



**Energy Science
Technology & Policy**
Carnegie Mellon University
College of Engineering

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Technology and Policy**
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EST&P Program and Career Guide

A student's voice to the program

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Introduction

Welcome to the *Program and Career Guide* for Energy Science, Technology and Policy in the Carnegie Mellon University College of Engineering. This document is designed to help you understand the program and the opportunities that it presents to you. This should help you make the right decisions in terms of selecting your degree, concentration, courses, and most importantly, equip you with the critical information necessary for your job/internship search.

This section will focus on getting you acquainted with the resources available to you. It will point you to a few documents that have been developed for this master's program and to make your life easier, you will find a summary of their important points in this document.

In the second section, we will explore and analyze all the details involved in making the right decision in terms of selecting between the EST&P degree and the EST&P – Applied Studies degree while applying to the program. This information is primarily targeted to help prospective students considering the options available to them. Section Three is devoted entirely to course selection will follow. Feedback from current students and alumni was taken into account while addressing the most common issues when selecting your courses and concentration.

Section Four is dedicated to your professional development. Here, we discuss the mysteries of what the future holds and how you can influence the future with some meticulous planning. Over the course of the EST&P program we have learned a few important things while speaking to alumni and current students, and these points have been included to help you gain a competitive job search advantage. A short section devoted to conversations with alumni is included along with a Career Pathway Appendix to help you with the questions that should inform and direct your job search.

Existing Resources

The EST&P website is the first place you should go to for basic program and logistical information. The website contains the program's student handbook and brochures. The brochures give you a brief introduction to the program and its structure. As you may be aware, this is a highly interdisciplinary program with a core course requirement followed by concentration courses and breadth elective options. Most CMU classes and EST&P use the Blackboard System, where you'll find academic, social, and professional information available there.

The *EST&P Student Handbook* is the fundamental guide to the program's goals, policies, practices, and expectations. The handbook contains a list of associated faculty members and the contact information to get in touch with the program coordinators to clarify your specific concerns that are not addressed in any of the existing documents. The handbook also covers important information with respect to degree requirements, application procedures and course registration upon admission to the program. Academic standards, graduation requirements and the academic integrity policy are other topics covered in the EST&P graduate student handbook.

In addition, the Carnegie Mellon Career and Professional Development Center (CPDC) career consultants and website should be utilized frequently. CPDC is the official career services

provider for CMU students, and beginning in 2015 has consultants dedicated to supporting engineering MS students, including EST&P. Their website contains a wealth of information that has been accumulated and consolidated by the CPDC. Upon admission to the EST&P program, you will receive your official Andrew ID and password; use this to login to Handshake via CPDC to explore internships, full-time positions and on-campus employment opportunities. Further details of using Handshake during your job search will be covered in section four. You will also find that Handshake provides access to presentation slides associated with a variety of topics ranging from preparing your elevator pitch to preparing for an on-site interview. It is also the primary source of information regarding on-campus company information sessions and tech-talks.

The CMU Academic Experience

The general CMU experience is summarized here to prepare you for the challenges you will face upon starting your graduate program. The most important advice is that you should not schedule 48-units of heavy (technical) courses in a single semester. The program limits you to 54 units per semester (a 6-unit overload). Exceptions can be requested after the first semester to allow students to take up to 60 units if previous academic performance is sufficient. This is not generally advisable as the course load can get extremely heavy and hard to manage if you are not used to the CMU workload.

The most optimal way to select courses are to include one or two good/heavy courses and one light/moderate course. This will allow you to strike a good work-life balance. With the world famous CMU stress culture, it would be a smart decision to ensure you have some free time to spare for fitness and rejuvenating yourself over the weekends.

Another important part of the CMU experience is the emphasis on interdisciplinary innovation. Especially with the EST&P program, you will be exposed to a lot of projects involving students from various disciplines and this will give you an opportunity to explore problems from very unique perspectives. Teamwork is highly encouraged at CMU and this is a very valuable skill in the industry. You can expect to work on many team projects over the course of your masters' degree and this will definitely develop your personality in many different ways.

The EST&P program organizes a number of events to encourage socializing with your fellow EST&P students. Try your best to make it to these events since they are a good break from the monotony and give you a chance to make some great friends (and free food and drink!). Getting to know people is also very helpful because there will be times when you are stuck on assignment problems, and knowing others to help you understand the problem is definitely helpful. You must be mindful of CMU academic integrity and plagiarism rules; however most professors encourage high level discussions of problem statements which is very helpful in many cases.

Degree Selection

When applying to the EST&P program you choose between the traditional 2-semester EST&P degree and the 3 semester EST&P Applied Studies project degree. A comparative analysis of the two options has been tabulated as follows.

