HM

Course description

Course title:

Sustainable Mobility: The New Age of Non-petroleum Transportation

Hours per week: 22h/week, 2 weeks

Number of credits recommended/ work load:

a) 44 contact hours

b) 3 US Quarter credits

c) 3 ECTS credits

Course description:

After over a century of petroleum-fuelled automotive transportation, a revolution is in progress as battery and fuel cell electric propulsion is rapidly replacing gasoline and diesel internal combustion engines. And unconventional combustion fuels including biodiesel, alcohols, hydrogen and dimethyl ether are gaining new attention as *transition fuels*, more sustainable and less harmful to the environment than petroleum-based fuels but utilizing existing fuel production, distribution and automotive design technologies. Along with this technical evolution comes new challenges for the supporting infrastructure, energy sources, and sociotechnical ramifications.

This accelerated course examines objectively the many aspects of this transformation by studying and comparing the technologies and social adaptations required for each mobile energy option. We hope to enhance awareness of the benefits and true costs of each option, including environmental, energy and financial sustainability. We welcome discussion and exchange of the diverse perspectives of the international student participants.

Course Content:

A) Sustainability: energy, environmental and financial

- Primary and final energy demands
- Sustainability, availability of resources and ecological balance
- Structure and behaviour of a sustainable energy system and how to evaluate it
- Key Performance Indicators of sustainable energy systems

B) Sustainable Mobility Technologies

Electric propulsion

Basic systems and components

Batteries – the current state of the art and cusp technologies

- Hydrogen fuel cell electric vehicles
- Renewable combustion fuel options
  - Ethanol
  - Methanol
  - Hydrogen
  - Organic oils and biodiesel
  - Dimethyl Ether
  - Biomethane
  - Wood
  - Ammonia

C) Electric and alternative fuel energy infrastructure requirements

- Where does the energy come from?
- EV public charging requirements for large-scale EV usage
- Grid accommodation of the electric loads of electric vehicles
- The misalignment of solar and wind power with electric demand
- Electric energy storage enables distributed generators
  - Pumped hydroelectric
  - Local battery storage
  - Hybrid solar PV systems
  - Utility scale battery storage
  - Vehicle-to-grid (V2G)
  - Hydrogen fuel cells
  - Gravity storage
  - Flywheel and kinetic energy storage
  - Non-electrical surrogates for electric energy storage
    - Well water tanks
    - Thermal mass heat storage
    - Solar water and space heating
    - Compressed and phase-change gas energy storage
- Alternatives to EV battery charging from electric grid
  - Direct solar or wind EV charging
  - Automated battery exchange
  - Roadway inductive charging
  - Green hydrogen from electrolysis using solar or wind power
  - Advanced fuel cells: Methanol, High temp natural gas, Sodium Borohydride
  - Electric range extenders

D) World-wide ramifications of transition of automotive energy sector to electricity

- Comparative GHG emissions of various propulsion technologies
- Highway issues due to increased mass of electric vehicles

Incompatibility of long range or light weight requirements with battery electric vehicles

Displaced automotive support industries: winners and losers

New workforce opportunities and challenges

- Technical innovations
- New manufacturing facilities
- Second-tier and aftermarket suppliers
- Vehicle sales and service
- Privacy and hijack protection for networked electric vehicles

Lessons learned from previous technology revolutions

Course Learning Objectives and Expected Outcomes:

- Awareness of the radical changes ahead for automotive and other forms of mobility
- Understand fundamental topology of sustainable energy systems and their key components for primary energy conversion and storage.
- Follow a methodological engineering approach for defining, designing, implementing and testing.
- Be able to select and compare different automotive and transportation energy options in terms of their energy and environmental sustainability.
- Understand the operation of an internal combustion engine to the level required to understand fuel combustion and emissions.
- Knowledge of transportation fuelling infrastructures, including the electric grid.
- Compare and specify different types of photovoltaic modules, including configurations, environmental requirements, electrical protection methods, and performance attributes.
- Knowledge of energy storage options, local and utility scale
- Understanding of integration issues with distributed and non-constant generation systems, and the ramifications for the electric grid.

Prerequisites:

- Any engineering or physical science major.
- Basic knowledge of chemistry and physics.
- Interest in energy and environmental sustainability.

Recommended reading:

- F. Vanek et al.: "Energy Systems Engineering: Evaluation and Implementation", McGraw-Hill, 3rd edition, 2016
- Karl Heinz Dietsch and others, "Automotive Handbook, 10th edition. Published by Robert Bosch GmbH, distributed by Society of Automotive Engineers (SAE), 2018.
- David JC MacKay, "Sustainable Energy without the Hot Air", Cambridge University Press, ISBN 978-0954452933, 2009. free download at http://withouthotair.com/download.html

Teaching methods:

- Lectures, class discussion, student research presentations on select topics.

Assessment methods:

- 20% Student presentations
- 80% Final Exam

Language of instruction:

- English

Name of lecturers:

- Prof. Dr. Engr Art MacCarley (California Polytechnic, San Luis Obispo)