**WRIGHT STATE’S MASTER DEGREE PROGRAM IN RENEWABLE/CLEAN ENERGY ENGINEERING**

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What is this Program?

* Wright State is offering a Master of Science Degree in Renewable/Clean Energy Engineering
* Renewable Energy is defined as energy sources that are replenished as fast, or faster, than we use them; thus, they will never run out.
* Clean Energy refers to energy sources and technology that are more environmentally friendly than our current use of fossil fuels.
* Many courses in the renewable and clean energy field are offered (please see back of this sheet). Because of a multi-university collaboration we have one of the largest renewable and clean energy course selections in the country.
* This degree generally takes about 2 years to complete.
* Both thesis and non-thesis options are available.
* The program is open to individuals that have a Bachelor’s Degree in an engineering or science discipline. At least 3 semesters of calculus and one semester of differential equations must have been taken in the undergraduate discipline.
* This program is done in collaboration with the University of Dayton, the Air Force Institute of Technology, Central State University, DAGSI, and SOCHE.

Interesting Information on the Program

* First program of its kind in the State of Ohio.
* One of a few Master’s Programs in Renewable and Clean Energy in the United States.
* Program started in January of 2009.
* Some people estimate that the renewable energy and the energy efficiency industries will generate $4.5 trillion dollars of revenue by the year 2030\*.
* Some estimate that as many as 40 million Americans could be working in the renewable energy and energy efficiency field by 2030\*.

\*From “Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century,” by Roger Bezedek, done by Management Information Services for the American Solar Energy Society, 2007.

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**Web site:** <http://www.engineering.wright.edu/mme/rce/>**CURRICULUM FOR PROGRAM**

Students will be expected to take five required courses; one Advanced Thermodynamics course, three Renewable and Clean Energy courses, and one course in mathematics. Additionally, students will be required to take two elective courses and chose a thesis or non-thesis option. Thesis option students will perform a detailed research/design project with a faculty adviser. Non-thesis students will be expected to take at least one project course and two additional elective courses. A total of 30 semester credit hours need to be completed. Distinctively, this program allows students to register for courses at each of the partner schools, the University of Dayton and the Air Force Institute of Technology. There is a requirement that at least one of the Renewable and Clean Energy courses or the Advanced Thermodynamics course be taken at the University of Dayton. Additional cross-registration is encouraged; however, a majority of the courses and the thesis must be taken at Wright State University.

**ACCEPTABLE UNDEGRADUATE DEGREES**

Any four year engineering degree.

Many science and math degrees that require at least 3 semesters of calculus and a differential equations course.

**PREREQUISITE UNDERGRADUATE COURSES FOR PROGRAM**

These courses can be taken after admission to the Renewable/Clean Energy Engineering Master’s Degree program if the student did not take them in their undergraduate program.

* Thermodynamics I (at Wright State this would be WSU/ME 3310/5310)
* Thermodynamics II (at Wright State this would be WSU/ME 3320/5320 or WSU/ME 3750/5750)
* Fluid Dynamics (at Wright State this would be WSU/ME 3350/5350)
* Heat Transfer (at Wright State this would be WSU/ME 3360/5360)
* Materials Science (at Wright State this would be WSU/ME 2700)

**REQUIRED ADVANCED THERMODYNAMICS COURSE**
Students are required to take 1 of the following courses to meet the Advanced Thermodynamics requirement.
**Advanced Thermodynamics Requirement** **(1 among the following required)**

* WSU/ME 7500 – Advanced Thermodynamics
* UD/RCL 511 – Advanced Thermodynamics
* UD/CME 515 – Statistical Thermodynamics
* AFIT/PHYS 635 – Thermal Physics

**REQUIRED RENEWABLE AND CLEAN ENERGY COURSES**
Students are required take 3 courses in the Renewable and Clean Energy area. This area comprises three categories: Renewable Energy, Clean Energy, and Energy Efficiency. These courses can be taken in a single category or in different categories.
**Renewable Energy**

* WSU-CSU/ME 6520 – Hydropower
* WSU/ME 6530 – Energy Conversion
* WSU/ME 6540 – Solar Thermal Engineering
* WSU/ME 6550 – Geothermal Energy
* WSU/ME 6560 – Wind Power
* WSU/ME 7520 – Hydrogen Energy
* WSU/ME 7550 – Photovoltaics
* UD/RCL 533 – Biofuels
* UD/MEE 573 – Renewable Energy Systems
* UD/MEE 590 – Wind Energy Engineering
* UD/MEE 590 – Geothermal Energy