CRITERIA FOR COMPARISON	EST&P (2 semesters)	EST&P Applied Studies (3 semester project degree)
COURSE LOAD	Average 48 (+/- 6) units per semester. Complete prescribed 96-unit degree requirements in core, concentration, and breadth.	Minimum 36 units each semester for full time student status; 120-unit degree coursework includes minimum of 24 units of project.
COURSE FLEXIBILITY	Limited flexibility to take courses beyond those meeting degree requirements. (e.g. undergrad / pre-requisite courses).	Additional flexibility for project work, project courses, and additional study. Helpful if supplemental (undergrad) prerequisite coursework is needed.
INTERNSHIP OPPORTUNITIES	Internships not generally possible during the course of study.	Fall semester admission international students have opportunity for summer internship.
PROJECT and RESEARCH OPPORTUNITIES	Limited opportunities for project or research work. Can take some project courses and can apply a maximum of 12 units of Master's Project or Independent Study towards the degree	Project work is required as part of the degree. Opportunity for additional project-oriented coursework and for project work with CIT faculty (student's responsibility). Fall admit students decide between industry internships and summer projects; spring admits only have on-campus project option available to them.
JOB OPPORTUNITIES	Need to start applying and networking early. Can be challenging without prior work experience.	Summer internship experience builds resume and networking connections; a successful internship may result in full-time job offer after graduation.
COST	This option is relatively less expensive.	Additional cost of 3 rd semester tuition & fees plus health insurance, housing and living expenses. May be partially offset by internship income.
HOUSING	One year lease agreements in Pittsburgh are common, and are easier to find	Additional 6 months on a lease agreement are hard to come by. Typically take up a half-year lease from a student who just graduated; or full year agreement & sublet for the second half of the lease.

Summer Internship/Research Opportunities

Students may take up summer internships during their course of study; some students tend to take up internships or fellowships after graduation as well in order to gain the required work experience for full-time employment. The details for applying to internships and the legal documents required will be covered in this section.

If you are a United States citizen, you do not face any restrictions in terms of applying and taking up an internship or a full time opportunity at any point of your education. However, the majority of graduate students at Carnegie Mellon are international students from all parts of the world. The next couple of paragraphs in this section are solely dedicated to get them up to speed with the legal restrictions of their student visa.

All international students are required to complete a minimum of two semesters of full-time study before they can legally work in the United States. EST&P students admitted in the Fall Semester can apply for a CPT (Curricular Practical Training) summer internship after two semesters of study. The CPT work assignment must be related to energy, and the appropriate ESTP and OIE forms must be filled out and approved. Students are required to register for three units of Master's Project when doing CPT, must pay part-time tuition for those units, and the units count towards the degree. Note also there is a very strict time frame during which you can be employed as a summer intern. This time frame aligns with the CMU Summer-All session as a 12-week period between the conclusion of the spring semester and the start of the fall semester. The work performed during the course of your internship must be directly related to your energy field of study.

The international students who join CMU in the spring semester are not permitted to work off-campus during the summer, since they would have completed only one semester of full-time study at Carnegie Mellon. These students may take up summer project or research work with professors and gain first-hand experience working with them. This can be especially useful to students who might be considering a PhD following the Master's degree in EST&P. International students are permitted to work on-campus during the summer under the same rules as a student from the United States. If a student has worked with the professor during their first semester, and has demonstrated a strong fundamental understanding of the research area, there is a possibility of being employed by the professor as a project or course assistant.

With that being said, it is highly recommended that students come into this program with a ready plan and start the process of connecting with companies/professors early. It is very important to start early since all these processes take a large amount of time.

Cost of Education

Now, we address the most important question of all, is the EST&P Applied Studies degree third semester worth the extra money? Well, there is no definitive answer to that, but as previously described it can be helpful in terms of course load, flexibility, networking and the ultimate job search. Also important is the additional time it gives you to soak up and enjoy the CMU experience.

The 3-semester project degree can be especially helpful for international students who have a number of legal restrictions and a limited pre-established social and professional network. Be advised that there is no simple option for you to administratively switch between the EST&P and the EST&P Applied Studies degree once you have been admitted and coded into the CMU system. Changing degree programs requires submitting an application to the new degree before the application deadline, being reviewed by the admission committee, and if admission is offered then the degree change can be entered into the CMU system.

For U.S. citizens however there is really no need for the extra time in terms of visa regulations and the only determining factor in selecting the Applied Studies degree route would be the interest to take additional master's project or project-oriented courses. This can certainly be a strong motivation to spend some extra time at CMU since the number of exceptionally mind-blowing courses here is quite large.

As for the net increase in cost for an Applied Studies degree student, some meticulous planning could result in minimizing the differential cost. If you plan all your courses ahead of time, you can select courses that have large class strength and a budget to accommodate a Course Assistant (CA) or Teaching Assistant (TA) such that, in your third semester, you would be eligible to apply for a TA position. This is a rare option, but a few EST&P students have successfully worked as CAs for engineering courses. It is also possible to establish strong connections with professors to take up a position as a Graduate Assistant (GA) or Project Assistant (PA), which would be an additional source of income. It is also possible to save up some of your earnings from your summer internship to help fund your third semester. Another possibility which is not recommended would be to work as a part-time student and a part-time employee by taking up a pre-completion OPT.

NOTE: This section has a lot of information related to visa restrictions and regulations. The Office of International Education (OIE) at CMU is the official and best place to direct all your questions related to this topic.

Consulting vs. Core Technical Job Profiles

At this point, it is helpful to note that you can select your courses in a way that helps you transition into a specific sector of the energy industry. The two main sectors we define here are classified as consulting profiles and technical profiles. In this sub-section, a brief outline of the skills necessary for each of these sectors is outlined.

Consulting job profiles are generally client facing and require great communication skills. The primary skills consulting companies seek are strong analytic and problem solving skills. Candidates are generally expected to be skilled at data analytics, strategy, and economic optimization of processes. Courses that focus on developing expertise in mathematical modeling with Excel, MATLAB and R are generally helpful while networking with people who work in this field. The EPP concentration in EST&P is suitable for students looking to pursue the path of consulting. EPP may also be suitable for some people with non-engineering technical or science backgrounds, and for engineers looking to shift out of the core technical job profiles.

