CHEMICAL AND BIOLOGICAL ENGINEERING Discipline Guide

Introduction

Chemical engineers are universal engineers, creatively and innovatively solving global energy, water and environmental issues while transforming raw materials into products that society depends on. Chemical Engineering is a general field of study that equips you with skills and knowledge that can be applied to a wide range of different industries and career paths.

This document is meant to provide an overview of the industries and companies that chemical engineers may work for. This is not a comprehensive list, as it would be impossible to fully capture all potential career paths for chemical engineers. The descriptions of each industry provided below are also generalized and are the opinion of a single or a few individuals, and some statements may be anecdotal.

The information here has been gathered through personal experience, discussion with members of industry, or online research. They may not necessarily apply to every company in that industry.

Industries

There are many industries that chemical engineers can work in based on their interests and passion. This section is meant to provide an overview of the industries that chemical engineers may work for.

ENGINEERING CONSULTING

Consulting firms are organizations contracted by other companies to design, research, and solve problems. A term you may hear frequently in the consulting industry is EPC: Engineering, Procurement, Construction. The scope of work that consulting firms complete varies depending on the client's needs. Projects could involve detailed design, high-level proof of concept, financial feasibility, and everything in between. People tend to gravitate towards consulting if they are interested in working on a broad range of projects that continuously evolve and change on a case-by-case basis.

If you choose to work in consulting, be prepared to work in multi-disciplinary teams comprised of engineers from various backgrounds and non-engineers. In general, consulting roles will involve occasional site visits (potentially international) and frequent stakeholder discussions.

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ENERGY

The energy sector represents one of the largest industries within the chemical and biological engineering specialization. Oil and gas accounts for a significant number of jobs within the energy sector and are also typically some of the highest paying for new grads. There are many roles within the oil and gas industry for chemical engineers, and they can include extraction, refining, transport, etc. Oil and gas engineers will also frequently assess environmental impact that new projects pose. It should be noted that the oil and gas sector is particularly susceptible to "boom-bust" cycles that coincide with the rising and falling price of oil, as well as government environmental policies and pushes towards renewable energy. While there is a refinery in the lower mainland, oil and gas jobs will be concentrated within Alberta and the prairies. Renewable energy is also a rapidly growing industry as society faces the issue of climate change. Some categories within renewable energy include solar, wind, hydro, renewable natural gas, and nuclear fusion. While a full transition towards renewables would be ideal for the environment, modern society does not yet have the means to function on renewables alone. As such, much of the work that renewable energy engineers perform includes feasibility studies, life-cycle analyses, and optimization of technologies to complement or replace fossil fuels.

PULP AND PAPER

Pulp and paper is a staple chemical engineering field in Canada due to the large forestry industry and resource based economy. The transformation from lumber to paper products involves considerable processing and a strong understanding of chemical engineering fundamentals. Again, work will likely be focused on optimization of a pre-existing process to reduce energy use, maximize throughput, and maintain quality. Like most other resource-based industries, there are limited positions around the lower mainland. There is much more opportunity in Northern BC or on Vancouver Island as these locations are closer to the forestry industry.

CHEMICAL PROCESSING

If you ask someone to imagine what a chemical engineer does, they will likely imagine a chemical processing plant. Chemical processing is the most 'classical' form of chemical engineering, and many of the other industries mentioned in this document like oil and gas, pulp and paper, food production, are all just specific forms of chemical processing. Processing plants will take chemical reagents and introduce heat, pressure, and agitation to produce the desired products. These chemical products become the basis of many items we use in our day-to-day lives. Look at the label of any shampoo bottle and you will see ingredients that were produced in a chemical engineering plant.

Engineers may be tasked with designing an entirely new processing plant, or more likely, improving overall plant efficiency by minimizing energy loss, reducing waste, and increasing throughput. Working in chemical plants requires strong understanding of chemical engineering fundamentals. You may be working in the office and frequently visiting the plant depending on your specific role. As with any processing industry, there is the risk of high temperatures, pressures, and toxic substances. You should always have a safety-first mindset when working in any field related to chemical processing.

