



## A holistic and Scalable Solution for research, innovation and Education in Energy Transition

### D3.2 ASSET Learning Materials v1

Work Package	WP3 Energy Transition Programmes Preparation
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0.1	25/03/2020	Wilbert Rey Tarnate, Ferdinanda Ponci (RWTH)	Initial Draft
0.2	15/04/2020	All authors	Description of and links to the ASSET Materials.
0.3	22/04/2020	Wilbert Rey Tarnate, Ferdinanda Ponci (RWTH)	Collection of inputs from different partners and conclusions
0.4	24/04/2020	Wilbert Rey Tarnate, Ferdinanda Ponci (RWTH)	Revision of introduction and executive summary
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## Executive Summary

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This deliverable is of type other and provides (as anticipated from the DoA) **the first version of the ASSET learning material** for short programmes and seminars, MOOCs and Train the Trainers programme, that is the learning offer that is going to be deployed and assessed during and after the project. The links to all the materials are provided. It is reminded that the first list of the learning materials per educational programme was provided under D3.1 thus this document is actually serving as an index to those materials.

*Moreover*, this deliverable provides the **updated version** of the learning graph instances for such learning offers, creating the operative basis for material re-use. This update came naturally as learning programme creation is a continuously evolving process towards the improvement of the final educational offer.

Finally, it provides the terminology for classifying the ASSET learning material.

This ASSET learning material is the output of Task 3.2 (Learning Content Preparation) so far, and Task 3.3 (Trainers' training programme) so far. These two tasks are still ongoing, as planned, and their remaining part will be devoted to updating this first version of the ASSET learning material, which will be presented in D3.4, using the feedback of the deployment experience. The ASSET consortium will provide the final and complete versions of the ASSET learning materials by December 2020 in deliverable D3.4.

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## List of Acronyms

Abbreviation / Acronym	Description
AC	Alternating Current
APC	Active Power Curtailment
CBL	case-based modules
CCM	current-controlled mode
CSP	Concentrating Solar Power systems
CZT	Cadmium zinc telluride
DC	Direct Current
DG	Distributed Generator
EED	Energy efficiency directive
EMAS	Eco-Management and Audit Scheme
EPBD	Energy performance of buildings directive
EQF	European Qualifications Framework
FIPA	Foundation for Intelligent Physical Agents
FLL	Frequency-locked loop
GUM	Guide to the Expression of Uncertainty in Measurement
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
KPI	Key Performance Indicator
LCA	Life-Cycle Assessment
LCC	Life-Cycle Costing
LCOE	Levelized cost of energy
LG	Learning Graph
LM	Learning Material
LO	Learning Outcome
LV	Low voltage
MC	Marginal Cost
MCFC	Molten Carbonate Fuel Cell
MG	Microgrid

Abbreviation / Acronym	Description
MILP	Mixed Integer Linear Programming
MMS	Multimedia Messaging Service
MOOC	Massive Open Online Course
MSc	Master of Science
MTDC	Multi-terminal Direct Current
MVDC	Medium Voltage Direct Current
NP	Naval Package
OCV	open-circuit voltage
OER	Open Educational Resources
PAFC	Phosphoric Acid Fuel Cell
PCC	Point of common coupling
PhD	Philosophiae Doctor (Doctor of Philosophy)
PLL	Phase-locked loop
PMU	Phasor Measurement Unit
PPT	Powerpoint Presentation
PQ	Power quality
PV	PhotoVoltaic systems
RES	Renewable Energy Source
RoHS	Restriction of Hazardous Substances
RTO	Real-time Optimization
SOFC	Solid Oxide Fuel Cell
SOGI	Second-order generalized integrator
SRF	Synchronous Reference Frame
TCO	Total Cost of Ownership
THD	Total Harmonic Distortion
UPS	Uninterruptible Power Systems
VCM	voltage-controlled mode
VSC	voltage source inverter



# 1. Introduction

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## 1.1 Context and Scope

This deliverable provides the intermediate outcomes of Task 3.2 “Learning content preparation” and Task 3.3 “Trainers’ training programme”. The outcomes consist of the actual learning material to be used by trainers/instructors and learners, for example, slides, notes, videos, etc. and the learning graph framing of the ASSET offer.

Overall in these two tasks, the members of the ASSET consortium prepare the materials for the different ASSET programmes, which are the following:

- 25 short programmes, 18 of which in the form of both courses and MOOCs
- More than 5 Interdisciplinary programmes
- At least four challenge- and case-based modules (CBLs), which are used in different courses
- More than two special programmes for citizens to raise awareness
- And two educational programmes-on-demand.

This deliverable consists of the first version of the learning materials for:

- 25 short programmes, including seminars
- Train the Trainers programme

Also, this deliverable provides the fine-tuned instantiation of the learning graph models, based on D3.1 Learning graphs.

The remaining work in these tasks will use the learning graph tool to reuse the materials for developing interdisciplinary programmes. The consortium will also prepare CBLs and map them to the learning graph tool. Doing so allows the consortium to use the CBLs in its programmes.

## 1.2 Structure

This deliverable has the following structure:

Chapter 1 is an introduction and provides the scope, structure and connections of the document.

Chapter 2 lists the ASSET programmes with the mode of delivery and the relevance of the content of this deliverable.

Chapter 3 gives the scheme and terminology used for the classification of the learning materials.

Chapter 4 provides the main contents of this deliverable – the learning graph instances and the learning materials (in the form of links to the materials on repositories).

Chapter 5 yields the concluding remarks.

Annex A provides a set of guidelines for considering copyright when creating learning materials.

Annex B provides a set of guidelines for creating reusable content.

### 1.3 Relation to other WPs

In D2.3 Learning goals catalogue for the energy sector, we have provided the learning topics and learning outcomes for the ASSET programmes, thus providing the modelling frame for the learning graph. Then, in D3.1 Learning graphs, we provided the learning graph instances, linking the learning topics, outcomes, and material for most ASSET programmes. Here in D3.2, we provide the following:

- The current version of the learning material (via links to access them in the repositories).
- The learning graph instances for the ASSET short-programmes, seminars, and MOOCs, which were not included in D3.1.

The ASSET learning materials of this deliverable are still in their first version. They will be updated before and during the delivery period using the feedback of the users. The final version of these materials will be provided in D3.4 ASSET Learning Materials - complete version.

## 2. ASSET Programmes – An overview

Table 1 shows the list of ASSET programmes with the mode of delivery (or learning style) and the host institution. This deliverable provides the ASSET learning material for items 1 through 26.

So far, the host institutions have created the learning graph instances for the short programmes, seminars, and MOOCs in ASSET. These learning graphs are now being uploaded into the online version of the learning graph tool. Once this process is finished, the learning graph tool will be used to identify the materials that can be used for the remaining ASSET programmes, namely Interdisciplinary programmes, Special programmes for citizens to raise awareness, and Programmes on demand.

Thanks to the explicit links between learning material and learning outcomes, the reusability and (possibly) recombination of the existing ASSET learning material is enabled.

The complete version of the materials will be provided by the end of December 2020 in D3.4, which is the second version of this deliverable.

No.	ASSET Courses	Delivery Mode (Face-to-face, blended, or MOOC)	Host Institution
<b>Short Programmes</b>			
1	AC Microgrids	Face-to-face, MOOC	AAU
2	Power Quality in Microgrids	Face-to-face and MOOC	AAU
3	DC Microgrids	Face-to-face and MOOC	AAU
4	Measurement techniques and distributed intelligence for power systems	Face-to-face	RWTH
5	Implementation of automation functions for monitoring and control	Face-to-face	RWTH
6	Maritime Microgrids	Face-to-face and MOOC	AAU
7	Power Systems Dynamics	Face-to-face	RWTH
8	Optimization Strategies and Energy Management Systems	Face-to-face and MOOC	AAU
9	Hydrogen as energy vector	Blended and MOOC	UPV
10	Energy and environment	Face-to-face and MOOC	UWA
11	New Materials for solar cells applications	Face-to-face and MOOC	UWA
12	Innovation processes in the energy sector	Face-to-face	OTEA
13	Energy Efficient and Ecological Design of Products and Equipment	Face-to-face, MOOC	UWA
<b>Short programmes/Seminars</b>			
14	Multi-terminal DC grids	Face-to-face	RWTH
15	Case study on distribution grid operation	Face-to-face	RWTH
16	Understanding responsibility in research and Innovation	Face-to-face	RWTH

No.	ASSET Courses	Delivery Mode (Face-to-face, blended, or MOOC)	Host Institution
17	Economics of energy sources and the optimal integration of renewable energies and energy conservation measures	Face-to-face MOOC	LS
18	Behavioural change as a powerful drive to minimize the energy consumption while providing the same level of energy service	Face-to-face MOOC	LS
<b>MOOCs</b>			
19	Challenges and solutions in Future Power Networks	MOOC	RWTH
20	Innovation and Diversity in engineering	MOOC	RWTH
21	Renewable Energy Technologies	MOOC	UNINA
22	Electric heat pumps in the energy transition framework	MOOC	UNINA
23	Green professionalization and ethics	MOOC	UNINA
24	Corporate Communication and Corporate Social Responsibility	MOOC	UNINA
25	A holistic approach for Energy Transition: territory, networks, and sustainability	MOOC	UNINA
26	Train the trainer	Face-to-Face, MOOC	OTEA
<b>Interdisciplinary Courses</b>			
27	Programme 1	*	UWA
28	Programme 2	*	UWA
29	Programme 3	*	UWA
30	Programme 4	*	RWTH
31	Programme 5	*	*
32	Programme 6	*	*
<b>Programmes for Citizens to raise awareness</b>			
33	Programme 1	MOOC	*
34	Programme 2	MOOC	*
35	Programme 3	*	*
<b>Programmes on demand</b>			
36	Programme 1	*	*
37	Programme 2	*	*

Table 1: The ASSET programmes, the online links to the materials, and their delivery modes and dates

\* = to be determined

### 3. Types of Learning Materials

The ASSET consortium classifies the learning materials based on the definitions in Table 2. By having a standard convention in naming the type of materials, it is easier for training actors to search for reusable contents. The material types and definitions in Table 2 are based on the classification used in the Open Educational Resources (OER) Commons. OER Commons is an online platform that hosts open educational resources, which can be used, reused, adapted, and shared for free.

Material Type	Description
<b>Activity/Lab</b>	Supplemental, student-facing resource requiring students to provide answers or feedback based on taking specified steps.
<b>Assessment</b>	Student-facing question or prompt that measures understanding of a topic or idea.
<b>Case Study</b>	When actually occurring events or scenarios are used to illustrate scientific or academic principles.
<b>Data Set</b>	A collection of related sets of data.
<b>Diagram/Illustration</b>	Visual media, including but not limited to pictures, graphics, diagrams, figures, illustrations, charts, and maps.
<b>Full Course</b>	A series of units and lessons used to teach the skills and knowledge required by its curriculum.
<b>Game</b>	A game designed with an educational purpose.
<b>Homework/Assignment</b>	An activity engaged in by the learner for the purpose of acquiring certain skills, concepts, or knowledge, whether guided by an instructor or not.
<b>Interactive</b>	A visual tool in which students can move items around, enter variables, and/or answer questions.
<b>Lecture</b>	Recording or transcript of an educational speech.
<b>Lecture Notes</b>	Instructor-created notes to support student understanding of lectures.
<b>Lesson</b>	Lessons organize content within a course and may cover one or more concepts or topics. Typically used in K-12 education.
<b>Lesson Plan</b>	A teacher-facing description of a course of instruction.
<b>Module</b>	Modules organize content within a course; may cover one or more concepts or topics. Typically used in higher education. In K-12 may be used to organize the presentation of several units.
<b>Primary Source</b>	Original document or object created at the time of the period of time being studied, i.e. newspaper article or government document.
<b>Reading</b>	The body of a printed work, to include reading passages.
<b>Simulation</b>	Imitation of a physical process over time.
<b>Student Guide</b>	A student-facing supplement to a course that provides additional content and tutorial instruction for a specific course or topic.
<b>Syllabus</b>	An outline of the contents and requirements of a course.
<b>Teaching/Learning Strategy</b>	Method or strategy to facilitate effective teaching and learning.
<b>Textbook</b>	A book used in the study of an academic or scientific subject.
<b>Unit of Study</b>	A plan of instruction on a particular concept; it contains multiple lessons that are related.

**Table 2: Material Classification**

## 4. Material Descriptions for Short Programmes

This chapter provides the main contents of this deliverable – the learning graph instances and the links to the learning materials. Some of the contents of this chapter are already provided in D3.1. However, in addition to D3.1, this chapter provides the following:

- the updated description of the materials;
- the classification of materials using the categories in Chapter 3;
- the ASSET learning material via links to repositories;
- the descriptions of the materials for the ASSET courses that were missing in D3.1.
- the level of completion per material which estimates the amount of work, (e.g. in terms of aesthetics, copyrighted contents, etc.) that is still needed before the material can be shared with the public.

### 4.1 Short Programmes

Each short programme is described in terms of learning graph structure first and then each learning material.

#### 4.1.1 AC Microgrids

##### 4.1.1.1 The Structure

Topic	Learning outcomes	Learning Materials
AC Microgrids	Illustrate the concepts and Modelling of distributed AC power systems and AC microgrids.	Learning Material 1: Slides Learning Material 2: Paper Learning Material 3: Paper Learning Material 4: Paper Learning Material 5: Paper Learning Material 6: Paper
	Examine various control schemes for power electronic converters, including voltage source inverter (VSC).	Learning Material 7: Slides Learning Material 8: Paper Learning Material 19: Paper Learning Material 10: Paper Learning Material 11: Simulation handout Learning Material 12: Simulation Exercise Learning Material 13: Simulation handout Learning Material 14: Simulation Exercise
	Examine Microgrids in grid-connected and islanded modes and design the control schemes for the parallel operation of power converters, including master-slave and droop control using virtual impedance.	Learning Material 15: Slides Learning Material 16: Paper Learning Material 17: Paper Learning Material 18: Paper Learning Material 19: Paper Learning Material 20: Simulation handout Learning Material 21: Simulation Exercise Learning Material 22: Simulation handout Learning Material 23: Simulation Exercise

	Examine the converter control for soft starting, harmonic current sharing and low voltage ride-through capability.	Learning Material 24: Slides Learning Material 25: Paper Learning Material 26: Paper Learning Material 27: Paper Learning Material 28: Paper Learning Material 29: Paper
	Illustrate hierarchical control on AC microgrids with primary, secondary and tertiary layers.	Learning Material 30: Slides Learning Material 31: Paper Learning Material 32: Paper Learning Material 33: Paper Learning Material 34: Simulation handout Learning Material 35: Simulation Exercise
	Illustrate the operation of an AC microgrids cluster and interconnections of multiple AC microgrids clusters.	Learning Material 36: Slides Learning Material 37: Paper Learning Material 38: Paper Learning Material 39: Paper
	Illustrate consensus and cooperation strategies for microgrids using networked multi-agent systems.	Learning Material 40: Slides Learning Material 41: Paper Learning Material 42: Paper Learning Material 43: Paper

#### 4.1.1.1 The Materials

Learning Material 1	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in detail.</p> <ul style="list-style-type: none"> <li>• Distributed power systems</li> <li>• Microgrid definition</li> <li>• Microgrid configurations</li> <li>• Examples of Microgrid Projects</li> <li>• Uninterruptible Power Systems (UPS)</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM_1.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM_1.pptx</a></p>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 2	
Short description or summary	Microgrid configuration example from the demonstration Project in Hachinohe: Microgrid with Private Distribution Line.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/4304276?arnumber=4304276">https://ieeexplore.ieee.org/document/4304276?arnumber=4304276</a>
Author & organisation	Kojima, Y. Koshio, M. Nakamura, S. Maejima, H. Fujioka, Y. Goda, T.A, Mitsubishi Electric Corp. Amagasaki, Hyogo, Japan
Material Type	Reading
Level of Completion (%)	100%

Learning Material 3	
Short description or summary	An overview and summary of real-world microgrids.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/4304255">https://ieeexplore.ieee.org/abstract/document/4304255</a>
Author & organisation	Barnes, M. Kondoh, J. Asano, H. Oyarzabal, J. Ventakaramanan, G. Lasseter, R. Hatzigiorgiou, N. Green, T. School of Electrical and Electronic Engineering, University of Manchester, UK
Material Type	Reading
Level of Completion (%)	100%

Learning Material 4	
Short description or summary	In this learning material, the modelling of DGs in the utility control and information technology infrastructures of power system operators is discussed. The communication standards International Electrotechnical



Learning Material 4	
	Commission (IEC) 61400-25 and IEC 61850 and their extensions for DGs are also introduced.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/4808328">https://ieeexplore.ieee.org/abstract/document/4808328</a>
Author & organisation	Adrian Timbus; Mats Larsson; Cherry Yuen Corp. Res., ABB Switzerland Ltd., Baden-Daettwil, Switzerland
Material Type	Reading
Level of Completion (%)	100%

Learning Material 5	
Short description or summary	This learning material discusses the flexible system integration and advanced hierarchical control architectures in the microgrid research laboratory of Aalborg University. As an example facility, the structure of the laboratory, including the facilities, configurations and communication network, are discussed in detail.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://vbn.aau.dk/en/publications/flexible-system-integration-and-advanced-hierarchical-control-arc">https://vbn.aau.dk/en/publications/flexible-system-integration-and-advanced-hierarchical-control-arc</a>
Author & organisation	Lexuan Meng, Adriana Carolina Luna Hernández, Enrique Rodriguez Diaz, Bo Sun, Tomislav Dragicevic, Mehdi Savaghebi, Juan Carlos Vasquez Quintero, Josep M. Guerrero, Moises Graells, Fabio Andrade Department of Energy Technology, Aalborg University, Aalborg Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 6	
Short description or summary	An overview and summary of how various utilities embrace smart grid concepts, technologies, and systems.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/5357331">https://ieeexplore.ieee.org/abstract/document/5357331</a>
Author & organisation	Hassan Farhangi British Columbia Institute of Technology
Material Type	Reading
Level of Completion (%)	100%

Learning Material 7	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in detail.</p> <ul style="list-style-type: none"> <li>Control principles for Voltage Source Inverter</li> <li>Voltage and frequency control</li> <li>Active and reactive power control</li> </ul> <p>These topics will be covered for both with and without communication techniques.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM7.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM7.pptx</a>
Author & organisation	Ernane Antônio Alves Coelho, Universidade Federal de Uberlândia
Material Type	Lecture Notes

Learning Material 7	
Level of Completion (%)	10%

Learning Material 8	
Short description or summary	This learning material presents a review of commonly used current regulation techniques for voltage source pulse width modulated (VS-PWM) inverters.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/397839">https://ieeexplore.ieee.org/abstract/document/397839</a>
Author & organisation	M.P. Kazmierkowski ; M.A. Dzieciakowski Inst. of Control & Ind. Electron., Warsaw Univ. of Technol., Poland
Material Type	Reading
Level of Completion (%)	100%

Learning Material 9	
Short description or summary	A review of current control techniques for three-phase voltage-source pulse width modulated converters is presented in this learning material. The details of both linear and no-linear control methods and the distinction between both are elaborated.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/720325">https://ieeexplore.ieee.org/abstract/document/720325</a>
Author & organisation	M.P. Kazmierkowski ; L. Malesani Inst. of Control & Ind. Electron., Warsaw Univ. of Technol., Poland
Material Type	Reading

Learning Material 9	
Level of Completion (%)	100%

Learning Material 10	
Short description or summary	Discussions about simple, low-cost control architecture for low-voltage hysteretic regulators supplying loads with low-to-medium current consumption for synchronous buck converters.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/4267740">https://ieeexplore.ieee.org/abstract/document/4267740</a>
Author & organisation	Miguel Castilla ; Luis Garcia de Vicuna ; Josep Maria Guerrero ; Jaume Miret ; Nstor Berbel Tech. Univ. of Catalonia, Vilanova I la Geltru (Primary Author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 11	
Short description or summary	This learning material is a simulation handout that guides the student to design both the current control and the voltage control parameters for a three-phase VSI in standalone mode. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 11 will be given in learning material 12.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM11%2612.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM11%2612.pdf</a>

Learning Material 11	
Author & organisation	Yajuan Guan, Aalborg University, Denmark
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 12	
Short description or summary	Based on the learning material 11, two exercise tasks will be given in this learning material, and a guide file will be provided where students have to <ol style="list-style-type: none"> <li>1) Obtain the system closed-loop transfer function.</li> <li>2) Design the voltage and current control parameters for fundamental frequency (without harmonics) in a stationary frame.</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>● 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>● Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>● PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM11%2612.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM11%2612.pdf</a>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Choose an item.
Level of Completion (%)	

Learning Material 13	
Short description or summary	Evaluation of a standalone VSI with voltage control: The objective of this simulation handout learning material is to guide the student to experimentally test the control parameters designed for a three-phase VSI in standalone mode when a nonlinear load is connected. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 13 will be given in learning material 14. The learning material 13 will provide a step-by-step guide to perform these tasks.
Targeted EQF level	<ul style="list-style-type: none"> <li>● 7-8</li> </ul>

Learning Material 13	
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM13%2614.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM13%2614.pdf</a>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 14	
Short description or summary	Based on the learning material 13, two simulation exercise tasks will be given in this learning material, and a guide file will be provided where students have to <ol style="list-style-type: none"> <li>1) Control the VSI by using the Inverter current and Capacitor voltage as feedback variables</li> <li>2) Observe harmonic compensation performance by using different reference frame control strategies</li> </ol> The learning material 14 will provide a step-by-step guide to perform these tasks.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM13%2614.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM13%2614.pdf</a>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Activity/Lab

