Energy Industry Core Skills Study

FINAL REPORT

Prepared for:

Minnesota State Colleges & Universities

Coordinated by:

Alexandria Technical College

and

Minnesota Energy Consortium

In Partnership with:

GP™

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Executive Summary

The Minnesota State Colleges and Universities System has undertaken the task of developing an Energy Industry Core Curriculum that will be among the best in the nation. Development of this core curriculum will enable Minnesota State Colleges and Universities to support the needs of the energy industries that comprise a vital segment of the Minnesota economy by:

- Increasing the number of available qualified workers to fill entry-level vacancies
- Reducing the time to full competency for entry-level hires

Under the coordination of Alexandria Technical College and the Minnesota Energy Consortium, Minnesota State Colleges and Universities has partnered with General Physics Corporation (GP) to complete a high level study of common knowledge and skill sets and competencies required for entry-level workers entering the energy industry.

This report presents the findings of that study, and includes GP's recommendations regarding core curricula for future job candidates for operations, mechanical maintenance, electrical maintenance, and instrumentation and controls in the energy industry. Minnesota State Colleges and Universities can use the data from this report to create an energy curriculum that will serve the needs of Minnesota's energy industries.

The following energy industry segments were included in the study:

- Coal-Fired Electrical Power Generation
- Natural Gas-Fired Electrical Power Generation
- Wind Power Electrical Generation
- Solar Power
- Ethanol Production
- Biodiesel Production
- Natural Gas Distribution

Overall, the results/findings indicate that certain skill sets and competencies are common across the seven energy industry segments.

The fundamental attribute needed for any individual choosing to enter the energy industry would be mechanical aptitude. In addition, all study participants stated that a strong foundation in math, electricity, piping and instrumentation diagram (P&ID) reading, and industrial safety were essential.

Within Minnesota State Colleges and Universities' vision of a two-year technical college curriculum for individuals intending to pursue careers in the energy industry, it is GP's recommendation that the curriculum be structured in three technical phases:

1. Core Fundamentals
2. Trade Specialization
3. Industry Specialization

The first phase would contain the fundamental technical courses that apply to all of the energy industry segments included in the study.

During the second phase, students would complete courses in one or more trade-focused groups, depending on the industry specialization they ultimately intend to complete. The four trade-focused groups would be mechanical, electrical, instrumentation & control (I&C), and operations. This recommendation is based on the structure of current workforces at major power plants. For example, if a student is ultimately hired as a maintenance mechanic, there is limited value in being deeply trained in control systems.

That being said, we also recognize that some industries do not observe these traditional trade boundaries in their workforce structure, and we have made recommendations concerning this.

In the third phase, students would complete courses required for one of the following industry specializations:

- Fossil-Fueled Power Production
- Wind Power Production
- Solar Power Production
- Ethanol and Biodiesel Production
- Gas Distribution

The curricula should include hands-on laboratory components where applicable.

The recommended curriculum structure is shown in Figure 1, found on page 11.

Because of current and near-term industry market shares and demographics, the Energy Industry Core Curriculum should be tailored to meet the needs of the large electrical generators and natural gas distribution utilities first and foremost, with a secondary priority on wind power electrical generation, alternative fuel production, and solar power. This prioritization will help to ensure that the largest needs are addressed first, thereby making the greatest progress toward meeting the ultimate goals of providing greater numbers of qualified entry-level candidates to the energy industry.

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INTRODUCTION

The current average age of the coal and natural gas fired electrical power generation industry workforce nationwide is approaching 50 years old. The same holds true for the natural gas distribution industry. An alarmingly high percentage of these personnel can retire now or within the next 5 to 10 years. In many cases, these individuals have worked in the energy industry for 20-30 years and have gained a large volume of knowledge and skills that will leave with them when they retire. Not only must utility companies fill the large number of vacancies that will result from the retirements, but they must also retain or replace the wealth of operations and maintenance know-how that these workers possess. Undoubtedly, there will be a dramatic increase in the demand for well trained entry-level hires.

Furthermore, advances in technologies, rising costs of fossil fuels, and growing public interest in protecting our environment have helped to spur new construction of alternative source power plants, biofuel production facilities, and applications of solar energy. These emerging industries will require workers with new and specialized knowledge and skills, placing yet more demand on the already strained technical workforce.

Minnesota State Colleges and Universities and the Minnesota Energy Consortium members are currently taking an active role in addressing this very issue through the implementation of knowledge transfer, recruitment, and energy industry curriculum projects. This study is the initial step in establishing curricula statewide that will support the needs of Minnesota's energy industry.

