2024 Energy Technology II

Program CIP: 15.0503 — Energy Management and Systems Technology/Technician

Direct inquiries to:

Project Manager
Research and Curriculum Unit
P.O. Drawer DX
Mississippi State, MS 39762
662.325.2510
helpdesk@rcu.msstate.edu

Program Supervisor
Office of Career and Technical Education
Mississippi Department of Education
P.O. Box 771
Jackson, MS 39205
601.359.3974

Published by:

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Mississippi Department of Education
Jackson, MS 39205

Research and Curriculum Unit
Mississippi State University
Mississippi State, MS 39762

The Research and Curriculum Unit (RCU), located in Starkville, as part of Mississippi State University (MSU), was established to foster educational enhancements and innovations. In keeping with the land-grant mission of MSU, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances the intellectual and professional development of Mississippi students and educators while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Acknowledgments

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Dr. Ray Morgigno, interim state superintendent of education, executive secretary
Mr. Glen V. East, chair
Mr. Matt Miller, vice chair
Dr. Ronnie L. McGehee
Mr. Bill Jacobs
Mr. Mike Pruitt
Mrs. Mary Werner
Dr. Wendi Barrett
Mr. Charlie Frugé, student representative
Ms. Kate Riddle, student representative

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Standards

Standards and alignment crosswalks are referenced in the appendix. Depending on the curriculum, these crosswalks should identify alignment to the standards mentioned below, as well as possible related academic topics as required in the Subject Area Testing Program in Algebra I, Biology I, English II, and U.S. History from 1877, which could be integrated into the content of the units. Mississippi's CTE energy technology is aligned to the following standards:

Next Generation Science Standards (NGSS)
NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press. The NGSS were developed by practicing scientists, including two Nobel laureates, cognitive scientists, science education researchers, and science education standards and policy experts, using as a guiding document A Framework for K-12 Science Education from the National Research Council. The K-12 academic standards in science were developed by and for educators and school leaders. (nextgenscience.org)

National Energy Education Development Project (NEED)
NEED intends to implement comprehensive energy education within our public-school systems. It calls attention to the need for a reducing our dependence on fossil fuels and the necessity for increasing the use of renewable energy technologies and energy efficiency. It promotes an energy-conscious and educated society by creating effective networks of students, educators, businesses, government, and community leaders to design and deliver objective, multi-sided energy education programs. NEED works with energy companies, agencies, and organizations to bring balanced energy programs to the nation's schools with a focus on strong teacher professional development, timely and balanced curriculum materials, signature program capabilities and turn-key program management. (need.org)

International Society for Technology in Education Standards (ISTE)
Reprinted with permission from *ISTE Standards for Students* (2016). All rights reserved. Permission does not constitute an endorsement by ISTE. (iste.org)

College- and Career-Readiness Standards
College- and career-readiness standards emphasize critical thinking, teamwork, and problem-solving skills. Students will learn the skills and abilities demanded by the workforce of today and the future. Mississippi adopted Mississippi College- and Career-Readiness Standards (MCCRS) to provide a consistent, clear understanding of what students are expected to learn and so teachers and parents know what they need to do to help them.
mdek12.org/oae/college-and-career-readiness-standards

Framework for 21st Century Learning
In defining 21st-century learning, the Partnership for 21st Century Skills has embraced key themes and skill areas that represent the essential knowledge for the 21st century: global awareness; financial, economic, business, and entrepreneurial literacy; civic literacy; health literacy; environmental literacy; learning and innovation skills; information, media, and technology skills; and life and career skills.
battelleforkids.org/networks/p21/frameworks-resources

Preface

Secondary CTE programs in Mississippi face many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing applied learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments. This document provides information, tools, and solutions that will aid students, teachers, and schools in creating and implementing applied, interactive, and innovative lessons. Through best practices, alignment with national standards and certifications, community partnerships, and a hands-on, student-centered concept, educators will be able to truly engage students in meaningful and collaborative learning opportunities.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, *Mississippi Code of 1972*, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, Ch. 487, §14; Laws, 1991, Ch. 423, §1; Laws, 1992, Ch. 519, §4 eff. from and after July 1, 1992; Strengthening Career and Technical Education for the 21st Century Act, 2019 [Perkins V]; and Every Student Succeeds Act, 2015).

Mississippi Teacher Professional Resources

The following are resources for Mississippi teachers:

- Curriculum, Assessment, Professional Learning
  - Program resources can be found at the RCU's website, rcu.msstate.edu.
- Learning Management System: An Online Resource
  - Learning management system information can be found at the RCU's website, under Professional Learning.

Should you need additional instructions, contact the RCU at 662.325.2510 or helpdesk@rcu.msstate.edu.

Executive Summary

Pathway Description

Energy Technology is a pathway in the science, technology, engineering & mathematics (STEM) career cluster. This program is designed for students who wish to obtain knowledge and skills required to receive employment in a variety of energy-related occupations regarding electrical leadership, power generation, power transmission, and power distribution operations. After completing this course, students may begin training in an entry-level energy technology-related field under the supervision of an industry professional.

College, Career, and Certifications

Energy technology industry job opportunities can be found throughout Mississippi. The fundamental goal for this course is to prepare students for an entry-level position in many of the energy technology-related occupations across the state. There are numerous community colleges and universities that offer educational programs to prepare students for higher-wage occupations in the energy technology industrial sector.

Grade Level and Class Size Recommendations

It is recommended that students enter this program as sophomores or juniors. Exceptions to this are a district-level decision based on class size, enrollment numbers, student maturity, and CTE delivery method. This is a hands-on, lab- or shop-based course. Therefore, a maximum of 15 students is recommended per class with only one class with the teacher at a time.