Learning Material 14	
Level of Completion (%)	10%

Learning Material 15	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in details.</p> <ul style="list-style-type: none"> <li>• Microgrid operation: grid-connected and islanded</li> <li>• Control for parallel power converters</li> <li>• Master-slave control</li> <li>• Virtual impedance</li> <li>• Virtual Impedance</li> <li>• Droop control in AC systems</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM15.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM15.pptx</a></p>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 16	
Short description or summary	<p>This learning material presents a hybrid scheme for an island-mode system with many inverters. Inverters in close proximity operate in master-slave mode, whereas load sharing between distant groups uses frequency droop.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>

Learning Material 16	
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/1218274">https://ieeexplore.ieee.org/abstract/document/1218274</a>
Author & organisation	J. Liang; T.C. Green; G. Weiss; Q.-C. Zhong Imperial College, London
Material Type	Reading
Level of Completion (%)	100%

Learning Material 17	
Short description or summary	This learning material discusses the general problems associated with parallel operation of UPS systems, and control strategy for parallel operation with different ratings.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/1295848">https://ieeexplore.ieee.org/abstract/document/1295848</a>
Author & organisation	Woo-Cheol Lee; Taeck-Ki Lee; Sang-Hoon Lee; Kyung-Hwan Kim; Dong-Seok Hyun; In-Young Suh Dept. of Electr. Eng., HanKyon Nat. Univ., South Korea (Primary Author's affiliation).
Material Type	Reading
Level of Completion (%)	10%

Learning Material 18	
Short description or summary	This learning material describes a strategy for parallel inverters of distributed generation units in an AC distribution system. The presented control technique is based on the droop control method and uses only locally measurable feedback signals.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>



Learning Material 18	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://vbn.aau.dk/en/publications/a-wireless-controller-to-enhance-dynamic-performance-of-parallel-">https://vbn.aau.dk/en/publications/a-wireless-controller-to-enhance-dynamic-performance-of-parallel-</a>
Author & organisation	Josep M. Guerrero, Luis García de Vicuna, José Matas, Miguel Castilla, Jaume Miret Dept. d'Enginyeria de Sistemes, Univ. Politecnica de Catalunya, Barcelona, Spain and Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	10%

Learning Material 19	
Short description or summary	This learning material describes a design strategy for the output impedance of the uninterruptible power system (UPS) inverters with parallel-connection capability. The presented method utilizes power-sharing control loops based on the P/Q droop method in order to avoid the need for any communication among modules.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://vbn.aau.dk/en/publications/output-impedance-design-of-parallel-connected-ups-inverters-with-">https://vbn.aau.dk/en/publications/output-impedance-design-of-parallel-connected-ups-inverters-with-</a>
Author & organisation	Josep M. Guerrero, Luis García de Vicuna, José Matas, Miguel Castilla, Jaume Miret Dept. d'Enginyeria de Sistemes, Univ. Politecnica de Catalunya, Barcelona, Spain and Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100

Learning Material 20	
Short description or summary	<p>This learning material is a simulation handout that guides the student to evaluate a grid-interactive VSI with droop control. In particular, the followings are discussed in detail</p> <ol style="list-style-type: none"> <li>1) Synchronization process taking into account the grid and inverter alpha-beta voltage components.</li> <li>2) Droop control strategy in order to exchange active and reactive power with the grid.</li> </ol> <p>This learning material also serves as the basis of CBL learning as a specific design exercise based upon learning material 20 will be given in learning material 21.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM20%2621.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM20%2621.pdf</a></p>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 21	
Short description or summary	<p>Based on the learning material 20, two exercise tasks will be given in this learning material, and a guide file will be provided where students have to</p> <ol style="list-style-type: none"> <li>1) Understand the dynamics of the power control loops for grid interactivity.</li> <li>2) Evaluate the power injection by using different reference values for active and reactive power.</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>

Learning Material 21	
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM20%2621.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM20%2621.pdf</a>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 22	
Short description or summary	This learning material is a simulation handout that aims to introduce the students to systematic design and comprehend the droop method as well as the virtual impedance concept. This learning material also serves as the basis of CBL learning as a specific design exercise based upon learning material 22 will be given in learning material 23.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM22%2623.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM22%2623.pdf</a>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 23	
Short description or summary	<p>Based on the learning material 22, the following exercise tasks will be given in this learning material, and a guide file will be provided where students have to</p> <ol style="list-style-type: none"> <li>1) Design the virtual impedance</li> <li>2) Design of the droop coefficients of the conventional droop method</li> </ol>

Learning Material 23	
	3) Design of the grid-connected controller coefficients. 4) Design of the Droop Controller based on small-signal analysis
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM22%2623.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM22%2623.pdf</a>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 24	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in details. <ul style="list-style-type: none"> <li>Soft starting mechanism</li> <li>Harmonic current sharing control strategies</li> <li>Low voltage ride-through capability scheme design</li> </ul> These topics will be covered in context to the parallel operation of distributed generators.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM24.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM24.pptx</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.

Learning Material 24	
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 25	
Short description or summary	This learning material presents a method for the parallel operation of inverters in an ac-distributed system. The material explains the control of active and reactive power flow through the analysis of the output impedance of the inverters and its impact on power-sharing. A soft-start operation is also discussed to avoid the initial current peak that enables a seamless hot-swap operation. The improved power-sharing for linear and nonlinear loads by the inclusion of harmonic current loop is also discussed in detail.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://vbn.aau.dk/en/publications/wireless-control-strategy-for-parallel-operation-of-distributed-g">https://vbn.aau.dk/en/publications/wireless-control-strategy-for-parallel-operation-of-distributed-g</a>
Author & organisation	J.M. Guerrero ; J. Matas ; L. Garcia De Vicunagarcia De Vicuna ; M. Castilla ; J. Miret Univ. Politecnica de Catalunya, Barcelona, and Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 26	
Short description or summary	This learning material discusses the control design of synchronous buck hysteretic regulators based on sliding-mode control theory. The applicability of regular linear control techniques is also discussed to verify the ease of stability assessment and achieve a satisfactory transient as well as steady-state performance.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>

Learning Material 26	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://digital-library.theiet.org/content/journals/10.1049/ip-epa_20045276">https://digital-library.theiet.org/content/journals/10.1049/ip-epa_20045276</a>
Author & organisation	M. Castilla; L. García de Vicuña; J.M. Guerrero; J. Matas; J. Miret Departament d'Enginyeria Electrònica, Universitat Politècnica de Catalunya, Vilanova i la Geltrú, Spain (Primary Author's affiliation).
Material Type	Reading
Level of Completion (%)	100%

Learning Material 27	
Short description or summary	<p>Discussions about the decentralized control for parallel operation of distributed generation inverters using resistive output impedance.</p> <p>The focus is given to improve the steady-state and transient response of parallel-connected inverters in a low voltage microgrid environment where the line resistances are more dominant than inductances. The controller uses resistive output impedance, which allows good power-sharing with low sensitivity to the line-impedance unbalances. Finally, the design of output impedance to share not only active and reactive powers but also the harmonic content of the total loads are discussed.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://vbn.aau.dk/en/publications/decentralized-control-for-parallel-operation-of-distributed-gener">https://vbn.aau.dk/en/publications/decentralized-control-for-parallel-operation-of-distributed-gener</a>
Author & organisation	Josep M. Guerrero, José Matas, Luis Garcia de Vicuna, Miguel Castilla, Jaume Miret Departament d'Enginyeria de Sistemes, Escola Univ. d'Enginyeria Tècnica Ind. de Barcelona, and Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 28	
Short description or summary	Discussions about the design approach that optimizes the transient response during large consumption changes by imposing constant closed-loop output impedance.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/4200880">https://ieeexplore.ieee.org/abstract/document/4200880</a>
Author & organisation	Miguel Castilla; Luis Garcia de Vicuna; Josep M. Guerrero; Jos Matas; Jaume Miret Tech. Univ. of Catalonia, Vilanova i la Geltru (Primary Author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 29	
Short description or summary	Discussions about the most important control schemes for the parallel operation of UPS systems. Active load-sharing techniques and droop control approaches, along with recent improvements and variants of these control techniques are discussed in this learning material.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://vbn.aau.dk/en/publications/control-of-distributed-uninterruptible-power-supply-systems">https://vbn.aau.dk/en/publications/control-of-distributed-uninterruptible-power-supply-systems</a>
Author & organisation	Josep M. Guerrero ; Lijun Hang ; Javier Uceda Dept. of Autom. Control & Comput. Eng., Tech. Univ. of Catalonia, Barcelona, and Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 30	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in detail.</p> <ul style="list-style-type: none"> <li>• Hierarchical control principle</li> <li>• Secondary control: Frequency and amplitude deviations</li> <li>• Synchronous and Virtual Synchronous generators</li> <li>• Secondary control in electrical power systems</li> <li>• Secondary control for microgrids</li> <li>• Microgrid Synchronization with the main grid</li> <li>• Tertiary control for AC microgrids</li> <li>• Distributed Vs. Centralized control</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM30.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM30.pptx</a></p>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 31	
Short description or summary	<p>This learning material discusses the hierarchical control standardization for both AC and DC microgrids and presents its three levels, i.e., i) the primary control based on the droop method, including an output impedance virtual loop; ii) the secondary control restoring the deviations produced by the primary control, and iii) the tertiary control managing the power flow between the microgrid and the external electrical distribution system.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>



Learning Material 31	
Format and/or link to the material	PDF, Online <a href="https://vbn.aau.dk/ws/portalfiles/portal/19147627/Publication">https://vbn.aau.dk/ws/portalfiles/portal/19147627/Publication</a>
Author & organisation	Josep M. Guerrero; Juan C. Vásquez; Remus Teodorescu, Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 32	
Short description or summary	This learning material describes the feasibility of control strategies to be adopted for the operation of a microgrid when it becomes isolated. In isolated conditions, the ability to operate stably and autonomously are discussed in detail.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/1626398">https://ieeexplore.ieee.org/abstract/document/1626398</a>
Author & organisation	J.A.P. Lopes ; C.L. Moreira ; A.G. Madureira FEUP-Faculdade de Engenharia, Porto Univ., Portugal.

Learning Material 33	
Short description or summary	This learning material provides an overview of advanced control techniques for microgrids, including decentralized, distributed, and hierarchical control of grid-connected and islanded microgrids. Also, the recent developments in the stability analysis of decentralized, controlled microgrids are discussed. Finally, hierarchical control for microgrids that mimic the behaviour of the mains grid is reviewed.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>

Learning Material 33	
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/6184305">https://ieeexplore.ieee.org/abstract/document/6184305</a>
Author & organisation	Josep M. Guerrero; Mukul Chandorkar; Tzung-Lin Lee; Poh Chiang Loh Department of Energy Technology, Aalborg University, Aalborg East, Denmark
Material Type	Reading
Level of Completion (%)	100%

Learning Material 34	
Short description or summary	This learning material is a simulation handout that guides the student to test the different secondary control strategies for islanded MGs, in order to regulate the frequency and voltage as well as to share reactive power inside the MG units. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 34 will be given in learning material 35.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM34%2635.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM34%2635.pdf</a>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 35	
Short description or summary	<p>Based on the learning material 34, two exercise tasks will be given in this learning material, and a guide file will be provided where students have to</p> <ol style="list-style-type: none"> <li>1) Test the control performance during load disturbance and restoration frequency and amplitude.</li> <li>2) Analyse the reactive power sharing affected by amplitude error.</li> </ol>

Learning Material 35	
	3) Analyse the impact of communication delay on the performance of secondary control strategies.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM34%2635.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM34%2635.pdf</a>
Author & organisation	Yajuan Guan, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 36	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in details. <ul style="list-style-type: none"> <li>Smart-grids</li> <li>Interconnection of Microgrids</li> <li>Clusters of AC Microgrids</li> <li>Control and stability challenges of the Microgrid Cluster</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM36.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM36.pptx</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Lecture Notes

Learning Material 36	
Level of Completion (%)	10%

Learning Material 37	
Short description or summary	The concept of future smart grids as a cluster of multiple nanogrids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/5357331">https://ieeexplore.ieee.org/abstract/document/5357331</a>
Author & organisation	Hassan Farhangi British Columbia Institute of Technology
Material Type	Reading
Level of Completion (%)	100%

Learning Material 38	
Short description or summary	This learning material describes the reasons leading to unreliability and insecurity in microgrids systems. Meanwhile, a modular user-oriented approach is discussed to enhance reliability and expansibility. Finally, a unified dispatching and hierarchical management approach are discussed to effectively optimize and manage modular microgrid architectures.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/6835422">https://ieeexplore.ieee.org/abstract/document/6835422</a>
Author & organization	Hengwei Lin; Chengxi Liu; Josep M. Guerrero; Juan C. Vasquez; Tomislav Dragicevic  Aalborg University, Denmark.

Learning Material 38	
Material Type	Reading
Level of Completion (%)	100%

Learning Material 39	
Short description or summary	This learning material describes hierarchical cooperative control strategy for a cluster of islanded microgrids (MGs) with intermittent communication, which can regulate the frequency/voltage of all distributed generators (DGs) within each MG as well as ensure the active/reactive power-sharing among MGs.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/8207598">https://ieeexplore.ieee.org/abstract/document/8207598</a>
Author & organization	Xiaoqing Lu; Jingang Lai; Xinghuo Yu; Yaonan Wang; Josep M. Guerrero Wuhan University, China, and Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 40	
Short description or summary	Presentation (PPT) slides will be used to cover the details of Consensus and Cooperation in Networked Multi-Agent Systems for Microgrids. Also, the concepts of small signal stability analysis for primary and secondary control are discussed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT

Learning Material 40	
	<a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM40.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/AC%20Microgrids/ACMG_LM40.pptx</a>
Author & organisation	Ernane Antônio Alves Coelho Universidade Federal de Uberlândia
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 41	
Short description or summary	This learning material describes a small-signal analysis method for parallel-connected inverters in stand-alone AC supply systems.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/993176">https://ieeexplore.ieee.org/abstract/document/993176</a>
Author & organisation	E.A.A. Coelho ; P.C. Cortizo ; P.F.D. Garcia Sch. of Electr. Eng., Fed. Univ. of Uberlandia, Brazil.
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 42	
Short description or summary	This learning material describes an approach for small-signal analysis applied to an islanded microgrid composed of two or more voltage-source inverters connected in parallel. The frequency restoration function implemented at the secondary control level, which executes a consensus algorithm that consists of a load-frequency control and a single time delay communication network is discussed in detail.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>

Learning Material 42	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/7492603">https://ieeexplore.ieee.org/abstract/document/7492603</a>
Author & organization	Ernane Antônio Coelho ; Dan Wu ; Josep M. Guerrero ; Juan C. Vasquez ; Tomislav Dragičević Sch. of Electr. Eng., Fed. Univ. of Uberlandia, Brazil. (Primary Author's Affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 43	
Short description or summary	This learning material provides an overview of basic concepts of information consensus in networks and methods of convergence and performance. Further, a theoretical framework for the analysis of consensus algorithms for multi-agent networked systems with an emphasis on the role of directed information flow, robustness to changes in network topology due to link/node failures, time-delays, and performance guarantees in the context of microgrids.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/4118472">https://ieeexplore.ieee.org/document/4118472</a>
Author & organization	Reza Olfati-Saber ; J. Alex Fax ; Richard M. Murray Thayer Sch. of Eng., Dartmouth Coll., Hanover, NH
Material Type	Reading
Level of Completion (%)	100%

#### 4.1.1.2 The implementation

- The short program will be delivered in the energy technology department of Aalborg University, Denmark to the PhD students. The number of participants range from 25-30 for this course.

- Additionally, some PhD students from Aalborg University, Esbjerg campus will also join this course.
- As a supplement, some of the modules/learning materials can be used in Challenges and solutions in Future Power Networks (Form: MOOC for Industry and PhD/MSc students) and Measurement Techniques and Distributed Intelligence for Power Systems (Form: course for Industry and PhD/MSc students) to the RWTH courses.

#### 4.1.2 Power Quality in Microgrids

##### 4.1.2.1 The Structure

Topic	Learning outcomes	Learning Materials
Power Quality in Microgrids	Illustrate the power quality problems including harmonics, power-frequency deviations, voltage fluctuations, voltage dips, swells, interruptions and voltage unbalance	Learning Material 1: Slides Learning Material 2: Paper Learning Material 3: Paper Learning Material 4: Paper Learning Material 5: Paper Learning Material 6: Paper
	Examine various techniques for power quality improvement in microgrids including active power injection, reactive power-sharing, harmonic current sharing and voltage regulation via smart loads	Learning Material 7: Slides Learning Material 8: Paper Learning Material 9: Paper Learning Material 10: Paper Learning Material 11: Simulation handout Learning Material 12: Simulation Exercise
	Examine microgrid hierarchical architecture for voltage regulation and reactive power-sharing	Learning Material 13: Slides Learning Material 14: Paper Learning Material 15: Paper Learning Material 16: Paper Learning Material 17: Paper
	Illustrate the concept of virtual impedance loops for load sharing and power quality improvement	Learning Material 18: Slides Learning Material 19: Paper Learning Material 20: Paper Learning Material 21: Paper Learning Material 22: Simulation handout Learning Material 23: Simulation Exercise
	Illustrate Primary and Secondary Control for Compensation of Voltage Unbalance and Harmonics in Microgrids	Learning Material 24: Slides Learning Material 25: Paper Learning Material 26: Paper Learning Material 27: Simulation handout Learning Material 28: Simulation Exercise
	Employ Current-/Voltage-Controlled Inverters for Power Quality Improvement in Microgrids	Learning Material 29: Slides Learning Material 30: Paper Learning Material 31: Paper Learning Material 32: Paper
	Illustrate synchronization techniques for power converters including open loop, Phase-locked loops (PLLs) and Frequency-locked loops (FLLs) based synchronization techniques	Learning Material 33: Slides Learning Material 34: Paper Learning Material 35: Paper Learning Material 36: Paper Learning Material 37: Paper



		Learning Material 38: Simulation handout Learning Material 39: Simulation Exercise Learning Material 40: Simulation handout Learning Material 41: Simulation Exercise
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#### 4.1.2.2 The Materials

Learning Material 1	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in detail. <ul style="list-style-type: none"> <li>● Introduction to Power Quality Issues</li> <li>● Harmonics</li> <li>● Power-Frequency Deviations</li> <li>● Voltage Fluctuations</li> <li>● Voltage Dips, Swells and Interruptions</li> <li>● Voltage Unbalance</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>● 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>● Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>● PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM1.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM1.pptx</a>
Author & organisation	Alexander Micallef, Department of IEPC, University of Malta
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 2	
Short description or summary	A detailed explanation of working principle, operation and design of conventional passive filters and their comparison with recent the active filters
Targeted EQF level	<ul style="list-style-type: none"> <li>● 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>● Discussed face to face in class</li> <li>● Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>● PhD/Industrial Participants</li> </ul>

Learning Material 2	
Format and/or link to the material	PDF, Online <a href="http://bluebox.ippt.pan.pl/~bulletin/(54-3)255.pdf">http://bluebox.ippt.pan.pl/~bulletin/(54-3)255.pdf</a>
Author & organisation	H. AKAGI, Department of Electrical and Electronic Engineering, Tokyo Institute of Technology, Japan
Material Type	Reading
Level of Completion (%)	100%

Learning Material 3	
Short description or summary	This learning material highlights some of the limitations of parallel islanded single-phase inverters using droop control. Algorithms with the aim to address the following limitations in islanded operation are presented. The suitability of the presented algorithms in achieving reactive power-sharing and in improving the voltage harmonic distortion at the PCC is also discussed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/6748034">https://ieeexplore.ieee.org/document/6748034</a>
Author & organisation	Alexander Micallef; Maurice Apap; Cyril Spiteri-Staines; Josep M. Guerrero; Juan C. Vasquez, Department of Industrial Electrical Power Conversion, University of Malta, Malta Department of Energy Technology, Aalborg University (AAU), Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 4	
Short description or summary	This learning material presents the cooperative harmonic filtering strategies for the interface converters of distributed generation sources. The operation and control principle of a droop control method based on the reactive volt-ampere consumption of harmonics of each interface converter is discussed in detail.

Learning Material 4	
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/4300886/">https://ieeexplore.ieee.org/document/4300886/</a>
Author & organisation	Tzung-Lin Lee ; Po-Tai Cheng, Chang Gung Univ., Taiwan
Material Type	Reading
Level of Completion (%)	100%

Learning Material 5	
Short description or summary	This learning material discusses a strategy to achieve equal reactive power-sharing between the inverters and to restore the voltage deviations caused by the droop control by implementing secondary control loops.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/6254048">https://ieeexplore.ieee.org/document/6254048</a>
Author & organisation	A. Micallef; M. Apap; C. Spiteri Staines; J. M. Guerrero Zapata, Department of Industrial Electrical Power Conversion, University of Malta, Malta Department of Energy Technology, Aalborg University (AAU), Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 6	
Short description or summary	In this learning material, a stationary-frame control method for voltage unbalance compensation in an islanded microgrid is discussed.

