Battery management connection and control

Structure and FAQ

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1.1. Course description

Battery storage is the future. But that future hinges on maintaining full control over the operation of batteries and building a robust system that enables connection to the electric grid, the consumer or the electric vehicle.

The Battery management, connection and control course will allow learners to dive deep into power conversion systems that connect storage systems to smart grids and consumers, learning how to choose the right type of converter while assessing overall system performance with respect to energy efficiency. It will also be their introduction to battery management systems (BMS): the masterminds behind battery packs. They will thoroughly explore the BMS and the critical parametres that we can control. Learners will lastly discover the use of battery testing and operation simulation in order to predict real-world in-service behaviour.

1.2. Learning outcomes

This course empowers learners to:

- Expertly discuss the role of power conversion systems
- Distinguish and assess the type of power converters for battery applications
- Understand and explain the importance and function of battery management systems in the control and operation of batteries
- Describe different battery testing procedures and the relevant characteristics that can be determined
- Understand how we can simulate battery operation in order to predict in-service behaviour

1.3. Course structure and content

Battery management connection and control is a fully online course that consists of six self-paced online modules (***Figure 1***) and optionally a follow-up by a topic specialist. The learners will have the possibility to share their opinion and thoughts on relevant topics via the discussion elements throughout the course.

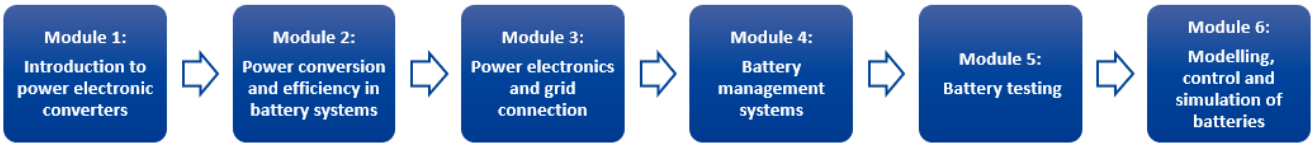

Figure 1: *Structure of Battery management connection and control course*

- **Module 1:** Diving into the world of power conversion starting with an introduction, to the basic principles of power conversion and the relation to the energy efficiency of the energy system
- **Module 2:** Discovering why power converters are needed for battery applications and how can we choose the right type for a specific application.
- **Module 3:** Diving deeper into the typical topologies and main functionalities of power conversion systems (PCSs) for connecting batteries to diverse electrical systems.
- **Module 4:** Discovering battery management systems and explain their components and functions.
- **Module 5:** Exploring the different types of battery testing and related standards and regulations.
- **Module 6:** Exploring modelling, control and simulation of batteries.

The topics included under the six modules are as follows:

- Module 1: Introduction to power electronic converters
  - The need for power conversion
  - Principles of switched power converters
  - Types of switched power converters
  - Converter Losses and Efficiency
- Module 2: Power conversion and efficiency in battery systems
  - Battery Capacity and Energy
  - Battery Losses and Efficiency
  - Power Electronic Interfaces for Batteries
  - Total System Energy Efficiency in Battery Applications
  - Application Example: Energy Efficiency of a USB Power Bank
  - Application Example: Home Battery Storage Systems
  - Application Example: Wireless charging
  - Business example
- Module 3: Power electronics and grid connection
  - General introduction and overview
  - Power conversion steps in PCSs for batteries
  - Operating basics of DC-DC buck converters
  - Operating basis of DC-DC boost converters
  - Functionalities for power inverters
  - Current and voltage related constraints while designing PCSs for batteries
  - Application fields for battery solutions
- Module 4: Battery management systems
  - Introduction to Battery Management Systems
  - Battery Management Systems Topologies
  - Battery Management Systems Components and Requirements
  - Functional Safety and Security
  - State of Charge estimation
  - State of Health estimation
  - Battery cell balancing
- Module 5: Battery testing
  - The importance of battery testing
  - Battery definitions, datasheets and characteristics
  - Battery Standards and Regulations
  - Electrical, Thermal and Mechanical tests
  - Battery laboratory and battery testing equipment
  - Battery testing procedures and examples
  - Battery analysis - From raw data to specific battery parameters
  - Battery modelling at cell and pack level

- Module 6: Modelling, control and simulation of batteries
  - Modelling, control and simulation of batteries
  - Discharge curves
  - Equivalent electrical circuits modelling battery cells

- Identification of parameters from datasheets
- Modelling of DC-DC converters and batteries for control purposes
- Tuning of battery voltage controller
- Tuning of battery current controller

1.4. Who are the experts in the course?

This course was developed in collaboration with experts from the EIT InnoEnergy ecosystem, authorities in sustainable energy from the worlds of research and industry. Faculty for this course are:

Francisco Díaz-González
Professor at Universitat Politècnica de Catalunya in subjects linked with the grid integration of renewable energies. His current research interests include the fields of power electronics for electrochemical energy storages and renewable energies.