Technical job profiles generally require a disciplinary concentration in one of the remaining five concentration areas listed under EST&P. Ideally, students take up a concentration area

similar to their undergraduate degree. In some cases, people looking to shift focus areas switch between similar concentrations such as chemical to material science or chemical to civil and environmental. Switching between chemical and mechanical may also be a possibility for some students. Selecting a disciplinary concentration in ECE without prior work experience or undergraduate ECE pre-requisites is not advisable. Although course pre-requisite requirements are waived for CMU grad students, we encourage you to review the concepts outlined in the pre-requisites and ensure that you are familiar with the basic concepts at the very least. Some grad courses in CMU are EXTREMELY difficult and challenging. You are encouraged to reach out to former students and alumni to discuss the depth and intensity of the course while planning your course schedule for a given semester (they are always happy to help you avoid the mistakes they committed!). Also, it is worthwhile to point out that “good” courses generally are the ones that entail relatively heavy assignments and workloads (well, that’s how CMU students think and you will too once you get started!).

When it comes to looking for a technical job profile, you should remember that breadth electives give you a flexibility to pick interesting courses, but not focusing on a specific area can make your job search a little harder. As a graduate student, industries expect you to be a master of at least one specific topic although they appreciate interdisciplinary skills. Dabbling in many different fields can make it hard for you to specialize in a specific field and therefore make it hard to stand out amongst the competition for a specific job profile.

Disciplinary Concentrations: Courses & Career Path

Now that you have been introduced to the main career paths available to you in terms of technical and consulting job profiles, we will discuss these in greater detail and focus on specific concentrations and the relevant courses.

Chemical Engineering (CHE)

The Chemical Engineering Disciplinary Concentration is well suited for students looking to enhance the knowledge acquired in their undergraduate chemical engineering degree. Unlike some other engineering concentrations (such as EPP and Civil Engineering) it is advisable that students entering the Chemical Engineering concentration have a deep understanding of BS-degree chemical engineering concepts.

The required course for the CHE disciplinary concentration is 06-665 Process Systems Modeling. The PhD level 06-705 Advanced Chemical Engineering Thermodynamics course may be substituted for 06-655 but is not recommended. Students in this concentration have two options with regards to course selection for the remaining 24 units. They can either take M.S. or PhD level Chemical Engineering course or a mix of both. In the M.S level, 06-623 Mathematical Modeling of Chemical Engineering Processes offered in the fall semester, requires an understanding of linear and non-linear differential equations and mathematical optimization problems with or without constraints. 06-625 Chemical and Reactive systems also offered in the fall, focuses on simulation software to develop models of chemical and reactive systems using thermochemical and kinetic data. This requires knowledge of the fundamental concepts in kinetic modeling of chemical reactions. The final M.S level course 06-663, Analysis and Modeling of Transport Phenomena offered in the spring semester,

assumes a prior knowledge of heat and mass transfer. These courses also make-up 3 of the 4 core classes required for an M.S. in Chemical Engineering degree. Thus, the courses are designed so that a student with B.S. in chemical engineering has the necessary background but will be challenged by more complex, non-linear and coupled engineering problems. Students will also learn how to effectively use advanced computational tools to solve these problems.

Five PhD level courses are also permitted within the CHE disciplinary concentration. These are Advanced Reaction Kinetics, Advanced Fluid Dynamics, Heat and Mass transfer, Mathematical Techniques in Chemical Engineering and Advanced Process Systems Engineering. Students also have the opportunity to explore the details of polymers and colloids by taking courses in this specific area of chemical engineering. Although a majority of the courses in Chemical Engineering are not directly related to Energy, they are useful to enter the chemical engineering industry, in which, oil and gas companies hold a large share of the jobs. Ideally, students from EST&P with a chemical engineering concentration and with a majority of chemical engineering breadth electives will be able to master the chemical engineering material and will be competent in joining the oil and gas industry.

Industries that Chemical engineers can join include the alternative fuel industry developing alternative fuels, solar power, bio-fuels etc. Opportunities lie in the development of reformulated and alternative fuels, design, engineering and operation of refinery processes, combustion system design and operation etc. Other opportunities include research engineer positions for large companies. Some of the major recruiters of chemical engineers in the United States include Exxon Mobil, Dow Chemicals, Siemens, Chevron, and Shell for technical positions, and Accenture for consulting positions.

Combining energy with Chemical engineering brings a new dimension to a student's chemical engineering degree. Through this program and concentration students will gain expertise in energy use and chemical engineering aspects of refining, conversion, and utilization. This gives them a competitive edge over the traditional chemical engineers while applying to oil and gas companies, which hold a majority of the jobs in this field.

Civil and Environmental Engineering (CEE)

Civil and Environmental Engineering covers a broad range of very specialized fields, given that the Civil Engineering component doesn't necessarily always overlap with the Environmental Engineering components. The reason why they are not always included together is because large-scale systems (such as those Civil Engineers concern themselves with) noticeably affect the environment. Civil and Environmental Engineering addresses physical systems and concepts as does Mechanical Engineering, except things do not move together and are very large scale.

Within Civil Engineering there are a few areas of concentration: Transportation Engineering/Urban Planning and Structural Engineering/Green Building. Transportation Engineering involves efficient design of large transportation networks such as freeways and roadways as well as flow optimization and traffic scheduling. Structural Engineering involves the safe and efficient design of large building networks. It incorporates energy efficiency, materials, construction management, design, data analytics, energy and a host of other fields.

