Course guide
295326 - 295SE111 - Electric Mobility

Last modified: 03/03/2026

Unit in charge: Barcelona East School of Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.
748 - FIS - Department of Physics.
709 - DEE - Department of Electrical Engineering.

Degree: MASTER'S DEGREE IN TECHNOLOGIES FOR DISTRIBUTED ENERGY SYSTEMS (Syllabus 2025). (Optional subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: ANGEL CUADRAS TOMAS - JOSE LOPEZ LOPEZ

Others:

Primer quadrimestre:
ANGEL CUADRAS TOMAS - Grup: T1
JOSE LOPEZ LOPEZ - Grup: T1
LLUÍS MONJO MUR - Grup: T1

Segon quadrimestre:
ANGEL CUADRAS TOMAS - Grup: T1
JOSE LOPEZ LOPEZ - Grup: T1
LLUÍS MONJO MUR - Grup: T1

PRIOR SKILLS

The ones required for accessing the master's degree.

LEARNING RESULTS

Knowledges:
K4. Identify methods for studying the environmental impact of a distributed electricity system with renewable sources and relate it to the decarbonisation of energy generation.
K1. Identify renewable resources as sources of electrical energy.
K2. Identify the structural and functional particularities and applicable regulations of decentralised electrical systems.

Skills:
S3. Assess the impact and needs of new electricity consumption models and relate them to the change in energy model resulting from the decarbonisation of energy sources.

Competences:
C1. Integrate the values of sustainability and understand the complexity of systems, with the aim of undertaking or promoting actions that restore and maintain the health of ecosystems and improve justice, thereby generating visions of sustainable futures.

TEACHING METHODOLOGY

The teaching methodology that will be used will combine lectures, problem-solving and application classes. In the participatory lecture sessions, the theoretical content necessary to achieve the objectives will be introduced. In the problem sessions, the concepts seen in theory will be applied. In the application sessions, students will develop particular applications of real cases of electric mobility in small groups, proposing solutions that combine technical, economic, social and environmental aspects in a balanced way.

LEARNING OBJECTIVES OF THE SUBJECT

- To know the importance of electrification of transport in order to improve its efficiency and its environmental impact.
- To know the importance of electrification in land transport, both road and rail.
- To know energy storage systems that allow achieving electric mobility.

STUDY LOAD

Type	Hours	Percentage
Hours small group	21,0	14.00
Self study	108,0	72.00
Hours large group	21,0	14.00

Total learning time: 150 h

CONTENTS

Movility Policies

Description:
1. Basic concepts of mobility and transport. Types of mobility.
2. Sustainable mobility: definitions, regulatory framework, pillars and objectives.
3. Social impact
4. Climate change and transport

Specific objectives:
1 – Understand the fundamentals of mobility and the policies and strategies of different governments.
2 – Identify the basic regulations relating to mobility and electric mobility.

Full-or-part-time: 5h 15m
Theory classes: 1h 30m
Self study : 3h 45m

Electric motors

Description:
1. Electric traction motors
2. Motor characterization
3. Motor selection

Specific objectives:
Describe the operating principle of electric motors used in electric mobility vehicles

Full-or-part-time: 5h 15m
Theory classes: 1h 30m
Self study : 3h 45m

Challenges to transition towards electric mobility

Description:
1. Evolution of energy consumption in the transport sector.
2. Pollution associated with the transport sector.
3. The challenge of energy autonomy in transport.
4. Estimated introduction of the electric vehicle. Horizon 2035 and 2050.
5. Increase in electrical energy generation to cover new needs.
6. Assessment of modification of electricity demand. Change in the consumption curve.
7. Environmental transformation. Change in emissions.

Specific objectives:
1.- To identify the changes that will occur in the transport sector in Europe and other developed countries.
2.- To know the advantages of changing from thermal vehicles to electric vehicles.
3.- To be able to assess the new energy needs of the energy transition in transport
4.- To know how to identify the advantages, but also the difficulties of the energy transition in transport.

Full-or-part-time: 12h 10m
Theory classes: 3h
Self study : 9h 10m

Electric Vehicles

Description:
1. Types of electric vehicles.
2. Estimates of energy needs of electric vehicles. Future scenarios.
3. Types of connectors for charging electric vehicles.
4. Problems of managing electric load vs. thermal vehicles.
5. Example of analysis of an electric power station.
6. Electric power station and smartgrid

Specific objectives:
1- To know the elements that come into play with the implementation of the electric vehicle.
2- To know the components that form part of an electric vehicle.
3- To know the power range of the engine of an electric vehicle.

Full-or-part-time: 10h 30m
Theory classes: 3h
Self study : 7h 30m

Special electric motors and electric mobility of the future

Description:
1. Types of motors for different electric vehicles. Extreme cases.
2. Introduction to superconductivity.
3. Superconducting motors.
4. Electric aircraft propulsion

Specific objectives:
1.- To learn what superconductivity is and the possibility of application in motors.
2.- To know types of motors with very high specific power. Superconducting motors and their particularities.

