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## Energy Efficiency Improvement - Petrochemical Industry

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## Module 1: Introduction

### Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** the economic and environmental drivers for energy efficiency in the U.S. petrochemical industry.
- **Identify** the core components of the "triple bottom line" and its relation to industrial energy management.
- **Analyze** the market share and energy intensity of the petrochemical sector relative to the total U.S. chemical industry.

*Executive Summary:* Energy efficiency is a critical business strategy for the petrochemical industry, where energy and raw materials represent approximately two-thirds of the total value of shipments. Beyond direct cost reduction, efficiency investments mitigate the risks of energy price volatility, increase productivity, and provide a cost-effective pathway for emissions reduction.

### Industry Drivers and Economic Context

As U.S. manufacturers navigate a competitive global environment, reducing production costs without compromising **product yield or quality** is essential. The petrochemical industry is particularly sensitive to **uncertain energy prices**, which directly impact predictable earnings for both public and private entities.

- **Bottom Line Impact:** Improving energy efficiency is a direct lever for increasing a plant's profitability.
- **Value Added:** Rising energy costs are currently driving up operating expenses and decreasing the industry's value added.
- **Co-benefits:** Modern energy-efficient practices often lead to increased company productivity and significant reductions in **greenhouse gas emissions**.

### Environmental Strategy and the Triple Bottom Line

Energy use serves as a primary source of emissions, making efficiency improvements an attractive alternative to expensive **end-of-pipe solutions**.

- **Strategic Integration:** Energy efficiency should be a core pillar of a firm's environmental strategy.
- **Triple Bottom Line:** This concept focuses on the interconnectedness of **social, economic, and environmental** business aspects.
- **Ecosystem Dependency:** Society depends on the economy, and the economy remains dependent on the global ecosystem, which represents the ultimate bottom line.



### Sector Scope and Market Scale

The U.S. chemical industry maintains its position as the largest in the world, employing nearly **800,000 people**. Within this Energy Guide, the petrochemical industry is defined by facilities producing:


- Basic petrochemicals.
- Other organic chemicals.
- Plastic materials and resins.

The petrochemical sector accounts for roughly **20% of employees and value added**, yet it commands **30% of product shipments** for the total chemical industry.

### Energy Intensity and Cost Factors

The petrochemical sub-sector is significantly more energy-intensive than other chemical industries. Its energy profile includes:

- **70%** of the chemical industry's total fuel expenditures.
- **40%** of the chemical industry's total electricity expenditures.
- **Raw Materials:** Costs for raw materials and energy (largely fossil fuel-derived) constitute about **2/3rd of the total value of shipments**.

 **Design Tip:** Focus on proven and **commercially available** practices. While new technologies emerge continuously, implementing demonstrated, cost-effective measures provides the most immediate impact on energy intensity and emissions.

### Guide Objectives

This report provides a framework for energy managers to develop effective corporate and plant management programs. The methodology includes:

1. Describing industry trends and **production structures**.
2. Detailing main **production processes**.
3. Summarizing **energy end uses**.
4. Identifying specific **demonstrated efficiency opportunities**.



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Checkpoint Quiz

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**1. What percentage of the total U.S. chemical industry's fuel expenditures is attributed to the petrochemical sector?**

- a) 20%
- b) 40%
- c) 70%
- d) 90%

**Answer:** (c). The petrochemical industry is highly energy-intensive, responsible for 70% of fuel expenditures and 40% of electricity expenditures within the total chemical sector.

**2. According to the "Triple Bottom Line" concept, which three aspects must a business focus on?**

- a) Production, Quality, and Yield
- b) Social, Economic, and Environmental
- c) Research, Development, and Marketing
- d) Domestic, Global, and Financial

**Answer:** (b). These three interconnected aspects form the "triple bottom line" introduced by the World Business Council on Sustainable Development.

**3. In the petrochemical industry, energy and raw material costs typically represent what fraction of the total value of shipments?**

- a) 1/4th
- b) 1/3rd
- c) 1/2
- d) 2/3rds

**Answer:** (d). Energy and raw materials derived from fossil fuels are the most significant cost factors, roughly totaling two-thirds of industry shipments.



## Module 2: The U.S. Petrochemical Industry

### Learning Objectives

By the end of this section, you will be able to:

- **Differentiate** between the organic and inorganic chemical industries based on raw materials and base products.
- **Classify** facilities using NAICS codes and identify the three primary 6-digit industries focused on in this guide.
- **Analyze** the economic significance, geographic distribution, and trade dynamics of the U.S. petrochemical sector.