Minnesota State Colleges and Universities is dedicated to serving the needs of an expanding energy industry in the state of Minnesota by providing a degree program through which students can obtain the fundamental knowledge and skills needed to become viable candidates for entry-level jobs. Complete and accurate development of this curriculum requires a thorough examination of the entry-level requirements of the energy industry. Minnesota State Colleges and Universities and the Minnesota Energy Consortium have decided to include the following energy segments in the scope of this initiative:

- Coal-Fired Electrical Power Generation
- Natural Gas-Fired Electrical Power Generation
- Wind Power Electrical Generation
- Solar Power
- Ethanol Production
- Biodiesel Production
- Natural Gas Distribution

The following trades within the above energy segments were considered:

- Operations
- Mechanical Maintenance Technicians
- Electricians
- Instrumentation and Control (I&C) Technicians

The energy industry is facing great demands for highly qualified entry-level employees and this will only increase in the very near future. As previously stated, the coal and natural gas fired electrical power generation industry workforce will require the greatest number of qualified new hires due to the proliferation of these types of power generating stations. Likewise, due to the aging workforce issue, the same holds true for the natural gas distribution industry. Interviews with the less prevalent renewable or alternative energy industry segments indicate that they are poised to significantly expand in production, causing an increase in the demand for specifically trained new hires as well.

PROJECT GOALS

Minnesota State Colleges and Universities has identified the need for energy industry workforce training at the state college level. To help address this need, they have partnered with GP to perform a high-level study of the entry-level knowledge and skill requirements of various technical job positions in the various segments of the state's energy industry. The overall goals of the study are to determine (1) to what degree the industry segments have common entry-level knowledge and skill requirements, and (2) how a college degree program should be structured to provide the knowledge and skills, thereby producing a source of qualified entry-level candidates to the industry.

The study methodology was designed to accomplish the project goals by achieving the following:

- Identify the common skill sets and competencies needed for entry-level workers entering each segment of the energy industry.
- Identify the common skill sets and competencies needed for entry-level workers entering the energy industry as a whole.
- Organize and prioritize these skills sets and develop a core curriculum for entry-level workers.

METHODOLOGY

This project was divided into two phases. Phase 1 consisted of the project kick-off meeting, preliminary GP internal existing data gathering, and interviews of the biodiesel, ethanol, and solar power representatives. A preliminary report was delivered to Minnesota State Colleges and Universities and Minnesota Energy Consortium members on June 13, 2008, outlining the findings to date, project update, and a vision on how to proceed toward successful project completion.

Phase 2 consisted of conducting interviews with representatives from the remaining energy industry segments (coal- and natural gas-fired electrical power generation, wind electrical power generation, and natural gas distribution) and concluded the internal and external data gathering and analysis.

All of the data was compiled and analyzed to determine the core knowledge and skills for each departmental position for each of the seven energy segments. The departmental trade positions differed for each energy segment but the majority consisted of:

- Operations
- Mechanical Maintenance Technicians
- Electricians
- Instrumentation and Control Technicians

GP began the study by reviewing information available within GP. This included data related to job duties and skills required from the previously mentioned departmental trade positions in the following industries:

- Coal-fired power plants
- Natural gas-fired power plants
- Wind farms

The bulk of the initial data gathering represented the coal and natural gas fired electrical power generation. This is due to the proliferation of these types of power generating stations and also represents the vast majority of GP's client base. This data included:

- Training programs in place with current clients
- Job and Task Analysis results from current clients
- Job Performance Measures from current clients
- Previously developed core curricula (Institute of Nuclear Power Operations Academy - INPO ACAD-ABC's)
- Subject matter expert (SME) experience

GP also reviewed the following:

- National Center for Construction Education and Research (NCCER) curriculum catalogue
- Curricula in place with GP partners
  - Bismarck State College
  - Centralia College
  - Excelsior College
- Curricula in place at other technical colleges
- Ongoing (within GP) comparisons between current power plant fundamentals training courses and college curricula

Interviews with representatives from various energy industry segments were conducted by GP to determine the core skills and knowledge that make up the entry-level new hire requirements for the energy industry. During the two phases of the project, representatives from the coal- and natural gas-fired electrical power generation, wind electrical power generation, solar power, ethanol, biodiesel, and natural gas distribution industries were interviewed. All participants were asked the following questions to guide the discussion:

1. What critical skills are lacking in new hires?
2. What minimum knowledge and skill sets do you expect an entry-level new hire to possess?
3. What are the "ideal" knowledge and skill sets you would like each new hire to possess?
4. Describe your departmental positions.
5. Describe any training programs you currently have in place.
6. What curriculum recommendations can you make to this study?

