



Course description

Course title:

Sustainable Mobility: The New Age of Non-petroleum Transportation

Hours per week: 20h/week, 2 weeks

Number of credits recommended/ work load:

- a) 40 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 now gaining attention as *transition fuels*, more sustainable and less harmful to the environment than petroleum-based fuels. Along with this technical evolution comes new challenges for the supporting infrastructure, energy sources, and sociotechnical ramifications.

This accelerated course examines objectively and in a pragmatic way the many aspects of this transformation by studying and comparing each mobility energy option, including existing fossil fuels. We hope to enhance awareness of the benefits as well as the true costs of each option, including environmental impacts. We welcome discussion and exchange of the diverse perspectives of the international student participants. We will conclude with an effort to identify future career opportunities enabled by this revolution.

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 presentations on select topics.

Assessment methods:

- 20% Student presentations
- 80% Final Exam

Language of instruction:

- English

Name of lecturers:

- Prof. Dr. Ing. Oliver Mayer (HM)
- Prof. Dr. Art MacCarley (California Polytechnic)