Module 1: Pollution Prevention and Hazardous Substance Reduction Fundamentals
Pollution Prevention: Region 5
Hazardous Substance Reduction on the Path To Greener Chemistry

U.S. EPA, Region 5
December 9, 2013
Purpose of this Training

• Increase hazardous substance reductions in small and medium businesses in Region 5
  – Best Management Practices
  – Case Studies
  – Tools and Resources
    • Disclaimer: The tools and resources identified in this presentation are not an endorsement of, or intended to be an endorsement of any particular tool, unless it was developed by EPA.
  – Targeting Strategies
Training Perspective

Life Cycle Perspective 12 Principles of Green Chemistry

1. **Prevention**
   It’s better to prevent waste than to treat or clean up waste afterwards

2. Atom Economy

3. Less Hazardous Chemical Syntheses

4. **Designing Safer Chemicals**
   Design chemical products to affect their desired function while minimizing their toxicity.

5. **Safer Solvents and Auxiliaries**
   Minimize the use of auxiliary substances wherever possible make them innocuous when used.

6. Design for Energy Efficiency

7. Use of Renewable Feedstocks

8. Reduce Derivatives


10. Design for Degradation

11. Real-time Analysis for Pollution Prevention

12. Inherently Safer Chemistry for Accident Prevention
Feedback/Comments

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Fundamental Concepts of P2 and Hazard Reduction
The Pollution Prevention Act of 1990 (which authorizes P2 grants) defines P2 as source reduction, which:

- Is any practice that reduces a hazardous substance, pollutant, or contaminant (HSPC) entering the environment pre-recycling and thereby reduces hazard.
- Includes equipment/technology/process modification, product redesign, material substitution, better housekeeping, maintenance, training, inventory practices.
- Excludes altering HSPC characteristics (physical, chemical, biological, volume) through a process not integral to producing product/service.
Defining Pollution Prevention

• EPA 1992 P2 Policy Statement
  – Clarifies that in-process recycling is pollution prevention.
  – Defines P2 as source reduction (PPA) plus conserving and using energy, water, and other resources more efficiently.

• Executive Orders on Greening Government
  – The first 1993 EO on P2 compliance defined P2 as the EPA 1992 Policy Statement does. Subsequent ones rely on multiple statutes; EO 13148 emphasized source reduction, and others include conservation and efficient use of resources.
Source reduction has a *history of broadening*.

- **1986:** EPA finalized closed loop exclusion.
- **1987:** D.C. Circuit Court ruled that hazardous waste regulation is not limited to closed-loop recycling.
- **1990:** Congress enacted P2Act.
- **1992:** EPA released P2 policy statement that in-process recycling is P2.
Source Reduction Assistance: Hazard Assessment

Focus:

• Applies to products purchased, used, and made by a facility.
  – Products are chemicals, materials, formulations, etc.
• Goal is to reduce hazard by degree or volume.
• The value of hazard assessment has been demonstrated by DfE, Green Chemistry, Region 9 solvent substitution work, etc.
• EPA supports multiple P2 tools for this purpose:
  – Green Chemistry (www.epa.gov/greenchemistry)
  – Design for the Environment (www.epa.gov/DfE)
  – Green Engineering (www.epa.gov/oppt/greenengineering)
  – EPA’s P2 resources (www.epa.gov/p2/tools/p2tools.htm)
Context for Hazard Assessment

• Assessing and reducing the hazards of chemical products
• At the same time, some hazardous chemicals and materials currently have specific industrial uses and few existing substitutes. They are often “building-block” chemicals (the first yields of refining of oil and gas, obtained whether desired or not).
• Managing the environmental footprint of these materials can include:
  – For spent building-block chemicals and some other hazardous secondary materials, pollution is prevented by reusing and remanufacturing them to extend their commercial “afterlife.” This reduces the pace of their creation and destruction, which are their most environmentally intense aspects. These activities generally relate to remanufacturing and green engineering.
Examples from State P2 Leadership Program results reported to EPA in FY 2011:

- Dupont (VA) reported that it reclaimed toluene for third part reuse to Virginia Environmental Excellence Program.
- Pfizer (MI) reported to Michigan Environmental Leadership Program that its pharmaceutical production plant is recovering solvent for reuse on site and for third party reuse.
Remanufacturing and principles of extending material life include:

- Design for separation
- design for commercial “afterlife”
- renew rather than deplete; maximize efficiency
- meet need, minimize excess
- Integrate material and energy flows
Example: Extending the Life of Solvents

Grade 3: Commercial Grades  End Markets  Basic Organic Sector

Natural Gas

Water

Grades 1&2: Laboratory Grades Supply & Middle Markets Pharma and Specialty Sector
Current Scenario: Purify Grades 1 & 2

Use material once* and destruct

* Used as a Reaction Solvent: A Chemical used to dissolve the ingredients in a batch reactor
CREATE Pure Substance (Grade 1 & 2)

Replace Virgin Use as Ingredient

Cascade Uses Grades 1 & 2

Cascade Uses Grade 3

DESTROCT When no longer able to use substance for original purpose

"Adapted from EPA's GREENSCOPE Sustainability Evaluation Model“, Slide 42
Current Grade 1 (Pharmaceutical) Offsite Destruction Routes Transport & Fuel Blending. High Volume Grade 3 Users also shown.
What is Green Engineering?