Learning Material 6	
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/6140564">https://ieeexplore.ieee.org/document/6140564</a>
Author & organisation	Mehdi Savaghebi ; Alireza Jalilian ; Juan C. Vasquez ; Josep M. Guerrero Department of Energy Technology, Aalborg University (AAU), Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 7	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in detail.</p> <ul style="list-style-type: none"> <li>Active Power Injection</li> <li>Voltage Regulation</li> <li>Reactive Power Sharing Problem &amp; Voltage Regulation</li> <li>Active Power Curtailment (APC)</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM7.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM7.pptx</a>
Author & organisation	Alexander Micallef, Department of IEPC, University of Malta
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 8	
Short description or summary	In this learning material, the effect of current harmonics in single-phase microgrids during islanded and grid-connected mode is explained. A detailed analysis of the effect of the output impedance of the considered primary control loops on the harmonic output of the considered voltage source inverters is discussed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/7328733">https://ieeexplore.ieee.org/document/7328733</a>
Author & organisation	Alexander Micallef; Maurice Apap; Cyril Spiteri-Staines; Josep M. Guerrero, Department of Industrial Electrical Power Conversion, University of Malta, Malta Department of Energy Technology, Aalborg University (AAU), Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 9	
Short description or summary	A detailed overview of the main power quality issues related to single-phase microgrids, including reactive power exchange; voltage and frequency fluctuation; and current and voltage harmonic distortion is presented in this learning material.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/document/8746901">https://ieeexplore.ieee.org/document/8746901</a>
Author & organisation	Alexander Micallef, Department of Industrial Electrical Power Conversion, University of Malta, Malta
Material Type	Reading

Learning Material 9	
Level of Completion (%)	100%

Learning Material 10	
Short description or summary	This learning material discusses the use of droop-based active power curtailment techniques for overvoltage prevention in radial LV feeders as a means for increasing the installed PV capacity and energy yield.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/5664808">https://ieeexplore.ieee.org/abstract/document/5664808</a>
Author & organisation	Reinaldo Tonkoski; Luiz A. C. Lopes; Tarek H. M. El-Fouly, Concordia University, Montreal, Canada
Material Type	Reading
Level of Completion (%)	100%

Learning Material 11	
Short description or summary	This learning material is a simulation handout that guides the student to analyze and simulate the harmonic sharing problem that occurs between parallel inverters during islanded operation. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 11 will be given in learning material 12.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM11%2612.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM11%2612.pdf</a>

Learning Material 11	
Author & organisation	Saeed Golestan, Aalborg University, Denmark
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 12	
Short description or summary	<p>Based on the learning material 11, exercise tasks will be given in this learning material, and a guide file will be provided where students have to :</p> <ol style="list-style-type: none"> <li>1) Determine the THD of the output current supplied by the respective inverter (in %).</li> <li>2) Determine the PCC voltage harmonics due to the load demand.</li> <li>3) Determine the voltage THD at the PCC (in %).</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM11%2612.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM11%2612.pdf</a></p>
Author & organisation	Saeed Golestan, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 13	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in detail.</p> <ul style="list-style-type: none"> <li>• Microgrid Hierarchical Architecture for Voltage Regulation and Reactive Power Sharing</li> <li>• Voltage Regulation via Smart Loads</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>

Learning Material 13	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM13.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM13.pptx</a>
Author & organisation	Alexander Micallef, Department of Industrial Electrical Power Conversion, University of Malta, Malta
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 14	
Short description or summary	In this learning material, a cascaded hierarchical architecture is discussed with the aim to regulate the voltage magnitude and reactive power at the point of common coupling (PCC) of the microgrid. The functionality of hierarchical architecture to support the LV grid during faults due to the added low voltage ride-through capability of the microgrid is also discussed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/8099027">https://ieeexplore.ieee.org/document/8099027</a>
Author & organisation	Alexander Micallef; Cyril Spiteri Staines, Department of Industrial Electrical Power Conversion, University of Malta, Malta
Material Type	Reading
Level of Completion (%)	100%

Learning Material 15	
Short description or summary	This learning material discusses the scientific principle, the operating modes, the limitations, and the practical realization of the electric springs. It is discussed that such a novel concept has huge potential in stabilizing



Learning Material 15	
	future power systems with substantial penetration of intermittent renewable energy sources.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/document/6220904">https://ieeexplore.ieee.org/document/6220904</a>
Author & organisation	Shu Yuen Hui; Chi Kwan Lee; Felix F. Wu Department of Electrical & Electronic Engineering, The University of Hong Kong
Material Type	Reading
Level of Completion (%)	100%

Learning Material 16	
Short description or summary	This learning material describes an overview of decentralized, distributed, and hierarchical control of grid-connected and islanded microgrids.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/6184305">https://ieeexplore.ieee.org/document/6184305</a>
Author & organisation	Josep M. Guerrero ; Mukul Chandorkar ; Tzung-Lin Lee ; Poh Chiang Loh Aalborg University, Denmark (Primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 17	
Short description or summary	This learning material summarizes the main problems and solutions of power quality in microgrids, distributed-energy-storage systems, and ac/dc hybrid microgrids.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/6191321">https://ieeexplore.ieee.org/abstract/document/6191321</a>
Author & organisation	Josep M. Guerrero; Poh Chiang Loh; Tzung-Lin Lee; Mukul Chandorkar Aalborg University, Denmark (Primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 18	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics: <ul style="list-style-type: none"> <li>Islanded Harmonic Current Sharing Problem</li> <li>Primary Harmonic Sharing via Inner Control Loops</li> <li>Virtual Impedance Concept</li> <li>Resistive, inductive, and inductive-resistive virtual impedances</li> <li>Capacitive virtual impedances</li> <li>Resistive-capacitive virtual impedances</li> <li>Performance comparison of virtual impedance techniques</li> <li>Three-phase adaptive virtual impedance</li> <li>Grid-Connected Current Harmonic Injection Problem</li> <li>Virtual admittances to reduce harmonic injection</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM18.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM18.pptx</a>

Learning Material 18	
Author & organisation	Alexander Micallef, Department of Industrial Electrical Power Conversion, University of Malta, Malta
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 19	
Short description or summary	This learning material presents a method of overcoming the limitation of the capacitive virtual impedance with additional virtual resistance for selective harmonic compensation in islanded microgrids.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/6700464">https://ieeexplore.ieee.org/document/6700464</a>
Author & organisation	Alexander Micallef; Maurice Apap; Cyril Spiteri-Staines; Josep M. Guerrero Department of Industrial Electrical Power Conversion, University of Malta, Malta Department of Energy Technology, Aalborg University (AAU), Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 20	
Short description or summary	This learning material discusses a comparison among the performance of resistive, inductive, inductive-resistive and resistive-capacitive virtual impedance loops with respect to current sharing and voltage harmonic distortion at the PCC in a single-phase microgrid.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>

Learning Material 20	
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/document/7526013">https://ieeexplore.ieee.org/document/7526013</a>
Author & organisation	Alexander Micallef; Maurice Apap; Cyril Spiteri-Staines; Josep M. Guerrero Department of Industrial Electrical Power Conversion, University of Malta, Malta Department of Energy Technology, Aalborg University (AAU), Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 21	
Short description or summary	Discussions about the effect of current harmonics in single-phase microgrids during grid-connected and islanded modes of operation. A detailed analysis of the effect of the output impedance of the considered primary control loops on the harmonic output of the considered voltage source inverters is presented. Additionally, the design of a virtual admittance loop to attenuate the current harmonic output in grid-connected operation is discussed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/7328733">https://ieeexplore.ieee.org/document/7328733</a>
Author & organisation	Alexander Micallef; Maurice Apap; Cyril Spiteri-Staines; Josep M. Guerrero Department of Industrial Electrical Power Conversion, University of Malta, Malta Department of Energy Technology, Aalborg University (AAU), Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 22	
Short description or summary	This learning material is a simulation handout that guides the student to simulate and compare the operation of two different virtual impedance loops using Matlab/Simulink. This also serves as the basis of CBL learning

Learning Material 22	
	as a specific design exercise based upon learning material 22 will be given in learning material 23.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM22%2623.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM22%2623.pdf</a>
Author & organisation	Saeed Golestan, Aalborg University, Denmark
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 23	
Short description or summary	Based on the learning material 22, exercise tasks will be given in this learning material, and a guide file will be provided where students have to: <ol style="list-style-type: none"> <li>1) Simulate a resistive virtual impedance of specified resistance</li> <li>2) Design and simulate a resistive-capacitive virtual impedance.</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM22%2623.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM22%2623.pdf</a>
Author & organisation	Saeed Golestan, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 24	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in details.</p> <ul style="list-style-type: none"> <li>• Primary Control for Microgrids Power Quality Improvement</li> <li>• Secondary Control for Microgrids Power Quality Improvement</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM24.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM24.pptx</a></p>
Author & organisation	Mehdi Savaghebi, Associate Professor, University of Southern Denmark (SDU)
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 25	
Short description or summary	<p>This learning material discusses the control approach for selective compensation of the main voltage and current harmonics in grid-connected microgrids.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF, Online</p> <p><a href="https://ieeexplore.ieee.org/document/6237331">https://ieeexplore.ieee.org/document/6237331</a></p>
Author & organisation	<p>Mehdi Savaghebi; Josep M. Guerrero; Alireza Jalilian; Juan C. Vasquez, Center of Excellence for Power System Automation and Operation, Iran University of Science and Technology, Iran.</p> <p>University of Southern Denmark, and Aalborg University, Denmark.</p>

Learning Material 25	
Material Type	Reading
Level of Completion (%)	100%

Learning Material 26	
Short description or summary	This learning material describes the design of the secondary controller to manage the compensation of voltage unbalance at the point of common coupling (PCC) in an islanded microgrid.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/6151875">https://ieeexplore.ieee.org/document/6151875</a>
Author & organisation	Mehdi Savaghebi; Josep M. Guerrero; Alireza Jalilian; Juan C. Vasquez, Center of Excellence for Power System Automation and Operation, Iran University of Science and Technology, Iran. University of Southern Denmark, and Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 27	
Short description or summary	This learning material is a simulation handout that guides the student to simulate and examine various aspects about compensation of power quality problems in microgrids based on the hierarchical control structure, in particular secondary control. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 27 will be given in learning material 28.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>

Learning Material 27	
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM27%2628.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM27%2628.pdf</a>
Author & organisation	Saeed Golestan, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 28	
Short description or summary	Based on the learning material 27, two exercise tasks will be given in this learning material, and a guide file will be provided where students have to <ol style="list-style-type: none"> <li>1) Evaluate and discuss the effect of compensation activation on fundamental positive-sequence active and reactive powers</li> <li>2) Analyze the compensation performance by changing <math>k_p</math> and <math>k_i</math> values of the secondary level PI controller.</li> <li>3) Discuss the impact on the control system performance.</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM27%2628.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM27%2628.pdf</a>
Author & organisation	Saeed Golestan, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 29	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in detail. <ul style="list-style-type: none"> <li>• Coordinated Control of CCM Inverters</li> <li>• Coordinated Control of VCM and CCM inverters</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>



Learning Material 29	
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM29.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM29.pptx</a>
Author & organisation	Mehdi Savaghebi, Associate Professor, University of Southern Denmark (SDU)
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 30	
Short description or summary	<p>This learning material presents an overview of microgrid structures and control techniques at different hierarchical levels. At the power converter level, a detailed analysis of the main operation modes and control structures for power converters belonging to microgrids is discussed, focusing mainly on grid-forming, grid-feeding, and grid-supporting configurations. This discussion is extended as well toward the hierarchical control scheme of microgrids, which, based on the primary, secondary, and tertiary control layer division is devoted to minimize the operation cost, coordinating support services, meanwhile maximizing the reliability and the controllability of microgrids.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/6200347">https://ieeexplore.ieee.org/document/6200347</a>
Author & organisation	Joan Rocabert ; Alvaro Luna ; Frede Blaabjerg ; Pedro Rodríguez Department of Electrical Engineering, Technical University of Catalonia, 08222 Barcelona, Spain (Primary author's affiliation)
Material Type	Reading

Learning Material 30	
Level of Completion (%)	100%

Learning Material 31	
Short description or summary	This learning material describes the coordinated harmonic compensation and voltage support scheme for distributed generations' (DGs') interface inverters in a resistive grid-connected microgrid.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://www.sciencedirect.com/science/article/abs/pii/S0378779617304224">https://www.sciencedirect.com/science/article/abs/pii/S0378779617304224</a>
Author & organization	Seyyed Yousef Mousazadeh Mousavi, Alireza Jalilian, Mehdi Savaghebi, and Josep M.Guerrero  School of Electrical Engineering, Iran University of Science and Technology, Iran (Primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 32	
Short description or summary	This learning material describes a coordinated control of CCM and VCM units for reactive power sharing and voltage harmonics compensation.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/8263177">https://ieeexplore.ieee.org/document/8263177</a>
Author & organization	Seyyed Yousef Mousazadeh Mousavi, Alireza Jalilian, Mehdi Savaghebi, and Josep M.Guerrero

Learning Material 32	
	School of Electrical Engineering, Iran University of Science and Technology, Iran (Primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 33	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the details of synchronization techniques including</p> <ul style="list-style-type: none"> <li>• Phase-locked loops (PLLs)</li> <li>• Frequency-locked loops (FLLs)</li> <li>• Open-loop synchronization techniques</li> <li>• Dynamic interaction between power converter and PLL</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM33.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM33.pptx</a></p>
Author & organisation	<p>Saeed Golestan</p> <p>Department of Energy Technology, Aalborg University, Denmark</p>
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 34	
Short description or summary	This learning material presents an overview of the single-phase PLLs for the synchronization of power-electronics-based converters.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>

Learning Material 34	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/7819538">https://ieeexplore.ieee.org/document/7819538</a>
Author & organisation	Saeed Golestan ; Josep M. Guerrero ; Juan C. Vasquez Department of Energy Technology, Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 35	
Short description or summary	This learning material presents an overview of the three-phase PLLs for the synchronization of power-electronics-based converters.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/document/7467498">https://ieeexplore.ieee.org/document/7467498</a>
Author & organisation	Saeed Golestan ; Josep M. Guerrero ; Juan C. Vasquez Department of Energy Technology, Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 36	
Short description or summary	This learning material provides a unifying approach to the understanding and analysis of the synchronous reference frames-PLLs. This also integrates several synchronous reference frames-PLLs having apparently different structures into a single structure.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>

Learning Material 36	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/6392294">https://ieeexplore.ieee.org/abstract/document/6392294</a>
Author & organization	Masoud Karimi-Ghartemani Department of Electrical and Computer Engineering, Mississippi State University, Starkville, MS, USA
Material Type	Reading
Level of Completion (%)	100%

Learning Material 37	
Short description or summary	This learning material provides an overview of modelling and stability assessment for single-phase grid synchronization techniques with a detailed comparison between linear time-periodic and linear time-invariant Frameworks
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/8357505">https://ieeexplore.ieee.org/abstract/document/8357505</a>
Author & organization	Saeed Golestan ; Josep M. Guerrero ; Juan C. Vasquez Department of Energy Technology, Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 38	
Short description or summary	This learning material is a simulation handout that guides the student to analyse and design phase-locked loops, and frequency-locked loops. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 38 will be given in learning material 39.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>

Learning Material 38	
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM38%2639.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM38%2639.pdf</a>
Author & organisation	Saeed Golestan, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 39	
Short description or summary	Based on the learning material 38, two exercise tasks will be given in this learning material, and a guide file will be provided where students have to <ol style="list-style-type: none"> <li>1) Implement a conventional SRF-PLL.</li> <li>2) Design its parameters so that its settling time in response to a phase angle jump is around two cycles of the nominal frequency</li> <li>3) Implement a single-phase second-order generalized integrator based frequency-locked loop (SOGI-FLL).</li> <li>4) Design its parameters so that it's settling time in response to a frequency jump is around two cycles of the nominal frequency.</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM38%2639.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM38%2639.pdf</a>
Author & organisation	Saeed Golestan, Aalborg University, Denmark.
Material Type	Activity/Lab

Learning Material 39	
Level of Completion (%)	10%

Learning Material 40	
Short description or summary	This learning material is a simulation handout that guides the student to analyse and design open-loop synchronization techniques. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 40 will be given in learning material 41.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM40%2641.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM40%2641.pdf</a>
Author & organisation	Saeed Golestan, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 41	
Short description or summary	Based on the learning material 40, two exercise tasks will be given in this learning material, and a guide Matlab file (.slx) will be provided where students have to <ol style="list-style-type: none"> <li>1) Remove the phase error under off-nominal frequencies</li> <li>2) Design a compensator and include into its structure using the inverse compensation method or the frequency feedforward compensation method.</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>

Learning Material 41	
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM40%2641.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Power%20Quality%20in%20Microgrids/PQ_LM40%2641.pdf</a>
Author & organisation	Saeed Golestan, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	100%

#### 4.1.2.3 The implementation

- The short program will be delivered in the energy technology department of Aalborg University, Denmark to the PhD students. The number of participant range from 25-30 for this course.
- Additionally, some PhD students from Aalborg University, Esbjerg campus will also join this course.
- Parts of it is a tentative interdisciplinary PhD/industrial seminar together with the department Energy Technology for Sustainable Development of UPV and the department of Electrical and Electronic Engineering of the University of West Attica.
- As a supplement, some of the modules/learning materials can be used in Challenges and solutions in Future Power Networks (Form: MOOC for Industry and PhD/MSc students) and Measurement Techniques and Distributed Intelligence for Power Systems (Form: course for Industry and PhD/MSc students) to the RWTH courses.

#### 4.1.3 DC Microgrids

##### 4.1.3.1 The Structure

Topic	Learning outcomes	Learning Materials
DC Microgrids	Recognize the importance of DC Microgrids as a reliable, resilient and efficient technology for the integration, distribution, and utilization of renewable/non-renewable based generation and storage resources	Learning Material 1: Slides Learning Material 2: Paper Learning Material 3: Paper
	Illustrate various architectures, configurations and applications of DC Microgrids at the residential, commercial and industrial level	Learning Material 4: Slides Learning Material 5: Paper Learning Material 6: Paper Learning Material 7: Paper
	Design various control schemes on the individual power electronic converters for DC microgrids	Learning Material 8: Slides Learning Material 9: Paper Learning Material 10: Paper



		Learning Material 11: Paper Learning Material 12: Simulation handout Learning Material 13: Simulation Exercise Learning Material 14: Simulation handout Learning Material 15: Simulation Exercise
	Design various control schemes on the parallel converters for DC microgrids	Learning Material 16: Slides Learning Material 17: Paper Learning Material 18: Paper Learning Material 19: Paper Learning Material 20: Paper Learning Material 21: Simulation handout Learning Material 22: Simulation Exercise
	Design and apply various layers of hierarchical control including primary, secondary and tertiary control for DC microgrids	Learning Material 23: Slides Learning Material 24: Paper Learning Material 25: Paper Learning Material 26: Paper Learning Material 27: Simulation handout Learning Material 28: Simulation handout Learning Material 29: Simulation Exercise Learning Material 30: Simulation handout Learning Material 31: Simulation Exercise Learning Material 32: Simulation Exercise

#### 4.1.3.2 The Materials

Learning Material 1	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in detail. <ul style="list-style-type: none"> <li>• Distributed Renewable/Non-renewable Energy Resources</li> <li>• Overview of Microgrid Technology</li> <li>• Microgrid Configurations and Examples</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM1.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM1.pptx</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 2	
Short description or summary	Microgrid configuration example from the demonstration Project in Hachinohe: Microgrid with Private Distribution Line
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/4304276?arnumber=4304276">https://ieeexplore.ieee.org/document/4304276?arnumber=4304276</a>
Author & organisation	Kojima, Y. Koshio, M. Nakamura, S. Maejima, H. Fujioka, Y. Goda, T.A, Mitsubishi Electric Corp. Amagasaki, Hyogo, Japan
Material Type	Reading
Level of Completion (%)	100%

Learning Material 3	
Short description or summary	An overview and summary of real-world microgrids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://ieeexplore.ieee.org/abstract/document/4304255">https://ieeexplore.ieee.org/abstract/document/4304255</a>
Author & organisation	Barnes, M. Kondoh, J. Asano, H. Oyarzabal, J. Ventakaramanan, G. Lasseter, R. Hatziaargyriou, N. Green, T. School of Electrical and Electronic Engineering, University of Manchester, UK
Material Type	Reading
Level of Completion (%)	100%

Learning Material 4	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in details.</p> <ul style="list-style-type: none"> <li>• AC and DC Current war</li> <li>• DC Microgrids configurations</li> <li>• DC Microgrids at home and residential buildings</li> <li>• DC Microgrids facilities</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM4.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM4.pptx</a></p>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 5	
Short description or summary	The impact of voltage level and DC distribution architecture on the performance and efficiency of a data centre
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF, Online</p> <p><a href="https://ieeexplore.ieee.org/abstract/document/4448733">https://ieeexplore.ieee.org/abstract/document/4448733</a></p>
Author & organisation	Annabelle Pratt; Pavan Kumar; Tom V. Aldridge Corporate Technology Group, Intel Corporation, Hillsboro, Oregon, USA
Material Type	Reading
Level of Completion (%)	100%

Learning Material 6	
Short description or summary	Overview of the architecture of residential microgrids with the case studies of Japanese residential microgrid
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/5587899">https://ieeexplore.ieee.org/abstract/document/5587899</a>
Author & organisation	Hiroaki Kakigano; Yushi Miura; Toshifumi Ise Osaka University, Osaka, Japan
Material Type	Reading
Level of Completion (%)	100%