Coal- and Natural Gas-Fired Electrical Power Generation

Coal- and natural gas-fired electrical power generation interviews were conducted concurrently. Consortium members' plant sites were close enough to allow this and the principles of operation deemed sufficiently similar. New-hire knowledge and skills appear to lack necessary mechanical aptitude, similar to all industry segments that were investigated. Potential employees must pass a pre-employment test assessing their electrical power generation understanding and prospective aptitude. Ideal entry-level hires would have U.S. Navy experience, a process or other large industrial setting background, or degree from a college-level Electrical Power Technology program. Departmental positions are essentially universal across all plants of these types, and include operators, mechanical maintenance technicians, electricians, and I&C technicians.

Knowledge and skills considered essential for entry-level candidates include:

- Combustion Fundamentals
- Mechanical Fundamentals
- Basic Electricity
- Piping and Instrumentation Diagram Reading
- Basic Instrumentation and Controls

Wind Electrical Power Generation

The interview with the wind electrical power generation representative indicated that this less-prevalent power generation industry is growing every year in Minnesota, probably more quickly than the other renewable/alternative energy industries. An electrical background is important in this field because the trade craft positions are primarily focused on electrical maintenance. Electrical print and P&ID reading is also strongly

desired in entry-level candidates. Basic electricity, AC/DC circuit theory, use of test equipment, and knowledge of electrical motors are critical skills as well. Wind energy fundamentals, hydraulics, blade theory, fiberglass strengths and repair, computer basics, and fiber optics are needs specific to this industry segment.

Solar Power

Interviews with solar power industry professionals indicated a need for a broader solar power knowledge base across all trade positions. Trade positions differ significantly from the traditional power generation professions and other alternative/renewable energy source production plant positions. Solar power trade positions are primarily in the following areas:

- Manufacturing
- Design
- Sales
- Site Assessment
- Installation

Required knowledge and skill sets differ from other industry segments as well. For example, individuals pursuing solar power professions will need higher-level math and science skills, including trigonometry, geometry, and basic meteorology, in addition to building construction skills and knowledge. Solar power designers and site assessors will require an even greater knowledge of solar economics, electronic drafting, physics, statics and dynamics, and a fundamental understanding of geo-environmental trends and policies. Installers will require construction knowledge and skills including plumbing and pipe fitting, HVAC, carpentry and the requisite OSHA training.

Interviewees indicated that the solar power industry in Minnesota is growing and the need for knowledgeable professionals will only increase. The immediate needs for solar power trade positions are primarily in sales and site assessment, which require extensive solar power background knowledge. Manufacturing jobs closely follow.

Ethanol Production

Interviews with professionals from the ethanol production industry indicate a growing industry and point to an immediate need for qualified production personnel. Ethanol production shares many trade characteristics with the larger electrical power generation plants. Therefore, entry-level knowledge and skill sets are somewhat similar. Differences do exist though, as ethanol production processes differ from those of producing electricity. Trade positions are again similar to the larger electrical power generation plants with operations weighing more heavily than others. Individuals pursuing employment at an ethanol production facility would benefit from studies of chemistry and biology as well as process fundamentals and programmable logic controls.

Biodiesel Production

The process underlying biodiesel production, a chemical process, differs from ethanol production, a biological process. However, specific knowledge and skills are similar. Emphasis on advanced chemistry will separate this trade from ethanol production. Interviews with biodiesel production industry professionals indicate a growing biodiesel industry and point to an immediate need for qualified production personnel. Trade positions are focused primarily on the operations department of the biodiesel production plant.

Natural Gas Distribution

As with the other energy sectors studied, interviewees from the natural gas distribution industry also point to a lack of mechanical aptitude in new hires. This energy sector differs from the others in that training is regulated by the Department of Transportation (DOT) and the Federal Energy Regulatory Commission (FERC). All new hires are placed in a federally mandated two-year training program. Entry-level new hires that bring some type of background in process industry, instrumentation and controls, mechanical skills, heavy equipment operation, welding, pipefitting or iron working will be better prepared for the available jobs. Trade positions are in line with the large power utilities, with these additional positions being prominent:

- Heavy Equipment Operator
- Corrosion Technician
- Environmental Technician

ANALYSIS

After compiling the data gathered through the internal GP review, investigations of other community college curricula, and interview results, GP began a comprehensive analysis to determine the curriculum structure that would best meet Minnesota State Colleges and Universities' objectives.

The core knowledge and skills for each major trade position within each industry segment were reviewed. To determine curriculum recommendations, the following factors were considered:

- Which industry segments have the greatest needs in terms of numbers of new workforce members?
- Which industry segments have the most unique needs in terms of specialized knowledge and skills, and what are they?
- What curriculum structure would most efficiently serve the industry's needs?
- What curriculum structure would provide students sufficient flexibility and career choices?