**Clean Energy**

* WSU/ME 6570 – Energy Materials
* WSU/ME 6580 – Fuel Cell Science and Technology
* WSU-CSU/ME 6590 – Advances in Clean Coal Technology
* AFIT/NENG 620 – Nuclear Reactor Theory and Engineering
* UD/MEE/RCL 524 – Electrochemical Power
* UD/MEE/CME 579 – Materials for Advanced Energy Application

**Energy Efficiency**

* WSU/ME 6240 – Vehicle Engineering
* UD/RCL 569 – Energy Efficient Buildings
* UD/RCL 571 – Design of Thermal Systems
* UD/RCL 572 – Design for Environment
* UD/RCL 578 – Energy Efficient Manufacturing
* UD/RCL 590 – Building Energy Informatics
* UD/RCL 590 – Electrical Utility Management

**REQUIRED MATH COURSE**Students are required to take one of the two math courses listed below:

* MTH 5040 – Advanced Engineering Mathematics
* MTH 6040 – Advanced Engineering Mathematics II

**ELECTIVES**Students will need to take 2 graduate level elective courses to fulfill the 30 semester credit degree requirement. These courses can be taken in the Engineering, Computer Science, Physics, Chemistry, Biology, Microbiology, Geology, Environmental Sciences, Mathematics, and Statistics disciplines. Additional Renewable and Clean Energy courses may be taken to fulfill this elective requirement also. Because enough elective courses must be taken to reach the required 30 credit hours for the degree, there may be rare cases where the student has to take an extra elective course.

**THESIS OPTION**

Students can take up to 9 semester hours of thesis credits.

* ME 7950 – Master Thesis Research

**NON-THESIS OPTION**Students who elect to do the non-thesis option must replace thesis credits with graduate level courses. These courses must be at the 7000 level or above, at UD these courses must be at the 500 level or above, and at AFIT these courses must be at the 600 level or above. At least one of these courses must be a project orientated course for 3 credit hours.

* ME 7990 – Independent Study

**UNIVERSITY OF DAYTON REQUIREMENT**Students must take at least one renewable and clean energy course or the Advanced Thermodynamics course at the University of Dayton. Students may take additional classes at the University of Dayton and the Air Force Institute of Technology if they wish, but they must take at least 15 semester credits at Wright State. All thesis credits must be done at Wright State.

**7000 LEVEL COURSE REQUIREMENT**Students must take at least 6 credit hours above the thesis and project credits at the 7000 level at Wright State.

**COURSE DESCRIPTIONS**

**PREREQUISITE UNDERGRADUATE COURSES FOR PROGRAM (all are needed as prerequisites for program with a choice between ME 5320 and ME 5750)**

WSU/ME 5310 – Thermodynamics I (Credits: 3)

This course studies energy and energy conversion from the classical thermodynamics perspective. Properties of fluids, conservation of mass, conservation of energy, and the second law of thermodynamics are studied. These principles are applied to engineering problems. **Prerequisites:** (EGR 1010 or MTH 2310 { MTH 2310 may be taken concurrently} ) and (PHY 2400).

WSU/ME 5320 – Thermodynamics II (Credits: 3) (can be replaced with ME 5750)

This course will apply the 0th, 1st, 2nd, and 3rd laws of thermodynamics, as well as conservation of mass, to a range of classical thermodynamic systems and phenomena. These include power and refrigeration cycles, gas mixtures, ideal vapor-gas mixtures, air conditioning, combustion, and chemical equilibrium. **Prerequisites:** (ME 1020) and (ME 3310 or ME 5310).

WSU/ME 5750 – Thermodynamics of Materials (Credits: 3) (can be replaced with ME 5320)

Application of classical thermodynamics to engineering materials. Heats of formation and reaction; behavior of solutions; free energy concepts; thermodynamic fundamentals of phase equilibria. **Prerequisite:** (ME 2700).

WSU/ME 5350 – Fluid Dynamics (Credits: 3)

Study of fluid properties, fluid statics, incompressible flows, real fluid flows, and flow measurement. **Prerequisites:** (ME 2210) and (ME 3310 or ME 5310).