Within Environmental Engineering, the areas of concentration typically deal with Air, Water, or Land. For example, there is Air Quality Engineering that deals with emission mitigation and climate impacts. Water Resources Engineering deals with water quality and availability. Land use typically goes back to Urban Planning and Urban System Modeling within Civil Engineering.

A number of interesting projects such as the Sensor Andrew project culminate at the intersection of computer science, embedded systems and civil engineering to deal with energy efficiency of buildings. The interdisciplinary nature of these projects, makes them unique to CMU and gives conventional civil engineers a very unique perspective. The breadth elective options in the EST&P program enables a student in this concentration to select courses from multiple disciplines to successfully gain all the required skills to effectively execute such highly interdisciplinary projects.

The most popular and highly ranked courses in the CEE department that are directly associated with EST&P are:

1. Introduction to Sustainable Engineering (12-712)
2. Environmental Life Cycle Assessment (12-714)
3. Special Topics Classes (usually rotate every year but many have energy components – “Data-Driven Building Energy Management (12-752)” or “Climate Change Adaptation (12-749)” – both taught by current or former EST&P professors)

Electrical and Computer Engineering (ECE)

A disciplinary concentration in ECE in itself is quite broad. ECE concentration students can choose to pursue the path of embedded systems for a career in energy efficiency, or specialize in power systems and transmission networks to start a career in energy and utilities or pursue a career in the renewable energy industry.

Students who decide to follow the ECE path of embedded systems will have the most opportunities at the on-campus CMU career fairs. Carnegie Mellon has a very strong reputation of churning out the most talented embedded software engineers in the world and many companies visit the TOC to hire them. This is however an extremely difficult path and would typically benefit from the Applied Studies degree option to successfully complete the required course work. Some of the top companies that you can seek to join upon completing this concentration could include Nest Labs, Lutron and Tesla Motors.

Most of the embedded system courses require you to have the pre-requisite knowledge of the concepts covered in 15/18-213 (Introduction to Computer Systems). Unfortunately, this sophomore level undergraduate course will not count towards your degree at all (Editor’s note: there may be cross listed 500-level version of the course at a later date which could potentially count as a breadth elective). Distributed Embedded Systems (18-649) is a great course and counts towards the disciplinary concentration; if you’re interested you must pre-register early to gain a spot in this popular but challenging course. Additional embedded system courses that could be taken up to strengthen your profile in this field include 18-342/348/349 (“Fundamentals of Embedded Systems”; but a junior level undergrad course that also will not count towards your degree), 18-648 (“Real Time Operating Systems”; will count as breadth elective but a very challenging course that is not recommended without completing the equivalent of 18-213 and 18-342. Green computing is new and seems like a

fantastic course touching upon the hardware and software elements of energy efficient embedded systems.

To pursue a career in electricity price forecasting or the utilities, 18-618 (Smart Grids), 18-879 (Optimization in Energy Networks) and 18-875 (Economics and Engineering of Electric Energy Systems) are a good set of courses to complete. 18-882 (Advanced Power Electronics) is another popular course amongst EST&P students who are extremely interested in working with utility companies on power electronics modeling and design of transmission level switching devices.

For people interested in working with renewables, ECE offers a remote course from the Silicon Valley campus on modeling and design analysis of solar cells (18-819). This is a relatively new course and is not highly structured. It is only recommended if you are extremely interested in acquiring a strong skill set in modeling of solar arrays.

It is worthwhile to point out 18-587 (Electric Energy Conversion, Control & Management), which is a capstone project in Electrical Engineering. This is a very flexible course and it gives you an opportunity to go all out and build a project of your choice. This project can then be presented at conferences or published in journals as a paper, further enhancing your profile and credibility amongst employers.

The most popular and highly ranked courses amongst the course listed for disciplinary concentration in ECE are:

1. Optimization in Energy Networks (18-879M)
2. Economics and Engineering of Electric Energy Systems (18-875)
3. Distributed Embedded Systems (18-649)

Engineering and Public Policy (EPP)

The students who select EPP as their concentration typically align their coursework into one of the following three areas.

Climate Modeling: Climate modeling is one of the key areas of focus at EPP in CMU. Students looking to pursue and excel in this specialty typically enroll into Climate Change Mitigation (19-653), Climate Science and Policy (19-626) and Combustion and Air Pollution Control (19-740). Please refer to a more [comprehensive list of climate related courses](#) and the [CAPS website](#) for a more detailed explanation and course list for climate and air quality related courses.

Energy Consulting/Energy Analytics: Some of the best consulting firms in the United States are present at the Career Fairs organized by CMU and almost every one of these companies has a division focused on energy consulting. The top energy courses relevant for this concentration are Environmental Life Cycle Assessment (19-714), Energy System Modeling (24-722 – counts as a breadth elective) and Sustainability and Innovation (19-696 -- a very broad class). It is worthwhile to point out that most of the consulting companies look for some amount of programming skills and experience to work with large data sets. The ability to program in R would be a valuable asset while interviewing for these positions and the Heinz College offers a course called Programming in R for Analytics. This could be an

appropriate breadth elective for a student pursuing this concentration, however the R class has been very popular with long waitlist so early registration is recommended.

