THE UNIVERSITY OF BRITISH COLUMBIA Experiential Learning Hub Faculty of Applied Science

CHEMICAL AND BIOLOGICAL ENGINEERING Industry Guide

Introduction

Chemical and Biological Engineers are often regarded as "universal problem solvers" for their ability to creatively and innovatively address some of the world's most critical challenges, such as sustainable energy, clean water, environmental preservation, and human health. By transforming raw materials and biological resources into essential products and processes, these engineers play a pivotal role in shaping efficient, sustainable, and innovative solutions across numerous industries.

Chemical and Biological Engineering (CHBE) is a highly interdisciplinary and versatile field, equipping professionals with a robust foundation in chemical, biological, and physical sciences, along with practical engineering skills. This unique combination enables CHBE graduates to excel in a wide range of industries and pursue diverse career paths.

This document provides an overview of the industries and organizations where chemical and biological engineers can apply their expertise. While not an exhaustive catalog, it offers insights into various career opportunities. The industry descriptions included here are based on personal experiences, discussions with industry professionals, and extensive research. However, they may not fully capture the specific practices or nuances of every company and should be seen as generalized overviews rather than definitive guides.

Key Areas of Study:

 Thermodynamics, Fluid Mechanics, Heat and Mass Transfer, Process Design, Process Control, Reaction Engineering, Materials Science, Biochemical Engineering, Environmental Engineering, Energy Systems, Separation Processes, Polymer Science, Catalysis, Nanotechnology, Pharmaceutical Engineering, Food Processing, Sustainability Engineering, Computational Modeling, Process Safety, Waste Management.

Industries

Chemical and Biological Engineering (CHBE) is foundational to a wide range of industries that address critical societal needs and drive innovation. In the energy sector, CHBE professionals develop and optimize processes for sustainable fuel production, including renewable energy sources such as biofuels and hydrogen. The environmental industry benefits from CHBE expertise in waste management, pollution control, and water treatment, promoting sustainable resource use and ecosystem protection. In pharmaceuticals and biotechnology, chemical and biological engineers design processes for drug development, manufacturing, and bioprocess optimization, improving healthcare outcomes. The food and beverage industry relies on CHBE for innovations in food processing, safety, and preservation. In materials science, CHBE contributes to the development of advanced materials like polymers, composites, and nanomaterials for diverse applications. These industries underscore the critical role of CHBE professionals in addressing global challenges and fostering innovation across sectors.

Industries

ENGINEERING CONSULTING

Engineering consulting combines expertise and innovation to deliver tailored solutions for complex Chemical and Biological Engineering (CHBE) challenges. Consulting firms address intricate problems in process design, optimization, and sustainability using proprietary tools, cutting-edge methodologies, and deep industry insights. This career path enables CHBE graduates to apply their technical knowledge in diverse industries, positioning them as versatile and effective problem solvers.

ESSENTIAL SKILLS:

- Project Management
- Process Optimization
- Compliance with Environmental and Safety Standards
- Data Analysis & Simulation
- Technical Expertise in CHBE Disciplines
- Communication and Stakeholder Engagement

POSITIONS:

- Entry Level: Junior Process Engineer, Junior Consultant
- Mid-Level: Process Optimization Engineer, Consulting Engineer
- Senior: Lead Project Engineer, Senior Consultant, Principal
 Process Engineer

ENERGY

The energy sector offers diverse opportunities for Chemical and Biological Engineers, encompassing both traditional and renewable energy industries. Engineers play a critical role in optimizing energy processes, assessing environmental impacts, and driving the transition to sustainable energy solutions. This field allows CHBE professionals to apply their expertise to address pressing global challenges in energy production and consumption.

ESSENTIAL SKILLS:

- Process Design and Optimization
- Environmental Impact Assessment
- Energy Systems Analysis
- Compliance with Regulatory Standards
- Problem-Solving and Innovation

POSITIONS:

- Entry Level: Process Engineer, Energy Analyst
- Mid-Level: Renewable Energy Engineer, Refinery Engineer
- Senior: Energy Systems Consultant, Sustainability Manager

CHEMICAL PROCESSING

Chemical processing is one of the most traditional and foundational areas within Chemical and Biological Engineering. This industry involves the transformation of raw materials into valuable chemical products through processes such as heating, cooling, pressure control, and agitation. Engineers in this field design, optimize, and maintain the systems that produce chemicals used in everyday products, ranging from pharmaceuticals to cleaning products.

ESSENTIAL SKILLS:

- Process Design and Optimization
- Heat and Mass Transfer
- Safety Management and Hazard Analysis
- Energy Efficiency and Waste Reduction
- Chemical Reaction Engineering

POSITIONS:

- Entry Level: Process Engineer, Chemical Plant Engineer
- Mid-Level: Process Design Engineer, Operations Engineer
- Senior: Plant Manager, Senior Process Engineer, Process
 Improvement Specialist

PULP AND PAPER

The pulp and paper industry is a key sector within Chemical and Biological Engineering, particularly in Canada due to the country's strong forestry industry. The transformation of raw lumber into paper products requires extensive chemical processing and a solid understanding of chemical engineering principles. Engineers in this field focus on optimizing processes to reduce energy consumption, maximize efficiency, and ensure consistent product quality.