WSU/ME 5350 – Heat Transfer (Credits: 3)

Study of the movement of energy due to a temperature difference. The three modes of heat transfer are investigated: conduction, convection, and radiation. Detailed look at heat equation. **Prerequisites:** (ME 1020) and (ME 3350 or ME 5350) and (MTH 2350).

WSU/ME 2700 – Structure and Properties of Materials I (Credits: 3)

This course covers the fundamentals of the structures of solids and their effect on the mechanical properties of metals, polymers, and ceramics. Additional topics include phase diagrams and heat treatment. An overview of engineering materials is also presented. **Prerequisites:** (CHM 1210 and PHY 2401).

**ADVANCED THERMODYNAMICS COURSE (1 required)**

WSU/ME 7500 – Advanced Thermodynamics (Credits: 3)

Thermodynamics is studied from both the classical (macroscopic) and statistical (microscopic) viewpoints with emphasis on statistical thermodynamics. Property relationships, Maxwell relations, partition functions, distribution functions, kinetic theory and the Boltzmann transport equation are discussed. **Prerequisites:** (ME 3320 or ME 5320 or ME 3750 or ME 5750).

UD/RCL 511 – Advanced Thermodynamics (Credits: 3)

Equilibrium, first law, second law, state principle, and zeroth law; development of entropy and temperature from availability concepts; chemical potential, chemical equilibrium, and phase equilibrium. Thermodynamics of irreversible processes; Onsager reciprocal relations; application of these concepts to direct energy conversion. **Prerequisites:** (ME 3320 or ME 5320 or ME 3750 or ME 5750).

UD/CME 515 – Statistical Thermodynamics (Credits: 3)

Microscopic thermodynamics; Boltzmann, Bose-Einstein, Fermi-Dirac statistics; statistical interpretation of thermodynamic quantities. Applications to perfect and real gases, liquids, crystalline solids, and thermal radiation. **Prerequisites:** (ME 3320 or ME 5320 or ME 3750 or ME 5750) and (MTH 2350).

AFIT/PHYS 635 – Thermal Physics (Credits: 2.6 which equals 4 quarter credits)

Treats statistical mechanics and thermodynamics. Topics include statistical methods, statistical thermodynamics with applications, ensemble theory, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics with applications. **Prerequisites:** (AFIT/PHYS 556 or AFIT/PHYS 655 or PHY 4600 or PHY 6600 {A quantum mechanics course is required}).

**RENEWABLE AND CLEAN ENERGY COURSES (3 required)**

**Renewable Energy**

WSU-CSU/ME 6520 – Hydropower (Credits: 3)

Topics covered are hydraulics of turbomachines for power generation, hydrologic analysis for hydropower development for run-of the river systems and reservoir systems, dams and environmental impacts, environmental impact assessment, operations of reservoir systems, and economics of hydropower generation. **Prerequisite:** (ME 3350 or ME 5350).

WSU/ME 6530 – Energy Conversion (Credits: 3)

This course will study the fundamentals of energy and energy conversion, the conversion of energy from mechanical, thermal, chemical, and nuclear will be discussed. To demonstrate these energy forms generators, wind, ocean, steam turbines, direct energy conversion, fossil fuels, biofuels, and nuclear power will be presented. **Prerequisite:** (ME 3310 or ME 5310).

WSU/ME 6540 – Solar Thermal Engineering (Credits: 3)

Fundamentals of solar radiation and how it can be utilized as a thermal energy source. Solar insolation on a surface, flat plate collectors, concentrating collectors, thermal energy storage, and solar hot water heating will be discussed. **Prerequisite:** (ME 3360 or ME 5360).

WSU/ME 6550 – Geothermal Energy (Credits: 3)

Techniques for tapping the energy of the earth will be discussed. This will include hot and cold geothermal energy. Use of geothermal energy to produce electricity, for space and district heating and cooling, and for industrial applications will be presented. In addition, geothermal energy's effect on the environment and its economics will be discussed. **Prerequisite:** (ME 3360 or ME 5360).

WSU/ME 6560 – Wind Power (Credits: 3)

Power in the wind, the wind turbine and its parts, performance of wind turbines, and economics of wind turbines will be presented. **Prerequisite:** (ME 3350 or ME 5350).

