

# WM986-15 Energy Storage Systems

**22/23**

**Department**

WMG

**Level**

Taught Postgraduate Level

**Module leader**

Carlos Pastor Fernandez

**Credit value**

15

**Module duration**

1 week

**Assessment**

Multiple

**Study location**

University of Warwick main campus, Coventry

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## Description

### Introductory description

30 hours over 1 week consisting of interactive presentations, question and answer sessions and discussion, videos, small group exercises and problem classes.

The module includes a significant practical element (~30%) where students gain hands-on experience of battery and fuel-cell testing in WMG's Vehicle Energy Facility and classroom-based design representative of real-world vehicle applications.

### Module aims

The module provides a comprehensive study of energy storage systems for hybrid and electric vehicle applications in the automotive industry, and the complexities and challenges of introducing high voltage technology to passenger vehicles. Students will gain hands-on experience of battery and fuel-cell testing, including under the widely varying conditions of real-world applications.

### Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

- Energy storage requirements for vehicle applications

- Storage technologies and metrics for comparison
- Fuel cells theory and applications
- Modular battery packs, packaging, thermal control and legislative implications
- High voltage distribution, safety systems and battery charging
- Hands-on practical: Fuel-Cell characterisation and modeling
- Hands-on practical: Battery characterisation and testing
- Hands-on practical: Fuel-Cell and Battery interaction
- Problem class: Battery pack design
- Battery management systems
- Battery life cycle

## Learning outcomes

By the end of the module, students should be able to:

- 2. Independently make a systematic and sound choice of energy storage technologies, architecture and means of conversion for practical real-world vehicle applications
- 3. Independently design the electrical configuration of a traction energy storage pack, interpreting thermal management, energy management, safety and environmental considerations.
- 4. Creatively design the integration of high voltage systems into vehicle platforms, critiquing design trade-offs and autonomously applying a sound knowledge of integration issues, best practice guidelines, safety systems, legislation and practical considerations.
- 1. Evaluate the wide variety of energy storage technology for vehicle applications.
- 5. Systematically compare energy storage designs of electric vehicles.

## Subject specific skills

Energy storage requirements for vehicle applications; Storage technologies and metrics for comparison; Fuel cells and applications; Modular battery packs, packaging, thermal control and legislative implications; High voltage distribution, safety systems and battery charging; Battery management systems. Hands-on practical: Fuel-Cell characterisation and modeling, Battery characterisation and testing and Fuel-Cell and Battery interaction. In-Class problem: energy storage design.

## Transferable skills

Critical thinking; Problem solving; Self-awareness; Communication; Teamwork and working effectively with others; Information literacy (research skills); Digital literacy; Sustainability; Professionalism; Organisational awareness.

## Study

## Study time

<b>Type</b>	<b>Required</b>
Lectures	8 sessions of 1 hour 30 minutes (8%)
Seminars	1 session of 8 hours (5%)
Supervised practical classes	2 sessions of 4 hours (5%)
Other activity	2 hours (1%)
Private study	60 hours (40%)
Assessment	60 hours (40%)
Total	150 hours

### **Private study description**

Private study and independent learning include:

- Preparation and completion of prework
- Preparation of lectures before delivery and revision after delivery
- Prior research before starting the PMA

### **Other activity description**

Introduction to the PMA and to the practicals

### **Costs**

No further costs have been identified for this module.

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### **Assessment**

You do not need to pass all assessment components to pass the module.

#### **Assessment group A**

	<b>Weighting</b>	<b>Study time</b>
Evaluation of technology application	60%	37 hours
This part is related to discussing a typical energy storage design based on given requirements. It covers all the ILOs.		
Energy Storage Design Class	10%	6 hours
Energy Storage Design Class consists to design three alternative energy storage solutions for a real-world automotive application, based on each of three different technologies: electrochemical, electrostatic and mechanical flywheel. The student should also make a final recommendation to the customer.		

This is a group task where students are divided into groups of 4 or 5 supported by a group leader.

## Weighting

## Study time

The assessment is conducted via a presentation of each group. Each group receives a mark. This mark is the same for each of the students that form a group.

This part covers all ILOs.

Evaluation of practical activities

30%

17 hours

This is a group task and consists in reporting the investigations of one of the practicals undertaken in the module. The group chooses which practical to report. This written report covers ILO 2 and 3 it is related to the work completed in the practical sessions. This written report is marked collectively.

## Assessment group R1

### Weighting

### Study time

Evaluation of tests and technology application 100%

PMA is comprised of one part. This part covers all ILOs. It is related to discuss a typical energy storage design based on given requirements.

Students only need to work on the failed LOs for the resubmission, being able to reuse the content of the original resubmission.

## Feedback on assessment

Scaled ratings for Comprehension, Effort and Presentation, individual written feedback and overall mark following on from WMG feedback sheet templates.

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## Availability

### Pre-requisites

To take this module, you must have passed:

- All of
  - [WM985-15 Automotive Hybridisation and Electrification](#)

### Post-requisite modules

If you pass this module, you can take:

- WM995-15 Battery Electrochemistry, Design and Manufacturing

## Courses

This module is Core optional for:

- Engineering Competence (Sustainable Automotive Electrification) [New Course]
- MSc in Sustainable Automotive Electrification (FT) [New Course]
- MSc in Sustainable Automotive Electrification (PT) [New Course]