ESSENTIAL SKILLS:

- Process Optimization and Control
- Chemical Reaction Engineering
- Pulping and Papermaking Technologies
- Energy Management and Waste Reduction
- Environmental and Sustainability Practices

POSITIONS:

- Entry Level: Process Engineer, Pulping Engineer
- Mid-Level: Production Engineer, Chemical Process
 Engineer
- Senior: Plant Manager, Senior Process Engineer, Operations Manager

Industries

ELECTROCHEMISTRY AND FUEL CELLS

The electrochemistry and fuel cell industry is experiencing rapid growth, driven by the rise of electric vehicles and the continued use of batteries in portable electronics. The demand for advanced energy storage and conversion technologies makes this field an exciting area for Chemical and Biological Engineers. Engineers may work on research and development of novel electrochemical processes, or scale up existing technologies for commercial use. Electrochemistry also applications extend beyond energy production to include processes such as electroplating, electrosynthesis, and electrocatalysis.

ESSENTIAL SKILLS:

- Electrochemical Systems Design
- Battery Technology and Fuel Cell Engineering
- Materials Science and Nanotechnology
- Process Scale-up and Optimization
- Research and Development

POSITIONS:

- Entry Level: Electrochemical Engineer, Battery
 Development Engineer
- Mid-Level: Fuel Cell Engineer, Process Development Engineer
- Senior: Senior Electrochemical Engineer, R&D Manager, Principal Engineer

CONTROL SYSTEMS

Control systems are integral to the operation of chemical plants, ensuring the safe, efficient, and consistent operation of processes. Control engineers design the systems that regulate and automate plant operations. While control systems are typically a subfield of either chemical or electrical engineering, they are essential in managing complex processes and automating tasks within a plant. These engineers use principles of automation, feedback loops, and sensor integration to ensure optimal performance and safety

ESSENTIAL SKILLS:

- Process Control Design
- Automation and Feedback Systems
- Systems Modeling and Simulation
- Instrumentation and Sensor Technology
- Troubleshooting and Optimization

Positions:

- Entry Level: Control Systems Engineer, Process Control Engineer
- Mid-Level: Automation Engineer, Control Systems Analyst
- Senior: Senior Control Engineer, Process Control Manager, Systems Integration Specialist

MINING AND METALS

While mining is a distinct engineering discipline, a background in chemical engineering provides valuable knowledge applicable to various roles within the mining and metals industry. This sector plays a major role in resource extraction, refinement, and transport, especially in regions like Canada and Australia. Chemical engineers in mining are involved in extracting valuable minerals, optimizing refining processes, and addressing the environmental impact of mining operations. Mining engineers also engage in site exploration, feasibility studies, and waste minimization strategies. However, similar to the oil and gas industry, mining is vulnerable to cyclical fluctuations driven by commodity prices. Mining roles are often located in rural or remote areas and may require rotational shifts for site work.

ESSENTIAL SKILLS:

- Mineral Processing and Metallurgy
- Resource Extraction and Refining
- Environmental Impact Assessment
- · Feasibility Studies and Site Exploration
- · Waste Minimization and Sustainability

POSITIONS:

- Entry Level: Process Engineer, Mining Engineer
- Mid-Level: Metallurgist, Resource Development Engineer
- Senior: Senior Mining Engineer, Environmental Engineer, Operations Manager



Industries

ENVIRONMENTAL ENGINEERING

Environmental engineering, while its own distinct program, shares significant overlap with chemical and biological engineering. At UBC, CHBE offers several electives that are foundational to environmental engineering, including waste management, air pollution, water treatment, sustainability, and life cycle analysis. Many companies hire "in-house" environmental engineers to design or optimize processes aimed at minimizing emissions and ensuring compliance with environmental regulations at municipal, provincial, or federal levels. Additionally, there are specialized environmental consulting firms that work on behalf of organizations to tackle these challenges. Environmental engineers are also employed by governments to create and enforce legislation governing emission standards.

However, it's important to note that some engineers are contracted by companies to identify ways to comply with environmental regulations while avoiding penalties. In some cases, the focus may be more on technicalities than on making significant improvements in sustainability practices. For engineers passionate about environmental protection and sustainability, this aspect of the field can sometimes be a point of frustration.