Currently, the majority of new hires in the industry sectors studied are local high school graduates with minimal or no experience. If they possess the willingness and motivation to learn, most companies have training programs in place that allow them to train the candidates to craft competency. However, this is costly, and with the increased demand to fill positions, companies would benefit from sources of job candidates with adequate technical foundations. Ideal new hires bring with them past process or power plant experience and/or degrees or certificates from technical colleges.

Across all industry sectors, **mechanical aptitude** headed the list of critical attributes perceived as lacking in new hires. It is important to note that aptitude is not a skill, and is not characterized by how much knowledge someone possesses. Rather, it is the **ability** to learn. College curricula cannot provide an individual with aptitude. However, degree or certificate completion can serve as an indicator of one's aptitude, since it obviously requires the proper aptitude to successfully complete a particular program. Therefore, candidates who have successfully completed a college degree or certificate program can probably be assumed to possess the required aptitude for a related job. However, for those companies selecting candidates from other sources, it would be beneficial for them to use some other type of instrument to judge candidates' aptitudes for the job in question.

Job skills that were consistently noted as lacking in today's new hires were the ability to read piping and instrumentation diagrams (P&IDs) and electrical drawings. These, unlike "mechanical aptitude," can and should be part of an energy degree curriculum, regardless of the industry sector.

Renewable/alternative energy technologies are slowly but surely gaining prominence on the landscape of the energy industry, particularly in Minnesota. And, since these technologies have been put into widespread commercial practice only recently, they have somewhat specialized knowledge and skill needs that are not readily available in the workforce. However, it is important to recognize that fossil-fueled electric generation and direct use of natural gas still dominate this industry, and likely will continue to do so for at least the next few decades. Moreover, with large and aging workforces, these mature industries will be more affected by the ongoing wave of Baby Boomer retirements than the new renewable/alternative energy production subsectors will be.

Therefore, curricula should be carefully designed to match the industry profile as closely as possible. That is, it should focus on the needs of the largest industry subsectors, but also provide pathways, via specialized electives, to the emerging and maturing renewable/alternative subsectors.

Appendix A contains tables of skill and knowledge topics for each trade position within each target subsector. These tables represent the "raw data" from the study. That is, they contain all of the major skill and knowledge areas required by each industry subsector, independent of the other subsectors.

Appendix B contains essentially the same information as Appendix A, except that it is simplified by removing the individual trades within each subsector, and it is presented in a graphical format. This allows us to easily see what commonalities exist across the industry subsectors. While the requirements for each trade are not explicitly shown on this chart, the knowledge and skill topics are broken into groups that roughly translate to the various trades.

RECOMMENDATIONS

The curriculum recommendations that GP makes herein are based on the data gathered and analyzed during this study. The basic recommended curriculum structure is shown in Figure 1, and is further explained below.

Within Minnesota State Colleges and Universities' vision of a two-year technical college curriculum for individual's intending to pursue careers in the energy industry, it is GP's recommendation that the curriculum be structured in three technical phases:

1. Core Fundamentals
2. Trade Specialization
3. Industry Subsector Specialization

The first phase would contain the fundamental technical courses that apply to all of the energy industry subsectors included in the study.

During the second phase, students would complete courses in one or more trade-focused groups, depending on the industry subsector specialization they ultimately intend to complete. The four trade-focused groups would be mechanical, electrical, I&C, and operations. This recommendation is based on the structure of current workforces at major power plants. For example, if a student is ultimately hired as a maintenance mechanic, there is limited value in being deeply trained in control systems.

That being said, we also recognize that some subsectors do not observe these traditional trade boundaries in their workforce structure, and we have made recommendations concerning this in the Notes section of Figure 1.

In the third phase, students would complete courses required for specialization in one of the following industry subsectors:

- Fossil Fueled Power Production
- Wind Power Production
- Solar Power Production
- Ethanol and Biodiesel Production
- Gas Distribution

It should be noted that the topics listed in the various phases of Figure 1 are, at this point, *general topics of instruction*, and are not necessarily representative of the