Dr. Jeroen Büscher
Product Manager Electrical Storage of Vito / Energy Ville. Since 2016 Jeroen is leading the VITO team working on electrical storage technologies and is responsible for the development and execution of the related activity roadmap. Since 2011, Jeroen has been coordinating several projects within Europe on electrical storage, smart grids and e-mobility.

Jolien Despeghel
PhD student in Electrical Engineering at KU Leuven/Energyville. She is a researcher on the project Energy Storage as a Disruptive Technology in the Energy System of the Future.

1.5. Target audience

This course is beneficial for professionals interested in understanding all elements related to the management and testing of batteries and in getting involved in the power conversion systems for batteries' design, efficiency, and operation.

1.6. What qualifications does a learner need to join to the Battery management, connection and control course?

In order to be able to follow and benefit from the Battery management connection and control course learners would need to have a basic understanding of battery cells, system components and their working principles. Also, a basic understanding of electrical systems. It is recommended for learners to join Fundamentals on batteries course prior to taking this course.

1.7. What is the expected time investment by each learner?

The required time investment is around 7-9 hours/week on average, including the course evaluation. Below appears a suggested timeline (***Figure 2***).

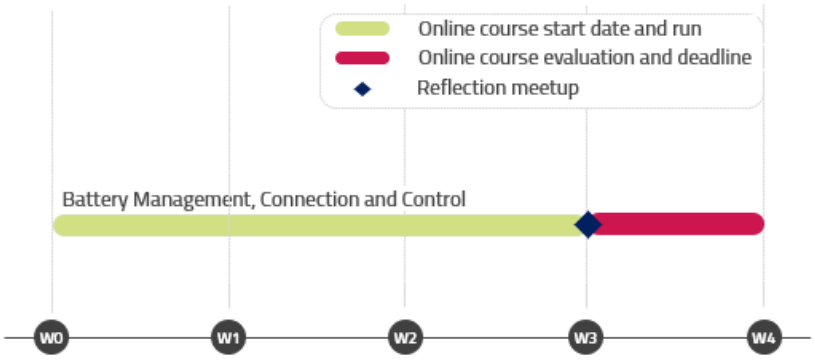

Figure 2: Suggested timeline for the Battery management connection and control course

1.8. What is the meaning of the deadline of the course?

With regards to the Battery management connection and control dates:

- The online course's general assessment date is fixed, and learners would need to respect this. The online contents will be available at a certain start date and learners can start pursuing the contents at their usual study location, at a pace and rhythm that meets their schedule, while respecting the course's general assessment deadline. An end date is recommended to finalise the course content and allow enough time to submit the assessment.
- The submission of the general assessment is required by the deadline. It is recommended that learners are able to save their answers and come back later for submission prior to the respective deadlines.
- The contents of the course will remain open for the learners for a specific time period after the deadline and the end of the online course.

1.9. Interaction with the course leader

This online course has a dedicated course leader (topic specialist). The course leader shall be available for a (suggested) total of two hours throughout the course run to answer questions and give further explanations on the course content. Out of these two hours, one refers to a Reflection meetup (live session) at a predefined slot and the remaining one hour to asynchronous Q&A via the learning platform or other means. This is recommended to take place in a forum where all learners have access and can benefit from the answers or any discussion.

The course leader's profile is expected as follows: Research or industrial experience with battery systems components and operation, power electronics and grid integration of battery systems, battery testing and simulation of batteries. Good presentation skills. Preferred to have also pedagogical experience. Open to integrating mobile and VR game formats.

1.10. Course evaluation

To succeed in the Battery management connection and control and receive a Certificate of Accomplishment, a learner needs to obtain a minimum score of 75 points in the general assessment. This general assessment

serves as a test on the understanding of the course content by each learner. In-lesson quizzes are only meant for self-evaluation and do not count towards the final Certificate.

- The general assessment is composed of both automatically graded questions and open questions. The assessment requires an estimated time effort of 2-3 hours.
- It is recommended that the number of points per section is visible throughout the assessment.
- The automatically graded questions include single choice and association questions.
- The open questions are graded by the course leader, and it is recommended that the results are available 1 week after the deadline.
- There is no negative grading. A wrong answer simply gives 0 points.
- If a learner does not pass the general assessment with the first attempt, it will be possible to retake it once more. It is recommended that the retake is available a week after the general assessment deadline of the last course and remains open for 1 additional week.