Related activities:
Activity on superconducting motors

Full-or-part-time: 21h
Theory classes: 4h
Laboratory classes: 2h
Self study : 15h

Electrochemical cells, batteries and supercapacitors

Description:
1. Electrochemical operation of a battery. Types of chemistries, importance of components, chemical safety, internal design structure.
2. Electrical analysis: Definition of SoC, SoH, internal resistance, currents, voltages
3. Thermal analysis: Energy dissipation, overvoltage, hysteresis,

Specific objectives:
1 – To know what type of energy storage is appropriate in electric mobility
2 – To know the internal structure of batteries and different types of batteries (lithium, lead, solid state, sodium, LiS)
3 – To know how to identify which storage system is most suitable for each application and know how to size it.
4 – To know the most common models to describe batteries and supercapacitors (electrochemical, equivalent circuit and data-driven)
5 – To know the impact that environmental conditions (loads, temperatures, atmospheric conditions) have on batteries

Full-or-part-time: 10h 30m
Theory classes: 3h
Self study : 7h 30m

Battery management

Description:
1. Cell groupings
2. Mechanical considerations
3. BMS types
4. Thermal considerations
5. How to choose and size a battery
6. Energy dissipation during operation.
7. Thermal runaway and explosion risk.
8. Cooling systems: by ventilation, by fluids, by phase change materials

Specific objectives:
1 – To know how to estimate the states of a battery.
2 – To know and develop battery management systems (BMS)
3 – To know how to describe battery recycling processes.

Related activities:
Application Session 1: Storage system design for a particular application (batteries and supercapacitors).

Full-or-part-time: 31h 30m
Theory classes: 3h
Laboratory classes: 6h
Self study : 22h 30m

Battery models

Description:
1. Electrochemical models
2. Electrical models
3. Data Driven models
4. New models

Specific objectives:
To know different types of battery models, as well as their limitations, for a correct use.

Related activities:
Application Session 2: Extracting Parameters from a Battery.
Application Session 3: Implementing a Battery Model.

Full-or-part-time: 15h 45m
Theory classes: 1h 30m
Laboratory classes: 3h
Self study : 11h 15m

LCAs, recycling and business models

Description:
1. Types of recycling. Cost.
2. 2nd life of batteries.
3. Battery life cycle analysis evaluation. Pros and cons of the method.
4. V2G network connected vehicles

Specific objectives:
1 – To know how to interpret battery life cycle analyses.
2 – To know possible business models linked to batteries (2nd life, vehicle to grid, swapping…)

Full-or-part-time: 6h 35m
Theory classes: 1h 30m
Self study : 5h 05m

title english

Description:
1. The railway system. Concepts, subsystems and organization
2. Railway systems technology
3. Energy efficiency
4. Railway mobility management

Specific objectives:
1 - To describe the railway sector in its different areas.
2 - To identify the main technological systems of a railway system.
3 - To describe the principles of railway management.

Full-or-part-time: 31h 30m
Theory classes: 9h
Self study : 22h 30m

GRADING SYSTEM

The course is divided into four different modules: introduction module, road vehicle module, storage module and rail transport module. Each module (except the introduction module) will have an exam that will be held during class hours: exam for the vehicle module (EV1), storage module (EE2) and rail module (EF3). In addition, the proposed application activities will also be evaluated: introduction activity (AI), road vehicle module (AV) and storage module (AE).
Course grade (out of 10)= 22.5%*EV1+20%*EE2+22.5%*EF3+7.5%*AI+7.5%*AV+20%*AE

BIBLIOGRAPHY

Basic:
- Xiong, Rui. Battery management algorithm for electric vehicles [on line]. Singapore: Springer Nature Singapore, 2020 [Consultation: 12/09/2025]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-981-15-0248-4. ISBN 981150248X.
- Plett, Gregory L. Battery management systems : volume II : equivalent-circuit methods [on line]. Boston: Artech House, 2016 [Consultation: 12/09/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4821265. ISBN 9781523116997.
- Plett, Gregory L. Battery management systems. Vol 1 [on line]. Boston: Artech House, 2016 [Consultation: 12/09/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4821261. ISBN 9781630810245.
- Plett, Gregory L.; Scott Trimboli, M. Battery management systems. Vol III : Physics-based methods. Norwood: Artech House Publishers, 2024. ISBN 9781630819040.
- Behaviour of lithium-Ion batteries in electric vehicles : battery health, performance, safety, and cost [on line]. Cham: Springer International Publishing, 2018 [Consultation: 18/09/2025]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-319-69950-9. ISBN 3319699504.
- Fuentes Losa, Julio; González Fernández, Francisco Javier. Ingeniería ferroviaria [on line]. Segunda edición. Madrid: Universidad Nacional de Educación a Distancia, 2010 [Consultation: 18/09/2025]. Available on: https://lectura-unebook-es.recursos.biblioteca.upc.edu/viewer/9788436261844/2. ISBN 9788436260748.
- Ihme, Joachim. Rail vehicle technology [on line]. Wiesbaden, Germany: Springer, 2022 [Consultation: 18/09/2025]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-658-36969-9. ISBN 9783658369682.
- Husain, Iqbal. Electric and hybrid vehicles : design fundamentals [on line]. Boca Raton: CRC Press, 2011 [Consultation: 18/09/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=1446939. ISBN 9781439894972.
- Anubla, Eugenio [et al.]. Manual de ferrocarriles : el sistema ferroviario español. Madrid: Garceta, 2024. ISBN 9788419034458.

RESOURCES

Other resources:
1.- ES_Global Electricity Review 2024_EMBER.pdf
https://ember-energy.org/latest-insights/global-electricity-review-2024/ />
2.- IRENA_UAE_Consensus_2030_tripling_renewables_doubling_efficiency_2024.pdf
https://www.irena.org/Publications />
3.- IRENA_Rare_Earth_Elements_2022.pdf
https://www.irena.org/Technical-Papers/Critical-Materials-For-The-Energy-Transition-Rare-Earth-elements />
4.- Análisis de la infraestructura frente el aumento de vehículos eléctricos enchufables.pdf
López Ramos, Gerard. TFG (EEBE 2025)

5.- 231219 GBS Report.pdf
GLOBAL BIOENERGY STATISTICS REPORT
https://www.worldbioenergy.org › uploads