Student Prerequisites

For students to experience success in the program, the following student prerequisites are suggested:

1. C or higher in English (the previous year)
2. C or higher in high school-level math (last course taken or the instructor can specify the level of math instruction needed)
3. Instructor approval and Test of Adult Basic Education (TABE) reading score (eighth grade or higher)

or

1. TABE reading and math score (eighth grade or higher)
2. Instructor approval

or

1. Instructor approval

Assessment

The latest assessment blueprint for the curriculum can be found at https://www.rcu.msstate.edu/curriculum

Applied Academic Credit

The latest academic credit information can be found at mdek12.org/ese/approved-course-for-the-secondary-schools.

Teacher Licensure
The latest teacher licensure information can be found at mdek12.org/oel/apply-for-an-educator-license.

Professional Learning
If you have specific questions about the content of any training sessions provided, please contact the RCU at 662.325.2510 or helpdesk@rcu.msstate.edu.

Course Outlines

Option 1—Two 1-Carnegie Unit Courses

This curriculum consists of two 1-credit courses that should be completed in the following sequence:

1. **Energy Technology – Power Generation—Course Code: 994204**
2. **Energy Technology – Power Operations—Course Code: 994205**

Course Description: Energy Technology – Power Generation
This credit introduces students to energy technology-related emerging technologies that have been implemented within the energy utilities industry. Students will explore power generation technologies, their environmental considerations, and the principles that apply to both renewable power generation (including solar, wind, hydroelectric, geothermal, and biomass methods) and non-renewable power generation (including coal-fired, natural gas-fired, and nuclear power plants). They will investigate the management and operational structure of each energy source, including tasks such as data analysis, systems monitoring, and predictive maintenance. They will discover how power plant operators, technicians, and engineers work to ensure that both regulatory compliance and the optimal power needs of the local community are met. They will investigate how energy professionals mitigate carbon dioxide emissions through carbon capture, decentralize power energy production through distributed generation, reduce reliance on fossil fuels by using electric vehicles (EVs), intelligently plan urban area power systems through smart neighborhoods, and prevent power disruptions by monitoring and controlling systems through self-healing networks. Within the context of community events, students will showcase their investigated solution to real-world energy issues. School faculty, industry professionals, and community stakeholders are encouraged to build a network of support around their energy technology students' innovative accomplishments that generate potential solutions to energy technology-related issues.

Course Description: Energy Technology – Power Operations
This credit offers an exciting introduction into power transmission, power substations, power distribution, and other advanced topics regarding emerging technologies. It considers the vast impact that economic and environmental factors have on investor-owned utilities, electric power associations, and municipal utilities. Students will evaluate how emerging technologies such as carbon capture, distributed generation, electric vehicles (EVs), green hydrogen, microgrids, self-healing networks, and smart neighborhoods can benefit the environment and the overall energy production, power transmission, and power distribution systems. Students will develop a deep understanding of energy technology-related structures such as poles, towers, conductors, etc. They will discover the varied world of vehicles used in the field of energy, for example, bucket trucks, cranes, Digger Derrick trucks, drones, and helicopters and how they assist with power systems and even vegetation management. Regarding vegetation management, students will be introduced to Light Detection and Ranging (LiDAR) and satellite imagery applications. They will be taken through the process of understanding reliability metrics and the benefits of Regional Mutual Assistance Groups (RMAGs), when mitigating decisions made during power disruptions to restore power to communities and businesses. They are encouraged to engage with

local utility contacts to gain insights into storm preparation and response. They will be introduced to environmental, social, and governance (ESG) principals to emphasize sustainability practices and responsible corporate behavior. Students will discover the economic impact that energy industry jobs such as lineworkers, process technicians, and relay technicians – among others – have within Mississippi. Emphasis will also be placed on understanding environmental impacts, climate change mitigation, regulatory agencies, and the types of electrical utilities within Mississippi.

Energy Technology – Power Generation—Course Code: 994204

Unit	Unit Title	Hours
1	Introduction to Emerging Technologies	10
2	Capstone	40
3	Power Generation Overview	15
4	Renewable Power Generation Technologies	25
5	Non-Renewable Power Generation Technologies	25
6	Power Generation Operations and Management	25
Total		**140**

Energy Technology – Power Operations—Course Code: 994205

Unit	Unit Title	Hours
7	Power Transmission	30
8	Power Substations	30
9	Power Distribution	30
10	Economic, Environmental, and Regulatory Considerations	25
11	Advanced Topics in Emerging Technologies	25
Total		**140**

Option 2—One 2-Carnegie Unit Course

This curriculum consists of one 2-credit course that should be completed in the following sequence:

Energy Technician II—Course Code: 994201

Course Description: Energy Technician II
This course introduces students to energy technology-related emerging technologies that have been implemented within the energy utilities industry. Students will explore power generation technologies, their environmental considerations, and the principles that apply to both renewable power generation (including solar, wind, hydroelectric, geothermal, biomass methods) and non-renewable power generation (including coal-fired, natural gas-fired, and nuclear power plants). They will investigate the management and operational structure of each energy source, including tasks such as data analysis, systems monitoring, and predictive maintenance. They will discover how power plant operators, technicians, and engineers work to ensure that both regulatory compliance and the optimal power needs of the local community are met. They will investigate how energy professionals mitigate carbon dioxide emissions through carbon capture, decentralize power energy production through distributed generation, reduce reliance on fossil fuels by using electric vehicles (EVs), intelligently plan urban area power systems through smart neighborhoods, and prevent power disruptions by monitoring and controlling systems through self-healing networks. Within the context of community events, students will showcase their investigated solution to real-world energy issues. School faculty, industry professionals, and community stakeholders are encouraged to build a network of support around their energy technology students' innovative accomplishments that generate potential solutions to energy technology-related issues. This course offers an exciting introduction into power transmission, power substations, power distribution, and other advanced topics regarding emerging technologies. It considers the vast impact that economic and environmental factors have on investor-owned utilities, electric power associations, and municipal utilities. Students will develop a deep understanding of energy technology-related structures such as poles, towers, conductors, etc. They will discover the varied world of vehicles used in the field of energy, for example, bucket trucks, cranes, Digger Derrick trucks, drones, and helicopters and how they assist with power systems and even vegetation management. Regarding vegetation management, students will be introduced to Light Detection and Ranging (LiDAR) and satellite imagery applications. They will be taken through the process of understanding reliability metrics and the benefits of Regional Mutual Assistance Groups (RMAGs), when mitigating decisions made during power disruptions to restore power to communities and businesses. They are encouraged to engage with local utility contacts to gain insights into storm preparation and response. They will be introduced to environmental, social, and governance (ESG) principals to emphasize sustainability practices and responsible corporate behavior. Students will discover the economic impact that energy industry jobs such as lineworkers, process technicians, and relay technicians – among others – have within Mississippi. Emphasis will also be placed on understanding environmental impacts, climate change mitigation, regulatory agencies, and the types of electrical utilities within Mississippi.

Energy Technician II—Course Code: 994201

Unit	Unit Title	Hours
1	Introduction to Emerging Technologies	10
2	Capstone	40
3	Power Generation Overview	15
4	Renewable Power Generation Technologies	25
5	Non-Renewable Power Generation Technologies	25
6	Power Generation Operations and Management	25
7	Power Transmission	30
8	Power Substations	30
9	Power Distribution	30
10	Economic, Environmental, and Regulatory Considerations	25
11	Advanced Topics in Emerging Technologies	25
Total		**280**

Career Pathway Outlook

Overview

The Energy Technology II course within the science, technology, engineering & mathematics career (STEM) cluster covers a broad range of occupations related to power generation, power transmission, power substations, and power distribution. Students enrolled in this course will be given the opportunity to interact with and learn from energy industry professionals. This varied field of energy technology covers a broad spectrum of careers. This course includes fascinating learning experiences regarding both renewable emerging technologies and non-renewable innovative power generation technologies. Students will explore the importance of vegetation management and the use of LiDAR and satellite imagery to ensure reliable electrical systems. According to the annual U.S. Energy and Employment Report (USEER), the electric power generation sector employed nearly 900,000 people in 2021, which was an increase of just over 24,000 jobs or 2.9% overall. The energy technology transmission, distribution, and storage (TDS) sector employed more than 1.3 million people nationally. The fuel sector employed just under one million people in 2021, which includes the petroleum, coal, and biofuel sectors. Particularly, renewable diesel fuels, biodiesel fuels, and waste fuels added 1,180 jobs which equates to a 6.7% increase. Interestingly, smart grids outpaced all other TDS technologies in growth rate, which added 1,136 jobs nationally, a percent increase of 4.9% overall. Currently, the U.S. Bureau of Labor Statistics indicates that there are approximately 124,000 electrical power-line installers and repairers nationwide. Also, they forecast that solar photovoltaic installers will be one of the top five fastest-growing occupations through 2030 and are expected to grow by 52% and pay $48,000 per year.

In terms of work environment, energy technology employees may work indoors or outdoors in extreme temperatures, on rural or offshore wind farms. They may work in homes, businesses, factories, or construction sites which may involve noisy machinery. Line installers occasionally work at great heights or in confined spaces, including utility poles and transmission towers. These workers may drive utility vehicles and at times travel long distances. Digger Derrick truck operators work primarily outdoors at construction sites or utility projects. Nuclear engineers typically work in office settings. Power generation and supply employees could work in power plants, in offices, or at drilling/well sites. Travel may be required to visit sites or meet with engineers, field workers, and customers. Petroleum engineers may work internationally for large oil and gas companies, which could involve having those individuals travel to energy production sites around the world.

Most careers related to energy technology require at least a high school diploma, although careers with the highest earning potential–data scientists, engineers, and postsecondary teachers, for example **require** advanced degrees. Students can accomplish this level of education by attending any of the two-year and four-year degree energy technology-related programs available within Mississippi and across the nation as well.

Needs of the Future Workforce

Wind turbine service technicians (windtechs) maintain and fix the components of wind turbines, large mechanical structures that convert wind energy into electricity. This occupation has the second highest projected percent increase of employment between 2021 and 2031 nationally, with a 44% growth rate in the next decade. They were paid on the average over $56,000 annually in 2021, according to the US Bureau of Labor and Statistics. Development of taller towers with larger blades has reduced the cost of wind power generation, making it more competitive with coal, natural gas, and other forms of power generation. As additional wind turbines are assembled, more technicians will be needed to install and maintain them. However, the fast growth is expected to result in only about 4,900 projected new jobs over the decade. Data scientist is the sixth fastest growing occupation, projected to involve a 36% increase through 2030. Data scientists are needed when building predictive models for energy demand forecasting, optimizing energy generation and distribution, or improving energy efficiency to encourage the implementation of sustainable energy solutions that are integrated into energy infrastructure, such as solar panels or wind turbines. Other notable occupations, within the top twenty fastest growing careers relating to energy technology, in order of growth projection are: information security analysts, statisticians, logisticians, and solar photovoltaic installers. The needs and patterns of growth shown in Table 1.1 include a broad range of occupations connected to the overall energy technology industry regarding power generation, power transmission, and power distribution. Some of the occupations listed are associated with business-related careers within energy technology and energy regulation policy.

