually.

3M's Valley, Nebraska Facility Reduces Packaging Waste

3M's Valley, Nebraska facility has worked with its vendor to switch to reusable packaging for some of the components it purchases to make respirators. Before this project, Valley received the components on spools packaged in a box. The components vendor did not want the original boxes back, and the empty spools had to be returned to the vendor in new, different boxes.

The facility now uses a packaging system where both the empty spools and their containers are returned, reducing shipping waste by approximately 8 tons in the first year of the project and saving 3M Valley over $1,500 in packaging and disposal costs.
Returnable Steel Crates for International Shipment

3M's facility in Cottage Grove MN developed a collapsible, reusable steel crate that reduces waste and saves money.

Prior to the development of this 3P project, all shipments of automotive products to Germany went in a multi-piece wooden crate. When received in Germany, the automotive products were removed from the crate, and the crate thrown away.

An employee team looked at many alternatives to reduce waste from these shipments and soon settled on the idea of using returnable packaging. After developing concepts, the team worked with an outside contractor to build prototypes for testing.

The final design had to be robust to hold 1,800 pounds of product, double stacked in a shipping container. As a result, the new crates are made of steel and collapse to one-third of their height for the return trip to the U.S.

The team's work eliminated 315 tons of solid waste and produced $101,800 savings in the first year alone.

1) Solid-waste reduction: Accomplishments and issues

From 1990 to 2000, solid waste sent to landfills was reduced by 24%, from 295 million lbs in 1990 to 224 million lbs in 2000. 2010 target reached in 2009.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Waste (excludes recycling) (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>30,000</td>
</tr>
<tr>
<td>2001</td>
<td>25,000</td>
</tr>
<tr>
<td>2002</td>
<td>20,000</td>
</tr>
<tr>
<td>2003</td>
<td>15,000</td>
</tr>
<tr>
<td>2004</td>
<td>10,000</td>
</tr>
<tr>
<td>2005</td>
<td>5,000</td>
</tr>
<tr>
<td>2006</td>
<td>0</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
</tr>
</tbody>
</table>

Issues being faced:
- Highly fluctuating recycling markets (some declining)
- Reaching plateau → need to engage in product redesign
2) Reduction of releases to water: Accomplishments and issues

3M global operations released 1.2 million lbs to water in 2000, compared to 6.4 million lbs in 1990. Thus, from 1990 to 2000, 82% of water releases were eliminated, just shy of the 90% target.

These reductions were accomplished by means of pollution prevention projects (43%) and better pollution control (57%).

![Aggregate First Year Water Pollution Prevented](chart.png)

3M Spain Reduces the Water Used to Produce Scotch Brite Scourers

In 2007, 3M’s facility in Rivas, Spain implemented a project to reuse the wastewater from cleaning the facility’s manufacturing equipment in the production of Scotch Brite Scourers.

The facility installed new equipment and modified its Scotch Brite Scourer production process to allow the facility to put its cleaning waste water to good use.
3) 3M’s efforts in reducing air emissions

- 88% of air emissions were eliminated between 1990 and 2000
  then 96% more from 2000 to 2009  (255 million lbs in 1990 → 10.9 million lbs in 2009)

- 55% of these reductions were accomplished by pollution prevention
  and 45% by improved pollution controls

- Much of the effort concentrated on solvent technologies
  reducing variety of organic solvents
  replacing organic solvents by water
  developing solvent-free deposition processes

- More recent efforts are focusing on reduction of greenhouse gas emissions

Currently, 3M pursues a three-pronged approach:

<table>
<thead>
<tr>
<th>Challenge</th>
<th>2025 Goals</th>
<th>2018 Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Materials</td>
<td>• Reduce manufacturing waste by 10%*</td>
<td>• 11.7% reduction achieved</td>
</tr>
<tr>
<td></td>
<td>• Achieve zero landfill</td>
<td>• 30.4% achieved (56 facilities)</td>
</tr>
<tr>
<td></td>
<td>• Invest in more sustainable materials and products</td>
<td>• Sustainability Value program launched</td>
</tr>
<tr>
<td></td>
<td>• Drive supply chain toward sustainability</td>
<td>• 3M’s Supplier Responsibility Code</td>
</tr>
<tr>
<td>Water</td>
<td>• Reduce water consumption by 10%*</td>
<td>• +0.7% water consumption</td>
</tr>
<tr>
<td></td>
<td>• Engage communities were water is scarce</td>
<td>• 100% communities engaged</td>
</tr>
<tr>
<td>Climate &amp; Energy</td>
<td>• Improve energy efficiency by 30%*</td>
<td>• 2.8% reduction achieved</td>
</tr>
<tr>
<td></td>
<td>• Increase fraction of renewable energy to 25%</td>
<td>• 26.8% achieved</td>
</tr>
<tr>
<td></td>
<td>• Bring GHG emissions to 50% below 2002 baseline</td>
<td>• 63.7% below 2002 baseline</td>
</tr>
<tr>
<td></td>
<td>• Help customers reduce their CO₂ emissions by 250 million tons</td>
<td>• 40 million tons of CO₂ reduction</td>
</tr>
</tbody>
</table>

* indexed to sales

https://www.3m.com/3M/en_US/sustainability-us/goals-progress/
The lessons learned from 3M have led to underlying principles and been formalized.

---

**POLLUTION PREVENTION**

Rule of priorities  
according to the  
U.S. Environmental Protection Agency

1. Avoidance  
(search for an alternative)

2. Reduction  
(dematerialization, fewer defects, better tools)

3. Re-use  
(capture and reuse as is; ex: solvent)

4. Recycling  
(capture and reprocessing; ex: metal)

5. Energy recovery  
(burning at least to get the energy)

6. Treatment  
(hopefully down to benign products)

7. Safe disposal  
(last resort)

This ranked list is often presented as an inverted pyramid to emphasize the priorities.
An example of solvent vapor emission reduction

Pollution Prevention benefits

1. Serious money savings
2. Pollution prevention → lower cost of end-of-pipe treatment & waste disposal
3. Pollution prevention usually implies dematerialization → lower manufacturing cost
4. Manufacturing flexibility
5. Products of higher quality
6. Less regulatory hassle
7. Better image in front of public environmental organizations

Downsides

1. Difficult to generalize across industrial sectors
2. Companies are competitive → secretive processes not shared with others although licensing can be sought.
Endorsement and promotion by the U.S. EPA

And there exists a non-profit organization entirely dedicated to pollution prevention that organizes events and gives awards.