ELECTROCHEMISTRY AND FUEL CELLS

The battery/fuel cell industry is growing with the rapid adoption of electric vehicles and continued use of batteries within hand-held devices. There are already several start-ups in the lower mainland and the number continues to grow every year. The job market will likely be stable with continued growth in the future as society becomes increasingly reliant on battery technology. The work can entail research and development of novel processes, or scale-up of existing technologies. Electrochemistry includes other processes aside from ones focused on just energy production such as electroplating, electrosynthesis and electrocatalysis.

Electrochemistry is a highly technical field that is still rapidly advancing. Currently there is limited exposure to the material within the CHBE curriculum. Further development in the field may require additional personal study, courses, or on the job training.

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CONTROL SYSTEMS

At the core of every processing plant is a control logic and philosophy that governs the plant and ensures the quality, throughput, and safety of the process is maintained. Control systems is not a traditional engineering discipline itself, so the fundamental principles are typically covered within chemical or electrical engineering, depending on the school. Control engineers design and develop the control philosophy for a plant and how certain equipment should be tuned and optimized so that parts of the plant can be automated.

For example, if you wanted a system that maintained the temperature of a reactor, what would you need? How many temperature sensors? How many valves? If a valve malfunctions, should it default to open or closed? What is the thermal conductivity of the cooling solution? These are all questions that the control engineers must be able to answer. The roles typically require excellent analytical and logic-based reasoning skills. Generally, this role is more office-work, with occasional site visits. If you are a control/instrumentation technician who is installing and repairing equipment, then you may be in the field much more often.

MINING AND METALS

Although mining is its own engineering specialization, a chemical engineering background provides a strong foundation of knowledge that can be applied to mining roles. The mining industry is particularly large in Canada and Australia, but it is a global industry. Like oil and gas engineers, mining engineers are primarily concerned with the extraction, refinement, and transport of minerals/metals. Some mining engineers will be tasked with exploration to discover viable mine sites and conduct feasibility studies for opening said sites. Mining engineers also need to assess the environmental impacts of the mining process and design methods to minimize waste and contamination. Like oil & gas, the mining industry can pay very well but it can also be susceptible to boom and bust cycles. It should be noted that mining roles will often be concentrated in rural areas, away from large cities. Sometimes, they will involve rotational shifts that involve flying to site for weeks at a time and then having 1-2 weeks off.

ENVIRONMENTAL ENGINEERING

While environmental engineering is its own program at UBC, there is considerable overlap between the two disciplines. CHBE has multiple electives that are foundational for environmental engineers, such as waste management, air pollution, water treatment, sustainability, and life cycle analysis. Some companies will hire 'in-house' environmental engineers that design or optimize processes to minimize emissions and ensure that the company is meeting all environmental regulations/requirements set by the municipal, provincial or federal governments. There are also dedicated environmental engineering consulting firms that are contracted by companies to do the tasks mentioned earlier. Environmental engineers are also often hired by the government to create the legislation that specifies the emission limits.
It should be noted that some environmental engineers are occasionally hired or contracted by companies specifically to see how they can 'find loopholes' within environmental legislation and meet requirements on a technicality. The goal for some companies is to minimize the number of fines they receive without significantly altering their business practices. This absolutely does not apply to every company, but for engineers that are passionate about sustainability and the environment, this can often be an area of disappointment.

PHARMACEUTICALS

In contrast to the resource-based positions that are typically in more rural areas, the pharmaceutical industry is clustered mainly around the metropolitan areas of Montreal, Toronto, and Vancouver. Following the events of COVID-19 pandemic there have been recommendations that Canada should bolster its domestic pharmaceutical production and avoid relying too heavily on global capacity. Since then, construction of a domestic vaccine production facility has started and is expected to be completed no earlier than 2024. The pharmaceutical industry is highly regulated and attention to detail is key. Negligence could result in serious injury or death. In the pharmaceutical industry engineers typically design or scale-up production processes, optimize existing processes and ensure compliance with government regulations. You may also be tasked with developing and maintain quality control procedures to monitor and test products. A background in biological processes will be beneficial when pursuing a role in this field.