Table 1.1: Current and Projected Occupation Report

Description	**Jobs, 2020**	**Projected Jobs, 2030**	**Change (Number)**	**Change (Percent)**	**Average Hourly Earnings, 2023**
Administrative Services and Facilities Managers	2,490	2,640	150	6%	$45.48
Aircraft Mechanics and Service Technicians – Wind Turbine Service Technician	1,130	1,180	50	4.4%	$32.24
Business and Financial Operations Occupations	41,920	44,540	2,620	6.3%	$32.39
Compliance Officers	2,180	2,320	140	6.4%	$28.71
Computer and Information Systems Managers	`1,140	1,250	110	9.6%	$53.44
Construction and Building Inspectors	670	700	30	4.5%	$27.22
Construction and Extraction Occupations	51,130	53,810	2,680	5.2%	$21.94
Construction Laborers	12,210	12,530	320	2.6%	$16.46
Customer Service Representatives	17,210	18,430	1,220	7.1%	$16.09
Data Scientists and Mathematical Science Occupations	70	70	0	0%	$24.31
Derrick Operators, Oil and Gas	140	190	50	35.7%	$21.00

Earth Drillers, Except Oil and Gas; and Explosives Workers, Ordnance Handling Experts, and Blasters	130	140	10	7.7%	$24.24
Electrical and Electronics Engineering Technicians	850	870	20	2.4%	$28.79
Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	290	300	10	3.4%	$35.72
Electrical Engineers	1,260	1,300	40	3.2%	$46.42
Electrical Power-Line Installers and Repairers	2,020	2,130	110	5.4%	$33.14
Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	2,130	2,370	240	11.3%	$17.67
Electricians	5,780	6,280	500	8.7%	$27.02
Emergency Management Directors	140	150	10	7.1%	$24.48
Environmental Engineering Technologists and Technicians	110	140	30	27.3%	$25.13
Excavating and Loading Machine and Dragline Operators, Surface Mining	420	430	10	2.4%	$21.83
Financial and Investment Analysts, Financial Risk Specialists, and Financial Specialists	1,020	1,050	30	2.9%	$31.60
Financial Examiners	180	190	10	5.6%	$37.77
First-Line Supervisors of Construction Trades and Extraction Workers	6,380	6,620	240	3.8%	$30.82
First-Line Supervisors of Mechanics, Installers, and Repairers	4,550	4,800	250	5.5%	$33.16
Gas Plant Operators	190	190	0	0%	$30.75
General and Operations Managers	19,310	20,980	1,670	8.6%	$42.51

Helpers – Electricians	780	790	10	1.3%	$16.44
Helpers – Pipelayers, Plumbers, Pipefitters, and Steamfitters	350	390	40	11.4%	$15.93
Human Resources Manager	640	700	60	9.4%	$49.59
Human Resources Specialist	3,440	3,630	190	5.5%	$26.22
Industrial Machinery Mechanics	5,110	5,450	340	6.7%	$27.77
Industrial Production Managers	1,760	1,840	80	4.5%	$53.77
Installation, Maintenance, and Repair Occupations	55,600	58,480	2,880	5.2%	$23.68
Lawyers	3,830	4,030	200	5.2%	$48.67
Maintenance and Repair Workers, General	13,760	15,160	1,400	10.2%	$18.50
Maintenance Workers, Machinery	520	560	40	7.7%	$25.80
Market Research Analysts and Marketing Specialists	2,720	3,320	600	22.1%	$28.65
Marketing Manager	750	820	70	9.3%	$46.30
Materials Engineers	190	190	0	0%	$43.02
Mechanical Engineering Technologists and Technicians	100	110	10	10%	$28.57
Nuclear Technicians	80	80	0	0%	$41.68
Operations Research Analysts	410	520	110	26.8%	$40.58
Petroleum Engineers	240	310	70	29.2%	$49.11
Petroleum Pump System Operators, Refinery Operators, and Gaugers	1,460	1,590	130	8.9%	$42.64
Pipelayers	390	410	20	5.1%	$17.79
Plant and System Operators, All Other	120	120	0	0%	$25.78
Plumbers, Pipefitters, and Steamfitters	3,050	3,300	250	8.2%	$24.13
Power Plant Distributors, Dispatchers, and Operators	60	60	0	0%	$43.04
Production, Planning, and Expediting Clerks	2,960	3,080	120	4.1%	$22.57

Project Management Specialists and Business Operations Specialists	6,790	6,980	190	2.8%	$34.65
Roustabouts, Oil and Gas	500	710	210	42%	$19.95
Sales Manager	1,190	1,270	80	6.7%	$57.73
Sales Representative	470	500	30	6.4%	$38.07
Service Unit Operators, Oil, Gas, and Mining	140	190	50	35.7%	$26.99
Shipping, Receiving, and Inventory Clerks	7,020	7,160	140	2%	$17.50
Social and Community Service Managers	1,240	1,430	190	15.3%	$28.10
Stationary Engineers and Boiler Operators	300	300	0	0%	$27.18
Telecommunications Equipment Installers and Repairers, Except Line Installers	3,050	3,190	140	4.6%	$27.87
Telecommunications Line Installers and Repairers	270	310	40	14.8%	$21.72
Training and Development Managers	180	210	30	16.7%	$49.62
Urban and Regional Planners	170	200	30	17.6%	$31.97
Welders, Cutters, Solderers, and Brazers	6,370	6,830	460	7.2%	$23.75

Source: Mississippi Department of Employment Security; mdes.ms.gov (2023).