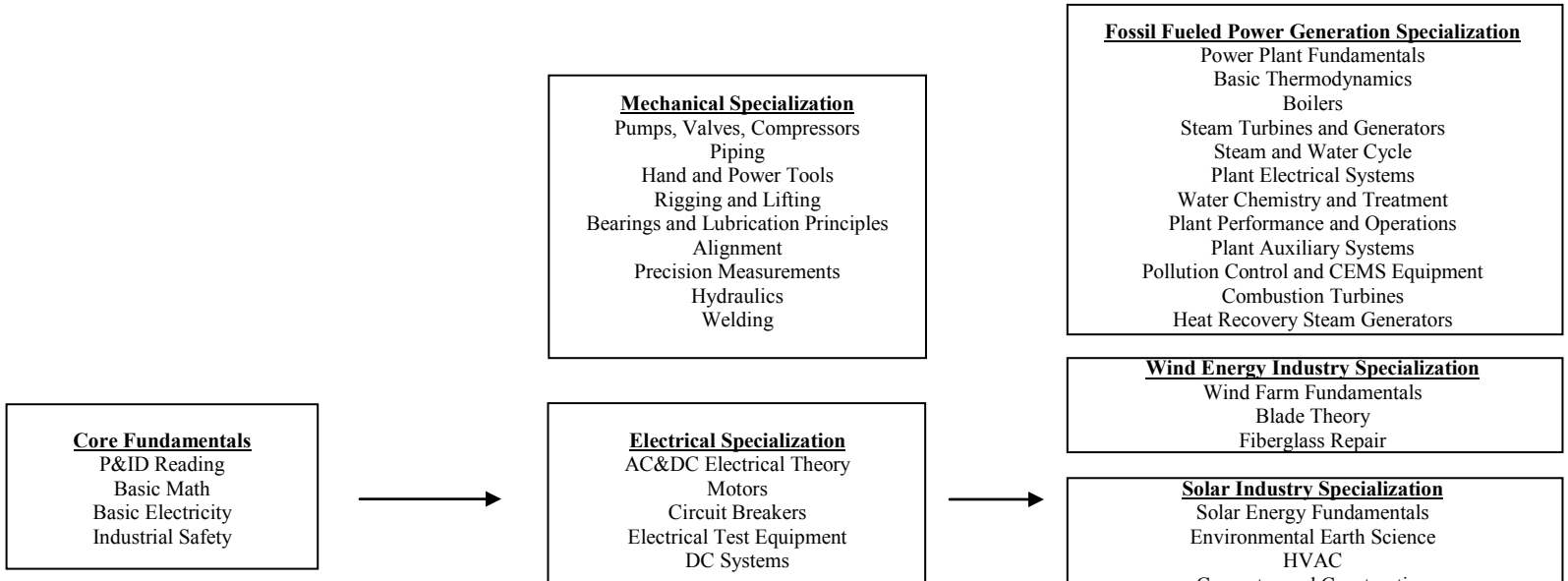
numbers of courses that may be ultimately needed. In many cases, these general topics may be combined to form courses.

It should also be noted that Figure 1 is concerned only with the technical courses that make up the proposed degree program. General education courses should be inserted as appropriate.

The curricula should include hands-on laboratory components where applicable.

Because of current and near-term industry market shares and demographics, Minnesota State Colleges and Universities' Energy Industry Core Curriculum should be tailored to meet the needs of the large electrical generators and natural gas distribution utilities first and foremost, with a secondary priority on wind power electrical generation, alternative fuel production, and solar power. This prioritization will help to ensure that the largest needs are addressed first, thereby making the greatest progress toward meeting the ultimate goals of providing greater numbers of qualified entry-level candidates to the energy industry.

Energy Technology Degree Program Basic Structure
Technical Requirements



Notes:

1. For the Fossil Fueled Power Generation and/or Ethanol/Biodiesel industry specializations, it may be desirable to combine the Electrical and I&C courses into a single "Electrical and I&C Specialization." (Some companies have chosen to combine these specialties into a single job.)
2. For the Wind Energy industry specialization, we recommend requiring the Mechanical, Electrical, and I&C trade specializations, due to the nature of staffing plans for wind facilities, and to make the Wind Energy degree program similar in length to the other programs. The Operations trade specialization would not be an option for this industry specialization.
3. For the Solar industry specialization, we recommend requiring applicable courses from the Mechanical specialization. Other courses, if there are available slots, could be electives.
4. For the Gas Distribution industry specialization, we recommend requiring either the Mechanical or I&C trade specialization. The Operations and Electrical trade specializations would not be options for this industry specialization.

Figure 1

CONCLUSIONS AND NEXT STEPS

The major goals of this study were to determine what core curriculum topics would be needed to meet the requirements of the various energy industries in Minnesota, and to what degree there is commonality among those requirements.

Through a combination of research activities, GP has determined, at a high level, what are the most important technical knowledge areas for each industry segment. We have also mapped out and compared the requirements of each industry segment to determine the degree of overlap. Finally, we have transformed that information into a recommended technical curriculum structure that will allow Minnesota State Colleges and Universities to provide students with the foundational knowledge and skills needed to be desirable candidates for employment in these industries. The curriculum is structured such that it will provide opportunities for students with varied career interests, and meets the varied needs of the different industry segments with a single program through its trade and industry specialization options.

