Course Guide

Title: Energy Physics and Technology

Code: ENERGI210

Aim and Content

This course provides an insight into the physics behind various energy technologies for the production of mechanical energy, heat and electricity. The course deals with practical energy conversion devices, their efficiency, their technology maturity along with their potential for improvement, and future technologies with their prospects.

During the semester the students are expected to deepen their subject knowledge in: the extraction of fossil fuels (oil, natural gas and coal) along with their processing ready for subsequent use, the physics and chemistry of combustion including thermodynamic laws and energy concepts, pollutant formation, internal combustion engines (including steam turbines and heat engines), the impact of pollutants on the environment, the conversion of light into electrical power and associated solar technologies, the design and aerodynamics of wind energy devices, nuclear and fusion reactor physics and aspects of proliferation. A common theme is that, for the topics covered, the student will be given a comprehensive explanation of the physics, the state of current knowledge, and future predictions and implementation.

Learning Outcomes

Upon completion of the subject the student should be able to:

* understand and describe the physics of energy conversion processes,

* critically understand the principals which govern the design of energy harnessing devices,

* show a critical awareness of and be able to explain societal aspects of energy conversion including health and environmental issues

* demonstrate an expanded knowledge on various topics and challenges related to all stages between the sourcing and the end use of various sources of energy,

* communicate with technologists and scientists about the physics and design of energy conversion equipment in a critical and informed manner.

Curriculum

Fossil fuels

Origin of fossil fuels; the North Sea oil/gas era; detection of oil/gas reservoirs

– geology, seismic surveys; technology of extraction: Examples from the North Sea: drilling; the production phase and transportation; coal extraction

– examples. Discussion/tutorial: Energy density and CO_2 footprint from fossil fuels

Combustion of fuels: thermodynamics, combustion physics and chemistry

The motivation and fundamentals of combustion, the thermodynamics of combustion, chemistry and chemical kinetic of combustion, simplified transport equations and an introduction to laminar and diffusion flames.

Pollutants of combustion

The impact from pollutants emitted from combustion systems on environment and mankind. How these emissions are typically formed and possible ways to reduce them.

Turbo Machinery

Fundamental understanding of many aspects of stationary and propulsive gas turbine engines (including concepts of performance and efficiency).

Reciprocating Machinery and Heat Recovery

The functioning of reciprocating engines with internal and external heat input and their main operational characteristics (specific power, efficiency and typical emission). The potential benefits of alternative fuel types, emission reduction technology, and future development trends including waste heat recovery strategies from IC engines.

Environmental impact of energy harvesting, distribution and use

Environmental impacts of construction and operation (thermal power, hydropower, wind, solar, geothermal, distribution). Local, regional and global impacts of emissions from combustion (power plants and land, water and air transport). Modelling of transport and then consideration of dispersion, transformation and deposition.

Photovoltaic Devices

Fundamentals of Photovoltaics (PV); Historical Developments; Four generations of solar technologies (Crystalline solar cells - mono and multi, Thinfilm solar cells, Dye sensitized Solar Cells, Quantum Dot Solar Cells and Polymer solar Cells); Nano materials for solar cell applications; Recent activities in solar cell research (modelling, synthesis and fabrication); Challenges and opportunities in PV research.

Wind Turbines: their aerodynamics and design

Aerodynamic properties of vertical and horizontal axis wind turbines (VAWTs and HAWTs), power production on a VAWT, power production on a HAWT, overview of numerical tools used for the design and analysis of wind turbines, theory of the blade element momentum (BEM) method, simple wind turbine rotor blade design using BEM, generation the aerodynamic data needed in the BEM method using XFOIL

Nuclear energy – fission

Basic reactor physics, Reactor technology, Thermal reactors, Breeders, Fuel cycle, Waste management, Proliferation.

Nuclear energy – fusion

Basic physics processes, Reactor technology, Magnetic confinement – ITER, Inertial (laser) confinement

Reading List

1. Stephen R. Turns, An Introduction to Combustion: Concepts and Applications, 3rd Edition, McGraw Hill, 2011. ISBN-13: 978-0073380193.
2. Richard Stone, Introduction to internal combustion engines, 4th edition Palgrave Macmillan, 2012. ISBN-139-781137028297
3. Martin O. L. Hansen, Aerodynamics of Wind Turbines, 3rd Edition, Routledge, 2015. ISBN: 978-1-138-77507.
4. Paul A Lynn, Electricity from Sunlight: An Introduction to Photovoltaics" Wiley, 2010. ISBN: 978-0-470-74560-1.

Other Material

1. "Produksjon av mekanisk og elektrisk energi til havs" Fra «Havromsteknologier» Sec 7 issued by NTNU.

Note: This reading list is given for the benefit of students who wish to pursue topics beyond that which is covered in class. Comprehensive lecture slides will be available on Mitt for all topics covered in this course. It is not essential to own a personal copy when taking Energi210.