Perkins V Requirements and Academic Infusion

The Energy Technology curriculum meets Perkins V requirements of introducing students to and preparing them for high-skill, high-wage occupations in energy technology fields. It also offers students a program of study, including secondary, postsecondary, and institutions of higher learning courses, that will further prepare them for energy technology careers. Additionally, this curriculum is integrated with academic college- and career-readiness standards. Lastly, it focuses on ongoing and meaningful professional development for teachers as well as relationships with industry.

Transition to Postsecondary Education

The latest articulation information for secondary to postsecondary can be found at the Mississippi Community College Board website, mccb.edu.

Best Practices

Innovative Instructional Technologies

Classrooms should be equipped with tools that will teach today's digital learners through applicable and modern practices. The energy technology educator's goal should be to include teaching strategies that incorporate current technology. To make use of the latest online communication tools—wikis, blogs, podcasts, and social media platforms, for example—the classroom teacher is encouraged to use a learning management system that introduces students to education in an online environment and places more of the responsibility of learning on the student.

Differentiated Instruction

Students learn in a variety of ways, and numerous factors—students' background, emotional health, and circumstances, for example—create unique learners. By providing various teaching and assessment strategies, students with various learning preferences can have more opportunities to succeed.

CTE Student Organizations

Teachers should investigate opportunities to sponsor a student organization. There are several here in Mississippi that will foster the types of learning expected from the energy technology curriculum. SkillsUSA and Technology Student Association (TSA) are examples of student organizations with many outlets for energy technology. Student organizations provide participants and members with growth opportunities and competitive events. They also open the doors to the world of energy technology careers and scholarship opportunities.

Cooperative Learning

Cooperative learning can help students understand topics when independent learning cannot. Therefore, you will see several opportunities in the energy technology curriculum for group work. To function in today's workforce, students need to be able to work collaboratively with others and solve problems without excessive conflict. The energy technology curriculum provides opportunities for students to work together and help each other complete complex tasks. There are many field experiences within the energy technology curriculum that will allow and encourage collaboration with professionals currently in the energy technology field.

Work-Based Learning

Work-based learning is an extension of understanding competencies taught in the energy technology classroom. This curriculum is designed in a way that necessitates active involvement by the students in the community around them and the global environment. These real-world connections and applications link all types of students to knowledge, skills, and professional dispositions. Work-based learning should encompass ongoing and increasingly more complex involvement with local companies and industry professionals. Thus, supervised collaboration and immersion into the industry around the students are keys to students' success, knowledge, and skills development.

Professional Organizations

The American Clean Power Association (ACP)
cleanpower.org

Association of Energy Engineers (AEE)
aeecenter.org

Advanced Energy United (AEU)
advancedenergyunited.org

American Nuclear Society (ANS)
ans.org

American Society of Certified Engineering Technicians (ASCET)
ascet.org

American Solar Energy Society (ASES)
ases.org

Biomass Power Association (BPA)
usabiomass.org

Center for Energy Workforce Development (CEWD)
cewd.org

Energy Efficiency and Conservation Authority (EECA)
aceee.org

Office of Energy Efficiency and Renewable Energy (EERE)
energy.gov/eere

U.S. Energy Information Administration (EIA)
eia.gov

Energy Management Association (EMA)
energymgmt.org

Electric Power Research Institute (EPRI)
epri.com

Energy Storage Association (ESA)
energystorage.org

Electronics Technicians Association International (ETAI)
etai.org

Geothermal Energy Association (GEA)
geo-energy.org

International Brotherhood of Electrical Workers (IBEW)
ibew.org

Institute of Electrical and Electronics Engineers (IEEE)
ieee.org

Mississippi Construction Education Foundation (MCEF)
mcef.net

Mississippi Public Service Commission (Mississippi PSC)
psc.ms.gov

North American Board of Certified Energy Practitioners (NABCEP)
nabcep.org

National Association of Regulatory Utility Commissioners (NARUC)
naruc.org

National Center for Construction Education & Research (NCCER)
nccer.org

The National Energy Education Development Project (NEED)
need.org

National Hydropower Association (NHA)
hydro.org

National Renewable Energy Laboratory (NREL)
nrel.gov

Nuclear Energy Institute (NEI)
nei.org

Society of Petroleum Engineers (SPE)
spe.org

Solar Energy Industries Association (SEIA)
seia.org

Smart Electric Power Alliance (SEPA)
sepapower.org

The Energy Professionals Association (TEPA)
tepausa.org

Using This Document

Competencies and Suggested Objectives

A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.

Teacher Resources

All teachers should request to be added to the Canvas Resource Guide for their course. For questions or to be added to the guide, send a Help Desk ticket to the RCU by emailing helpdesk@rcu.msstate.edu.

Perkins V Quality Indicators and Enrichment Material

Some of the units may include an enrichment section at the end. This material will greatly enhance the learning experiences of students. If the energy technology program is using a national certification, work-based learning, or another measure of accountability that aligns with Perkins V as a quality indicator, this material could very well be assessed on that quality indicator. It is the responsibility of the teacher to ensure all competencies for the selected quality indicator are covered throughout the year.