Instructionally speaking, the next step in this process would be to refine the proposed curriculum by creating a detailed curriculum design. This would involve activities such as:

- Combining and transforming the proposed topics into proposed courses
- Writing course specifications for each course to be included in the curriculum, including specific course objectives, outlines, delivery methods, and lab activities
- Defining course lengths/credit hours
- Choosing or developing appropriate course materials
- Adding general education courses to the curriculum

We recommend that the members of the Minnesota Energy Consortium continue to have input in to the process to ensure that the final curriculum reflects their needs.

Appendix A

Appendix A

Coal Fired Electrical Power Generation Core Knowledge and Skills			
Operations	**Mechanics**	**Electricians**	**I&C Technicians**
• Power Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam Turbines and Generators • Steam and Water Cycle • Plant Electrical Systems • Water Chemistry and Treatment • Plant Performance and Operations • Plant Auxiliary Systems • Pumps • Valves • Compressors • Pollution Control • Thermodynamics • Heat and Heat Transfer • Hand and Power Tools • Rigging and Lifting • CEMS Equipment • Industrial Safety • Hand and Power Tools • Rigging and Lifting • CEMS Equipment	• Power Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam Turbines and Generators • Steam and Water Cycle • Pumps • Bearings • Lubrication Principles • Hand and Power Tools • Alignments • Precision Measurements • Valves • Compressors • Hydraulics • Welding • Industrial Safety	• Power Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam Turbines and Generators • Steam and Water Cycle • Plant Electrical Systems • AC/DC Electrical Theory • Pollution Control • Bearings • Lubrication Principles • Hand and Power Tools • Rigging and Lifting • Precision Measurements • Programmable Logic Computers • Piping • AC/DC Electrical Motors and Generators • Circuit Breakers • Test Equipment and Measuring Devices • Battery Chargers • Industrial Safety	• Power Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam Turbines and Generators • Steam and Water Cycle • Plant Electrical Systems • AC/DC Electrical Theory • Basic Electronics • Pollution Control • Plant Performance and Operations • Bearings • Lubrication Principles • Power Plant Control Systems • Rigging and Lifting • Pneumatic Controls • Programmable Logic Computers • Microprocessors • Control Instrumentation and Loops • Test Equipment and Measuring Devices • Field Devices • CEMS Equipment • Industrial Safety

Natural Gas Fired Electrical Power Generation Core Knowledge and Skills			
Operations	**Mechanics**	**Electricians**	**I & C Technicians**
• Power Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Combustion Turbines • Heat Recovery Steam Generators • Steam Turbines and Generators • Steam and Water Cycle • Plant Electrical Systems • Water Chemistry and Treatment • Plant Performance and Operations • Plant Auxiliary Systems • Pumps • Valves • Compressors • Pollution Control • Thermodynamics • Heat and Heat Transfer • Hand and Power Tools • Rigging and Lifting • CEMS Equipment • Industrial Safety	• Power Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Combustion Turbines • Heat Recovery Steam Generators • Steam Turbines and Generators • Steam and Water Cycle • Pumps • Bearings • Lubrication Principles • Hand and Power Tools • Alignments • Precision Measurements • Valves • Compressors • Hydraulics • Welding • Diesel Engines • Industrial Safety	• Power Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Combustion Turbines • Heat Recovery Steam Generators • Steam Turbines and Generators • Steam and Water Cycle • Plant Electrical Systems • AC/DC Electrical Theory • Pollution Control • Bearings • Lubrication Principles • Hand and Power Tools • Rigging and Lifting • Precision Measurements • Programmable Logic Computers • Piping • AC/DC Electrical Motors and Generators • Circuit Breakers • Test Equipment and Measuring Devices • Battery Chargers • Industrial Safety	• Power Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Combustion Turbines • Heat Recovery Steam Generators • Steam Turbines and Generators • Steam and Water Cycle • Plant Electrical Systems • AC/DC Electrical Theory • Basic Electronics • Pollution Control • Plant Performance and Operations • Bearings • Lubrication Principles • Power Plant Control Systems • Rigging and Lifting • Pneumatic Controls • Programmable Logic Computers • Microprocessors • Control Instrumentation and Loops • Test Equipment and Measuring Devices • Field Devices • CEMS Equipment • Industrial Safety

NOTE: Typically at wind farms, the craft trade position lines are “blurred,” meaning most employees are capable of and required to do all of the tasks.