Policy Analyst: Another concentration that EPP students could follow is the analysis of Energy Policies. The courses relevant to this concentration are Emerging Shale Gas Policy (19-655), Quantitative Methods for Policy Analysis (19-702) and Seminar in Electricity Market Restructuring/Low Carbon Electric Power (19-881/882).

Material Science and Engineering (MSE)

MSE is a very technical and specialized field and the general perspective is that a Masters in this field is at a level midway between a bachelor's degree where students have a broad area of technical skills and can be trained on the job, and PhD where graduates have very specific focused technical expertise suitable for research labs. Masters level students who seek a job in industry must convince an employer that have valuable skills to offer, and are not simply over qualified for entry-level jobs and under qualified for research labs.

Generally, students with an undergraduate degree in Materials Science, Materials Engineering, or possibly Chemical Engineering have a suitable background to take up this concentration. Mechanical Engineers who have taken some materials classes at the BS level may be capable of putting in the necessary extra effort and succeeding in this disciplinary concentration.

With that being said, here are the required courses and recommendations for MSE from the student perspective. The courses Thermodynamics 1 and 2 (27-798/799) are mandatory. They are part of the larger set of core MSE graduate classes that include: 27-796/797 (Structure and Bonding of materials – challenging and time consuming), 27-788 (Defects in Materials) and 27-766 (Diffusion in Materials). These courses lay the foundation necessary for strong technical skills in Material Science, especially for pursuing a PhD. Although some of these courses are not directly related to energy, they play a key role in developing a strong understating and foundation for highly specific courses in Material Science.

Materials Science will give you a strong foundation in the processing and manufacturing aspects of energy systems. Although the field of Materials Science is highly focused on cutting edge research, the processing aspects of Materials Science can be applied to industrial applications. The paths that you can pursue in Materials Science include; Metallurgy, Energy Storage and Renewable Technologies. Metallurgy is not very closely associated with energy except for 27-730: Minimizing Energy in Metal Processes. This course is the most closely linked course to energy efficiency in Metallurgy. Students looking to capitalize on the long history and research strength of Carnegie Mellon in the field of Metallurgy are encouraged to take this course.

The courses relevant to Material Science in the field of renewables are 27-729 (Solid State Devices for Energy Conversion), 27-733 (Principles of Growth and Processing of Semiconductors – challenging) and 27-729 (Solid State Devices for Energy Conversion, Fuel Cell based). These generally focus on solar cells, LED technology and solid-state implementation of fuel cells. 27-742 (Processing and Properties of Thin Films) and 27-788 (Defects in Materials) are also courses that have been recommended by former EST&P grads.

The courses relevant to Energy Storage technologies in Material Science include:

1. Texture and Microstructure analysis: (significant background needed). This course is targeted towards PhD's, however the course focuses on understanding mathematical modeling and use of programs such as Mtex to understand how orientation affect properties which can help you understand how the same material but with different orientations can have a radical effect on the end property.
2. Materials for Energy Storage: (27-724) Mix of technical and market aspects of energy storage systems. Coming with a prior knowledge in the field is essential to make the most of this course.

Mechanical Engineering (MEG)

Mechanical Engineering is an extremely broad field in engineering. This section will focus specifically on the Energy related topics associated with Mechanical Engineering. Once again, the interdisciplinary nature of CMU brings about a strong connection between Mechanical Engineering, Mathematical Modeling and Computational Design.

The Energy System Modeling (24-722) class is required for all students in the MEG concentration. The three most significant areas of focus for EST&P student in the Mechanical Engineering concentration can be broadly classified into: Thermodynamics, Fluids, and Heat Transfer. The core technical courses directly associated with these topics are Advanced Thermodynamics for Thermodynamics, Computational Fluid Dynamics for Fluids and Advanced Heat Transfer for Heat Transfer. A more structured set of courses to consider are described in the following paragraph.

A combination of thermodynamics and fluids along with Fuel Cells and Batteries will provide a student with a good understanding of Energy Storage and System design. A combination of Fluids and Heat Transfer will provide a base to understand Transport of Energy. Transport of Energy can either be studied at the Nano scale or the macro scale. A combination of the mini courses, Conductive Heat Transfer and Radiative Heat Transfer along with Advanced Heat Transfer is a great combination for understanding Energy Transport at a macro scale. Advanced Thermodynamics (24-721), Energy Transport and Conversion at Nano Scale (24-628) and Direct Solar and Thermal Conversion (24-629) are a good combination of courses for Energy Transport at the Nano Scale. Direct Solar and Thermal Conversion is a course that starts off with a theoretical approach to statistical mechanics of physical components before going into their applications.

Professional Development and Job Search Techniques

This section will focus on professional development in terms of determining your career plan followed by a detailed description of the techniques you can use while searching and applying for a job. You will be introduced to the resources available to you when you begin your search for a job. Once you have a clear understanding of your goal and have the right skills to get there, this part gets relatively easier. A well-planned course schedule with the right blend of courses is very critical to have a smooth job search process. But before we proceed into the

actual details of getting a job, it is important to understand the legal paper work required for work authorization for international students. If you are a US Citizen, you can skip the subsection that immediately follows.

Introduction to CPT and OPT

The first and foremost entity associated with working in the United States is the legal work authorization and paper work for the same. While you are still in the process of obtaining a degree, you can apply for a Curricular Practical Training (CPT) authorization on your I-20. This will enable you to work off campus and take up paid internships before graduating. Once you graduate, you should apply for an Optional Practical Training (OPT) authorization and receive an Employment Authorization Document (EAD). This will give you one year to work in the US while trying to secure an H1B visa with that company. Significant additional OPT time is possible working at an eVerified employer under the STEM extension. A brief outline of both processes is described below.