Learning Material 7	
Short description or summary	DC distribution microgrids based on modular photovoltaic modules and battery storage
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/4304276?arnumber=4304276">https://ieeexplore.ieee.org/document/4304276?arnumber=4304276</a>
Author & organisation	Kai Sun, Tsinghua University, Beijing, China Li Zhang, Yan Xing, University of Aeronautics and Astronautics, Nanjing, China Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 8	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in detail.</p> <ul style="list-style-type: none"> <li>• Feedback linearization control</li> <li>• One cycle control</li> <li>• Buck converter</li> <li>• Half-bridge with synchronous rectifiers</li> <li>• Half-bridge current doubler rectifier</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM8.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM8.pptx</a></p>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 9	
Short description or summary	Switching flow graph models and one cycle control techniques for PWM switched power electronic converters
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF, Online</p> <p><a href="http://thesis.library.caltech.edu/2476">http://thesis.library.caltech.edu/2476</a></p>
Author & organisation	<p>Smedley, Keyue Ma</p> <p>California Institute of Technology, USA</p>
Material Type	Reading

Learning Material 9	
Level of Completion (%)	100%

Learning Material 10	
Short description or summary	Control of DC Microgrid converters with the emphasis on the control of half-bridge synchronous rectifier.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/1137507">https://ieeexplore.ieee.org/abstract/document/1137507</a>
Author & organisation	L. Garcia de Vicuna, Univ. Politecnica de Catalunya, Vilanova, Spain Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 11	
Short description or summary	Design of Simple feedback linearizing controller to reduce audio susceptibility and load disturbance in the full-bridge current doubler synchronous rectifier
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/1453042">https://ieeexplore.ieee.org/abstract/document/1453042</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark & Sustainable Distributed Generation Syst. & Renewable Energy Group, Escola Univ. d'Enginyeria Tecnica Ind. de Barcelona, Spain.
Material Type	Reading

Learning Material 11	
Level of Completion (%)	100%

Learning Material 12	
Short description or summary	Design of control parameters for DC microgrids: the objective of this simulation handout is to guide the student to achieve AC current and DC voltage control for a DC microgrid. And also, the droop controller for load current sharing is designed. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 12 will be given in learning material 13.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM12%2613.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM12%2613.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 13	
Short description or summary	Based on the learning material 12, two simulation exercise tasks will be given in this learning material, and a guide file will be provided where Matlab rlocus, margin, bandwidth commands are used for designing the controller parameters.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>

Learning Material 13	
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM12%2613.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM12%2613.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 14	
Short description or summary	Simulation Evaluation of Stand-alone Converter with DC Voltage Control: the objective of this simulation handout is to guide the student to test the designed control of a DC microgrid, including DC current droop control. The student will see DC voltage deviation by using the virtual impedance. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 14 will be given in learning material 15. The learning material 14 will provide a step-by-step guide to perform these tasks.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM14%2615.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM14%2615.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%



Learning Material 15	
Short description or summary	Based on the learning material 14, two simulation exercise tasks will be given in this learning material, and a guide file will be provided where a) DC bus voltage forming by parallel rectifiers, and b) Proportional current sharing by parallel rectifiers will be designed by the students. The learning material 14 will provide a step-by-step guide to perform these tasks.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM14%2615.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM14%2615.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 16	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in detail. <ul style="list-style-type: none"> <li>Parallel control schemes</li> <li>Centralized control</li> <li>Master-slave control</li> <li>Averaged control</li> <li>Droop control</li> <li>Virtual impedance</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM16.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM16.pptx</a>

Learning Material 16	
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 17	
Short description or summary	Modelling and Design for a Novel Adaptive Voltage Positioning (AVP) Scheme for Multiphase VRMs
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/4558239">https://ieeexplore.ieee.org/abstract/document/4558239</a>
Author & organisation	Martin Lee; Dan Chen; Kevin Huang; Chih-Wen Liu; Ben Tai Taiwan University, Taipei
Material Type	Reading
Level of Completion (%)	100%

Learning Material 18	
Short description or summary	Comparative study and discussions of hysteretic controllers for single-phase voltage regulators used in low-voltage applications
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://digital-library.theiet.org/content/journals/10.1049/iet-pel_20070151">https://digital-library.theiet.org/content/journals/10.1049/iet-pel_20070151</a>
Author & organisation	M. Castilla; J.M. Guerrero; J. Matas; J. Miret; J. Sosa Department of Electronic Engineering, Universitat Politècnica de Catalunya, Spain (Primary author's affiliation)

Learning Material 18	
Material Type	Reading
Level of Completion (%)	100%

Learning Material 19	
Short description or summary	Control of parallel-connected bidirectional AC-DC converters in a stationary frame for microgrid applications
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/6064335">https://ieeexplore.ieee.org/abstract/document/6064335</a>
Author & organisation	Xiaonan Lu; Josep Guerrero; Remus Teodorescu; Tamas Kerekes; Kai Sun; Lipei Huang State Key Lab of Power Systems, Department of Electrical Engineering, Tsinghua University, Beijing, China (Primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 20	
Short description or summary	Distributed Control to Ensure Proportional Load Sharing and Improve Voltage Regulation in Low Voltage DC Microgrids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/4558239">https://ieeexplore.ieee.org/abstract/document/4558239</a>
Author & organisation	Sandeep Anand; Baylon G. Fernandes; Indian Institute of Technology Bombay, Mumbai, India Josep M. Guerrero, AAU, Denmark

Learning Material 20	
Material Type	Reading
Level of Completion (%)	100%

Learning Material 21	
Short description or summary	Control design of a standalone voltage-droop regulated dc microgrid: This material is focused on the coordinated tuning of control parameters of a multi-source DC Microgrid. At first, the student will learn how to use the state-space technique for modelling the coupled differential equations that represent particular elements of the DC MG. Then, these equations will be linked to assembling the state-space model of the general N-unit system. Impact analysis of changing virtual resistance is performed for both configurations, as this control parameter has an influence on stability. This will also serve as the basis of CBL for the simulation exercise tasks presented in learning material 22.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM21%2622.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM21%2622.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 22	
Short description or summary	Based on the learning material 21, four simulation exercise tasks will be given in this learning material, and a guide file will be provided where students have to design simulations for the following cases. <ol style="list-style-type: none"> <li>1) Construction of the one-unit state-space model and tuning the parameters of inner control loops</li> <li>2) Droop impact analysis on system stability</li> <li>3) Common voltage control by four paralleled sources</li> </ol>

Learning Material 22	
	4) Analysis of secondary control for restoring the common voltage deviation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM21%2622.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM21%2622.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 23	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in detail. <ul style="list-style-type: none"> <li>Voltage droop: Primary control</li> <li>Secondary control</li> <li>Secondary control for DC Microgrids</li> <li>Tertiary control for DC Microgrids</li> <li>Clusters of DC Microgrids</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM23.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM23.pptx</a>
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 24	
Short description or summary	Hierarchical Control of Droop-Controlled AC and DC Microgrids—A General Approach Toward Standardization
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/5546958">https://ieeexplore.ieee.org/document/5546958</a>
Author & organisation	Josep M. Guerrero ; Juan C. Vasquez; José Matas; Luis García de Vicuna ; Miguel Castilla Department of Automatic Control Systems and Computer Engineering, Universitat Politècnica de Catalunya, Barcelona, Spain AAU, Denmark
Material Type	Reading
Level of Completion (%)	100%

Learning Material 25	
Short description or summary	Hierarchical Control for Multiple DC-Microgrids Clusters based upon distributed SOC and consensus-based secondary control
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/6939722">https://ieeexplore.ieee.org/abstract/document/6939722</a>
Author & organisation	Qobad Shafiee ; Tomislav Dragičević ; Juan C. Vasquez ; Josep M. Guerrero Aalborg University, Aalborg, East, Denmark
Material Type	Reading
Level of Completion (%)	100%

Learning Material 26	
Short description or summary	Hierarchical control of power plants with microgrid operation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/5674954">https://ieeexplore.ieee.org/document/5674954</a>
Author & organisation	Josep M. Guerrero, AAU, Denmark
Material Type	Reading
Level of Completion (%)	100%

Learning Material 27	
Short description or summary	Design of hierarchical control for dc microgrids: the objective of this learning module is to guide the student to achieve each control level of a hierarchical control system. Previously designed local AC current, DC voltage and droop controllers are for the primary control level. A secondary controller for restoring the DC voltage and tertiary controller for DC grid current regulation will be reached in this learning material. This will also serve as the basis of CBL for the simulation exercise tasks presented in learning material 28.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM27%2628.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM27%2628.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Simulation

Learning Material 27	
Level of Completion (%)	10%

Learning Material 28	
Short description or summary	Based on the learning material 27, two simulation exercise tasks will be given in this learning material, and a guide file will be provided where students have to design simulations for the following cases. 1) Design secondary controller 2) Design tertiary controller
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM27%2628.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM27%2628.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 29	
Short description or summary	Evaluation of hierarchical control for dc microgrids: the aim of this learning material is to guide the student to test the designed hierarchical control system of a DC microgrid, including the primary, secondary and tertiary control levels. The student will see DC voltage deviation and restore them to nominal values by means of a secondary control strategy and the DC grid-connected current control by means of a tertiary control strategy. This will also serve as the basis of CBL for the simulation exercise tasks presented in learning material 30.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>



Learning Material 29	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM29%2630.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM29%2630.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 30	
Short description or summary	Based on the learning material 29, two simulation exercise tasks will be given in this learning material, and a guide file will be provided where students have to design simulations for the following cases. <ol style="list-style-type: none"> <li>1) Secondary control to restore DC voltage in the microgrid</li> <li>2) Tertiary control to control the DC-side grid-connected current in the microgrid</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM29%2630.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM29%2630.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 31	
Short description or summary	Balancing by using knowledge-based fuzzy inference system: the main aim of this learning material exercise is to completely understand how the

Learning Material 31	
	virtual resistance can be used in order to adjust the power-sharing in an islanded DC microgrid with distributed energy storage systems. The virtual resistance can be adjusted in order to balance the stored energy between distributed energy storage systems. Commonly, several different gain scheduling approaches have been proposed in order to achieve a balance between distributed energy storage systems. Particularly, in this learning material, a simple strategy based on an intuitive knowledge base fuzzy system will be proposed for equalizing the state of charge of distributed energy storage systems based on batteries. This will also serve as the basis of CBL for the simulation exercise tasks presented in learning material 32.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM31%2632.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM31%2632.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 32	
Short description or summary	Based on the learning material 31, two simulation exercise tasks will be given in this learning material, and a guide file will be provided where students have to design simulations for the following cases. 1) Manual Adjustment of weight coefficients for SoC equalization. 2) Task 2: Fuzzy adjustment of weight coefficient for automatic equalization.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>

Learning Material 32	
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM31%2632.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/DC%20Microgrids/DCMG_LM31%2632.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	0%

#### 4.1.3.3 The implementation

- The short program will be delivered in the energy technology department of Aalborg University, Denmark to the PhD students. The number of participants range from 25-30 for this course.
- Additionally, some PhD students from Aalborg University, Esbjerg campus will also join this course.
- As a supplement, some of the modules/learning materials can be used in Challenges and solutions in Future Power Networks (Form: MOOC for Industry and PhD/MSc students) and Measurement Techniques and Distributed Intelligence for Power Systems (Form: course for Industry and PhD/MSc students) to the RWTH courses.

#### 4.1.4 Measurement Techniques and Distributed Intelligence for Power Systems

##### 4.1.4.1 The Structure

Topic	Learning outcomes	Learning Materials
Measurement Techniques and Distributed Intelligence for Power Systems	Investigate and apply the basics of uncertainty propagation in measurements	Learning Material 1: Lecture slides: Introduction and features of the evolving power system Learning Material 2: Lecture slides: Fundamentals of metrology and measurement Uncertainty, GUM standard Learning Material 3: Exercise: Uncertainty calculation and propagation, and Power Measurements
	Assess the applications of measurements in power systems	Learning Material 4: Lecture slides: transducers for power systems Learning Material 5: Lecture slides: digitization of monitoring chain Learning Material 6: Lecture slides: RMS and power definition and calculation Learning Material 7: Lecture slides: Synchrophasor measurement, PMUs Learning Material 8: Exercise: Calculation of synchrophasors

	Examine and appraise the application of distributed measurements in power systems	Learning Material 9: Lecture slides: State Estimation -- Static, centralized state estimation Learning Material 10: Lecture slides: Integration of PMU data in state estimation (extension of classical state estimation, new linear problem form, post-processing) Learning Material 11: Exercise: state estimation
	Investigate and apply the fundamentals of distributed intelligence in the power system	Learning Material 12: Lecture slides: Agents in power systems: an introduction. Learning Material 13: Demo: Agents sample application

#### 4.1.4.2 The Materials

Learning Material 1	
Short description or summary	Introduction and features of the evolving power system
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Masurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Masurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 2	
Short description or summary	Fundamentals of metrology and measurement Uncertainty, GUM standard (Identify the basic principles of measurement and its uncertainty; Recognise the challenges in measurement in power systems; Analyse how uncertainties propagate in power system measurements; Arrange simple statistical evaluation of measurements; Evaluate measurement compatibilities)
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>

Learning Material 2	
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 3	
Short description or summary	Exercise: Uncertainty calculation and propagation (Analyse how uncertainties propagate in power system measurements)
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	90%

Learning Material 4	
Short description or summary	Lecture slides: transducers for power systems (Describe how transducers (voltmeter, ammeter) are used for measurements; Investigate how to perform power measurements in multi-phase systems)

Learning Material 4	
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	PDF
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 5	
Short description or summary	Lecture slides: digitization of monitoring chain
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 6	
Short description or summary	Lecture slides: RMS and power definition and calculation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>

Learning Material 6	
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 7	
Short description or summary	Lecture slides: Synchrophasor measurement, PMUs
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 8	
Short description or summary	Exercise: Calculation of synchrophasors
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	90%

Learning Material 9	
Short description or summary	Lecture slides: State Estimation -- Static, centralized state estimation (Analyse how state-estimation works)
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%



Learning Material 10	
Short description or summary	Lecture slides: Integration of PMU data in state estimation (extension of classical state estimation, new linear problem form, post-processing; Apply distributed measurements for state-estimation; Employ quantities measured by the PMU to improve the performance of state-estimation)
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 11	
Short description or summary	Exercise: state estimation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	90%

Learning Material 12	
Short description or summary	Lecture slides: Agents in power systems: an introduction (Identify the advantage and need of using agents in power system; Examine the use and significance of the FIPA standard)
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 13	
Short description or summary	Demo: Agents sample application
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Measurement%20Techniques%20and%20Distributed%20Intelligence%20for%20Power%20Systems&amp;fileid=292019</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Simulation
Level of Completion (%)	90%

#### 4.1.4.3 The implementation

This short programme will be delivered by the Institute for Automation of Complex Power Systems at RWTH Aachen University in Germany. This programme is part of the regular postgraduate programme at the university. As such, the target audience includes among other employees from the energy industry.

This programme introduces the fundamental elements and technologies for measurement and monitoring the usage for distribution automation, and it illustrates the ongoing evolution towards distributed solutions. The fundamentals of metrology are reviewed with emphasis on measurement uncertainty and its propagation within the framework of the current international standard. Traditional instrument transformers and new active devices are explained. The synchrophasor measurement is covered together with the application of synchrophasor measurement to monitoring, particularly state estimation. The architecture of measurement usage and acquisition within the substation is discussed together with the application of multi-agent systems in distributed monitoring and control applications.

Apart from the RWTH postgraduate programmes, learning components will be integrated into courses in the master courses of UWA electrical engineering department as well as in UPV's master courses.

#### 4.1.5 Implementation of automation functions for monitoring and control

##### 4.1.5.1 The Structure

Topic	Learning outcomes	Learning Materials
Implementation of automation functions for monitoring and control	To explain and apply the basics of IEC61850	Learning Material 1: Laboratory Module: IEC 61850 for Power System Communication  Learning Material 2: Laboratory Module: Communication automation within substation and IEC 61850 information model  Learning Material 3: Laboratory Module: MMS Mapping in IEC 61850
	To employ Intelligent Electronic Devices for monitoring, distribution and protection functions	Learning Material 4: Laboratory Module: Automation Functions in Power System Protection  Learning Material 5: Automation of MTDC grid  Learning Material 6: Monitoring States of Power System via PMU
	To examine and criticise the IED and substation configuration recognize and define the main features of advanced control methods applied in converter-level control	Learning Materials 1 to 6

#### 4.1.5.2 The Materials

Learning Material 1	
Short description or summary	Laboratory Module: Laboratory Module: IEC 61850 for Power System Communication
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034">https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	80%

Learning Material 2	
Short description or summary	Laboratory Module: Communication automation within substation and IEC 61850 information model
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face, could be blended</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034">https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab

Learning Material 2	
Level of Completion (%)	80%

Learning Material 3	
Short description or summary	Laboratory Module: MMS Mapping in IEC 61850
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034">https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	80%

Learning Material 4	
Short description or summary	Laboratory Module: Automation Functions in Power System Protection
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034">https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab

Learning Material 4	
Level of Completion (%)	80%

Learning Material 5	
Short description or summary	Laboratory Module: Automation of MTDC grid
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034">https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	60%

Learning Material 6	
Short description or summary	Laboratory Module: Monitoring States of Power System via PMU
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034">https://newrepository.atosresearch.eu/index.php/apps/files?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Implementation%20of%20automation%20functions%20for%20monitoring%20and%20control&amp;fileid=292034</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems

Learning Material 6	
Material Type	Activity/Lab
Level of Completion (%)	60%

#### 4.1.5.3 The implementation

This short programme will be delivered by the Institute for Automation of Complex Power Systems at RWTH Aachen University in Germany starting from the Summer Semester of 2020 (6th of April to 17th of July).

This programme focuses on the implementation of automation based on the standard series IEC61850. After an introduction to the main concepts of the standard and of the digital substation, the students will learn the Substation Configuration Language file structure, the IED capability description, configuration and instantiation, the System Specification Description and the Substation Configuration description. At the end of the module, students are able to understand and apply the basics of IEC61850, to configure and integrate Intelligent Electronic Devices for monitoring, distribution and protection functions and to validate the IED and substation configuration. This course has the structure of a “Praktikum” in the German system that it is this is a **“hands-on” course**. The students will program the IEDs, which in turn will acquire measurements and control from the virtual domain of real-time simulation. This course is intended for students and industry professionals.

#### 4.1.6 Maritime Microgrids

##### 4.1.6.1 The Structure

Topic	Learning outcomes	Learning Materials
Maritime Microgrids	Illustrate the shipboard power system and integrated electric applications in ships.	Learning Material 1: Slides Learning Material 2: Paper Learning Material 3: Paper Learning Material 4: Simulation handout
	Analyse maritime microgrid characteristics and identify power quality challenges in shipboard microgrid power systems	Learning Material 5: Slides Learning Material 6: Paper Learning Material 7: Paper Learning Material 8: Paper
	Apply signal processing techniques to analyse power quality disturbances in maritime microgrids	Learning Material 9: Slides Learning Material 10: Paper Learning Material 11: Paper Learning Material 12: Paper Learning Material 13: Simulation handout Learning Material 14: Simulation Exercise Learning Material 15: Simulation handout Learning Material 16: Simulation Exercise

	Categorise the ship power systems evolution and identify the directions for future research challenges	Learning Material 17: Slides Learning Material 18: Paper Learning Material 19: Paper Learning Material 20: Paper
	Analyse the stability of Multi-converter shipboard MVDC power system.	Learning Material 21: Slides Learning Material 22: Paper Learning Material 23: Paper Learning Material 24: Paper

#### 4.1.6.2 The Materials

Learning Material 1	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in detail.</p> <ul style="list-style-type: none"> <li>• Ships power system evolution.</li> <li>• Shipboard electrical applications (Integrated Power Systems)</li> <li>• MVDC power systems on ships.</li> <li>• Integrated Electrical/Electronics ships Power Systems design.</li> <li>• Integrated Power &amp; Energy Systems Dependability on ships</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM1.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM1.pptx</a></p>
Author & organisation	<p>Prof. Giorgio Sulligoi, PhD.</p> <p>The University of Trieste, Italy</p>
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 2	
Short description or summary	<p>The discussion and overview of a demonstrative technological implementation of a shipboard 2.15-MVA generation system along with its modelling, numeric simulation, and some factory tests.</p> <p>The system, named Naval Package (NP), is part of a demonstrative program commissioned by Italian Navy for preliminary evaluations of medium-voltage dc supply technologies aimed at equipping its future vessels.</p>



Learning Material 2	
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/5462859">https://ieeexplore.ieee.org/abstract/document/5462859</a>
Author & organisation	Giorgio Sulligoi ; Alberto Tassarolo ; Varo Benucci ; Massimo Baret ; Antonio Rebora ; Andrea Taffone Department of Electrical, Electronic and Computer Engineering, University of Trieste, Trieste, Italy (primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 3	
Short description or summary	Linearizing control of shipboard multi-machine MVDC power systems feeding Constant Power Loads
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/6342753">https://ieeexplore.ieee.org/abstract/document/6342753</a>
Author & organisation	Giorgio Sulligoi ; Daniele Bosich ; Lin Zhu ; Marco Cupelli ; Antonello Monti Department of Electrical, Electronic and Computer Engineering, University of Trieste, Trieste, Italy (primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 4	
Short description or summary	Design of DC ship power systems: DC distribution could provide better performance than conventional AC distribution technologies if properly

Learning Material 4	
	designed and deployed. In these exercises, the participants will be given a ship case study to propose a design concept. This exercise will serve as a CBL instance.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf</a>
Author & organisation	Josep M. Guerrero, Aalborg University, Denmark.
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 5	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in details. <ul style="list-style-type: none"> <li>Introduction to power quality in maritime microgrids</li> <li>Maritime microgrids characteristics</li> <li>Standard framework</li> <li>Power quality assessment in</li> <li>marine microgrids</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM5.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM5.pptx</a>
Author & organisation	Tomasz Tarasiuk Gdynia Maritime University