WSU/ME 7520 – Hydrogen Energy (Credits: 3)

This course focuses on hydrogen as a renewable and clean means of energy storage, and discusses hydrogen production and storage, as well as an overview of hydrogen energy conversion. **Prerequisites:** (ME 3310 or ME 5310) and (ME 3750 or ME 5750).

WSU/ME 7550 – Photovoltaics (Credits: 3)

Basic principles of solar cells will be covered including semiconductors, electrons and holes, and p-n junctions. Different types of solar cell materials including crystalline and amorphous cells as well as techniques for increasing their efficiency will be presented. **Prerequisite**: (ME 7500).

UD/RCL 533 – Biofuels (Credits: 3)

No description available at this time.

UD/RCL 573 – Renewable Energy Systems (Credits: 3)

Introduction to the impact of energy on the economy and environment. Engineering models of solar thermal and photovoltaic systems. Introduction to wind power. Fuel cells and renewable sources of hydrogen. **Co-requisite:** (ME 3360 or ME 5360).

UD/MEE 590 – Wind Energy Engineering (Credits: 3)

No description available at this time.

UD/MEE 590 – Geothermal Energy (Credits: 3)

No description available at this time.

**Clean Energy**

WSU/ME 6570 – Energy Materials (Credits: 3)

Students will understand the principles and the materials of advanced electrochemical energy storage systems including batteries, fuel cells, and supercapacitors. In this course, students will gain an understanding of material structures, material composition, and material morphologies in relation to applicable properties for electrochemical energy storage and conversion systems. Students will also be introduced to state-of-the-art materials research and development in these systems. **Prerequisites: (**ME 2700) and (ME 3310 or ME 5310 or ME 3750 or ME 5750)

WSU/ME 6580 – Fuel Cell Science and Technology (Credits: 3)

This course will cover the fundamentals, technologies, and applications of various types of fuel cells. The fundamentals covered are thermodynamic prediction, electrolyte conduction, and electrode kinetics. The types of fuel cells covered are polymer electrolyte fuel cell, solid oxide fuel cell, and fuel cell stack. **Prerequisites:** (ME 5310) and (ME 2700).

WSU-CSU/ME 6590 – Advances in Clean Coal Technology (Credits: 3)

Historical perspective on coal; sources of coal in the world; future dependence on coal for energy; power production using coal; general process description; principles of combustion, conventional combustion reactors, environmental impact; fluidized bed reactors, process improvements in minimizing emissions; and discussions on future innovations in for clean coal technology. **Prerequisite:** (ME 3360 or ME 5360)

AFIT/NENG 620 – Nuclear Reactor Theory and Engineering (Credits: 3)

This course presents nuclear reactor theory, building upon the coverage of nuclear physics (reactions, radiations, fission, etc.) and the coverage of neutron diffusion, prompt fast criticality and prompt kinetics. Delayed and thermal neutrons are incorporated into the treatment of criticality and kinetics. Reactor dynamics are examined, including aspects of reactor core and system design which provide reactivity feedback for reactor control. Nuclear reactor engineering topics include thermal management, energy conversion, radiation shielding, and mechanical and structural aspects of reactor and system design. This course provides a broadened exposure to applications of nuclear science, and provides the necessary foundation for the nuclear fuel cycle. **Prerequisite:** (ME 7500 or UD/RCL 511 or UD/CME 515 or AFIT/PHYS 635)

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UD/MEE/RCL 524 – Electrochemical Power (Credits: 3)

The course will cover fundamental as well as engineering aspects of fuel cell technology. Specifically, the course will cover basic principles of electrochemistry, electrical conductivity (electronic and ionic) of solids, and development/design of major fuel cells (alkaline, polymer electrolyte, phosphoric acid, molten carbonate, and solid oxide). A major part of the course will focus on solid oxide fuel cells (SOFC), as it is emerging to be dominant among various fuel cell technologies. The SOFC can readily and safely use many common hydrocarbon fuels such as natural gas, diesel, gasoline, alcohol, and coal gas. **Prerequisites:** (ME 5310) and (ME 2700).

UD/MEE/CME 579 –Energy Materials (Credits: 3)

Various advanced energy technologies (AMTEC, Fuel Cells, Thermoelectrics, Nuclear, etc.) will be discussed with an emphasis on the role that materials have/will play in their development. Critical "bottlenecks" in materials development delaying the introduction of new advanced energy systems will be identified. In addition, how material selections are made based on operational system environments in "real world" scenarios will be presented. **Prerequisites:** (UD/MAT 501) and (UD/MAT 502).