Unit 1: Introduction to Emerging Technologies

Competencies and Suggested Objectives
1. Research the impact of emerging technologies on the utility industry. DOK 1, 4 a. Carbon capture b. Distributed generation c. Electric vehicles (EVs) d. Green hydrogen e. Microgrids f. Self-healing networks g. Smart neighborhoods h. Other technologies

Unit 2: Capstone

Competencies and Suggested Objectives
1. Collaborate with industry professionals and school faculty to develop a detailed plan for investigating a real-world problem. DOK 4 a. Research the problem. b. Brainstorm possible solutions. c. Consider or establish constraints and specifications. d. Select option for further analysis. e. Create procedures appropriate to investigate the problem.
2. Create a project management framework to ensure completion. DOK 4 a. Develop multiple milestones using specific, measurable, achievable, relevant, and time bound (SMART) goal methodologies to accomplish during each phase of capstone completion. b. Discuss and utilize various project management tools (e.g., Gantt chart, software applications, etc.).
3. Exhibit or present the project to industry professionals and school faculty (e.g., maker fair, school fair, school board meeting, community STEM/STEAM night, or online). DOK 4

Enrichment:
1. Students can utilize any of these suggested capstone ideas to enhance or enrich their project experiences. This is not an exhaustive list of possible suggestions. a. Design a construction of a small-scale renewable energy system. b. Miniature electrical system model to promote safety around powerlines c. Energy house-related project d. Circuits-related project e. Solar oven-related project f. Moving water-related project g. Wind power-related project h. Incorporate any emerging technologies discovered in Unit 1 of this course.

Note: Safety is to be taught as an ongoing part of the program. Students are required to complete a written safety test with 100% accuracy before entering the shop for lab simulations and projects. This test should be documented in each student's file.
Note: It is important to understand that the capstone is not to be completed as an isolated unit, but rather an ongoing project that will address, teach, and utilize the other competencies in this course.
Note: Energy industry terms and acronyms are available and compiled at eia.gov/tools/glossary

Unit 3: Power Generation Overview

Competencies and Suggested Objectives
1. Understand the basics of power generation and its significance in the energy sector. [DOK 1, 2] a. Define power generation and its role in supplying electricity to various sectors. b. Describe the importance of reliable and sustainable power generation for economic growth and quality of life.
2. Explore the history and evolution of power generation technologies. [DOK 3] a. Study the development of power generation technologies over time, from traditional methods to modern systems. b. Analyze the impact of technological advancements on the efficiency and environmental performance of power generation.
3. Identify the varying types of power generation sources. [DOK 1, 3] a. Classify power generation sources into renewable and non-renewable categories. b. Examine various renewable energy sources such as solar, wind, hydroelectric, geothermal, and biomass. c. Explore non-renewable sources including fossil fuels (coal and natural gas) and nuclear energy.
4. Investigate the principles and operation of conventional power plants. [DOK 3] a. Understand the concept of converting thermal energy into electrical energy in power plants. b. Explore the various components and processes involved in coal-fired and gas-fired power plants. c. Discuss the environmental impact and challenges associated with conventional power generation.
5. Study the principles and operation of nuclear power plants. [DOK 3] a. Examine the principles of nuclear fission and its application in generating electricity. b. Understand the components and processes involved in nuclear power plants. c. Discuss the safety measures, waste management, and environmental considerations associated with nuclear power generation.

Unit 4: Renewable Power Generation Technologies

Competencies and Suggested Objectives
1. Explore solar power generation. DOK 3 a. Understand the principles of converting solar energy into electrical energy. b. Study and compare the varying types of solar power systems, including photovoltaic (PV) and concentrated solar power (CSP). c. Analyze the advantages, limitations, and applications of solar power generation.
2. Investigate wind power generation. DOK 3 a. Understand the principles of harnessing wind energy to generate electricity. b. Study the components and operation of wind turbines. c. Explore wind power potential, site selection (onshore and offshore), and environmental considerations.
3. Examine hydroelectric power generation. DOK 3 a. Understand the principles of converting the energy of flowing water into electrical energy. b. Study the components and operation of hydroelectric power plants, including dams and turbines. c. Discuss the environmental impacts and considerations related to hydroelectric power generation.
4. Explore geothermal power generation. DOK 3 a. Understand the principles of harnessing geothermal heat to generate electricity. b. Study the different types of geothermal power plants and their operation. c. Analyze the advantages, limitations, and environmental considerations associated with geothermal power generation. d. Distinguish geothermal power generation from geothermal ground source heat pumps.
5. Investigate biomass power generation. DOK 3 a. Understand the principles of converting organic materials into electrical energy. b. Learn about different types of biomasses. c. Study different biomass power technologies, including combustion, gasification, and anaerobic digestion. d. Explore the advantages, challenges, and sustainability aspects of biomass power generation.

Unit 5: Non-Renewable Power Generation Technologies

Competencies and Suggested Objectives
1. Assess the effectiveness of coal-fired power generation. DOK 4 a. Understand the principles of coal combustion and its role in power generation. b. Study the components and processes involved in coal-fired power plants. c. Evaluate the environmental impact of coal-based power generation and potential emission control technologies.
2. Assess the effectiveness of natural gas-fired power generation. DOK 4 a. Understand the principles of natural gas combustion in power generation. b. Study the components and operation of natural gas power plants, including combined cycle systems. c. Analyze the environmental advantages and considerations associated with natural gas power generation.
3. Assess the effectiveness of oil-fired power generation. DOK 4 a. Understand the principles of oil combustion in power generation. b. Study the components and operation of oil-fired power plants. c. Discuss the environmental impact and considerations related to oil-based power generation.
4. Assess the effectiveness of nuclear power generation. DOK 4 a. Understand the principles of nuclear fission and its application in power generation. b. Study the components and processes involved in nuclear power plants. c. Discuss the safety measures, waste management, and environmental considerations associated with nuclear power generation.
5. Analyze the future of power generation and emerging technologies. DOK 3, 4 a. Explore innovative power generation technologies, such as advanced nuclear reactors, tidal power, and wave energy. b. Discuss the potential of energy storage systems and their role in balancing intermittent renewable power generation. c. Analyze the economic, environmental, and technological factors influencing the future of power generation.
6. Research the advantages and disadvantages of each non-renewable power generation technology. DOK 4