Learning Material 5	
Material Type	Lecture
Level of Completion (%)	10%

Learning Material 6	
Short description or summary	The discussion and Mirroring overview of the terrestrial power system, naval warships including the design philosophy for naval power systems
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/7116681">https://ieeexplore.ieee.org/abstract/document/7116681</a>
Author & organisation	Norbert Doerry Naval Sea Systems Command, Washington, D.C., USA
Material Type	Reading
Level of Completion (%)	100%

Learning Material 7	
Short description or summary	Discussions about the Instruments and Measurements Committee report covering the developments and progress in that part of the electrical field.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/6592129">https://ieeexplore.ieee.org/abstract/document/6592129</a>
Author & organisation	S: G. Rhodes, Contributing author, Journal of the American Institute of Electrical Engineers
Material Type	Reading

Learning Material 7	
Level of Completion (%)	100%

Learning Material 8	
Short description or summary	The discussions about the experimental results of harmonics measurements in example ship microgrid containing varying nonlinear load, namely high power adjustable speed drive of a bow thruster
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/8515609">https://ieeexplore.ieee.org/abstract/document/8515609</a>
Author & organisation	Mariusz Gorniak ; Tomasz Tarasiuk Gdynia Maritime University
Material Type	Reading
Level of Completion (%)	100%

Learning Material 9	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in detail. <ul style="list-style-type: none"> <li>Basic standards related to PQ phenomena measurement</li> <li>Overview of measuring instruments hardware</li> <li>Standard methods of signal processing of PQ disturbances</li> <li>Recommendations for measurement of PQ disturbances in maritime microgrids</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM9.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM9.pptx</a>

Learning Material 9	
Author & organisation	Tomasz Tarasiuk Gdynia Maritime University Poland
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 10	
Short description or summary	Detailed discussions regarding signal processing of power quality disturbances
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF (BOOK) <a href="https://www.wiley.com/en-us/Signal+Processing+of+Power+Quality+Disturbances-p-9780471731689">https://www.wiley.com/en-us/Signal+Processing+of+Power+Quality+Disturbances-p-9780471731689</a>
Author & organisation	Math H. J. Bollen, STRI, Ludvika, Sweden Irene Y. H. Gu, Chalmers University of Technology, Sweden
Material Type	Reading
Level of Completion (%)	100%

Learning Material 11	
Short description or summary	Discussions about the various methods of calculating coefficients in Fourier series - in particular, the methods recommended in IEC Standard 61000-4-7 and the methods applied in commercial power quality analysers
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/5173548">https://ieeexplore.ieee.org/abstract/document/5173548</a>
Author & organisation	Tomasz Tarasiuk

Learning Material 11	
	Gdynia Maritime University Poland
Material Type	Reading
Level of Completion (%)	100%

Learning Material 12	
Short description or summary	<p>The discussions about the fast detection of a frequency band affected by the high-frequency content and time of its occurrence in context to power quality measurement in shipboard microgrids.</p> <p>The merits of the method, as well as its limitations, are described on the basis of real voltages registered in ships' electrical power systems are discussed in detail.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF</p> <p><a href="https://ieeexplore.ieee.org/abstract/document/4429839">https://ieeexplore.ieee.org/abstract/document/4429839</a></p>
Author & organisation	<p>Tomasz Tarasiuk</p> <p>Gdynia Maritime University Poland</p>
Material Type	Reading
Level of Completion (%)	100%

Learning Material 13	
Short description or summary	<p>Signal processing of power quality disturbances - standard approach: Mathcad is engineering math software that allows to perform, analyse, and share mathematical calculations as well as basic programming using conditional operation, loops etc. The software can be used to analyze experimental data sets, including complex signal processing for power quality (PQ) assessment. This learning module will cover the basics of Mathcad and some of the tools that can be used to analyze the power quality challenges in shipboard microgrids. This learning material will also serve as the basis of CBL for the simulation exercise tasks presented in learning material 14.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>

Learning Material 13	
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf</a>
Author & organisation	Tomasz Tarasiuk Gdynia Maritime University
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 14	
Short description or summary	<p>Based on the learning material 13, seven simulation exercise tasks will be given in this learning material, and a guide for Mathcad tools will be provided where students have to design simulations for the following cases.</p> <ol style="list-style-type: none"> <li>1) Write a low-pass filtration formula in Mathcad environment (develop a yellow block in the basic structure of the signal processing algorithm).</li> <li>2) Write a subroutine for extracting the samples representing the user-defined number of cycles using the zero-crossing method and subroutines for determining the instantaneous frequency and r.m.s. value (develop green blocks of the main loop of software for PQ measurement).</li> <li>3) Write a subroutine for DFT of selected data set representing a user-defined number of cycles and user-defined frequency bandwidth.</li> <li>4) Supersede a subroutine for DFT by Mathcad function FFT(v).</li> <li>5) Modify the formulae for SG and ISG calculation.</li> <li>6) Apply the Hann weighting to input samples.</li> <li>7) Modify the formulae for SG and ISG calculation.</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>

Learning Material 14	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf</a></p>
Author & organisation	<p>Tomasz Tarasiuk</p> <p>Gdynia Maritime University</p>
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 15	
Short description or summary	<p>Signal processing of power quality disturbances - standard approach and alternative solutions. Mathcad is engineering math software that allows to perform, analyze, and share mathematical calculations as well as basic programming using conditional operation, loops etc. The software can be used to analyze experimental data sets, including complex signal processing for power quality (PQ) assessment. This learning material will also serve as the basis of CBL for the simulation exercise tasks presented in learning material 16.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf</a></p>



Learning Material 15	
Author & organisation	Tomasz Tarasiuk Gdynia Maritime University
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 16	
Short description or summary	Based on the learning material 15, Simulation exercise tasks will be given in this learning material, and a guide for Mathcad tools will be provided where students have to design simulations for the following cases <ol style="list-style-type: none"> <li>1) Determining the distortions of the testing signal by CZT</li> <li>2) Determining the distortions of the testing signal by FFT and software resampling</li> <li>3) Determining the distortions of the real shipboard voltage by CZT</li> </ol>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM4%2C13-16.pdf</a>
Author & organisation	Tomasz Tarasiuk Gdynia Maritime University
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 17	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics in detail.</p> <ul style="list-style-type: none"> <li>• Shipboard DC microgrids configurations</li> <li>• Model parameters estimation</li> <li>• Options for the DC interface</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM17.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM17.pptx</a></p>
Author & organisation	<p>Prof. Giorgio Sulligoi, PhD.</p> <p>The University of Trieste, Italy</p>
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 18	
Short description or summary	<p>The discussion and overview of early stage in the proof of concept for commercial technologies useful for the electrification of pushboats employed in inland waterway navigation. Specifically, the optimal design solution is highlighted by evaluating proper attribute weights, which determine the degree of closeness among possible solution and the design target. In particular, computer-aided synthesis modelling methodology to minimize capital expenditures and operating expenses of a pushboat is adopted.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>

Learning Material 18	
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/7564401">https://ieeexplore.ieee.org/abstract/document/7564401</a>
Author & organisation	Vittorio Bucci ; Alberto Marinò ; Daniele Bosich ; Giorgio Sulligoi Department of Engineering and Architecture, University of Trieste, Trieste, Italy (primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 19	
Short description or summary	Volume/weight/cost comparison of a 1MVA 10 kV/400 V solid-state against a conventional low-frequency distribution transformer for its utilization in shipboard microgrid systems
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/6954023">https://ieeexplore.ieee.org/abstract/document/6954023</a>
Author & organisation	Jonas E. Huber, Johann W. Kolar Power Electronic Systems Laboratory, ETH Zurich, 8092 Zurich, Switzerland
Material Type	Reading

Learning Material 19	
Level of Completion (%)	100%

Learning Material 20	
Short description or summary	Discussions regarding the integration of innovative solutions to perform their proof-of-concept, not only related to their proper functioning, but also to their use onboard (assessment of the new system's impact on the main design drivers of the ship). In this learning material a Computer System Integrator software, which allows the comparison of several design solutions in order to define the one most suited to the purpose, already during the early-stage design phase will be discussed.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/8069325">https://ieeexplore.ieee.org/abstract/document/8069325</a>
Author & organisation	A. Vicenzutti ; U. la Monaca ; D. Bosich ; V. Bucci ; A. Marinò ; G. Sulligoi ; R. Pelaschiar  Dept. of Engineering and Architecture, University of Trieste, Trieste, Italy.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 21	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in detail. <ul style="list-style-type: none"> <li>• Multi-converter shipboard MVDC power system</li> <li>• Voltage control solutions in the multi-converter case</li> <li>• Constant Power Load (CPL) issue</li> <li>• CPL modelling</li> </ul>

Learning Material 21	
	<ul style="list-style-type: none"> <li>Control techniques to face the CPL instability</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM2_1.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Maritime%20Microgrids/Maritime_LM2_1.pptx</a>
Author & organisation	Daniele Bosich, PhD The University of Trieste, Italy
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 22	
Short description or summary	The discussion and overview of Multiconverter Medium Voltage DC Power Systems on Ships: Constant-Power Loads Instability Solution Using Linearization via State Feedback Control
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/6813657">https://ieeexplore.ieee.org/abstract/document/6813657</a>

Learning Material 22	
Author & organisation	Giorgio Sulligoi ; Daniele Bosich ; Giovanni Giadrossi ; Lin Zhu ; Marco Cupelli ; Antonello Monti  Department of Engineering and Architecture, University of Trieste, Trieste, Italy (primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 23	
Short description or summary	Discussions regarding Medium Voltage DC Power Systems on Ships: An Offline Parameter Estimation for Tuning the Controllers' Linearizing Function
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF  <a href="https://ieeexplore.ieee.org/abstract/document/7867753">https://ieeexplore.ieee.org/abstract/document/7867753</a>
Author & organisation	Daniele Bosich; Giorgio Sulligoi; Elena Mocanu; Madeleine Gibescu Department of Engineering and Architecture, University of Trieste, Trieste, Italy (primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100%

Learning Material 24	
Short description or summary	Discussions regarding large-signal stability analysis of two power converters solutions for DC shipboard microgrid

Learning Material 24	
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://ieeexplore.ieee.org/abstract/document/8001033">https://ieeexplore.ieee.org/abstract/document/8001033</a>
Author & organisation	Daniele Bosich ; Madeleine Gibescu ; Giorgio Sulligoi Dept. of Engineering and Architecture, University of Trieste, Trieste, Italy.
Material Type	Reading
Level of Completion (%)	100%

#### 4.1.6.3 The implementation

- The short program will be delivered in the energy technology department of Aalborg University, Denmark, to the PhD students. The number of participants range from 25-30 for this course.
- Additionally, some PhD students from Aalborg University, Esbjerg campus will also join this course.
- As a supplement, some of the modules/learning materials can be used in Challenges and solutions in Future Power Networks (Form: MOOC for Industry and PhD/MSc students and Measurement Techniques and Distributed Intelligence for Power Systems (Form: course for Industry and PhD/MSc students) to the RWTH courses.

#### 4.1.7 Power Systems Dynamics

##### 4.1.7.1 The Structure

Topic	Learning outcomes	Learning Materials
Measurement Techniques and Distributed	To explain and apply the principles of	Learning Material 1: Lecture slides: Trends in power system structure and services Learning Material 2: Lecture slides: Fundamentals on PSD: present and future

Intelligence for Power Systems	power system dynamics	Learning Material 3: Lecture slides: Electromagnetic Phenomena Learning Material 4: Lecture slides: Analytical study of electromechanical dynamics Learning Material 5: Lecture slides: Stability study via equal area criterion (graphical method) Learning Material 6: Exercise: Equal area criterion Learning Material 7: Exercise: Electromagnetic Phenomena and Electromechanical Dynamics
	To describe and show the fundamentals of the associated network components	Learning Material 8: Lecture slides: Transmission lines model Learning Material 9: Lecture slides: Synchronous machine model Learning Material 10: Exercise: transmission line modelling Learning Material 11: Exercise: electromagnetic phenomena
	To classify the division of power system dynamics	Learning Material 12: Lecture slide: Classification of Power System Dynamics
	To explain and apply stability control	Learning Material 13: Lecture slides: Voltage Stability Learning Material 14: Exercise: Voltage Stability Learning Material 15: Lecture slides: Frequency Stability Learning Material 16: Exercise: Frequency Stability

#### 4.1.7.2 The Materials

Learning Material 1	
Short description or summary	Lecture slides: Trends in power system structure and services
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%



Learning Material 2	
Short description or summary	Lecture slides: Fundamentals on PSD: present and future
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 3	
Short description or summary	Lecture slides: Stability problems and methods
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 4	
Short description or summary	Lecture slides: Swing equations (analytical method)
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 5	
Short description or summary	Lecture slides: Equal area criterion (graphic method)
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 6	
Short description or summary	Exercise: Equal area criterion
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	70%

Learning Material 7	
Short description or summary	Exercise: Electromagnetic Phenomena and Electromechanical Dynamics
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 8	
Short description or summary	Lecture slides: Transmission lines model

Learning Material 8	
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 9	
Short description or summary	Lecture slides: Synchronous machine model
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 10	
Short description or summary	Exercise: transmission line modelling
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>

Learning Material 10	
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	70%

Learning Material 11	
Short description or summary	Exercise: electromagnetic phenomena
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	70%

Learning Material 12	
Short description or summary	Lecture slide: Classification of Power System Dynamics
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Industry or MSc/PhD Students</li> </ul>

Learning Material 12	
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60

Learning Material 13	
Short description or summary	Lecture slides: Voltage Stability
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 14	
Short description or summary	Exercise: Voltage Stability
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamics&amp;fileid=292043</a>

Learning Material 14	
	<a href="#">eparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamic s&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	70%

Learning Material 15	
Short description or summary	Lecture slides: Frequency Stability
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamic s&amp;fileid=292043">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamic s&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	60%

Learning Material 16	
Short description or summary	Exercise: Frequency Stability
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry or MSc/PhD Students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20pr">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20pr</a>

Learning Material 16	
	<a href="https://www.rwth-aachen.de/operation/Learning%20Materials/RWTH/Power%20Systems%20Dynamic&amp;fileid=292043">eparation/Learning%20Materials/RWTH/Power%20Systems%20Dynamic&amp;fileid=292043</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Activity/Lab
Level of Completion (%)	70%

#### 4.1.7.3 The implementation

This short programme will be delivered by the Institute for Automation of Complex Power Systems at RWTH Aachen University in Germany. This programme is part of the regular postgraduate programme at the university.

This course covers the principles of Power System Dynamics. Starting with a review of the fundamentals of the modelling of the most significant network components, typical categories of power system transient behaviour will be introduced, as well as ways to relate these to control theory. The course covers steady-state classical analysis as well as electromagnetic phenomena. Small disturbances for unregulated systems and regulated systems are investigated, and for large disturbances, transient stability and the Lyapunov method are discussed. A special focus lies in the dynamics of wind farms. The voltage stability and frequency stability complete the course. This course uses simulation and real-time simulation of the RWTH simulation facility to introduce the analysis and control challenges and to help the students familiarize intuitively with the physical behaviour of power systems. The students will also see the effects of the correct application of control.

Apart from the RWTH postgraduate programmes, learning components of it will be integrated into courses in the master courses of UWA electrical engineering department as well as in UNINA's relevant master programmes.

#### 4.1.8 Optimization Strategies and Energy Management Systems

##### 4.1.8.1 The Structure

Topic	Learning outcomes	Learning Materials
Optimization Strategies and Energy Management Systems	Relate process system engineering with modelling and optimization techniques used in power systems.	Learning Material 1: Slides Learning Material 2: Paper Learning Material 3: Paper Learning Material 4: Paper
	Apply different optimization tools for solving continuous, semi-continuous and discrete optimization problems in energy systems.	Learning Material 5: Slides Learning Material 6: Paper Learning Material 7: Paper Learning Material 8: Paper Learning Material 9: Simulation handout Learning Material 10: Simulation Exercise



	Employ EXCEL, MATLAB, and GAMS for solving continuous, semi-continuous and discrete optimization problems	Learning Material 11: Slides Learning Material 12: Paper Learning Material 13: Paper Learning Material 14: Paper Learning Material 15: Simulation handout Learning Material 16: Simulation Exercise
	Employ various optimization and planning tools, including heuristic optimization, and population-based optimization.	Learning Material 17: Slides Learning Material 18: Paper Learning Material 19: Paper Learning Material 20: Paper Learning Material 21: Paper Learning Material 22: Paper Learning Material 23: Simulation handout Learning Material 24: Simulation Exercise
	Design the schemes for supply and demand-side management, including optimal power flow, unit commitment, economic power dispatch, peak shaving, and load shifting.	Learning Material 25: Slides Learning Material 26: Paper Learning Material 27: Simulation handout Learning Material 28: Simulation Exercise

#### 4.1.8.2 The Materials

Learning Material 1	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics in detail. <ul style="list-style-type: none"> <li>• Interlink between PSE and energy management systems (EMS)</li> <li>• Energy Management in Microgrids and smart grids</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM1.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM1.pptx</a>
Author & organisation	Moisés Graells, Professor, Technical University of Catalonia, Spain.

Learning Material 1	
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 2	
Short description or summary	This learning material delineates the theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	Book, <a href="https://www.amazon.com/Hierarchical-Multilevel-Systems-Mathematics-Engineering/dp/0124915507">https://www.amazon.com/Hierarchical-Multilevel-Systems-Mathematics-Engineering/dp/0124915507</a>
Author & organisation	M. D. Mesarovic, D. Macko, Y. Takahara professor of Systems Engineering and Mathematics at Case Western Reserve University (primary author's affiliation)
Material Type	Textbook
Level of Completion (%)	100%

Learning Material 3	
Short description or summary	This learning material discusses the impact and success of real-time optimization (RTO) technology in the process industries.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online, <a href="https://www.sciencedirect.com/science/article/pii/S0959152411000540">https://www.sciencedirect.com/science/article/pii/S0959152411000540</a>
Author & organisation	Mark L. Darby, Michael Nikolaou, James Jones, Doug Nicholson
Material Type	Reading

Learning Material 3	
Level of Completion (%)	100%

Learning Material 4	
Short description or summary	In this learning, material presents the cooperative harmonic filtering strategies for the interface converters of distributed generation sources. The operation and control principle of a droop control method based on the reactive volt-ampere consumption of harmonics of each interface converter is discussed in detail.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://dspace.mit.edu/bitstream/handle/1721.1/1868/SWP-0656-14561389.pdf">https://dspace.mit.edu/bitstream/handle/1721.1/1868/SWP-0656-14561389.pdf</a>
Author & organisation	Arnoldo C. Hax and Harlan C. Meal, Sloan School of Management of the Massachusetts Institute of Technology
Material Type	Reading
Level of Completion (%)	100%

Learning Material 5	
Short description or summary	Presentation (PPT) slides will be used to cover the details of the following topics <ul style="list-style-type: none"> <li>Linear Programming</li> <li>Quadratic Programming</li> <li>Mixed Integer Linear Programming (MILP)</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparati">https://newrepository atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparati</a>

Learning Material 5	
	<a href="on/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM5.pptx">on/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM5.pptx</a>
Author & organisation	Moisès Graells, Professor, Technical University of Catalonia, Spain.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 6	
Short description or summary	In this learning material, the methods to improve the production schedules are explained by developing a new concept for flexible manufacturing, which allows one to program production rate profiles within each semicontinuous operation campaign.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/document/7328733">https://ieeexplore.ieee.org/document/7328733</a>
Author & organisation	Elisabet Capón-García, Sergio Ferrer-Nadal, Moisès Graells, Luis Puigjaner, Technical University of Catalonia, Spain.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 7	
Short description or summary	In this learning material a method to overcome the computational expensiveness of traditional slot-based models for large instances, a novel TSP-based (travelling salesman problem) mixed-integer linear programming (MILP) model is presented that relies on a hybrid discrete/continuous time representation.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>

Learning Material 7	
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, online <a href="https://pubs.acs.org/doi/abs/10.1021/ie800646g">https://pubs.acs.org/doi/abs/10.1021/ie800646g</a>
Author & organisation	Songsong Liu, Jose M. Pinto, Lazaros G. Papageorgiou, University College London, Torrington Place, London.
Material Type	Reading
Level of Completion (%)	100%

Learning Material 8	
Short description or summary	This learning material presents a number of state-of-the-art topics including improved modelling, cutting plane theory and algorithms, heuristic methods, and branch-and-cut and integer programming decomposition algorithms.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	Book <a href="https://www.amazon.com/Integer-Programming-Laurence-Wolsey/dp/0471283665">https://www.amazon.com/Integer-Programming-Laurence-Wolsey/dp/0471283665</a>
Author & organisation	Laurence A. Wolsey, Université catholique de Louvain, Belgium
Material Type	Textbook
Level of Completion (%)	100%

Learning Material 9	
Short description or summary	This learning material is a simulation handout that guides the student to analyze and simulate the transportation problem, i.e. how to optimize the transportation of a commodity produced in different locations (factories) and shipped to different distribution centres (markets). This also serves as the basis of CBL learning as a specific design exercise based upon learning material 9 will be given in learning material 10.