**Energy Efficiency**

WSU/ME 6240 – Vehicle Engineering (Credits: 3)

Develops students' abilities to derive and solve vehicle equations, and introduce dynamic analysis in vehicle design. Various performance criteria, control concepts, and HEVs will be studied. **Prerequisites:** ME 2210.

UD/RCL 569 – Energy Efficient Buildings (Credits: 3)

Provides knowledge and skills necessary to design and operate healthier, more comfortable, more productive, and less environmentally destructive buildings; A specific design target of E/3 (typical energy use divided by three) is established as a goal. Economic, thermodynamic, and heat transfer analyses are utilized. Extensive software development. **Prerequisite:** (ME 3360 or ME 5360).

UD/RCL 571 – Design of Thermal Systems (Credits: 3)

Integration of thermodynamics, heat transfer, engineering economics, and simulation and optimization techniques in a design framework. Topics include design methodology, energy analysis, heat exchanger networks, thermal-system simulation, and optimization techniques. **Prerequisite:** (ME 3320 or ME 5320) and (ME 3360 or ME 5360).

UD/RCL 572 – Design for Environment (Credits: 3)

Emphasis on design for environment over the life cycle of a product or process, including consideration of mining, processing, manufacturing, use, and post-life stages. Course provides knowledge and experience in invention for the purpose of clean design, life cycle assessment strategies to estimate the environmental impact of products and processes, and cleaner manufacturing practices. Course includes a major design project. **Prerequisite:** (No prerequisites listed).

UD/RCL 578 – Energy Efficient Manufacturing (Credits: 3)

This course presents a systematic approach for improving energy efficiency in the manufacturing sector. Current patterns of manufacturing energy use, the need for increased energy efficiency, and models for sustainable manufacturing are reviewed. The lean-energy paradigm is applied to identify energy efficiency opportunities in industrial electrical, lighting, space conditioning, motor drive, compressed air, process heating, process cooling, and combined heat and power systems. **Prerequisites:** (ME 3320 or ME 5320) and (ME 3360 or ME 5360).

UD/RCL 590 – Building Energy Informatics (Credits: 3)

No description available at this time.

UD/RCL 590 – Electrical Utility Management (Credits: 3)

No description available at this time.

**MATH COURSE (1 required)**

MTH 5040 – Advanced Engineering Mathematics (Credits: 3)

Topics selected from linear algebra, ordinary differential equations, linear difference equations, geometry, and multivariable calculus. **Prerequisites:** (MTH 2320) and (MTH 2350 or MTH 2330)

MTH 6040 – Advanced Engineering Mathematics (Credits: 3)

Topics chosen from orthogonality, matrix factorizations, Rayleigh quotient, curvilinear and rotating coordinates, multivariable integration, Fourier series and integrals, and partial differential equations models and solutions. **Prerequisites:** (MTH 5040)

**ELECTIVES (2 to 4 needed)**

Many Options at the 6000 or 7000 Level

These courses can be taken in the Engineering, Computer Science, Physics, Chemistry, Biology, Microbiology, Geology, Environmental Sciences, Mathematics, and Statistics disciplines. Additional Renewable and Clean Energy courses may be taken to fulfill this elective requirement also. A listing of the graduate level courses offered in these areas can be found online in the Wright State graduate course descriptions.

**THESIS OPTION (up to 9 credits)**

ME 7950 – Master Thesis Research

This is an in depth research or design project into a topic agreed upon by the student and a faculty advisor. This option must be done under the guidance of a faculty member. This research project must culminate in a Master’s Thesis and an oral defense of that thesis.

**NON-THESIS OPTION (3 credits of independent study and 6 credits of 7000 electives)**

ME 7990 – Independent Study (Credits: 3)

A three credit study of some topic in renewable or clean energy. This study must be done under the guidance of a faculty advisor. This project is much smaller than a thesis project.

ME 7000 – Two additional 7000 level courses (Credits: 6)

These courses can be taken in the Engineering, Computer Science, Physics, Chemistry, Biology, Microbiology, Geology, Environmental Sciences, Mathematics, and Statistics disciplines. Additional Renewable and Clean Energy courses may be taken to fulfill this requirement also. A listing of the graduate level courses offered in these areas can be found online in the Wright State graduate course descriptions.