The CPT process includes the following steps:

1. A written offer letter from the company you want to intern with, specifying the start date and end date to lie between the dates indicated by OIE (within the start and end dates of CMU's Summer-all session)
2. Complete CPT authorization form and receive Dr. Landis's signature for approval, then submit to OIE for processing
3. A new I-20 issued from the OIE
4. Registering for the internship as a course with 39-660 Masters EST&P Project for a minimum of 3 units. Tuition must be paid for these units, a letter grade will be assigned, and the units can count towards the degree as breadth elective or Applied Studies project. The process to set up a Masters Project plan of study, method of evaluation and faculty approval is described in the EST&P student handbook.
5. A final internship summary report submitted by you, and a confirming letter signed by your manager.

A detailed description of the OPT application procedure can be found on the OIE website and detailed advice on your OPT requirements will be provided by your OIE advisor. Again, both OPT and CPT must be related to your EST&P degree.

The primary difference between OPT and CPT is outlined as follows:

1. CPT is applicable only before you graduate while OPT is required for working after graduation.
2. CPT is pre-authorized for a specific employer which means you need an offer letter before you apply for the CPT whereas OPT is pre-approved before receiving any offer letter. You cannot work for anyone other than the authorized employer during CPT unlike OPT.
3. CPT is authorized for a maximum duration defined between dates set by the OIE. OPT on the other hand has some flexibility in terms of selecting dates, though this is based on visa regulations.
4. CPT processing dates are much quicker (approx. 1 week +/-) as it is done locally at CMU while OPT can take 90 days or more for processing since it has to be done with the US Government.
5. OPT application also includes a fee of \$385 that needs to be paid in the form of a check to USCIS

Pre-Job Search Requirements

Before we proceed to the actual information in terms of professional development, let's take a minute to evaluate the knowledge required to successfully utilize the techniques and suggestions provided in the following section. Typically, at this point, you need to be aware of what is your disciplinary concentration, the specific set of courses you want to pursue and a set of companies that you would like to work for upon graduation. While determining this, you will need to make sure there is a direct connection between the skills you obtain from the courses yet to be completed at CMU and the skills required for working at the companies you have selected to pursue.

If you already know the majority of the courses you are going to take, the skills they endow, and the jobs you will be qualified to pursue, you can dive right into the next paragraph. If you are confused or lost, don't worry; we have an appendix at the end of this guide which should help steer your focus.

Once you have all the background information required for this process, we can get started with the job search techniques as outlined in the following sub sections.

Career Fairs at CMU

When you start your degree program at Carnegie Mellon, you will be informed about the Technical Opportunities Conference (Fall admits) or the Encompass Career Fairs, formerly called the Employment Opportunities Conferences (Spring & Fall admits), which will be held early in the semester. This is a great opportunity to give you a head start with the job search and application process in the United States, which is possibly quite different from your home country. Although, you have just begun your semester and don't have any significant projects from CMU to include in your resume, I encourage you to take this very seriously. It will motivate you to start building a basic framework for your resume and you will want to have the content reviewed by the CPDC. It will also work as a great practice run for the career fairs that you will be attending very seriously in your second/third semester. A couple of other important things you gain by attending this event is an understanding of how you must plan your time and present your elevator pitch in a very convincing manner to the recruiters. Practice makes perfect! You will come to realize the importance of good communication skills to a successful networking and job search process. Make sure that you attend the workshops conducted by CPDC to get some insight on how to make an elevator pitch and write an effective resume and cover letter.

Once you have completed your mock run in the first semester, you should follow up on the advice that recruiters give you during the fair, and this is always going to be as follows; "We think you have a great resume, please make sure you apply for X (insert associated position here) position online and we will get in touch with you shortly." There is no escape from this and you have to go through the process of applying online. You will realize how painful this process is, and how slow and low the response rates for online applications are in general. This is an important lesson because, when the time comes to seriously apply for a job, you will know what jobs deserve the time and you will not waste time applying for jobs that don't fit your profile or are only a remote match to your interests. This will certainly increase the response rate and you will be able to notice the difference. Another important lesson to take away from the mock experience is building on your communication skills to strike an

interesting and engaging conversation with the recruiters. You will be able to observe other people talking while you stand in the queue waiting for your turn with the recruiter and notice that some people tend to have a more engaging conversation compared to others. Learning by observation is definitely a very effective technique and can go a long way in preparing you for the real run down at the Career fair in the semester you plan on graduating. It is worthwhile to mention here that the TOC in the fall is much bigger and has a greater variety of companies in attendance.

Handshake

The other important resource you should explore during your first week and throughout your graduate career is Handshake. This is the official online recruiting system of the CPDC and has valuable information and links to useful websites. Of course, you can also apply to the job postings listed on this website, but don't be surprised if many of the jobs listed on this page are for software development positions and you need to spend some time to sort out the jobs relevant to your profile. There are also links to other sites and recruiter information for some companies that might be useful for sending out personal emails.

