# Rutgers, The State University
# Department of Electrical and Computer Engineering
# 14:332:402 and 16:332:585
# Sustainable Energy

This course is designed for the student interested in an overview of the technological methods for obtaining energy from non-renewable and renewable energy sources. The course will be divided into Four components:

1. Introduction to Sustainability and Energy
    - Defining sustainability
    - Energy sources
    - Historical perspective
    - Aspect of energy consumptions: what is the problem with the way we consume energy?

2. Non-renewable Energy Sources: Fossil Based Fuels. Primarily Coal, Natural Gas, and Petroleum. Including conventional electric power generation and transportation.

3. Renewable Energy Sources:

    - Wind Energy
    - Solar
    - Hydropower
    - Nuclear
    - Geothermal
    - Biomass
    - Ocean Waves, Tides, Thermal Energy Conversion

4. Transportation and Smart Grid as a Driver for Sustainable Energy

    - Technologies & architectures
    - Generation and analysis
    - Implementation drives: policy, social, economical & environmental factors

**Instructor:** Dr. Sasan Haghani
Times: Tuesdays 5:40 to 8:40 p.m.
Location:
Office Hours: Tuesdays 12- 2:00 p.m. in EE122
**Pre-Requisite Courses:** None. This course is multi-disciplinary, but a maturity level in science and engineering is necessary.

**Co-Requisite Courses:** None

**Pre-Requisite by Topic:** None beyond senior level standing in any SOE department

**Textbook & Materials**:

1. Textbook: Sustainable Energy by Richard A. Dunlap (MindTap Course List), Cengage, 2nd Edition,
2. Additional references: J. W. Tester, E. M. Drake, M. J. Driscoll, M. W. Golay and W. A. Peters: ***Sustainable Energy: Choosing Among Options***, MIT Press, Cambridge, Massachusetts, 2ed edition, 2012
3. Lecture slides
4. Notes and selected papers uploaded on the course online site @Canvas

**References:**

- Internet resources to which students will be directed by the instructor such as the sites of The World Bank, the Energy Information Administration, the World Research Institute, the Intergovernmental Panel on Climate Change etc.
- If smart classroom is available, in-class internet searches for fast-changing technological and policy aspects relating to the material.

**Overall Educational Objective:** To demonstrate multi-disciplinary strategic thinking in a sustainable development context taking into account diverse constraints

**Course Learning Outcomes:** A student who successfully completes this course will have demonstrated:

An ability to understand the scientific and engineering foundations of energy, including national and global patterns of energy supply and utilization, and the environmental effects of energy production and consumption.

An ability to estimate and evaluate energy resources by comparing different forms of energy and understanding the energy lifecycle, particularly focusing on fossil mineral fuels and their implications for sustainable development.

An ability to assess technical performance related to sustainability, including methods of thermodynamic analysis, chemical rate processes, and the physical transport of heat in energy conversion.

An ability to analyze the local, regional, and global environmental effects of energy systems, with a focus on adverse effects, global climate change, and methods of environmental protection and sustainability.

An ability to perform economic evaluations of energy projects, incorporating concepts such as the time value of money, payback periods, economies of scale, and the accounting of externalities in energy modeling.

An ability to understand energy systems and sustainability metrics, employing systems analysis approaches to measure sustainability, and recognizing the drivers of societal change and principles of sustainable development.

**How Course Outcomes are Assessed:**

Homework: 30%
Quizzes: 40%
Mid-Semester Project Presentation and One page Abstract: 10%
Final Project Report and Presentation 20%

**Topics Covered (Tentative):**

***Introduction****:* Definition of sustainable Energy; Defining Energy-Scientific and Engineering Foundations; Aspects of Energy Production and Consumption; National and Global Patterns of Energy Supply and Utilization; Environmental Effects of Energy;

***Estimation and Evaluation of Energy Resources***: Units of Measurement, Energy and Power; Comparison of Different Forms of Energy; The Energy Lifecycle; Estimation of Fossil Mineral Fuels; Lessons for Sustainable Development; ***Global Climate Change*** "6 degrees can change the world"; Attribution of Environmental Damage to Energy Utilization; Methods of Environmental Protection; Environmental Benefits of Energy; Implications for Sustainable Energy

***Technical Performance: Efficiency and Production Rates:*** Relation to Sustainability; An Introduction to Methods of Thermodynamic Analysis; Energy Resources and Energy Conversion.