Wind Electrical Power Generation Core Knowledge and Skills			
Operations	**Mechanics**	**Electricians**	**I & C Technicians**
• Wind Farm Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Blade Theory • Operation Control Systems • Basic Electricity • AC/DC Electrical Theory • Industrial Safety	• Wind Farm Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Bearings • Lubrication Principles • Hand and Power Tools • Alignments • Precision Measurements • Valves • Compressors • Hydraulics • Welding • Rigging and Lifting • Fiberglass Repair • Industrial Safety	• Wind Farm Fundamentals • P&ID Reading • Basic Math • Basic Electricity • AC/DC Electrical Theory • Hand and Power Tools • Alignments • Precision Measurements • Rigging and Lifting • Programmable Logic Computers • Piping • AC/DC Electrical Motors and Generators • Circuit Breakers • Test Equipment and Measuring Devices • Industrial Safety	• Wind Farm Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Basic Electronics • AC/DC Electrical Theory • Operation Control Systems • Rigging and Lifting • Pneumatic Controls • Programmable Logic Computers • Microprocessors • Control Instrumentation and Loops • Test Equipment and Measuring Devices • Field Devices • Industrial Safety

Solar Power Generation Core Knowledge and Skills			
Installers	**Designers**	**Sales**	**Site Assessors**
• Solar Energy Basics • Basic Math • Basic Electricity • Environmental Earth Science • Plumbing • HVAC • Pipefitting • Carpentry • Pumps • Construction • Building Energy Basics	• Solar Energy Basics • Basic Math • Basic Electricity • Environmental Earth Science • Physics • Auto CAD • Statics • Dynamics • Circuits • Pumps	• Solar Energy Basics • Basic Math • Basic Electricity • Environmental Earth Science • Solar Economics	• Solar Energy Basics • Basic Math • Basic Electricity • Environmental Earth Science • Advanced Math • Geometry • Trigonometry • Solar Economics • Solar Time

Ethanol Production Core Knowledge and Skills			
Operations	**Mechanics**	**Electricians**	**I & C Technicians**
• Process Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam and Water Cycle • Heat and Heat Transfer • Process Automation • Chemistry • Biology • Distillation Theory • Thermodynamics • Water Chemistry and Treatment • Instrumentation • Hand and Power Tools • Pumps • Valves • Compressors • Pollution Control • CEMS Equipment • Heavy Equipment Orientation • Industrial Safety	• Process Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam and Water Cycle • Pumps • Bearings • Lubrication Principles • Hand and Power Tools • Alignments • Precision Measurements • Valves • Compressors • Hydraulics • Welding • Industrial Safety	• Process Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam and Water Cycle • Plant Electrical Systems • AC/DC Electrical Theory • Bearings • Lubrication Principles • Hand and Power Tools • Rigging and Lifting • Precision Measurements • Programmable Logic Computers • Piping • AC/DC Electrical Motors and Generators • Circuit Breakers • Test Equipment and Measuring Devices • Battery Chargers • Industrial Safety	• Process Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam and Water Cycle • Plant Electrical Systems • AC/DC Electrical Theory • Basic Electronics • Pollution Control • Plant Performance and Operations • Bearings • Lubrication Principles • Power Plant Control Systems • Rigging and Lifting • Pneumatic Controls • Programmable Logic Computers • Microprocessors • Control Instrumentation and Loops • Test Equipment and Measuring Devices • Field Devices • CEMS Equipment • Industrial Safety

Biodiesel Production Core Knowledge and Skills			
Operations	**Mechanics**	**Electricians**	**I & C Technicians**
• Process Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam and Water Cycle • Heat and Heat Transfer • Process Automation • Chemistry • Advanced Chemistry • Biology • Distillation Theory • Thermodynamics • Water Chemistry and Treatment • Hand and Power Tools • Pollution Control • CEMS Equipment • Industrial Safety	• Process Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam and Water Cycle • Pumps • Bearings • Lubrication Principles • Hand and Power Tools • Alignments • Precision Measurements • Valves • Compressors • Hydraulics • Welding • Industrial Safety	• Process Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam and Water Cycle • Plant Electrical Systems • AC/DC Electrical Theory • Bearings • Lubrication Principles • Hand and Power Tools • Rigging and Lifting • Precision Measurements • Programmable Logic Computers • Piping • AC/DC Electrical Motors and Generators • Circuit Breakers • Test Equipment and Measuring Devices • Battery Chargers • Industrial Safety	• Process Plant Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Boilers • Steam and Water Cycle • Plant Electrical Systems • AC/DC Electrical Theory • Basic Electronics • Pollution Control • Plant Performance and Operations • Bearings • Lubrication Principles • Power Plant Control Systems • Rigging and Lifting • Pneumatic Controls • Programmable Logic Computers • Microprocessors • Control Instrumentation and Loops • Test Equipment and Measuring Devices • Field Devices • CEMS Equipment • Industrial Safety

NOTE: The natural gas distribution industry has a training program mandated by the Department of Transportation and the Federal Energy Regulatory Commission. All new hires are placed into a two year operator training program. Upon completion, the employee is entitled to choose any of the following craft trades listed below:

- Operations Technician
- Liquefied Natural Gas Operations
- Corrosion Technician
- Mechanic
- Environmental Technician
- Instrument & Controls Technician
- Welding/Heavy Equipment Operator

Natural Gas Distribution Core Knowledge and Skills						
Operations Technician	**LNG Operations**	**Corrosion Technician**	**Mechanic**	**Environmental Technician**	**I&C Technician**	**Welding/Heavy Equip Operator**
• Pipeline Industry Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Control Center Operations	• Pipeline Industry Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Refrigeration • Control Center Operations	• Pipeline Industry Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Painting • Cathodic Protection • Test Equipment and Measuring Devices	• Pipeline Industry Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Pumps • Bearings • Lubrication Principles • Hand and Power Tools • Alignments • Precision Measurements • Valves • Compressors • Hydraulics • Welding	• Pipeline Industry Fundamentals • P&ID Reading • Basic Math • Basic Electricity • CEMS Equipment • Pollution Control	• Pipeline Industry Fundamentals • P&ID Reading • Basic Math • Basic Electricity • AC/DC Electrical Theory • Basic Electronics • Pneumatic Controls • Programmable Logic Computers • Microprocessors • Control Instrumentation and Loops • Test Equipment and Measuring Devices • Field Devices • CEMS Equipment	• Pipeline Industry Fundamentals • P&ID Reading • Basic Math • Basic Electricity • Welding • Heavy Equipment Orientation • Industrial Safety

Appendix B

Core Skills Comparison Across Industries

	Coal	CT	Wind	Solar	Ethanol	Biodiesel	Gas Dist
Fundamentals							
P&ID Reading	■	■	■	■	■	■	■
Basic Math	■	■	■	■	■	■	■
Basic Electricity	■	■	■	■	■	■	■
Industrial Safety	■	■	■		■	■	■
Mechanical							
Pumps	■	■		■	■	■	■
Valves	■	■			■	■	■
Piping	■	■		■	■	■	■
Compressors	■	■	■		■	■	■
Hand and Power Tools	■	■	■		■	■	■
Rigging and Lifting	■	■	■		■	■	■
Bearings	■	■	■		■	■	■
Lubrication Principles	■	■	■		■	■	■
Alignment	■	■	■		■	■	
Precision Measurements	■	■	■		■	■	■
Hydraulics	■	■	■		■	■	■
Welding	■	■	■		■	■	■
Electrical							
AC & DC Electrical Theory	■	■	■		■	■	■
Motors	■	■	■		■	■	
Circuit Breakers	■	■	■		■	■	
Electrical Test Equipment	■	■	■		■	■	
DC Systems	■	■			■	■	
Instrumentation and Controls							
Basic Electronics	■	■	■			■	■

Core Skills Comparison Across Industries

	Coal	CT	Wind	Solar	Ethanol	Biodiesel	Gas Dist
Programmable Logic Controllers	■	■	■			■	■
Process Control Systems and Field Devices	■	■	■		■	■	■
Pneumatic Controls	■	■	■		■	■	■
Microprocessor Controls	■	■	■		■	■	■
Basic Instrumentation	■	■	■		■	■	■
Fossil Fueled Power Production							
Power Plant Fundamentals	■	■					
Basic Thermodynamics	■	■					
Boilers	■						
Steam Turbines and Generators	■	■					
Steam and Water Cycle	■	■					
Plant Electrical Systems	■	■					
Water Chemistry and Treatment	■	■					
Plant Performance and Operations	■	■					
Plant Auxiliary Systems	■	■					
Pollution Control and CEMS Equipment	■	■					
Combustion Turbines		■					
Heat Recovery Steam Generators		■					
Wind Energy							
Wind Farm Fundamentals			■				
Blade Theory			■				
Fiberglass Repair			■				
Solar Energy							
Solar Energy Fundamentals				■			
Environmental Earth Science				■			
HVAC				■			

Core Skills Comparison Across Industries

	Coal	CT	Wind	Solar	Ethanol	Biodiesel	Gas Dist
Carpentry and Construction				■			
Fundamentals of Energy Use in Buildings				■			
Basic Applied Physics				■			
Computer Aided Drafting				■			
Statics				■			
Dynamics				■			
Solar Economics				■			
Basic Algebra, Geometry, Trigonometry				■			
Solar Time				■			
Ethanol/Biodiesel Production							
Process Plant Fundamentals					■	■	
Chemistry					■	■	
Biology					■	■	
Distillation Theory					■	■	
Advanced Chemistry						■	
Gas Distribution							
Heavy Equipment Orientation					■		■
Pipeline Industry Fundamentals							■
Gas Control Center Operations							■
Refrigeration							■
Painting							■
Cathodic Protection							■