Online Job Applications

At the end of the day however, it is impossible to escape the monotony of filling out online job application forms for all the companies that you are interested to work for. We recommend an excel spread sheet to keep track on the companies you have applied to along with the relevant information such as job requisition numbers, login information to check the status of your application, recruiter information if applicable and follow up dates if needed. There is a high probability that you would have applied to at least a hundred positions by the time you get a job and it is definitely hard to keep track of so many data points. When you start your application process, you are bound to see rejects and this is normal. On an average, if you are getting one interview call for every 10-20 applications you submit, you are on track and should be getting a job in the near future. However, these numbers will not add up in the initial stages of the job application cycle since you will work on a number of revisions to modify your resume, cover letter and application strategy to target only the most suitable companies and positions that match your profile. Once again, these numbers are also dependent on your field/industry, experience, and associated security clearances for the jobs you apply to and your citizenship status. The numbers provided are mere estimates.

LinkedIn

LinkedIn can be another effective way to apply for jobs in a very unconventional way. It will take some time for you to get this right, but it is definitely a great way to pursue career opportunities. I recommend using LinkedIn with a premium account that you set up during the last couple of months at CMU. Your job searching effort should be equivalent to 12-24 units of workload. Once you have setup a premium account, you need to start using your InMail credits to get in touch with people in the company that you want to work for. The people you want to contact are recruiters and HR managers or the Directors/Managers of the divisions in the company that you are most likely going to fit into. Contacting anyone else is probably going to be a waste of your time and the reason for this is simple; recruiters are the ones who setup interviews to evaluate candidates for a specific role and directors are the ones who decide that they need to bring in more talent into their teams. Anyone else in

between cannot make any significant decision in terms of bringing you on board and will have to either recommend you to their director or the hiring managers. Please remember to keep your inMails brief and to the point and yet highlight the important message that you want to convey, since the people you are emailing are extremely busy and get many other similar emails. (As usual, don't lose heart when you don't hear back because that's bound to happen!) Once the connection is established, they will likely setup an interview and move forward with the usual recruitment process. Furthermore, use LinkedIn's alumni tool, as well as join EST&P's private LinkedIn group for alumni and current students.

Professional Meetings and Conferences

Conferences and professional meetings are a great place to network. Being present at a conference shows interest, enthusiasm and a thirst for knowledge. Presenting a project, paper, or poster at conferences only improves your recognition and shows your confidence and skills in a particular field. Most importantly, it gives you a chance to speak about yourself and market your skills. This goes a long way in building connections and generating opportunities for getting employed. For instance, The MIT energy conference has a showcase event where many young clean tech startups from Boston participate. Networking with the CEO's of these companies could lead you to an interview if you can create a good impression of your skill sets and communicate effectively. Remember that these are companies you cannot easily find with a Google Search. They are very young and provide a rich internship experience that can go a long way in your search for full time positions.

At this point it is worthwhile to mention EST&P's Energy Career Symposium organized by the students of the program. The success of this event is entirely dependent on how active your batch is with organizing the event. The event features an energy keynote, followed by an informative expert panel discussion of future career opportunities in Energy. Following the formal program there will be an extended opportunity for students to network and learn from energy industry representatives from the private, public and not-for-profit sectors. The more companies that you can invite to the event, the more successful it is likely to be.

Networking and the Elevator Pitch

The importance of networking cannot be emphasized enough. Time and time again, the concept of networking has been brought up in this section. This sub-section is entirely focused on helping you understand what networking is all about and how to get it right. Before we proceed, let's clarify the meaning of the term elevator pitch. An elevator pitch is basically a brief 30-second introduction about your skills and interests. The CPDC holds workshops to help you practice and improve your elevator pitch. It is definitely worth your time attending these sessions because this is what you will lead with during networking sessions. Your elevator pitch will typically outline that you go to CMU for a specialized degree in Energy with a focus on your specific concentration area. At this point it is entirely your decision on how you will sell yourself and steer the conversation in the direction you want it to proceed.

The three most important points about networking sessions are as follows:

1. It might seem like all the people talking to each other have been great friends for years, but that is not true. They just met at this event too. So don't feel shy to get into a conversation with them. This can be hard at first, but learning from observation and

practice is the only way to master this skill. When you are getting started with your first networking session, look for others who are standing alone so it's easier to start a casual conversation and warm up for the recruiters. DON'T be shy!

2. Your introduction within the first few seconds WILL be judged and it is important to make a good impression. The fact that you are in a specialized program at CMU is generally sufficient to catch their attention. Once you have introduced yourself, you can lead the conversation in a direction that you like after giving the others a chance to introduce themselves.
3. Time is extremely important and go early! Networking sessions don't last all day and even if they do, people are not as energetic after a while. So don't waste your time talking to someone who is not a potential contact. Excuse yourself politely (maybe you want to get some water?) and move on. On a similar note, don't tell them your life. Keep the conversation crisp, short, and make sure you bring business cards with you; typically, you should wait to give it to them until they ask you for one.

If you stay confident and have gotten the three key steps right, then you have built yourself a network of contacts at the end of the networking session. The follow-up is quite important. Nobody is going to remember you two weeks later so initiate an email thread on the same day or within the next 24-48 hours. Keep the email short and brief and ensure that you follow up on the discussion you had at the session.

Networking should not be limited to a specific set of people. Talk to as many people as you can because sometimes, you get an opportunity from the least expected source. It is also helpful to network with other students and learn about companies or other events that you might not have heard of before.