Unit 6: Power Generation Operations and Management

Competencies and Suggested Objectives
1. Understand power plant operations and maintenance. DOK 2, 3 a. Study the processes and tasks involved in operating and maintaining power plants. b. Explore the role of power plant operators, technicians, and engineers in ensuring safe and efficient operations.
2. Explore power plant efficiency and performance optimization. DOK 3 a. Study methods and techniques for improving power plant efficiency and reducing emissions. b. Explore technologies such as combined cycle gas turbine (CCGT) and combined heat and power (CHP) for enhancing energy utilization. c. Discuss the role of data analysis, monitoring systems, and predictive maintenance in optimizing power plant performance.
3. Analyze the environmental and social impacts of power generation. DOK 3, 4 a. Study the environmental effects of different power generation technologies, including air and water pollution, greenhouse gas emissions, and land use. b. Discuss strategies for mitigating environmental impacts, such as carbon capture and storage, renewable energy integration, and sustainable practices. c. Examine the social and community implications of power plant operations, including health and safety concerns, job creation, and local economic development.
4. Research power plant regulations and compliance standards. DOK 4 a. Understand the regulatory frameworks and standards governing power plant operations b. Study the environmental regulations, safety protocols, and reporting requirements for power generation facilities. c. Explore the roles of various regulatory agencies. (i.e., Environmental Protection Agency [EPA], Occupational Safety and Health Administration [OSHA], Mississippi Department of Environmental Quality [MDEQ], etc.). d. Discuss the importance of compliance with regulations and the consequences of non-compliance.
5. Investigate economic dispatch regarding a collection of power generating assets or plants. DOK 3

Unit 7: Power Transmission

Competencies and Suggested Objectives
1. List, identify, and discuss transmission voltages and associated structures, materials, equipment, and vehicles. DOK 1, 3 a. Types of structures (e.g., poles, towers, etc.) b. Types of conductors c. Explore the types and uses of utility vehicles (e.g., bucket trucks, Digger Derrick trucks, helicopter, drones, cranes, etc.).
2. Investigate the roles, responsibilities, and benefits of regional transmission organizations (RTOs) and independent system operators (ISOs). DOK 3
3. Investigate the importance of vegetation management to ensure reliable electrical systems. DOK 3 a. Explore various Light Detection and Ranging (LiDAR) applications. b. Construct an argument for incorporating satellite imagery in this context. c. Draw conclusions about Federal Energy Regulatory Commission (FERC) requirements.

Note: Safety is to be taught as an ongoing part of the program. Students are required to complete a written safety test with 100% accuracy before entering the shop for lab simulations and projects. This test should be documented in each student's file.

Unit 8: Power Substations

Competencies and Suggested Objectives
1. List, identify, and discuss the benefits and uses of different voltages, transformers, and associated equipment. DOK 1, 3 a. Voltage levels (e.g., 115 kV, 230 kV, 500 kV, etc.) b. Functions and purposes of transformers c. Types of associated equipment (e.g., switches, breakers, regulators, capacitors, etc.)

Note: Safety is to be taught as an ongoing part of the program. Students are required to complete a written safety test with 100% accuracy before entering the shop for lab simulations and projects. This test should be documented in each student’s file.

Unit 9: Power Distribution

Competencies and Suggested Objectives
1. List, identify, and discuss the benefits and uses of different voltages, transformers, equipment, and vehicles. DOK 1, 3 a. Primary voltage vs. secondary voltage b. Reclosers, fuses, transformers c. Overhead vs. underground systems d. Explore the types and uses of utility vehicles. (e.g., bucket trucks, Digger Derrick trucks, drones, etc.)
2. Explore decisions and processes to restore power. DOK 3 a. List, identify, and discuss the industry specific reliability metrics (i.e., System Average Interruption Duration Index [SAIDI], System Average Interruption Frequency Index [SAIFI], Equivalent Forced Outage Rates [EFOR], etc.) b. List, identify, and discuss the benefits of Regional Mutual Assistance Groups [RMAGs] after storms and other natural or man-made disasters. c. Local utility contact involvement (i.e., classroom presentation, discuss storm preparation and response, etc.)

Note: Safety is to be taught as an ongoing part of the program. Students are required to complete a written safety test with 100% accuracy before entering the shop for lab simulations and projects. This test should be documented in each student’s file.

Unit 10: Economic, Environmental, and Regulatory Considerations

Competencies and Suggested Objectives
1. Evaluate emissions that impact the environment. DOK 4
2. Explore the role of the utility industry in mitigating climate change, achieving net zero carbon emissions. DOK 3
3. Understand the role of state regulatory agencies (i.e., public service commission, etc.). DOK 1, 2
4. Understand the types of electrical utilities that operate in Mississippi (e.g., investor-owned utilities, electric power associations, municipal utilities, etc.). DOK 1, 2
5. Explore the concept of environmental, social, and governance (ESG). DOK 3
6. Understand the economic impact of jobs in the energy industry in Mississippi. DOK 4 a. Review general salary ranges for various industry positions, such as lineworker, process technician, relay technician, etc.

Note: Mississippi Public Service Commission (psc.ms.gov) regulates the following: electric utilities, gas pipeline safety, gas utilities, no call program, sewer utilities, telecom, and water utilities.

Unit 11: Advanced Topics in Emerging Technologies

Competencies and Suggested Objectives
1. Evaluate the impact of emerging technologies on the utility industry. DOK 4 a. Carbon capture b. Distributed generation c. Electric vehicles (EVs) d. Green hydrogen e. Microgrids f. Self-healing networks g. Smart neighborhoods h. Other technologies
2. Evaluate the impact of energy security on the utility industry. DOK 4 a. Cyber security b. Physical security

Student Competency Profile

Student's Name: ____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course.

In the blank before each competency, place the date on which the student mastered the competency.

