# Yale –UNIDO Train the FACILITATOR WORKSHOP

# day 1

## Learning Objectives

* Describe historical and current view of the society, economy and environment with sustainability
* Define Sustainability and its role as a business driver.
* Describe myths for businesses when integrating sustainability into their organizations.
* Recognize tools to measure sustainability.
* Understand the role of chemicals in the society, economy and environment.
* Recognize how chemicals can positively and negatively impact the world.

### 9.00 – 10.30 AM Morning Session I – Sustainability I (1.5h)

1. Sustainability – Myths and Facts
2. Society, Economy, and the Environment

### Break

### 10.45 – 12.15 PM Morning Session II – Sustainability II

1. Business and Sustainability
   1. Applying Green Chemistry to Management
2. Different Models of Sustainability
3. Case Study: The Interface Company
4. In-Class Discussion

### Lunch

### 1:15 – 2:45 PM Afternoon Session I - Sustainability III

1. Describe Processes for Reporting and Measuring Sustainable Actions
2. Life Cycle Assessment
3. Definitions & Examples
4. In-Class Exercise

### Break

### 3:00 – 4:30 PM Afternoon Session II – Disasters and Unintended Consequences

1. Chemical and Industrial Accidents
   1. Union Carbide, 1984
   2. Cuyahoga River, 1969
   3. Port of Tianjin, 2015
2. Unintended Consequences
3. Green Chemistry is Everybody’s Job
4. Perspective and Context
5. Green Chemistry – Where do we go from here?

# day 2

## Learning Objectives

* Review the definition and the Twelve Principles of Green Chemistry.
* Describe the benefits of green chemistry in society, economy and environment.
* Analyze the efficiency of various approaches to chemical design.
* Identify the advantages and disadvantages of various process feedstocks.

### 9.00 – 10.30 AM Morning Session I – Definition & Benefits of Green Chemistry

1. Green Chemistry and Design Criteria
2. Chemical Design
   1. Current Innovations in Chemical Design
3. Green Chemistry Design in Other Fields
4. The Market for Green Chemistry
5. Green Chemistry Benefits are In Demand
6. Applications of Green Chemistry - Examples

### Break

### 10.45 – 12.15 PM Morning Session II – The 12 Principles of Green Chemistry I

1. The Twelve Principles of Green Chemistry
2. Industrial examples of Green Chemistry

### Lunch

### 1:15 – 2:45 PM Afternoon Session I - The 12 Principles of Green Chemistry II

1. The Twelve Principles of Green Chemistry
2. Industrial examples of Green Chemistry
3. In-Class exercise

### Break

### 3:00 – 4:30 PM Afternoon Session II – Renewable Feedstocks

1. Energy and Feedstock Consumption
2. Petroleum
3. Renewable Feedstocks
   1. Biomass Feedstocks
   2. Carbohydrate Feedstocks
   3. Lipid Oils and Terpenes as Feedstocks
   4. Protein Feedstocks
4. Renewable Feedstocks as a Source of Energy
5. First, Second, and Third Generation Feedstocks
6. The Advantages and Drawbacks of Biofuel

# Day 3

## Learning Objectives

* Explain transformational role of catalysis on industry and the associated material and energy benefits, including biocatalysts.
* Assess impacts of solvent usage and identify green chemistry alternative solvent systems and the subsequent benefits.
* Discuss the ways to process waste and identify its potential as a feedstock.
* Identify different metrics in green chemistry for implementing best practices.

### 9.00 – 10.30 AM Morning Session I – Catalysis

1. Activation Energy for Reaction
2. What is a Catalyst?
3. Types of Catalysts
4. Catalysts and Sustainability
5. Important Improvements Using Catalysts
6. Enzymatic Reactions
7. Examples and Considerations

### Break

### 10.45 – 12.15 PM Morning Session II – Solvents

1. What are solvents and how are they used?
2. Conventional Solvents
3. Alternative Solvents
4. Solvent Selection
5. In-Class Exercise
6. Solvent Replacement

### Lunch

### 1:15 – 2:45 PM Afternoon Session I - Waste Prevention

1. The Waste Treatment Pyramid
2. Reduced Solvent Use
3. Waste as a Feedstock
4. Biodegradation of Waste
5. Designing Processes to Include Biodegradation of Waste
6. In-Class Exercise

### Break

### 3:00 – 4:30 PM Afternoon Session II – Metrics

1. Why do We Need Metrics in Green Chemistry?
2. Established Metrics in Green Chemistry
   1. Atom Economy
   2. Environmental (E) Factor
   3. Atom Utilization
   4. Reaction Mass Efficiency
3. Additional Metrics Used in Green Chemistry
   1. Process Mass Intensity
   2. Life Cycle Assessment
   3. Ecological Indicator/Ecological Footprint
4. In-Class Discussion

# Day 4

## Learning Objectives

* Identify estimation tools that integrate the chemical properties and toxicological data for chemical design.
* Recognize role of green chemistry in innovation, both incremental and transformational.
* Review the path from theory to practice.
* Discuss a successful case study examples of green chemistry in industry and small businesses.

### 9.00 – 10.30 AM Morning Session I – Designing for Reduced Hazard I

1. Hazard and Risk – Past and Present
2. Toxicology
3. In-Class Discussion
4. Assessing Hazards and Exposure
   1. What Happens When You’re Exposed?

### Break

### 10.45 – 12.15 PM Morning Session II - Designing for Reduced Hazard II

1. In-Class Exercise
2. Hazard Minimization Through Molecular Design
3. QSAR - Quantitative Structure Activity Relationship
4. Molecular Design Research Network (MoDRN)

### Lunch

### 1:15 – 2:45 PM Afternoon Session I – From Theory To Practice

1. Implementation: Why, What, and How
2. Understanding Context
   1. Green Chemistry in the Marketplace
3. Identifying Opportunities
   1. Life Cycle and Green Chemistry Principles as a Guide to Finding Opportunity
4. Delivering Innovation
5. Green Chemistry Strategies at All Stages
   1. Green Chemistry Assessment Tool
6. How to Proceed: Moving Forward

### Break

3:00 – 4:30 PM Afternoon Session II – Innovation

1. Transformative Innovation
   1. What is it that we really want?
2. Nature as Inspiration
   1. Design Challenges
3. Biomimicry
   1. Color
   2. Adhesives
   3. Self-Cleaning
4. There is Still More We Can Learn from Nature

# Day 5 Partnering Country

## Learning Objectives

* Learn about Green Chemistry Challenges and Opportunities in Partnering Countries

### 9.00 – 10.30 AM Morning Session I

* Learning about Green Chemistry Landscape
* Discuss Challenges and Opportunities
* Partner’s Case study

### Break

### 10.45 – 12.15 PM Morning Session II

* Partner’s Case study

### Lunch

### 1:15 – 2:45 PM Afternoon Session I (1.5h)

* Lessons Learned and the Path Forward

### Closing Remarks