ESSENTIAL SKILLS:

- Environmental Impact Assessment
- Waste Management and Treatment
- Sustainability and Energy Efficiency
- Regulatory Compliance
- Life Cycle Analysis

POSITIONS:

- Entry Level: Environmental Engineer, Waste Management Specialist
- Mid-Level: Air Quality Specialist, Water Treatment Engineer, Sustainability Consultant
- Senior: Senior Environmental Engineer, Regulatory Affairs Manager, Environmental Policy Advisor

PHARMACEUTICALS

The pharmaceutical industry, unlike resource-based sectors that are often located in rural areas, is primarily centered in urban hubs such as Montreal, Toronto, and Vancouver. The COVID-19 pandemic highlighted the importance of strengthening Canada's domestic pharmaceutical production, leading to initiatives like the construction of a vaccine production facility, set to be completed in 2024. This sector is highly regulated, where attention to detail is crucial, as lapses can lead to serious health risks.

Chemical and biological engineers in the pharmaceutical industry often focus on designing or scaling up production processes, optimizing existing methods, and ensuring compliance with rigorous government regulations. Engineers may also be responsible for developing and maintaining quality control systems to monitor and test products to meet safety standards. A solid foundation in biological processes is beneficial for those pursuing careers in this field, as it complements the technical expertise required in pharmaceutical production.

ESSENTIAL SKILLS:

- Process Design and Optimization
- Regulatory Compliance
- Quality Control and Assurance
- Biological Process Understanding
- Attention to Detail

POSITIONS:

- Entry Level: Process Engineer, Quality Control Analyst
- Mid-Level: Pharmaceutical Process Engineer, Validation
 Specialist
- Senior: Senior Production Engineer, Regulatory Affairs
 Manager, Quality Assurance Lead



Technical Skills

CORE SKILLS

MATERIALS SCIENCE:

Proficiency in understanding the properties, behaviors, and processing of materials, including polymers, ceramics, metals, and composites, and how they apply to product development and manufacturing.

PROCESS DESIGN & OPTIMIZATION:

Knowledge of process design principles, including mass and energy balances, process flow diagrams, and equipment selection. Focus on optimizing chemical processes for efficiency, safety, and sustainability.

THERMODYNAMICS:

A strong foundation in thermodynamics to analyze and predict the behavior of substances, phase equilibria, and energy transfer in chemical processes.

FLUID MECHANICS:

Understanding the principles of fluid flow, including laminar and turbulent flow, pressure drop calculations, and pump and piping system design, critical for transport processes in chemical engineering.

REACTION ENGINEERING:

Knowledge of chemical reaction kinetics and reactor design, including batch, continuous, and catalytic processes, to ensure efficient and safe production of chemical products.

BIOPROCESS ENGINEERING:

Understanding of biological processes used in pharmaceutical, food, and environmental industries, including fermentation, enzyme catalysis, and bioreactor design.

MATH & COMPUTATIONAL SKILLS:

Proficiency in mathematical modeling, numerical methods, and computational tools to solve complex chemical engineering problems, including simulations and optimization techniques.

REGULATORY COMPLIANCE & SAFETY:

Familiarity with industry standards, safety protocols, and environmental regulations that govern chemical production and processing industries, ensuring processes comply with legal and safety requirements.

SOFTWARES AND TOOLS

SIMULATION & DESIGN SOFTWARE:

- Aspen Plus, Aspen HYSYS, CHEMCAD: For process simulation and optimization in chemical production.
- COMSOL Multiphysics: For modeling chemical processes involving heat, mass, and momentum transfer.

PROCESS CONTROL & OPTIMIZATION SOFTWARE:

- MATLAB/Simulink: For process control modeling and dynamic simulations.
- PLC Software (Siemens Step 7, Rockwell Studio 5000): For process automation control.

BIOPROCESSING SOFTWARE:

- BIOCAD: For simulating bioprocesses like fermentation and cell culture.
- GAMS: For process optimization in bioprocessing systems.

MATERIALS & DESIGN SOFTWARE:

- ANSYS Fluent, COMSOL: For simulating fluid dynamics and heat transfer in processes.
- AutoCAD: For designing plant layouts and equipment.

DATA ANALYSIS & VISUALIZATION:

- Python (Pandas, Matplotlib, NumPy)
- Excel, Minitab: For statistical analysis

PROGRAMMING & SCRIPTING TOOLS:

- Python, MATLAB, R: For scripting in simulations
- LabVIEW: For automation in testing and control systems.

TESTING & MEASUREMENT:

- Process Analyzers (GC, Mass Spectrometers): For chemical analysis.
- pH Meters, Thermocouples, Flow Meters: For measuring process parameters.

How to get Involved

- Engineering Design Teams
- CHBE Undergraduate Council
- <u>EUS</u>
- UBC Clubs
- Personal Projects
- <u>UBC Work Learn Program</u>

Other Resources

- National Research Council Canada (NRC):
- <u>Canadian Society for Chemical Engineering</u> (CSChE)
- About your degree Chemical & Biological
- UBC's <u>CHBE Website</u>

• SuperPro Designer