Learning Material 9	
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM%209%2610%2C15%2616%2C%2023%2624.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM%209%2610%2C15%2616%2C%2023%2624.pdf</a>
Author & organisation	Najmeh Bazmohammadi, Aalborg University, Denmark
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 10	
Short description or summary	Based on the learning material 9, exercise tasks will be given in this learning material, where students have to find the optimum shipping plan for the transportation problem.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	GAMS File (.gms) <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM9%2610(coding).gms">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM9%2610(coding).gms</a>
Author & organisation	Najmeh Bazmohammadi, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 11	
Short description or summary	<p>Presentation (PPT) slides will be used to discuss how the following software and solvers can be used to solve the optimization problems.</p> <ul style="list-style-type: none"> <li>• EXCEL</li> <li>• MATLAB</li> <li>• GAMS</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM11.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM11.pptx</a></p>
Author & organisation	Moisès Graells, Professor, Technical University of Catalonia, Spain.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 12	
Short description or summary	This learning material consists of a tutorial on how to install and use Excel solver for solving optimization problems.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PDF, Online</p> <p><a href="https://support.office.com/en-us/article/define-and-solve-a-problem-by-using-solver-5d1a388f-079d-43ac-a7eb-f63e45925040">https://support.office.com/en-us/article/define-and-solve-a-problem-by-using-solver-5d1a388f-079d-43ac-a7eb-f63e45925040</a></p>
Author & organisation	Microsoft Office, official website
Material Type	Student Guide
Level of Completion (%)	100%

Learning Material 13	
Short description or summary	This learning material consists of a tutorial on how to install and use Matlab solver for solving optimization problems.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://www.mathworks.com/help/optim/ug/optimization-toolbox-tutorial.html">https://www.mathworks.com/help/optim/ug/optimization-toolbox-tutorial.html</a>
Author & organisation	Mathworks, official website.
Material Type	Student Guide
Level of Completion (%)	100%

Learning Material 14	
Short description or summary	This learning material consists of a tutorial on how to install and use GAMS solver for solving optimization problems.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://www.gams.com/latest/docs/UG_Tutorial.html">https://www.gams.com/latest/docs/UG_Tutorial.html</a>
Author & organisation	Richard E. Rosenthal. Distinguished Professor of Operations Research Naval Postgraduate School, Monterey, CA 93943.
Material Type	Student Guide
Level of Completion (%)	100%



Learning Material 15	
Short description or summary	This learning material is a simulation handout that guides the student to simulate the extended transportation problem considering multi-time multi-product indexes. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 15 will be given in learning material 16.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM%209%2610%2C15%2616%2C%2023%2624.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM%209%2610%2C15%2616%2C%2023%2624.pdf</a>
Author & organisation	Najmeh Bazmohammadi, Aalborg University, Denmark
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 16	
Short description or summary	Based on the learning material 15, exercise task and an excel file will be given in this learning material, where students have to modify the production in order to obtain a feasible solution.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	Excel File (.xls) <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/02_Multiperiod.xlsx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/02_Multiperiod.xlsx</a>
Author & organisation	Najmeh Bazmohammadi, Aalborg University, Denmark.

Learning Material 16	
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 17	
Short description or summary	<p>Presentation (PPT) slides will be used to cover the following topics:</p> <ul style="list-style-type: none"> <li>• Limits of classical optimization methods</li> <li>• Heuristic Optimization methods</li> <li>• Population-based Optimization and Swarm Intelligence</li> <li>• Multi-Objective Optimization</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	<p>PPT</p> <p><a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM17.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM17.pptx</a></p>
Author & organisation	Eleonora Riva Sanseverino, Professor Department of Engineering - University of Palermo, Italy.
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 18	
Short description or summary	This learning material presents the theory, operation, and application of genetic algorithms-search algorithms based on the mechanics of natural selection and genetics.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>

Learning Material 18	
Format and/or link to the material	Book <a href="https://www.amazon.com/exec/obidos/ASIN/0201157675/acmorg-20">https://www.amazon.com/exec/obidos/ASIN/0201157675/acmorg-20</a>
Author & organisation	David Edward Goldberg, University of Illinois at Urbana-Champaign.
Material Type	Textbook
Level of Completion (%)	100%

Learning Material 19	
Short description or summary	This learning material describes the latest types of heuristic procedures including artificial networks, simulated annealing, Tabu search, Lagrangean relaxation, genetic algorithms and evaluation of heuristics.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://www.amazon.com/Modern-Heuristic-Techniques-Combinatorial-Problems/dp/0470220791">https://www.amazon.com/Modern-Heuristic-Techniques-Combinatorial-Problems/dp/0470220791</a>
Author & organisation	C. R. Reeves.
Material Type	Textbook
Level of Completion (%)	100%

Learning Material 20	
Short description or summary	This learning material describes a modified version of simulated annealing for optimization applications.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Discussed face to face in class</li> <li>• Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://link.springer.com/article/10.1023/B:COAP.0000044187.23143.bd">https://link.springer.com/article/10.1023/B:COAP.0000044187.23143.bd</a>

Learning Material 20	
Author & organisation	Walid Ben-Ameur, Institut National des Télécommunications, Evry, Franc
Material Type	Reading
Level of Completion (%)	100 %

Learning Material 21	
Short description or summary	This learning material explains the basics of Ant-Colony optimization based on the study of ant's behaviour on problem-solving and optimization.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF, Online <a href="https://www.semanticscholar.org/paper/Distributed-Optimization-by-Ant-Colonies-Colorni-Dorigo/5a9bfcb078e22adb245a19cd5b7ff43bed1054ff">https://www.semanticscholar.org/paper/Distributed-Optimization-by-Ant-Colonies-Colorni-Dorigo/5a9bfcb078e22adb245a19cd5b7ff43bed1054ff</a>
Author & organisation	Alberto Colorni, Marco Dorigo, Vittorio Maniezzo, Francisco J. Varela, Paul Bourguine Politecnico di Milano, Milan, Italy (primary author's affiliation)
Material Type	Reading
Level of Completion (%)	100 %

Learning Material 22	
Short description or summary	This learning material provides a comprehensive overview of existing approaches to addressing different uncertainties are presented and the relationship between the different categories of uncertainties for optimization applications.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>

Learning Material 22	
Format and/or link to the material	PDF, Online <a href="https://ieeexplore.ieee.org/abstract/document/1438403">https://ieeexplore.ieee.org/abstract/document/1438403</a>
Author & organisation	Yaochu Jin ; J. Branke, Honda Res. Inst. Eur., Offenbach, Germany
Material Type	Reading
Level of Completion (%)	100 %

Learning Material 23	
Short description or summary	This learning material is a simulation handout that guides the student to optimize the usage of the energy resources with minimum operation cost. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 23, will be given in learning material 24.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM%209%2610%2C15%2616%2C%2023%2624.pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM%209%2610%2C15%2616%2C%2023%2624.pdf</a>
Author & organisation	Najmeh Bazmohammadi, Aalborg University, Denmark
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 24	
Short description or summary	Based on the learning material 23, exercise tasks will be given in this learning material, and a guide GAMS file will be provided where students have to : 1) Complete the model and verify its performance.

Learning Material 24	
	2) Vary the nominal capacity of the battery and determine the lowest value that produces the minimum cost. 3) Change the power of the load and determine the maximum value that does not imply any cost.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	GAMS File (.gms) <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM9%2610(coding).gms">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM9%2610(coding).gms</a>
Author & organisation	Najmeh Bamohammadi, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

Learning Material 25	
Short description or summary	Presentation (PPT) slides will be used to cover the following topics: <ul style="list-style-type: none"> <li>Optimal Power Flow</li> <li>Peak shaving</li> <li>Generation/Supply Side Management</li> <li>Demand/Load Side Management</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PPT <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM25.pptx">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM25.pptx</a>
Author & organisation	Eleonora Riva Sanseverino, Professor Department of Engineering - University of Palermo, Italy.

Learning Material 25	
Material Type	Lecture Notes
Level of Completion (%)	10%

Learning Material 26	
Short description or summary	This learning material outlines the principles of competitive electricity markets alongside the operation and development of the supporting transmission and distribution networks by applying basic economic principles to power system operation and planning.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Discussed face to face in class</li> <li>Further Reading Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://onlinelibrary.wiley.com/doi/book/10.1002/0470020598">https://onlinelibrary.wiley.com/doi/book/10.1002/0470020598</a>
Author & organisation	Daniel Kirschen Goran Strbac, Willey Online Library
Material Type	Textbook
Level of Completion (%)	100%

Learning Material 27	
Short description or summary	This learning material is a simulation handout that guides the student to solve a minimum losses Optimal Power flow problem using simulated annealing technique. This also serves as the basis of CBL learning as a specific design exercise based upon learning material 27, will be given in learning material 28.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	PDF <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparati">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparati</a>

Learning Material 27	
	on/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM27%2628.pdf
Author & organisation	Najmeh Bazmohammadi, Aalborg University, Denmark
Material Type	Simulation
Level of Completion (%)	10%

Learning Material 28	
Short description or summary	Based on the learning material 27, exercise tasks will be given in this learning material where students have to : 1) Find the active and reactive power injection at various busses to compute the optimal power flow with minimal distribution losses.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Industrial Participants</li> </ul>
Format and/or link to the material	Coding File <a href="https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM27%2628(codig%20file).pdf">https://newrepository.atosresearch.eu/remote.php/webdav/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/AAU/Optimization%20Strategies%20and%20Energy%20Management%20Systems/EMS_LM27%2628(codig%20file).pdf</a>
Author & organisation	Najmeh Bamohammadi, Aalborg University, Denmark.
Material Type	Activity/Lab
Level of Completion (%)	10%

#### 4.1.8.3 The implementation

- The short program will be delivered in the energy technology department of Aalborg University, Denmark to the PhD students. The number of participants range from 25-30 for this course.
- Additionally, some PhD students from Aalborg University, Esbjerg campus will also join this course.
- As a supplement, some of the modules/learning materials can be used in Challenges and solutions in Future Power Networks (Form: MOOC for Industry and PhD/MSc students) and



Measurement Techniques and Distributed Intelligence for Power Systems (Form: course for Industry and PhD/MSc students) to the RWTH courses.

#### 4.1.9 Hydrogen as energy vector

##### 4.1.9.1 The Structure

Topic	Learning outcomes	Learning Materials
Hydrogen as Energy Vector	Identify hydrogen properties and applications.	Learning material 1: Seminar Slides about Hydrogen properties Learning material 1B: Video presentation about Hydrogen properties Learning material 2: Seminar Slides about Hydrogen applications Learning material 2B: Video presentation about Hydrogen applications
	Recognise industrial hydrogen production processes.	Learning Material 3: Seminar Slides about Hydrogen production from fossil fuels Learning material 3B: Video presentation about Hydrogen production from fossil fuels Learning Material 4: Seminar Slides about Hydrogen production from biological methods Learning material 4B: Video presentation about Hydrogen production from biological methods Learning Material 5: Seminar Slides about Hydrogen production by means thermolysis Learning material 5B: Video presentation about Hydrogen production by means of thermolysis Learning material 6: Seminar slides about Hydrogen production methods comparison Learning material 6B: Video presentation about Hydrogen production methods comparison
	Explain electrolysis technology working.	Learning Material 7: Seminar slides about Electrolysis principles Learning material 7B: Video presentation about Electrolysis principles. Learning Material 8: Seminar slides about Alkaline electrolysis technology Learning material 8B: Video presentation about Alkaline electrolysis technology Learning Material 9: Seminar slides about PEM electrolysis technology Learning material 9B: Video presentation about PEM electrolysis technology Learning Material 10: Seminar slides about Electrolysis technology comparison Learning material 10B: Video presentation about Electrolysis technology comparison
	Describe hydrogen	Learning Material 11: Seminar slides about Hydrogen storage technology

	storage technology.	<p>Learning material 11B: Video presentation about Hydrogen storage technology</p> <p>Learning Material 12: Electrolyser functioning demonstration video (Laboratory session)</p> <p>Learning Material 13: Case study: Dimensioning of a hydrogen electrolysis production system and storage for a Hydrogen Refuelling Station</p>
	Explain electricity generation through the use of fuel cells.	<p>Learning Material 14: Seminar slides about Introduction to fuel cell technology</p> <p>Learning material 14B: Video presentation about Introduction to fuel cell technology</p> <p>Learning Material 15: Seminar slides about Low temperature Fuel Cells</p> <p>Learning material 15B: Video presentation about Low temperature Fuel Cells</p> <p>Learning Material 16: Seminar slides about Medium and high temperature Fuel Cells</p> <p>Learning material 16B: Video presentation about Medium and high temperature Fuel Cells</p> <p>Learning Material 17: Seminar slides about Fuel cells comparison</p> <p>Learning material 17B: Video presentation about Fuel cells comparison</p> <p>Learning Material 18: Seminar slides about Stationary applications of fuel cells</p> <p>Learning material 18B: Video presentation about Stationary applications of fuel cells</p> <p>Learning Material 19: Seminar slides about Non stationary applications of fuel cells</p> <p>Learning material 19B: Video presentation about Non-stationary applications of fuel cells</p> <p>Learning Material 20: Seminar slides about Fuel cell applications comparison</p> <p>Learning material 20B: Video presentation about Fuel cell applications comparison</p> <p>Learning Material 21: Seminar slides about Open circuit voltage generation in the electrochemical reaction</p> <p>Learning material 21B: Video presentation about Open circuit voltage generation in the electrochemical reaction</p> <p>Learning Material 22: Seminar slides about Irreversibility in fuel cell voltage generation</p> <p>Learning material 22B: Video presentation about Irreversibility in fuel cell voltage generation</p> <p>Learning Material 23: Seminar slides about Methods to determine irreversibility</p> <p>Learning material 23B: Video presentation about Methods to determine irreversibility</p> <p>Learning Material 24: Seminar slides about Elements of a PEM Fuel Cell</p> <p>Learning material 24B: Video presentation about Elements of a PEM Fuel Cell</p>

		<p>Learning Material 25: Seminar slides about Water and heat management on a PEMFC</p> <p>Learning material 25B: Video presentation about Water and heat management on a PEMFC</p> <p>Learning Material 26: Seminar slides about Balance of plant</p> <p>Learning material 26B: Video presentation about Balance of plant</p> <p>Learning Material 27: PEMFC demonstration video (Laboratory session)</p>
	Calculate a hydrogen energy storage system.	Learning Material 28: Case study: Solar photovoltaic autonomous system using hydrogen as energy storage.

#### 4.1.9.2 The Materials

Learning Material 1	
Short description or summary	Through the slides it is possible to develop the topics of the properties of hydrogen, hydrogen use, hydrogen economy and the future challenges and opportunities in this context.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	<p>Format: ppt</p> <p>Link:</p> <p><a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a></p>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València, Spain
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 1B	
Short description or summary	Through a video presentation, the different hydrogen properties are developed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>

Learning Material 1B	
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 2	
Short description or summary	Through the slides, it is possible to develop the topics of hydrogen use, hydrogen economy and the future challenges and opportunities in this context.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València, Spain
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 2B	
Short description or summary	Through a video presentation, the following topics are developed: hydrogen use, hydrogen economy and future challenges and opportunities in this context.

Learning Material 2B	
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 3	
Short description or summary	Through the slides, it is possible to develop the topics of hydrogen production from natural gas, hydrogen production from coal, hydrogen production from petroleum and hydrogen production from alcohols.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 3B	
Short description or summary	Through a video presentation, the following topics are developed: hydrogen production from natural gas, hydrogen production from coal, hydrogen production from petroleum and hydrogen production from alcohols.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 4	
Short description or summary	Through the slides, it is possible to develop the topics of hydrogen from biomass and hydrogen from biological processes.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 4B	
Short description or summary	Through a video presentation, the following topics are developed: hydrogen production from biomass and hydrogen production from biological processes.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 5	
Short description or summary	Through the slides, it is possible to develop the topics of medium temperature thermolysis, high temperature thermolysis and direct water thermolysis.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes

Learning Material 5	
Level of Completion (%)	100%

Learning Material 5B	
Short description or summary	Through a video presentation, the following topics are developed: hydrogen production from biomass, hydrogen production from biological processes, medium temperature thermolysis, high temperature thermolysis and direct water thermolysis.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 6	
Short description or summary	Through the slides, it is possible to develop a comparison of the different methods to produce hydrogen.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València



Learning Material 6	
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 6B	
Short description or summary	Through a video, presentation to develop a comparison of the different methods to produce hydrogen.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 7	
Short description or summary	Through the slides, it is possible to develop the topics of the fundamentals of water electrolysis, the efficiency of electrochemical water splitting, the temperature and pressure dependence, the electrolyser technology and the high-temperature electrolysis.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20pr">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20pr</a>

Learning Material 7	
	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">eparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 7B	
Short description or summary	Through a video presentation, the following topics are developed: fundamentals of water electrolysis, the efficiency of electrochemical water splitting, the temperature and pressure dependence, the electrolyser technology and the high-temperature electrolysis.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 8	
Short description or summary	Through the slides, it is possible to develop the topics of the fundamentals, the cell structure, the electrochemical performances and the market and future research of alkaline electrolysis technology.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>

Learning Material 8	
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 8B	
Short description or summary	Through a video presentation, the following topics are developed: the fundamentals, the cell structure, the electrochemical performances and the market and future research of alkaline electrolysis technology.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 9	
Short description or summary	Through the slides, it is possible to develop the topics of the fundamentals, the cell structure, the electrochemical performances, the balance of plant and the market and future research of PEM electrolysis technology.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>

Learning Material 9	
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 9B	
Short description or summary	Through a video presentation, the following topics are developed: the fundamentals, the cell structure, the electrochemical performances, the balance of plant and the market and future research of PEM electrolysis technology.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 10	
Short description or summary	Through the slides, it is possible to develop a comparison of the different electrolysis technologies.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>

Learning Material 10	
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 10B	
Short description or summary	Through a video, presentation to develop a comparison of the different electrolysis technologies.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 11	
Short description or summary	Through the slides it is possible to develop the topics of the gaseous hydrogen storage, the liquid hydrogen storage, the solid hydrogen storage, a comparison of these different technologies for hydrogen storage and the hydrogen transport and distribution.

Learning Material 11	
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 11B	
Short description or summary	Through a video presentation, the following topics are developed: the gaseous hydrogen storage, the liquid hydrogen storage, the solid hydrogen storage, a comparison of these different technologies for hydrogen storage and the hydrogen transport and distribution.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 12	
Short description or summary	A demonstration of how an electrolyzer works through a practical laboratory session video and seminar slides.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Blended</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: video  Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Activity/Lab
Level of Completion (%)	70%

Learning Material 13	
Short description or summary	Through the slides, it is possible to develop a case of study about the dimensioning of a hydrogen electrolysis production system and storage for a Hydrogen Refuelling Station.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Case Study

Learning Material 13	
Level of Completion (%)	80%

Learning Material 14	
Short description or summary	Through the slides, it is possible to develop the topics of the fuel Cell working principle.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 14B	
Short description or summary	Through a video presentation, the following topics the fuel Cell working principle is developed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València



Learning Material 14B	
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 15	
Short description or summary	Through the slides, it is possible to develop the topics of Alkaline Fuel Cells (AFC), Proton Exchange Membrane Fuel Cells (PEMFC) and Direct Methanol Fuel Cells (DMFC).
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 15B	
Short description or summary	Through a video presentation, the following topics are developed: Alkaline Fuel Cells (AFC), Proton Exchange Membrane Fuel Cells (PEMFC) and Direct Methanol Fuel Cells (DMFC).
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>

Learning Material 15B	
	<a href="#">Opreparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 16	
Short description or summary	Through the slides, it is possible to develop the topics of Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cell (SOFC) and Phosphoric Acid Fuel Cell (PAFC).
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 16B	
Short description or summary	Through a video presentation, the following topics are developed: Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cell (SOFC) and Phosphoric Acid Fuel Cell (PAFC).
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>

Learning Material 16B	
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 17	
Short description or summary	Through the slides, it is possible to develop a comparison of the different fuel cells technologies.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 17B	
Short description or summary	Through a video presentation, a comparison of the different fuel cells technologies is developed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>

Learning Material 17B	
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 18	
Short description or summary	Through the slides, it is possible to develop the topics of fuel cell stationary applications.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 18B	
Short description or summary	Through a video presentation, the fuel cell stationary applications topic is developed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>

Learning Material 18B	
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 19	
Short description or summary	Through the slides, it is possible to develop the topics of fuel cell non-stationary applications.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 19B	
Short description or summary	Through a video presentation, the fuel cell non-stationary applications topic is developed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>

Learning Material 19B	
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 20	
Short description or summary	Through the slides, it is possible to develop a comparison of the different fuel cells types of applications.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 20B	
Short description or summary	Through a video presentation, a comparison of the different fuel cells types of applications is developed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>

Learning Material 20B	
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 21	
Short description or summary	Through the slides, it is possible to develop the topics of the open-circuit voltage (OCV), the efficiency and the effect of pressure and gas concentration in fuel cells.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 21B	
Short description or summary	Through a video presentation, the following topics are developed: the open-circuit voltage (OCV), the efficiency and the effect of pressure and gas concentration in fuel cells.