• Green Engineering is about designing, commercializing and using feasible economical processes and products to reduce pollution at the source and minimize risk.
  – GE designs and improves processes, unit operations, and material management practices
    • e.g. extends the life of chemical products.

• Principles of Green Engineering integrate the fields of chemical engineering and risk assessment and include:
  • Design, retrofit, and optimize the use of feedstocks
  • Reduce or eliminate waste streams
  • Consider all unit operations in processes and products
  • Use of systems approaches that integrate environmental impact assessments
  • Use of life-cycle thinking
  • Use engineering solutions that are cognizant of local geography & culture
Green Engineering in EPA Region 5

- Illinois Institute of Technology
- Northwestern University
- Notre Dame University
- Michigan State University
- Michigan Tech University
- University of Minnesota-Minneapolis
- Ohio University-Athens
- University of Dayton
- University of Toledo
- Youngstown State University
What is Green Chemistry?

- Green Chemistry is about designing chemical products and processes that reduce or eliminate the use or generation of hazardous substances.
  - GC designs new chemical products and pathways

- Some of the Principles of Green Chemistry include:
  - A focus on all types of chemicals (and their lifecycle), e.g., greener products that are
    - Less toxic than current products
    - Inherently safer because they reduce the likelihood or severity of accidents
    - Recyclable or biodegradable after use
    - Safer for the atmosphere (e.g., do not deplete ozone or form smog)
  - Focus on all types of chemical activity, e.g., greener synthesis, reaction conditions, separations, analysis, and monitoring that
  - Use greener feedstocks, reagents, and solvents (e.g., that are innocuous or renewable)
    - Use novel processing methods that prevent pollution at its source
  - Eliminate energy-, material-, or water-intensive steps
  - Incorporate green chemistry at the earliest design stages of new chemical products and processes, but also
    - Make incremental improvements at any stage of a chemical’s lifecycle or a chemical activity
Market-based Opportunities for P2

- Green Chemistry is a key value proposition for business and regional economic development.
- There are a remarkable number of programs across Federal, State, and local government agencies poised to support green chemistry and business development.
- Green Chemistry training for TAPs serves as a critical venue for:
  - Stimulating interest in competitive P2 grants for Green Chemistry innovative research by public research institutions, in partnership with private organizations.
  - Providing advanced supply chain opportunities for reducing generation, use, and disposal of hazardous materials.
  - Supporting small business innovation.
  - Widespread adoption of recognized technologies.
Green Chemistry: Sources of Value Propositions

Improving Economic and Environmental Performance

**Cost Savings (materials & energy)**

- energy savings
- water savings
- natural resources (synthesis and processing efficiencies)
- pollution prevention (hazardous materials generation and waste handling)

**New Products (sources of revenue)**

- sustainable/sustainability products
- enhanced performance characteristics

**Managing/transforming waste**

- liability -> asset
Annual awards to recognize the most innovative green chemistry technologies & to document quantified benefits

• 2012 Awards marked the 17\textsuperscript{th} year
• 88 Winners from 1,492 nominations

\textit{Into the future:}

• Shifting emphasis to expanding upon innovations of nominees
• Amplifying innovation by leveraging technology/manufacturing initiatives at the federal/state/local level, and through private sector interests.
• EPA is working actively to help partner green chemistry innovators with supply chain opportunities, leveraging existing assistance programs.
National P2 Metrics

History of Grant Metrics

- Measuring multi-media hazardous reductions and related economic savings relate to P2 Act source reduction.
- Measuring energy and water savings relate to the P2 Policy Statement and Executive Orders.
- Energy savings metric was changed to greenhouse gas emissions in 2010.
- EPA coordinates with National Pollution Prevention Roundtable P2 Results Task Force.
Collecting Metrics Today

Measures are:

1. Pounds of hazardous materials/emissions reduced.
2. Million metric tons of carbon dioxide equivalent avoided.
4. Dollars that are saved from results produced under the first three measures.