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FOOD PROCESSING

Food production may not be the first thought that comes to mind when thinking about chemical engineering, but if you consider how your favourite snack foods or drinks are made then it may make more sense. Ultimately, a Pepsi factory or a Cheetos factory is just a chemical process like any other. The only difference is that the end products are for human consumption. Like the pharmaceutical industry, negligence or improper engineering can result in foodborne illness and extreme cases, death. Unlike the resource industry, the food processing industry will typically be closer to major metropolitan areas such as Vancouver, Toronto, or Montreal.

Career Paths

Chemical engineers have various career paths available to them. Some of the career paths for chemical engineers have been outlined here.

PROCESS / CHEMICAL ENGINEER

This is the most traditional role for CHBE grads upon graduation. Process Engineers work on process design and optimization. This means a thorough understanding of mass and energy balances, chemical interactions, and process flow, will be vital. The position may also involve equipment sizing, procurement, and budgeting. Important tools for this position are likely ASPEN, and Excel, among others.

The work may be a mix of office work, with occasional excursions to the plant. The typical hours for this position will vary but a standard 40-hour work week, 5 days a week is common. Different companies and industries may have differing schedules, and this applies to any role mentioned in this document. Keep in mind if you are directly responsible for a plant or process that operates 24/7, there is potential for you to be on call in the case of unexpected process upset. This may occur during time off such as on a weekend or during the evening as well. If you are working for a consulting company, you may be able to work hybrid or from home, but if you are overseeing a plant you will generally be asked to come in person.

TEST ENGINEER

Test engineers are focused on quality assurance and ensuring that all products meet the target specifications. As a test engineer, you will also have to develop the methodologies used to test products and identify the necessary testing parameters. Should a product fail to meet specifications, the test engineers may provide solutions on how to troubleshoot the process. Typically, this role will be quite hands on, and you may find yourself in the laboratory or plant more often than some other engineering positions. In terms of schedule test engineers will also follow a typical work schedule much like that of a chemical or process engineer's schedule.

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PROJECT MANAGER

Project management is a role that overlaps with all engineering disciplines. All the undergraduate engineering degrees embed the fundamentals of design and planning into the program through group assignments and projects such as your capstone design project. Project managers are chiefly responsible for the smooth and efficient completion of projects. This means ensuring that timelines, budgets, and project goals are being met. In addition, it involves the delegation of work to a team, so it is important to be able to recognize the strengths and weaknesses of others and how you can best utilize their unique skillsets.

If you want to increase your qualifications as a project manager, there are specific courses online that target project management. After some amount of experience in the project management field you will be able to apply for a Project Management Professional (PMP) certificate. While it can give you a competitive edge in applications, it is not an absolute necessity. Generally, project managers will work the standard 40-hour work week, and depending on the role, it could potentially be hybrid or fully remote work.

ENVIRONMENTAL ENGINEER

As mentioned previously, environmental engineers are often contracted by companies to ensure they are meeting environmental regulations and guidelines. The work typically involves considerable report writing and technical communications skills to parse the governmental regulations. With environmental engineering there is a broad scope of different tasks that you may be completing, and depending on the company you may be traveling to various sites across the country to conduct your environmental assessments, or maybe you'll be working from home and modifying your companies' emissions strategy based on new governmental regulations.

MECHANICAL ENGINEER

You may be surprised to see 'mechanical engineer' as a role that chemical engineers work in. However, there is a considerable amount of overlap between some of the work that mechanical and chemical engineers do within a plant. Depending on the company, fluid flow calculations, heat transfer calculations, pipe sizing, equipment sizing, P&ID flow-sheeting may all be done by either a mechanical or chemical engineer. Of course, chemical engineers won't be able to fulfill the duties of a mechanical engineer in industries that require certain specialized knowledge such as finite element analysis, or forced vibrations, unless you have studied these concepts independently.