Learning Material 21B	
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 22	
Short description or summary	Through the slides, it is possible to develop the topics of the different types of irreversibilities in a fuel cell.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%



Learning Material 22B	
Short description or summary	Through a video presentation, the different types of irreversibilities in a fuel cell are developed.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 23	
Short description or summary	Through the slides, it is possible to develop the topics of the different methods to determine irreversibilities in a fuel cell.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 23B	
Short description or summary	Through a video presentation, the following topics are developed: the different methods to determine irreversibilities in a fuel cell.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 23	
Short description or summary	Through the slides, it is possible to develop the topics of the different elements (polymeric electrolyte, electrodes and bipolar plates) of the PEM fuel cells.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 24B	
Short description or summary	Through a video presentation, the following topics are developed: the different elements (polymeric electrolyte, electrodes and bipolar plates) of the PEM fuel cells.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 25	
Short description or summary	Through the slides, it is possible to develop the topics of the water and heat management on a PEM fuel cell.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 25B	
Short description or summary	Through a video presentation, the following topics are developed: the water and heat management on a PEM fuel cell.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 26	
Short description or summary	Through the slides, it is possible to develop the topics of the balance of plant (based on a PEM fuel cell technology).
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Lecture Notes
Level of Completion (%)	100%

Learning Material 26B	
Short description or summary	Through a video presentation, the following topics are developed: the balance of plant (based on a PEM fuel cell technology).
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Online</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: Video <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/MOOC&amp;fileid=396863</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Unit of Study
Level of Completion (%)	100%

Learning Material 27	
Short description or summary	A demonstration of how a PEM fuel cell works through a practical laboratory session video and seminar slides.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Blended</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: video  Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Activity/Lab
Level of Completion (%)	80%

Learning Material 28	
Short description or summary	Through the slides, it is possible to develop a case of study about a solar photovoltaic autonomous system using hydrogen as energy storage.
Targeted EQF level	<ul style="list-style-type: none"> <li>7</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>These materials are intended for master's students, PhD students or industry.</li> </ul>
Format and/or link to the material	Format: ppt Link: <a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/UPV/Hydrogen%20as%20energy%20vector/Face%20to%20face&amp;fileid=396864</a>
Author & organisation	Carlos Sanchez Díaz. Universitat Politècnica de València
Material Type	Case Study
Level of Completion (%)	80%

#### 4.1.9.3 The implementation

The **blended** programme will be delivered in the Universitat Politècnica de València (València, Spain), as a part of the Master program on Energy Technology for Sustainable Development, in the second semester of the annual course, between 15<sup>th</sup> of February to 15<sup>th</sup> of June to 12 students from three countries, mainly from Spain.

#### 4.1.10 Energy and environment

##### 4.1.10.1 The Structure

Topic	Learning outcomes	Learning Materials
Energy and Environment	Relate the energy generation and consumption with the environment.	Learning Material 1 Learning Material 2 Learning Material 10
	Recognize the impact on the local and global climate that the energy generation and consumption have.	Learning Material 1 Learning Material 2 Learning Material 10
	Classify what is Renewable and non-renewable source of energy.	Learning Material 1 Learning Material 2

	Describe the energy efficiency, ecolabel EU legislation	Learning Material 3 Learning Material 4
	Select energy efficiency and energy savings actions in everyday life and especially in energy consumption, at the appliance level, house level, enterprise-level, country level.	Learning Material 3 Learning Material 4 Learning Material 5 Learning Material 10
	Identify and select equipment and devices based on energy efficiency criterion. Ability to perform the studies and work and to assess their results considering this parameter.	Learning Material 3 Learning Material 4 Learning Material 5 Learning Material 10
	Ability to use the principles of ecological design (Eco-Design) and environmental legislation regulations that define the design, operation and the end of life cycle of electrical equipment and installations, in his/hers professional activity.	Learning Material 8 Learning Material 9 Learning Material 10
	Describe the legislation on the end of life treatment and recycling potential of waste electrotechnical equipment, as a key activity related to energy consumption and environment	Learning Material 6 Learning Material 7 Learning Material 10
	Recognize the relationship of the profession of Electrical Engineering and the environment and their interdependence.	All Learning Material
	Ability to apply that knowledge in his/her business life.	All Learning Material

#### 4.1.10.2 The Materials

Learning Material 1	Introduction in energy and environment
Short description or summary	Basic terminology and definitions in the fields of energy and environment and climate change. Classification and availability of energy sources. Overview of renewable and non-renewable energy technologies. Environmental impact (greenhouse gas emissions, water impact, land impact) of energy sources.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	PowerPoint Presentation and short videos from youtube <a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpI1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpI1ao1E?usp=sharing</a>

Learning Material 1	Introduction in energy and environment
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 2	Energy, Environment and Climate Change
Short description or summary	<p>Solar geometry, solar radiation and greenhouse phenomenon: engineering basic concepts. Determination of the impact on the greenhouse phenomenon of different gasses, and the global warming potential.</p> <p>Greenhouse effect on climate change. Impact of climate change in energy usage and energy security. Impact of climate change on the planet and weather.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	<p>PowerPoint Presentation</p> <p><a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpI1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpI1ao1E?usp=sharing</a></p>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 3	Energy efficiency and energy saving: Introduction to energy efficiency in products and systems
Short description or summary	<p>Energy savings. Definition and actions. Role of human behaviour in energy savings. Energy-saving measures.</p> <p>Energy Efficiency and energy-efficient products.</p> <p>The role of energy savings and efficiency in reducing the impact on the environment.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>



Learning Material 3	Energy efficiency and energy saving: Introduction to energy efficiency in products and systems
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers</li> </ul>
Format and/or link to the material	PowerPoint Presentation <a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 4	Energy and Environmental Policies and their interconnection
Short description or summary	Classification and technical/economical characteristics of energy-related policies. The role of energy efficiency and renewables in energy policies. Environmental impact of different policies. Economic impact. Environmental protection and energy. Policies related to GHG emissions. Industry policies for environmental protection affecting energy. Economic impact on energy from environmental legislation.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	PowerPoint Presentation <a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 5	European Directives Energy Efficiency, EPBD, Eco-label, Energy-label, RoHS, EMAS
Short description or summary	Energy Efficiency Directive. Calculation of energy efficiency indicators. Fields of implementation. Expected results and benefits. EU Energy Label. Details and implementation. Products under Energy Label. EPBD and building's efficiency. Case studies. Market situation and perspectives.

Learning Material 5	European Directives Energy Efficiency, EPBD, Eco-label, Energy-label, RoHS, EMAS
	<p>RoHS Directive. Fields of implementation and environmental impact.</p> <p>Eco-Label in products. Description, fields of implementation in the energy-related fields and impacts.</p> <p>EMAS. Description, fields of implementation and its impact on energy and environment.</p> <p>Case studies. Market situation and perspectives.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>PowerPoint Presentation</li> <li>EU Legislation Portal</li> <li>EU case studies</li> </ul> <p><a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing</a></p>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 6	End-of-life of waste electrical, electronic and industrial equipment
Short description or summary	<p>WEEE Directive. Waste Directive. Presentation and fields of implementation.</p> <p>End-of-life treatment of waste electrical, electronic and industrial equipment</p> <p>Technical and economic assessment of basic approaches: criteria and tools. Energy consumption during the end of life.</p> <p>Case studies. Market situation and perspectives.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	<p>PowerPoint Presentation</p> <p><a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing</a></p>

Learning Material 6	End-of-life of waste electrical, electronic and industrial equipment
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 7	Waste as resources.
Short description or summary	Valuable materials in different waste streams. Waste biomass as an energy resource. Recyclables and non-recyclable materials. Waste derived fuels as alternative sources of energy. Utilization of waste biomass. Waste derived fuels as alternatives or substitutes of fossil fuels. The energy efficiency in the different industrial process from the use of recycled or recovered materials. Comparison between raw material and recycled in terms of environmental impact and energy utilization.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	PowerPoint Presentation <a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 8	The life cycle analysis in the production and operation of the equipment
Short description or summary	Life Cycle Analysis definitions. Stages in the life of a product. Life Cycle Costing. Energy and materials costs in different stages. Life Cycle Analysis in evaluating energy using products and the role of energy efficiency. Life Cycle Costing Analysis and Total Cost of Ownership approach in selecting equipment and products or services. Technical and economic assessment: criteria and tools. Case studies.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>

Learning Material 8	The life cycle analysis in the production and operation of the equipment
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	PowerPoint Presentation <a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 9	Designing systems in accordance with the instructions for EcoDesign.
Short description or summary	EcoDesign Legislation. Definitions and fields of implementation. EcoDesign Regulations. Definitions and regulated products. Ecodesign approach. Life cycle thinking, and eco-design. The maximum positive impact with the minimum cost approach in improvement. Energy efficiency and eco-design. Life stages approach in improvements implementation. Case studies and examples.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	PowerPoint Presentation <a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Lecture
Level of Completion (%)	

Learning Material 10	Case studies
Short description or summary	Case studies on equipment selection based on the total cost of ownership. Case studies on selecting energy policies based on environmental impact and economic benefits. Estimations of carbon fees and production cost under the different selection of energy resources.

Learning Material 10	Case studies
	Evaluation of the costs and benefits in terms of energy and environmental impact for selecting a different source of materials for products or services.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers,</li> </ul>
Format and/or link to the material	Case Studies and Examples delivered through PowerPoint Presentations <a href="https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing">https://drive.google.com/drive/folders/1_W_Jv2fnU3gHIOgry6KPj0WECpl1ao1E?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA
Material Type	Case Study
Level of Completion (%)	

#### 4.1.10.3 The implementation

The short programme will be delivered in the University of West Attica, Department of Electrical and Electronics Engineering, in semester 4th (March to June) to 90 students from Greece.

#### 4.1.11 New Materials for solar cells applications

##### 4.1.11.1 The Structure

Topic	Learning outcomes	Learning Materials
New Materials for solar cells applications	Recall the history of Solar Cells	Learning material 1 Learning material 2 Learning material 12
	Identify the importance of Solar Energy	Learning material 2 Learning material 3 Learning material 12
	Define the Power generation from solar cells	Learning material 2 Learning material 4 Learning material 12
	Describe Solar cells technology	Learning material 5 Learning material 12
	Recall the operation of solar cells	Learning material 4

		Learning material 5 Learning material 12
	Describe the Production of solar cells	Learning material 5 Learning material 6 Learning material 12
	List thin films solar cells	Learning material 6 Learning material 7 Learning material 12
	Describe the polymer solar cells	Learning material 6 Learning material 8 Learning material 12
	Define Methodology and Importance of materials characterization	Learning material 9 Learning material 12
	List the Characterization techniques	Learning material 9 Learning material 10 Learning material 12
	Describe the optical measurements	Learning material 9 Learning material 12
	Identify materials properties and characterization	Learning material 9 Learning material 10 Learning material 12
	Define implement Solar Energy Spectrum and the Necessity of Band Gap Tuning	Learning material 11 Learning material 12
	Recognize the relationship of the profession of Industrial Design and Production Engineering and the renewable resources of energy and their interdependence.	All Learning Material
	Ability to apply that knowledge in his/her business life.	All Learning Material

#### 4.1.11.2 The Materials

Learning Material 1	Introduction in new materials for solar cells applications
Short description or summary	History of Solar Cells. Basic terminology and definitions in the fields of solar cells, new materials for solar cells and applications. Overview of solar cells applications. Solar cell in space.
Targeted EQF level	<ul style="list-style-type: none"> <li>Level 6-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>

Learning Material 1	Introduction in new materials for solar cells applications
Format and link to the material	PowerPoint Presentation and short videos from youtube link: <a href="https://eclass.uniwa.gr/courses/IDPE236/">https://eclass.uniwa.gr/courses/IDPE236/</a> <ul style="list-style-type: none"> <li>(presentations saved inside documents)</li> </ul>
Author & organisation	Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira
Material Type	Lecture
Level of Completion (%)	

Learning Material 2	Solar Energy Potential
Short description or summary	Introduction to the fundamentals of solar energy. Why do we need solar energy? The importance of solar energy. Comparison of solar energy to other energy resources. (presentations saved inside documents)
Targeted EQF level	<ul style="list-style-type: none"> <li>Leve 6-8</li> </ul>
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	PowerPoint Presentation and short videos from youtube link: <a href="https://eclass.uniwa.gr/courses/IDPE236/">https://eclass.uniwa.gr/courses/IDPE236/</a>
Author & organisation	Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira
Material Type	Lecture
Level of Completion (%)	

Learning Material 3	Solar Radiation and Geometry
Short description or summary	Sunlight at Earth. Solar Radiation and the Earth's Energy Balance. The Different Components of Solar Radiation. Geographical distribution of solar radiation. Measurement of solar radiation. (presentations saved inside documents)
Targeted EQF level	<ul style="list-style-type: none"> <li>Level 6-8</li> </ul>

Learning Material 3	Solar Radiation and Geometry
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	PowerPoint Presentation and short videos from youtube link: <a href="https://eclass.uniwa.gr/courses/IDPE236/">https://eclass.uniwa.gr/courses/IDPE236/</a>
Author & organisation	Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira
Material Type	Lecture
Level of Completion (%)	

Learning Material 4	Power from solar cells
Short description or summary	<p>Solar cell power and characteristic curve: Solar cell efficiency, power from solar cell, the IV curve, measuring an IV curve.</p> <p>Light sources: Taking the sun inside.</p> <p>Equivalent circuit: Modelling a solar cell, Parasitic resistances.</p> <p>Connected solar cells: Series and parallel connections, shadow effects.</p> <p>Solar panel system installations: Key components in a basic photovoltaic (solar panel) system, explanation of the function of each component in the system.</p> <p>Knowledge on the power generation from solar cells: Explanation of how solar panels, or photovoltaics (PV for short), convert sunlight to electricity, Calculation the electrical demand of a building, how to reduce the overall demand, and then how to design a solar panel system that can meet that annual demand at a given location.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• Level 6-8</li> </ul>
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	PowerPoint Presentation and short videos from youtube Link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a>
Author & organisation	Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira



Learning Material 4	Power from solar cells
Material Type	Lecture
Level of Completion (%)	

Learning Material 5	Solar cell technology: How do solar cells work
Short description or summary	<p>Understanding of solar cell technologies. Description of the operation of solar cells. How do solar cells work? Semiconductors: The pn-junction, conductivity and doping, lights interaction. Theoretical limits: How efficient can a solar cell be, tandem and multi-junction solar cells, theoretical solar cell efficiency. Reflection and absorption.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>Level 6-8</li> </ul>
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	<p>PowerPoint Presentation and short videos from youtube Link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a></p>
Author & organisation	<p>Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira</p>
Material Type	Lecture
Level of Completion (%)	

Learning Material 6	Production of solar cell
Short description or summary	<p>Introduction in the Production of a solar cell. How are solar cells made? Raw materials, Knowledge on the use of silicon for the production of a solar cell. How are solar cells fabricated: The manufacturing process (Purifying the silicon, Making single crystal silicon, Making silicon wafers, Doping, Placing electrical contacts, The anti-reflective coating, Encapsulating the cell. Quality control. New materials, Future Case studies. Market situation and perspectives.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>Level 6-8</li> </ul>

Learning Material 6	Production of solar cell
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	PowerPoint Presentation and short videos from youtube Link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a>
Author & organisation	Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira
Material Type	Lecture
Level of Completion (%)	

Learning Material 7	Crystalline silicon solar cells
Short description or summary	<p>Silicon solar cells: How do silicon solar cells work, crystalline silicon solar cells, mono- and multi-crystalline solar cells.</p> <p>Production of standard silicon solar cells, from sand to high-quality silicon.</p> <p>Thin-film solar cells: a potential solution to the significant problem associated with silicon solar cells: namely energy payback time, knowledge on the use of thin-film solar cells.</p> <p>Thin-film technologies: Thin-film solar cell production, working principle of CIGS solar cells, production of CIGS solar cells.</p> <p>Case studies and examples.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• Level 6-8</li> </ul>
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>• PowerPoint Presentation and short videos from youtube</li> <li>• Link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a></li> </ul>
Author & organisation	Organisation: University of West Attica (UNIWA) authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira
Material Type	Lecture
Level of Completion (%)	

Learning Material 8	Polymer solar cells- Case study 1
Short description or summary	<p>Polymer solar cells: What are polymer solar cells, how do polymer solar cells work, the layer stack.</p> <p>Production of polymer solar cells: coating techniques, printing techniques.</p> <p>New emerging technologies, examples of a third-generation solar cell technology, pros and cons of this technology, knowledge on the use of Polymer solar cells.</p> <p>Selection of solar cell technologies and comparing all the different solar cell technologies.</p> <p>Case studies and examples.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>Level 6-8</li> </ul>
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	PowerPoint Presentation and short videos from youtube link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a>
Author & organisation	<p>Organisation: University of West Attica (UNIWA)</p> <p>authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira</p>
Material Type	Case Study
Level of Completion (%)	

Learning Material 9	Material characterization – Case study 2
Short description or summary	<p>Understanding of the concept, importance and methodologies for materials characterization.</p> <p>Description of the characterization techniques, the most important techniques used to characterize and study the properties of traditional and advanced materials (X-ray diffraction techniques, thermal analysis measurements, vibrational spectroscopy techniques as well as basic measurements of mechanical properties of materials such as strength and hardness measurements)</p> <p>Optical measurements: Optical properties of solar cells, Description of the Optical measurements, Design and perform of optical measurement.</p> <p>In-depth understanding of these techniques, the preparation of measurement samples, the performance of measurements and the analysis of measurements. Case studies examples</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>Level 6-8</li> </ul>

Learning Material 9	Material characterization – Case study 2
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	PowerPoint Presentation and short videos from youtube Link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a>
Author & organisation	Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira
Material Type	Case Study
Level of Completion (%)	

Learning Material 10	Material Properties - Case study 3
Short description or summary	<p>Identification of material properties, Understanding of material properties.</p> <p>Mechanical properties of the materials, the revelation of the microstructure, the chemical composition and their morphology, the formulation and characterization of the final product.</p> <p>Modelling a solar cell, Knowledge of solar energy conversion by semiconductors.</p> <p>Case studies for product improvement and new designs. Case study examples.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• Level 6-8</li> </ul>
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>• PowerPoint Presentation and short videos from youtube</li> <li>• Link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a></li> </ul>
Author & organisation	Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira
Material Type	Case Study
Level of Completion (%)	

Learning Material 11	Solar Energy Spectrum and the Necessity of Band Gap Tuning – Case study 4
Short description or summary	<p>Description of the Implement Solar Energy Spectrum and the Necessity of Band Gap Tuning.</p> <p>Perform experiments to measure Band Gap of ZnO Films Using UV-Vis Absorption Spectra (CBL).</p> <p>Preparation of Zn<sub>1-x</sub>M<sub>x</sub>O Films and analysis of results.</p> <p>Case studies and examples.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>Level 6-8</li> </ul>
The targeted delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>
Format and/or link to the material	<p>PowerPoint Presentation and short videos from youtube</p> <p>Link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a></p>
Author & organisation	<p>Organisation: University of West Attica (UNIWA)</p> <p>Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira</p>
Material Type	Case Study
Level of Completion (%)	

Learning Material 12	Case studies 5
Short description or summary	<p>Case studies on solar cell selection based on the total cost of ownership.</p> <p>Case studies on new materials for solar cells based on the total cost and environmental impact.</p> <p>Case studies on selecting raw materials based on environmental impact and economic benefits.</p> <p>Evaluation of the costs and benefits in terms of energy and environmental impact for selecting the different source of materials for products or services.</p> <p>Estimations of carbon fees and production cost under the different selection of raw materials and solar cells.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers - Industry</li> </ul>

Learning Material 12	Case studies 5
Format and/or link to the material	Case Studies and Examples delivered through PowerPoint Presentations Link: <a href="https://eclass.uniwa.gr/courses/IDPE235/">https://eclass.uniwa.gr/courses/IDPE235/</a>
Author & organisation	Organisation: University of West Attica (UNIWA) Authors: Dr Theodore Ganetsos - Dr Kyriaki Kiskira
Material Type	Case Study
Level of Completion (%)	

#### 4.1.11.3 The implementation

The short programme will be delivered in the University of West Attica, Department of Industrial Design and Production Engineering, Faculty of Engineering, in semester 7<sup>th</sup> (October to January) and 8<sup>th</sup> (April to June) to 100 students from Greece.

It will also be used with Erasmus students.

This programme will be offered:

- As a tentative interdisciplinary seminar to the MSc programme «Master's Degree in Industrial Automation». <http://mscinautomation.teipir.gr/>

#### 4.1.12 Innovation processes in the energy sector

##### 4.1.12.1 The Structure

Topic	Learning outcomes	Learning Materials
Innovation processes in the energy sector	What is Innovation The Adoption of Innovation	Learning material 1 Learning material 2
	Design Thinking Framework Understand Problems from Customer's Perspective Create Prototypes to test your Idea	Learning material 3 Learning material 4
	Innovation Management The importance of failure Analyze Markets Engage with customers	Learning material 5 Learning material 6

##### 4.1.12.2 The Materials

Learning Material 1	
Short description or summary	<p>Slides will be used to cover the following topics in details.</p> <ul style="list-style-type: none"> <li>• Innovation and entrepreneurship - definitions</li> <li>• Where does innovation come from?</li> <li>• The adoption lifecycle</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 5 or 6</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Employees in the Energy Sector</li> </ul>
Format and link to the material	Presentation (PPT)
Author & organisation	Marios Vlachos – OTEAcademy, Greece
Material Type	Choose an item.
Level of Completion (%)	

Learning Material 2	
Short description or summary	Assignment: Your dream company in the energy sector and disruptive innovation
Targeted EQF level	<ul style="list-style-type: none"> <li>• 5 or 6</li> </ul>
The targeted learning/delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Employees in the Energy Sector</li> </ul>
Format and link to the material	pdf
Author & organisation	Marios Vlachos - OTEAcademy, Greece
Material Type	Choose an item.
Level of Completion (%)	

Learning Material 3	
Short description or summary	<p>Slides will be used to cover the following topics in details.</p> <ul style="list-style-type: none"> <li>• What is Design Thinking</li> <li>• Design Thinking Framework</li> <li>• Case study: Design Thinking in the Energy Sector</li> <li>• Break down the case</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 5 or 6</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Employees in the Energy Sector</li> </ul>
Format and link to the material	Presentation (PPT)
Author & organisation	Marios Vlachos - OTEAcademy, Greece
Material Type	Choose an item.
Level of Completion (%)	

Learning Material 4	
Short description or summary	<p>Assignment: Apply Design Thinking to face a challenge in your ideal company.</p> <ul style="list-style-type: none"> <li>• Create your persona</li> <li>• Brainstorm ideas and choose the best one</li> <li>• Prototype and Test your idea</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 5 or 6</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Employees in the Energy Sector</li> </ul>
Format and link to the material	pdf
Author & organisation	Marios Vlachos - OTEAcademy, Greece
Material Type	Choose an item.
Level of Completion (%)	



Learning Material 5	
Short description or summary	Presentation: slides will be used to cover the following topics in details. <ul style="list-style-type: none"> <li>• Leveraging failure</li> <li>• Market segmentation</li> <li>• Common Mistakes</li> <li>• Customer Interviews</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 5 or 6</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Employees in the Energy Sector</li> </ul>
Format and link to the material	Presentation (PPT)
Author & organisation	Marios Vlachos - OTEAcademy, Greece
Material Type	Choose an item.
Level of Completion (%)	

Learning Material 6	
Short description or summary	Assignment: An open innovation culture Exchange, Experimentation, Enablement, Empowerment, and Encouragement.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 5 or 6</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• Face to face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Employees in the Energy Sector</li> </ul>
Format and link to the material	Pdf
Author & organisation	Marios Vlachos - OTEAcademy, Greece
Material Type	Choose an item.
Level of Completion (%)	

#### 4.1.12.3 The implementation

This will be offered as a face-to-face programme in the form of a short course to professionals of the energy sectors mainly from Greece and/or under and postgraduate students of Greek Universities and departments relevant to the energy transition.