*Executive Summary:* The U.S. petrochemical industry is a highly energy-intensive segment of the world's largest chemical industry. While it represents a smaller fraction of the total chemical workforce (17%), it generates nearly 30% of total shipments. The sector is characterized by heavy geographic concentration in the Gulf Coast and a shift toward global competition with low-cost feedstock regions like the Middle East.

### Industry Classification and Scope

The chemical industry produces over 70,000 diverse compounds. To manage this complexity, the industry is subdivided into two primary categories:

- **Inorganic Chemical Industry:** Produces products from non-carbon elements (e.g., phosphoric acid, nitrogenous fertilizers, chlorine).
- **Organic Chemical Industry:** Uses hydrocarbon raw materials to produce approximately 10 base products. Today, **95% of organic products** are derived from oil and natural gas, with a marginal but growing share from biomass.

### NAICS Sub-sectors

The North American Industry Classification System (NAICS) distinguishes seven 4-digit sub-sectors (3251 through 3259). This Guide specifically targets large-volume, energy-intensive organic chemicals and resins within the following three 6-digit industries:

- **325110 Petrochemical Manufacturing:** Aliphatic hydrocarbons (ethylene, propylene, butylene) and cyclic aromatic hydrocarbons (benzene, toluene, styrene).
- **325199 All Other Basic Organic Chemical Manufacturing:** Organic products excluding aromatics, industrial gases, and synthetic dyes.
- **325211 Plastic Material and Resin Manufacturing:** Resins, plastic materials, and non-vulcanizable thermoplastic elastomers.

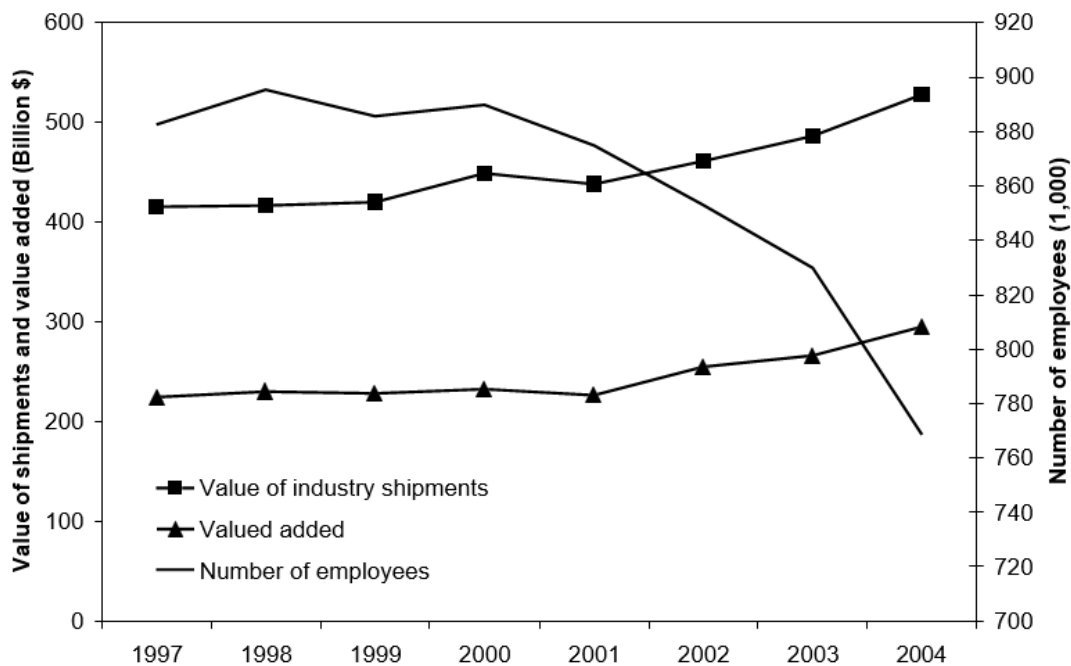


⚠ **Safety Constraint:** Industry classification is often complicated by **vertical integration**. A single site may operate a steam cracker (Petrochemicals) and convert the output into polyethylene (Resins), potentially shifting its statistical classification.

### Economic Trends for the Total Chemical Industry

In 2004, the U.S. chemical industry generated **\$528 billion** in shipments and **\$295 billion** in value added.

- **Efficiency Gains:** While value added increased by 31% from 1997 to 2004, the number of employees decreased from 883,000 to 769,000.
- **Sub-sector Contribution:** The **Pharmaceuticals and Medicines** sector (3254) creates the largest share of value added (30%), followed by **Basic Chemicals** (26%).



Source: U.S. Census Bureau (2003 and 2005)

Figure 2-1: Value of shipments, value added and number of employees in the U.S. chemical industry.



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