You can also apply some of the networking skills at information sessions organized at CMU. Talk to the recruiters and try to get in touch with them at the end of the information session. This is definitely much easier since the information session is setup in a way to help you start a conversation and express your interest to work at the recruiter's company. Sometimes the recruiters from a specific company are specialized for CS students at CMU, but they are always happy to help you get connected with the right recruiters/department in their company.

The Interview

The entire job application process culminates with a bunch of interview calls. This is the last step in the arduous process of getting a job. This step is by no means easier than the preceding ones. Interviews generally take up plenty of time and require a lot of preparation. Typically, handling interviews along with 48 units of coursework can be challenging. Applied Studies degree students are encouraged to dedicate sufficient time for the job search and interview process in their last semester by taking a minimum 36-unit full-time schedule.

The best way to prepare for interviews is to brush up on your fundamentals. Many students in this program come with a few years of work experience and sometimes this makes it hard to answer very fundamental questions from topics covered in your first year from undergrad. Spend a lot of time brushing up on these concepts. Typically, if your interviews are getting progressively harder, it is a good sign because you are getting most of your answers right. Remember that your interviewers do not expect you to know everything. They are merely testing the way you tackle a problem and understanding how you think. Other than revising

your fundamentals, make sure you know every detail about the projects you have mentioned on your resume and expect to have some highly technical discussions about your projects.

Interviews for internships generally involve multiple rounds of phone interviews. Book a room in the library or at the CPDC to take these calls. Make sure you are prepared to answer any questions about any project mentioned on your resume. The questions can range from general behavioral to hard core technical. It always helps to mentally prepare for the interview and keep a pen and paper ready to take notes during the interview process.

Interviews for full-time positions generally involve an initial phone screen followed by an on-site interview. Companies generally bear the expenses involved in going to their location. On-site interviews are definitely very tiring and intense. For technical positions, they expect you to have very strong fundamentals and it is extremely helpful to have these concepts revised multiple times before an on-site interview. Make sure you attend CPDC workshops to get familiar with the process and follow the etiquette tips that they provide.

It is not uncommon to mess up in the first couple of interviews; don't beat yourself up over it. Interviews are also a learning process and the more interviews you have, the more confident you become. Follow posts on [glassdoor](https://www.glassdoor.com) and other similar sites to get an idea about a company's interview process and the typical questions they ask. Another key point to remember is that the interview is a two-way street. Don't be nervous (definitely easier said than done!) and ask your interviewer some interesting questions. Do your research about the company and show genuine interest for the position. Confidence is another key trait that can land you the job.

With this basic knowledge, you are leaps ahead of fellow competitors. Good Luck!!

Career Pathway Appendix

To help you plan courses for your future career, we approach this as a set of questions that you need to answer for yourself. A sample answer is given to each question to help you think along the right lines.

Q. What do you expect to gain from this program?

A. I would like to get a job in the Energy Industry

Q. Great, now the energy industry is vast, be a little more specific?

A. Ok! I want to work in the field of Energy Efficiency

Q. That can still be very broad, let's see, what is your Undergraduate degree in? And what is your concentration here at EST&P?

A. I have a bachelor's degree in Electrical and Computer Engineering. I'm also following up with an ECE concentration. I'm specifically skilled at Power Electronics and Control Systems.

Q. Perfect! Now let's determine your top three dream companies?

A. Alright, I'd like to be in Makani Power (Google special projects team) / Tesla Motors / Nest Labs.

Q. Ok, now we need to figure out how you could get there? What are the top electrical engineering positions open in these companies?

A. Let's see, for an ECE grad, there are positions in Firmware/Embedded software development, Hardware (Analog) design, Controls engineering, Power management, Sensing and Communication etc. This is specific to Nest labs but chances are, similar positions are available in all three companies

Q. Of course, the big question now becomes, is that the specific position you are interested in? (You don't have to be interested in embedded systems, but CMU is definitely well known for the rigor of their embedded software development courses and you will certainly get a call from these companies for an interview at the very least)

A. Let's say you are not interested in embedded systems, and are more interested in power electronics or control systems. Well, you need to go through the ECE website and look for relevant courses and build up a set of related courses that will provide you with the necessary skills and expertise.

Q. Along similar lines, what are some great courses at CMU that will help me gain the necessary skills to qualify for the job?

A. Okay, time to go back to the career paths and disciplinary concentration section. While you are looking at the possible options in the ECE concentration, you'll notice that we have already covered the set of courses in the embedded systems track that can set you up for a job in one of these companies. (All concentrations may not have such directly available content for reference and you might need to spend some time getting an answer to this question. This could include talking to alumni and current students)

Q. Can I take any of these courses?

A. Now you need to discuss graduation requirements with your academic advisor and figure out the best set of courses that you could take and count towards your degree. Remember, we emphasized that the Applied Studies degree gives more options for courses and will certainly help you in the situation that some specific courses or pre requisites in your plan don't count towards your graduation requirements.

Repeat the above set of questions with your own answers until you come up with a reasonably good plan and set of courses for your EST&P degree. Note that you will probably get stuck on a number of these questions and this process not easy or short unless you have come here with a very clear goal and have already gotten answers to each of the sample questions above. Please note that the EST&P alumni are all very friendly and will be more than happy to help you find answers to these questions. Feel free to reach out to Alumni through Facebook/LinkedIn or drop by the EST&P office to inquire.

This probably seems like a very unsophisticated technique to figure out your career path, but most times a simple solution works best. You'll appreciate the value of simplicity once you start tackling complex and convoluted homework assignments!