***Fossil Fuels and Fossil Energy****:* Introduction; The Fossil Fuel Resource Base; Harvesting Energy and Energy Products from Fossil Fuels; Major Accidents: Exxon Valdez and Deepwater Horizon; Environmental Impacts; Economics of Fossil Energy; Some Principles for Evaluating Fossil and Other Energy Technology Options; Emerging Technologies; Why Are Fossil Fuels Important to Sustainable Energy;

***Energy Systems and Sustainability Metrics:*** Introduction and Historical Notes; Energy from a Systems Perspective; Systems Analysis Approaches; Measures of Sustainability; Drivers of Societal Change; Some General Principles of Sustainable Development

***Nuclear Power:*** Nuclear History; Physics; Nuclear Reactors ; Nuclear Power Economics; Reactor Safety; Different Reactor Technologies; RBMK and the Chernobyl disaster; Advanced Reactors; Nuclear Power Fuel Resources; Fuel Cycle; Fusion Energy; Future Prospects for Nuclear Power

***Project Economic Evaluation:*** Introduction; Time Value of Money Mechanics; Current versus Constant-Dollar Comparisons; Simple Payback; Economy of Scale and Learning Curve; Allowing for Uncertainty; Accounting for Externalities; Energy Accounting; Modeling Beyond

the Project Level.

***Generally on Renewables:*** Introduction and Historical Notes; Resource Assessment; Environmental Impacts; Technology Development and Deployment; The Importance of Storage; Connecting Renewables to Hydrogen; The Future for Renewable Energy;

***Hydropower:*** Overview; Hydropower Resource Assessment; Basic Energy Conversion Principles; Conversion Equipment and Civil Engineering Operations; Sustainability Attributes; Status of Hydropower Technology Today.

***Wind Energy:*** Introduction and Historical Notes; Wind Resources; Wind Machinery and Generating Systems; Wind Turbine Rating; Wind Power Economics; Measures of Sustainability; Current Status/Future Prospects.

***Solar Energy:*** General Characteristics of Solar Energy; Resource Assessment; Passive and Active Solar Thermal Energy for Buildings; Economic and policy issues; Solar Thermal Electric Systems-Concentrating Solar Power; Power tower-central receiver systems; Parabolic troughs; Dish systems

***Solar Energy:*** Solar Photovoltaic (PV) Systems: Semiconductor device physics fundamentals. Performance limits and design options; Silicon-based cells (crystalline and amorphous); Thin-film cells; Concentrator cells; Current status and future potential of PV; Economics of solar cell production; Sustainability Attributes; Prognosis

***Geothermal Energy:*** Characterization of Geothermal Resource Types; Geothermal Resource Size and Distribution; Practical Operation and Equipment for Recovering Energy; Sustainability Attributes; Status of Geothermal Technology Today; Competing in Today's Energy Markets; Research and Development Advances Needed; Potential for the Long Term

***Energy from Biomass:*** Characterizing the Biomass Resource; Biomass Relevance to Energy Production; Chemical and Physical Properties Relevant to Energy Production; Biomass Production: Useful Scaling Parameters; Thermal Conversion of Biomass; Bioconversion; Environmental Issues; Economics; Enabling Research and Development; Disruptive Technology.

***Ocean Waves, Tide, and Thermal Energy Conversion:*** Introduction; Energy from the Tides; Energy from the Waves; Energy from Temperature Differences; Economic Prospects; Environmental and Sustainability Considerations; The Ocean as an Externalities Sink; Current Status and Future Prospects

***Local, Regional, and Global Environmental Effects of Energy:*** How Energy Systems Interact with the Environment;
***Transportation:*** Introduction; Electric vehicles; Economic Prospects; Environmental and Sustainability Considerations; The Ocean as an Externalities Sink; Current Status and Future Prospects

**Computer Usage:** Homework Assignments

**Laboratory Experiences:** None

**Design Experiences:** Homework assignments, which have some design component and Final Project

**Independent Learning Experiences:** Homework involves information searches. Material is highly subject to updating and change; internet resources crucial.

**Resources for Students: (https://success.rutgers.edu/)**

a. Academic Integrity - https://academicintegrity.rutgers.edu/
b. Self-Reporting Absence Application - https://sims.rutgers.edu/ssra/
c. Absence Verification & Student Support - https://studentsupport.rutgers.edu/
d. Academic Advising & Policies - https://soe.rutgers.edu/academic-advising-and-policies/advising-resources
e. University Policies on Final Exams - https://scheduling.rutgers.edu/final-exam-policies
f. Tutoring, Academic Coaching, Learning Support - https://learningcenters.rutgers.edu/
g. Counseling (CAPS) - https://health.rutgers.edu/medical-and-counseling-services/counseling-services
h. Violence Prevention & Victim Assistance (VPVA) - https://vpva.rutgers.edu/
i. Disability Services -https://ods.rutgers.edu/