Unit 1: Introduction to Emerging Technologies		
	1.	Research the impact of emerging technologies on the utility industry.
Unit 2: Capstone		
	1.	Collaborate with industry professionals and school faculty to develop a detailed plan for investigating a real-world problem.
	2.	Create a project management framework to ensure completion.
	3.	Exhibit or present the project to industry professionals and school faculty (e.g., maker fair, school fair, school board meeting, community STEM/STEAM night, or online).
Unit 3: Power Generation Overview		
	1.	Understand the basics of power generation and its significance in the energy sector.
	2.	Explore the history and evolution of power generation technologies
	3.	Identify the varying types of power generation sources.
	4.	Investigate the principles and operation of conventional power plants.
	5.	Study the principles and operation of nuclear power plants.
Unit 4: Renewable Power Generation Technologies		
	1.	Explore solar power generation.
	2.	Investigate wind power generation.
	3.	Examine hydroelectric power generation.
	4.	Explore geothermal power generation.
	5.	Investigate biomass power generation.
Unit 5: Non-Renewable Power Generation Technologies		
	1.	Assess the effectiveness of coal-fired power generation.
	2.	Assess the effectiveness of natural gas-fired power generation.
	3.	Assess the effectiveness of oil-fired power generation.
	4.	Assess the effectiveness of nuclear power generation.
	5.	Analyze the future of power generation and emerging technologies.

	6.	Research the advantages and disadvantages of each non-renewable power generation technology.
Unit 6: Power Generation Operations and Management		
	1.	Understand power plant operations and maintenance.
	2.	Explore power plant efficiency and performance optimization.
	3.	Analyze the environmental and social impacts of power generation.
	4.	Research power plant regulations and compliance standards.
	5.	Investigate economic dispatch regarding a collection of power generating assets or plants.
Unit 7: Power Transmission		
	1.	List, identify, and discuss transmission voltages and associated structures, materials, equipment, and vehicles.
	2.	Investigate the roles, responsibilities, and benefits of regional transmission organizations (RTOs) and independent system operators (ISOs).
	3.	Investigate the importance of vegetation management to ensure reliable electrical systems.
Unit 8: Power Substations		
	1.	List, identify, and discuss the benefits and uses of different voltages, transformers, and associated equipment.
Unit 9: Power Distribution		
	1.	List, identify, and discuss the benefits and uses of different voltages, transformers, equipment, and vehicles.
	2.	Explore decisions and processes to restore power.
Unit 10: Economic, Environmental, and Regulatory Considerations		
	1.	Evaluate emissions that impact the environment.
	2.	Explore the role of the utility industry in mitigating climate change, achieving net zero carbon emissions.
	3.	Understand the role of state regulatory agencies (i.e., public service commission, etc.).
	4.	Understand the types of electrical utilities that operate in Mississippi (e.g., investor-owned utilities, electric power associations, municipal utilities, etc.).
	5.	Explore the concept of environmental, social, and governance (ESG).
	6.	Understand the economic impact of jobs in the energy industry in Mississippi.
Unit 11: Advanced Topics in Emerging Technologies		
	1.	Evaluate the impact of emerging technologies on the utility industry.
	2.	Evaluate the impact of energy security on the utility industry.

Appendix A: Industry Standards

	Units	1	2	3	4	5	6	7	8	9	10	11
Standards												
HS-PS1-1		X		X	X	X	X					X
HS-PS1-2		X		X	X	X						X
HS-PS1-3		X		X	X	X						X
HS-PS1-4							X					X
HS-PS1-5		X			X	X	X				X	
HS-PS1-6												X
HS-PS1-7			X							X		
HS-PS1-8				X								
HS-PS2-1		X			X	X	X					
HS-PS2-5								X	X	X		
HS-PS3-1		X	X		X	X	X		X		X	
HS-PS3-2		X		X	X	X	X					X
HS-PS3-3		X	X	X	X	X	X	X	X	X		
HS-PS3-4		X	X	X	X	X	X				X	
HS-PS3-5			X					X	X	X		X
HS-PS4-3		X	X		X		X					X
HS-PS4-4		X	X									X
HS-LS1-5				X	X							
HS-LS2-2											X	X
HS-LS2-3				X			X				X	X
HS-LS2-4				X							X	X
HS-LS2-5		X			X						X	
HS-LS2-6				X	X	X	X	X	X	X	X	X
HS-LS2-7											X	X
HS-LS4-6			X									X
HS-ESS1-1				X	X	X						X
HS-ESS1-5												X
HS-ESS2-1												X
HS-ESS2-2											X	
HS-ESS2-3				X								
HS-ESS2-4				X	X	X					X	X
HS-ESS2-5				X							X	
HS-ESS2-6		X			X						X	X
HS-ESS3-1				X	X	X					X	X
HS-ESS3-2				X	X	X	X				X	
HS-ESS3-4		X	X						X		X	X
HS-ESS3-5				X							X	X
HS-ESS3-6		X										X
HS-ETS1-1		X	X		X	X					X	
HS-ETS1-2		X	X								X	X
HS-ETS1-3		X	X				X	X			X	X

NGSS - A Framework for K-12 Science Education

HS-PS1 Matter and its Interactions

1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

HS-PS2 Motion and Stability: Forces and Interactions

1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS3 Energy

1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects).
3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

HS-PS4 Waves and their Applications in Technologies for Information Transfer

3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-LS1 From Molecules to Organisms: Structures and Processes

5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

HS-LS4 Biological Evolution: Unity and Diversity

6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

HS-ESS1 Earth's Place in the Universe

1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

HS-ESS2 Earth's Systems

1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

HS-ESS3 Earth and Human Activity

1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

HS-ETS1 Engineering Design

1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.