ANALYST

We are now leaving the realm of traditional engineering roles and entering some alternative roles that a chemical engineering degree sufficiently equips you for. Analysts can focus on many different specific fields such as financial analysts or market analysts. Ultimately, analysts use data and information to draw logical conclusions and make recommendations based on said information. Consider the role of an analyst to be like an engineer working at a consulting firm, except rather than optimizing a chemical process you might be tasked with optimizing client retention for a media company. The big four firms that hire analysts are EY, PwC, KPMG, and Deloitte. Although they are typically referred to as accounting firms, they provide professional services over a broad range of different industries. These positions almost always work a standard 9-5 schedule, and many also offer hybrid or remote options.

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PROCESS OPERATOR / TECHNICIAN

As the name implies, process operators are the ones who run the plant that a chemical engineer designs. Operators ensure the smooth operation of the plant and troubleshoot process upsets to the best of their ability. Work could include taking samples, utilizing specialized equipment, or general plant housekeeping. Schedules can vary wildly as an operator since plants are often running 24/7. This means that process operators may work night shifts, and up to 12 hours at a time. The work schedule isn't for everyone, but some people enjoy the extended breaks that it provides. A common schedule is to work for 12 hours at a time for four days and then take four days off. The nature of the work completely excludes it from any hybrid or remote work arrangement as the role involves the direct operation of the plant. If you are operating an established process, some may consider the work to be repetitive.

ANALYTICAL CHEMIST / LAB TECHNICIAN

The role of the lab technician is typically to perform tests on samples taken from the plant. For example, in wastewater a lab technician may test the pH, total dissolved solids, turbidity, among other things. Depending on the size of the company and plant, this testing may be contracted out to third party labs or be done in-house. This is a great role for those who enjoy spending time in the lab and are very meticulous individuals. The schedule also varies depending on the company but may be similar to that of a process operator. If the organization requires round the clock testing, then the lab technicians may also be working night shifts. Like for process operators, the work may be considered quite repetitive.

Skills for Development

The following skills will be useful in many chemical engineering roles and industries. I specifically picked these three as you will have been exposed to them in some capacity during your undergraduate degree but won't have an expert level of competency unless you further developed them independently. This list assumes you're already an expert in things like report writing, mass and energy balances, and technical communication, as you will have gone through significant practice throughout the program. I have also included links and resources where you can further develop these skills, but if you look online, I'm sure you will be able to find more yourself.

Aspen HYSYS

Aspen is the most widely used process simulation software used in industry. It is an invaluable tool for process design as it can size equipment for you and do much of the mass and energy balance calculations.

CHBE provides an introductory course on ASPEN that will cover the basics of the program, but if you would like to further develop your skills, CHBE 476 and CHBE 482 are technical electives offered that focus heavily on this piece of software.

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PYTHON

Python is one of the most popular programming languages for data processing and is very commonly used in the scientific industry. There are endless free resources available online that do a great job of teaching python, however they typically focus on using python for software development. You'll want to focus your efforts on learning python for data analysis.

Install the open source Anaconda distribution of python, which will come with the most common libraries needed for data analysis as well as Spyder, an integrated development environment designed specifically for scientists and data analysts.

EXCEL

Everyone lists "proficient in Microsoft Office on their resume" but Excel is an incredibly powerful tool that is essentially the backbone of the entire global economy. That is not an exaggeration. Some companies exist only to create custom excel spreadsheets to meet client needs. You may feel comfortable using Excel, but do you know how to set up vba macros, create a look up table, or pull data from a SQL server? Maybe you do, but that's still just dipping your feet into the massive abyss that is Excel.

BONUS: NATURAL LANGUAGE AI MODELS

As of writing this document, Natural Language AI models, like ChatGPT or Microsoft Co-Pilot, have just recently become an interesting development in the educational and professional sectors for their ability to quickly complete tasks that would typically be assigned to employees or students. To be frank, this is an extremely new and continuously developing technology. Any resources I include now will be outdated within months. While it is unclear what sort of regulation will be implemented regarding use, there is high potential for this technology to become ubiquitous in industry within the next five years. That means that now is the time for individuals to practice incorporating AI language models into their workflows and learn how to use the right language/prompt to receive a desired output.

Other Resources

- Your degree in Chemical Engineering
students.ubc.ca/career/your-degree/engineering/chemical-biological-engineering

- UBC's CHBE Website
chbe.ubc.ca/