- Details on how to appropriately collect metrics are current in the EPA Regional P2 Measurement Guidance.
- EPA applies formulas to account for results that last more than a year (recurring results).
National P2 Metrics

Metric #1: Hazardous Pounds

- Hazardous means hazardous, toxic, any chemical of regulation or concern (except greenhouse gases, metric #3) at national or state level.
- Hazardous excludes non-hazardous (paper, plastic, metal, wood, and so on.)
- Pounds includes air emissions, water emissions, hazardous waste, and hazardous production inputs.
- Excludes post-discard recycling, but not direct reuse and pre-discard remanufacturing.
- EPA has a gallon-to-pound converter available for putting liquid hazardous wastes into pounds.
**Metric # 2: Dollars Saved**

- **Dollars saved from pollution prevention activities.**
  - This measure counts cost savings associated with the following results achieved from P2 activities: hazardous materials and hazardous emissions reduced, GHG emissions reduced, and water saved.
  - EPA’s P2 Cost Savings Calculator is available on EPA’s Pollution Prevention web page (click on Measurement).
  - The tool converts hazardous materials and hazardous emissions reduced, GHG emissions reduced, and water savings into dollars saved.
  - EPA provides a P2 Cost Savings Calculator on the measurement page at www.epa.gov/p2
National P2 Metrics

**Metric #3: Greenhouse Gas Emissions Reduced**

- Greenhouse gas (GHG) measure: Million metric tons of carbon dioxide equivalent (MMTCO$_2$e).
  - EPA provides a P2 Greenhouse Gas Gas Calculator on the measurement page at www.epa.gov/p2
Metric #4: Gallons of Water Saved

- Focuses on water saved/conserved from P2 activities.
  - If a million gallons of water effluent are avoided, that would be a millions gallons of water saved and 10 pounds of hazardous pounds reduced.
The Greening Chemistry tab of the Greenhouse Gas Calculator addresses the global warming potential (GWP) of various chemicals, and provides for determining the benefits of chemical substitutions.

- The calculator is on measurement page of the P2 website. The link to the website is www.epa.gov/p2.
## GHG Calculator: Greening Chemistry Tab

The GHG Calculator: Greening Chemistry Tab is a tool designed to calculate GHG reductions from reducing the use of high global warming potential (GWP) chemicals and from switching to chemicals with little to no global warming impact. This tab is particularly useful for industries and projects that wish to reduce their carbon footprint and contribute to climate change mitigation.

### How to Use This Tab:

**Instructions to Obtain MTCO₂ₑ**

Enter the mass of each chemical avoided for a project in the column "lbs. Chemical Avoided." Total lbs. CO₂ₑ avoided and MTCO₂ₑ reduced will be displayed for each project in the rows "Total lbs. CO₂ₑ Avoided" and "Total MTCO₂ₑ Reduced."

**Calculation Description**

MTCO₂ₑ = lbs. Chemical Avoided \* (100-year Global Warming Potential\(^*\) \* (0.4536 kg / lbs.) \* (1 MTCO₂ₑ / 1,000 kg CO₂ₑ))

### Example

**Greening Chemistry: GHG Savings from Reduced Emission of GHG Chemicals Directly**

This tab calculates GHG reductions from reducing use of high GWP chemicals and from switching to chemicals with little to no global warming impact. The Greening Chemistry tab determines the CO₂ₑ equivalency of 95 chemicals listed by the International Panel on Climate Change (Carbon Dioxide (CO₂), Methane (CH₄), Nitrous Oxide (N₂O), Chlorofluorocarbons (CFCs), numerous Hydrofluorcarbons (HFCs), numerous Perfluorocarbons (PFCs), and Sulphur Hexafluoride (SF₆)) and those listed by EPA's GHG Reporting Program.

### Industrial Chemical Reduced

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>CAS Number</th>
<th>Global Warming Potential (100 year)</th>
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<tr>
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<td>Methane</td>
<td>74-85-1</td>
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<td>Halon-2402</td>
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<td>Carbon tetrachloride</td>
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### Project 1, Project 2, Project 3, Project 4

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<th>Project 4</th>
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<td>MTCO₂ₑ</td>
<td>MTCO₂ₑ</td>
<td>MTCO₂ₑ</td>
</tr>
</tbody>
</table>
Greening Chemistry Tab

• Calculates GHG reductions from: a) using less high-GWP chemicals; and, b) switching to chemicals with little to no global warming impact.
  – Gives CO2 equivalency of 95 chemicals from International Panel on Climate Change [Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Chlorofluorocarbons (CFCs), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur Hexafluoride (SF6)] plus ones from EPA’s GHG Reporting Program.
  – Enter mass of each chemical avoided for a project in "lbs. chemical avoided" column.
  – Total lbs CO2e avoided and MTCO2e reduced will be displayed for each project in rows "ALL CHEMICALS".
Greening Chemistry Tab -- Example

- ABC Company improved leak detection in their use of sulfur hexafluoride in their electrical distribution equipment.
- ABC saved 600 pounds of SF6 for the year. [Input 600 pounds into cell I47 and see Output of 14,340,000 pounds of CO2 in cell I12 and 6,504 MTCO2e in cell I10]