#### 4.1.13 Energy Efficient and Ecological Design of Products and Equipment

##### 4.1.13.1 The Structure

Topic	Learning outcomes	Learning Materials
Energy Efficient and Ecological Design of Products and Equipment	Analyze the EU Energy Efficiency, EcoLabel, EcoDesign, RoHS and WEEE Directives.	Learning Material 1 Learning Material 10
	Identify the Economics of Energy Efficient Design and EcoDesign of products and systems.	Learning Material 1 Learning Material 2 Learning Material 3 Learning Material 10
	Identify the Consumer Orientation - Innovation through Eco-Design and Energy-efficient Design, based on the total life cycle analysis approach.	Learning Material 1 Learning Material 2 Learning Material 3 Learning Material 10
	Combine methods for developing and adopting strategies for Eco and Energy-efficient design of products and systems through analysis of all phases in their life and reverse engineering approaches.	Learning Material 4 Learning Material 5 Learning Material 6 Learning Material 7 Learning Material 8 Learning Material 9 Learning Material 10
	Analyze different components and methods for reducing the impact of a product or equipment in the environment during the different phases of its life cycle.	Learning Material 4 Learning Material 5 Learning Material 6 Learning Material 7 Learning Material 8 Learning Material 9 Learning Material 10
	Combine the Concepts and Methodologies and Basic Tools for the Energy-efficient and Eco-Design of Products.	Learning Material 6 Learning Material 7 Learning Material 8 Learning Material 9 Learning Material 10
	Ability to perform Life Cycle Analysis and Life Cycle Costing Analysis during the design of a product and the calculation of the Total Cost of Ownership	Learning Material 6 Learning Material 7 Learning Material 8 Learning Material 9 Learning Material 10
	Ability to use the principles of ecological design (Eco-Design) and environmental legislation regulations that define the design, operation and the end of life cycle of electrical equipment and installations, in his/hers professional activity.	Learning Material 1 Learning Material 2 Learning Material 3 Learning Material 10

	Intergrade RES during the energy-efficient and ecological/ sustainable design process or during improvement schemes for systems and products	Learning Material 5 Learning Material 6 Learning Material 9 Learning Material 10
	Ability to perform the studies and work and to assess their results considering the sustainable/energy-efficient design parameter.	All Learning Material
	Ability to use the principles and methodologies of energy-efficient and ecological/sustainable design (Eco-Design) in his professional activity.	All Learning Material

#### 4.1.13.2 The Materials

Learning Material 1	Introduction to Energy Efficiency and EcoDesign. The EU Energy Efficiency and EcoDesign Directives.
Short description or summary	<ul style="list-style-type: none"> <li>• Basic terminology and definitions in the fields of energy, environment, and ecodesign.</li> <li>• Energy savings. Actions, measures. Energy Efficiency and energy-efficient products. Energy efficiency concepts and measures.</li> <li>• EcoDesign. Concepts, environmental impact and connection to energy efficiency.</li> <li>• Energy Efficiency Directive. Calculation of energy efficiency indicators. Fields of implementation. Expected results and benefits.</li> <li>• Ecodesign Directive. Restrictions and Calculations of indicators. Fields of implementation. EcoDesign Regulations Expected results and benefits.</li> <li>• Connected directives RoHS Directive, EcoLabel, EPBD Directive, EMAS.</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>• PowerPoint Presentation</li> <li>• EU Legislation Portal <a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJvOXjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJvOXjnBa6v_voZ8gUZflu?usp=sharing</a></li> </ul>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture
Level of Completion (%)	

Learning Material 2	Environmental indicators in energy-efficient design and ecodesign
Short description or summary	<ul style="list-style-type: none"> <li>Basic terminology and definitions in the fields of environment and toxicology and environmental indicators.</li> <li>Environmental indicators used in energy-efficient design and ecodesign. Toxicological indicators. Evaluating the toxic equivalent of substances and materials used in the product's design.</li> <li>Evaluation of the environmental impact under the ecodesign context. GHG emissions, emissions in water and land, toxicity calculation. Methods for reduction of the environmental impact.</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>PowerPoint Presentation</li> </ul> <a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture
Level of Completion (%)	

Learning Material 3	The Economics of Energy Efficient Design and EcoDesign of products
Short description or summary	Analysis of the economic issues associated and affecting the ecodesign and the energy-efficient design. The impacts on production cost and ownership costs. Economic issues for consumers and markets.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>PowerPoint Presentation</li> </ul> <a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture

Learning Material 3	The Economics of Energy Efficient Design and EcoDesign of products
Level of Completion (%)	

Learning Material 4	Consumer Orientation - Innovation through Eco-Design and Energy-efficient Design
Short description or summary	<p>The key role of consumers approach and viewpoint in energy-efficient design and ecodesign.</p> <p>Parameters affecting the selection of consumers and the role of labelling in consumer orientation.</p> <p>Relation of innovation through ecodesign. The role of life cycle thinking in products design as power driving to new innovative solutions. The different aspects of innovation under the ecodesign thinking.</p> <p>Case studies.</p> <p>Market situation and perspectives.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>PowerPoint Presentation</li> </ul> <p><a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJvOXjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJvOXjnBa6v_voZ8gUZflu?usp=sharing</a></p>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture
Level of Completion (%)	

Learning Material 5	The connection of the energy and environmental aspects during the design process. Analysis of the Concepts and Methodologies
Short description or summary	<p>The design process and what determines.</p> <p>The life cycle thinking during the design</p> <p>The concept of energy-efficient design of a product.</p> <p>The basic concept of ecodesign of a product.</p> <p>From energy-efficient design to ecodesign.</p> <p>Analysis of raw materials selection on environmental impact.</p> <p>The role of packaging and logistics.</p> <p>The impact from the manufacturing or construction process</p> <p>Materials and energy consumption in all phase of the life cycle.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>

Learning Material 5	The connection of the energy and environmental aspects during the design process. Analysis of the Concepts and Methodologies
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>• PowerPoint Presentation</li> <li>• Sustainable Design Portals</li> <li>• Case studies</li> </ul> <a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture
Level of Completion (%)	

Learning Material 6	The Life Cycle Analysis and Total Cost of Ownership
Short description or summary	<p>Definitions and vocabulary in Life Cycle Analysis. Boundaries and limits. Scope. Life Cycle stages evaluation. Cut-off Criteria. Impact Evaluation. Qualitative and semi-quantitative methods. Life Cycle Analysis implementation. Method 5x5</p> <p>Definitions and vocabulary in Life Cycle Costing Analysis and Total Cost of Ownership. Boundaries and limits. Scope. Life Cycle Costing stages evaluation. Criteria. Total Cost of Ownership for companies and consumers. Qualitative and quantitative methods. Life Cycle Costing Analysis implementation.</p> <p>Case studies</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>• PowerPoint Presentation</li> </ul> <a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture
Level of Completion (%)	

Learning Material 7	Basic Tools for the Energy-efficient and Eco Design. Part 1
Short description or summary	<p>The EU method for Ecodesign MEERP Methodology for Ecodesign of Energy-related Products used for every preparatory study to evaluate the impact and to implement eco-design regulations in products. The materials efficiency analysis under this method.</p> <p>The EU method for Ecodesign MEERP. Presentation and analysis of the tool. Case studies.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>PowerPoint Presentation</li> <li>EU Portal on MEERP</li> </ul> <p><a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing</a></p>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture
Level of Completion (%)	

Learning Material 8	Basic Tools for the Energy-efficient and Eco-Design of Products. Part 2
Short description or summary	<p>Presentation and analysis of the Product Investigation, Learning and Optimization Tool for Sustainable Product Development.</p> <p>Evaluating and comparing the two methodological approaches on eco-design using also the freeware calculation tools that they have.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>PowerPoint Presentation</li> <li>PILOT Tool</li> </ul> <p><a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing</a></p>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture

Learning Material 8	Basic Tools for the Energy-efficient and Eco-Design of Products. Part 2
Level of Completion (%)	

Learning Material 9	The development of a strategy for Eco and Energy-efficient design
Short description or summary	<ul style="list-style-type: none"> <li>• Identification of possible and potential improvements on different stages in the products life.</li> <li>• Evaluation of the possibility and obstacles for improvements.</li> <li>• Strategies targeting the usage phase of a product.</li> <li>• Strategies for specific phases of the product's or the system's life.</li> <li>• Strategies for the manufacturing /construction process.</li> <li>• Packaging and logistics strategies.</li> <li>• Strategies for end-of-life treatment alternatives.</li> <li>• Design for recyclability and repairability.</li> <li>• The design choices and their impact through specific cases studies.</li> <li>• Evaluation of the impact of each strategy.</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>• PowerPoint Presentation</li> </ul> <a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJvOXjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJvOXjnBa6v_voZ8gUZflu?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Lecture
Level of Completion (%)	

Learning Material 10	The role of RES in ecological design of systems and products
Short description or summary	<ul style="list-style-type: none"> <li>• Development of strategies for RES operating small electrical or electronic products. Integration of small scale RES in products. Efficiency improvement and improvement of environmental impact.</li> <li>• Integration of RES in the product's life cycle. Strategies for implementation. The role of RES in the in LCA, LCCA and TCO.</li> <li>• Technical and economic assessment: criteria and tools.</li> <li>• Case studies.</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Face-to-face presentation</li> <li>• Online presentation</li> </ul>



Learning Material 10	The role of RES in ecological design of systems and products
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>Case Studies and Examples delivered through PowerPoint Presentations</li> </ul> <a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Case Study
Level of Completion (%)	

Learning Material 11	Case Studies for products
Short description or summary	Products case studies in selected sectors: Electrical and Electronics products. Case studies for product improvement and new designs.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face presentation</li> <li>Online presentation</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers, Product designers and product managers</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>Case Studies and Examples delivered through PowerPoint Presentations</li> </ul> <a href="https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing">https://drive.google.com/drive/folders/12v2i-X1nkTNJv0XjnBa6v_voZ8gUZflu?usp=sharing</a>
Author & organisation	Prof. C.S. Psomopoulos, UNIWA, Greece
Material Type	Case Study
Level of Completion (%)	

#### 4.1.13.3 The implementation

The short programme will be delivered in the University of West Attica, Department of Electrical and Electronics Engineering, in the MSc in “Management and Optimization of Energy Systems” semester 2nd to 10 MSc students from Greece and additionally to professionals from the energy industry (both in face-to-face and MOOC format).

## 4.2 Seminars

### 4.2.1 Multi-terminal DC grids

Multi-terminal DC grids constitute a fundamental advancement to improve transmission and distribution system functionality and reliability, and to enable multiple DC connections to link several AC grids with different generation sources. This motivates their application in MVDC systems to enable bidirectional power flow, which is a fundamental characteristic of future distribution networks, to provide adequate power distribution with high controllability from different RES, provide controlled active and reactive power. This seminar presents the challenges, control methods and potential benefits of different operating modes of multiterminal DC grids.

#### 4.2.1.1 The Structure

Topic	Learning outcomes	Learning Materials
Multi-terminal DC grids	Explain the application areas of multi-terminal DC (MTDC) grids	Learning Material 1: Seminar slides – benefits and challenges of using MTDC grids.
	Identify and describe the differences in operation and control between AC and DC systems	Learning Material 2: Seminar slides - Key differences in the nature of AC and DC systems
	Recognise and discuss the main challenges for control of MTDC grids	Learning Material 3: Seminar slides – control challenges related to system dynamics, plug-n-play capability, types of distributed resources, emerging structures and topology.
	Determine and establish the control objectives of converter-level control	Learning Material 4: Seminar slides - control objectives for fast control, control design independent from converter model and system model, robustness and stability
	Clarify the main features of advanced control methods applied to converter-level control	Learning Material 5: Seminar slides - Virtual disturbance concept: estimation and rejection, disturbance decoupling for converters interactions in MTDC grids  Learning Material 6: Demo - Hardware-in-the-Loop test for validation of converter-level controller
	Determine and establish the control and energy management objectives of system-level control for MTDC grids	Learning Material 7: Seminar slides - control objectives related to: <ul style="list-style-type: none"> <li>- DC voltage restoration</li> <li>- Coordination of converter-interfaced distributed energy resources in MTDC grid</li> <li>- Power flow control in DC distribution networks</li> </ul>

		<ul style="list-style-type: none"> <li>- Reliability, scalability and modularity of control architectures – Data privacy</li> <li>- Resilience to changes in control structures</li> </ul>
	List and describe different control strategies for system-level control of MTDC grids	<p>Learning Material 8: Seminar slides - control strategies for:</p> <ul style="list-style-type: none"> <li>- Approaches for system-level control in MTDC distribution grids (centralised, decentralised, distributed)</li> <li>- Distributed optimal power flow algorithms</li> </ul> <p>Learning Material 9: Seminar slides - aspects of the communication network of distributed control structures</p>
	Explain and analyse the main challenges for monitoring and measurements in MTDC grids	<p>Learning Material 10: Seminar slides - Design considerations for converter data models for grid operation</p> <p>Learning Material 11: Seminar slides - State estimation</p>
	Explain and formulate state estimation methods for MTDC grids	<p>Learning Material 12: Seminar slides - Extended IEC 61850 data model for converters</p> <p>Learning Material 13: Seminar slides - Estimators in MTDC grids</p> <p>Learning Material 14: Seminar slides - State Estimation Model for AC/MTDC Distribution System</p>
	Describe the challenges for fault detection in MTDC grids	<p>Learning Material 15: Seminar slides - Fault Characteristics in MTDC Grids</p> <p>Learning Material 16: Seminar slides - Fault Impact on the Operation of MTDC Grids</p> <p>Learning Material 17: Seminar slides - Challenges of Fault Detection and Isolation in MTDC Grids</p>
	Clarify the main features of methods for fault detection in MTDC grids	<p>Learning Material 18: Seminar slides - Methods of Fault Detection and Isolation in MTDC Grids</p>

		Learning Material 19: Demo - Hardware-in-the-Loop test for validation of fault detection algorithm
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#### 4.2.1.2 The Materials

Learning Material 1	
Short description or summary	Seminar slides – benefits and challenges of using MTDC grids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 2	
Short description or summary	Seminar slides - Key differences in the nature of AC and DC systems
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	PDF
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 3	
Short description or summary	Seminar slides – control challenges related to system dynamics, plug-n-play capability, types of distributed resources, emerging structures and topology
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 4	
Short description or summary	Seminar slides – Seminar slides - control objectives for fast control, control design independent from converter model and system model, robustness and stability
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 5	
Short description or summary	Seminar slides – Seminar slides - Virtual disturbance concept: estimation and rejection, disturbance decoupling for converters interactions in MTDC grids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 6	
Short description or summary	Demo - Hardware-in-the-Loop test for validation of converter-level controller
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a></li> </ul>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Simulation
Level of Completion (%)	90%

Learning Material 7	
Short description or summary	Seminar slides - control objectives related to: <ul style="list-style-type: none"> <li>- DC voltage restoration</li> <li>- Coordination of converter-interfaced distributed energy resources in MTDC grid</li> <li>- Power flow control in DC distribution networks</li> <li>- Reliability, scalability and modularity of control architectures – Data privacy</li> <li>- Resilience to changes in control structures</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>● 7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>● Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>● Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 8	
Short description or summary	Seminar slides - control strategies for: <ul style="list-style-type: none"> <li>- Approaches for system-level control in MTDC distribution grids (centralised, decentralised, distributed)</li> <li>- Distributed optimal power flow algorithms</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>● 7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>● Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>● Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems

Learning Material 8	
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 9	
Short description or summary	Seminar slides – Seminar slides - aspects of the communication network of distributed control structures
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 10	
Short description or summary	Seminar slides - Design considerations for converter data models for grid operation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes



Learning Material 10	
Level of Completion (%)	90%

Learning Material 11	
Short description or summary	Seminar slides - State estimation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 12	
Short description or summary	Seminar slides - Extended IEC 61850 data model for converters
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 13	
Short description or summary	Seminar slides - Estimators in MTDC grids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 14	
Short description or summary	Seminar slides - State Estimation Model for AC/MTDC Distribution System
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 15	
Short description or summary	Learning Material 15: Seminar slides - Fault Characteristics in MTDC Grids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 16	
Short description or summary	Learning Material 16: Seminar slides - Fault Impact on the Operation of MTDC Grids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 17	
Short description or summary	Learning Material 17: Seminar slides - Challenges of Fault Detection and Isolation in MTDC Grids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 18	
Short description or summary	Learning Material 18: Seminar slides - Methods of Fault Detection and Isolation in MTDC Grids
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 19	
Short description or summary	Learning Material 19: Demo - Hardware-in-the-Loop test for validation of fault detection algorithm
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Multi-terminal%20DC%20grids&amp;fileid=291997</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Simulation
Level of Completion (%)	90%

#### 4.2.2 Case study on distribution grid operation

This seminar consists of the introduction of analysis, monitoring and control needs of modern power systems based on a well-defined case study derived from industrial practice. The scenarios and operating conditions reflect real-world cases. The technical content of this seminar can be re-used as a component of other courses. The case study is implemented in the form of a simulation schema with suitable parameters and forcing terms, accompanied by the description of the operating conditions and the relevant observations. The students will see the simulation results and will be able to set up new cases for self-learning.

##### 4.2.2.1 The Structure

Topic	Learning outcomes	Learning Materials
New Materials for solar cells applications	Explain the new measurement and monitoring needs in distribution systems	Learning material 1: Lecture slides - problem definition in the operation of an active distribution grid  Learning material 2: Lecture slides - Monitoring devices Learning material 3: Lecture slides - distribution system state estimation
	Explain the automation requirements in distribution systems for measurement and monitoring	Learning Material 4: Lecture Slides - Distribution Automation Concept, Architecture Design and Implementation

Topic	Learning outcomes	Learning Materials
	Explain the problems and automation solutions for monitoring based on an actual implementation on a distribution grid	<p>Learning Material 5: Lecture slides - The grid topology from Unareti</p> <p>Learning Material 6: Lecture slides: the automation architecture for monitoring the grid</p> <p>Learning Material 7: Video - a demo shows sending and storing the measurements</p>

#### 4.2.2.2 The Materials

Learning Material 1	
Short description or summary	Lecture slides - problem definition in the operation of an active distribution grid
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	85%

Learning Material 2	
Short description or summary	Lecture slides - Monitoring devices
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>

Learning Material 2	
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Choose an item.
Level of Completion (%)	85%

Learning Material 3	
Short description or summary	Lecture slides - distribution system state estimation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	85%

Learning Material 4	
Short description or summary	Lecture Slides - Distribution Automation Concept, Architecture Design and Implementation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>

Learning Material 4	
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	85%

Learning Material 5	
Short description or summary	Lecture slides - The grid topology from Unareti
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	85%

Learning Material 6	
Short description or summary	Lecture slides: the automation architecture for monitoring the grid
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>



Learning Material 6	
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture Notes
Level of Completion (%)	85%

Learning Material 7	
Short description or summary	A demo shows sending and storing the measurements
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Case%20study%20on%20distribution%20grid%20operation&amp;fileid=292047</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Simulation
Level of Completion (%)	70%

#### 4.2.3 Understanding responsibility in research and Innovation

This seminar explores the concept of responsibility in research and innovation processes. A researcher is expected to extend boundaries of knowledge, produce new insights into a specific issue or push forward technological development. But what does it mean to do responsible research? Several questions will be discussed in an interactive manner and in an interdisciplinary context: In what way is it (or not) the researcher's responsibility to respond to social needs, values and demands? Should any researcher consider ethics, public engagement, science education, etc. in his/her work? How could one maximize the social impact of the research results? Responsible Research and Innovation (RRI) is a cross-cutting issue in numerous European funding programmes that aims to bridge the gap between science and society and foster sustainable innovation. In this workshop, students will develop different approaches to promote responsible research. They will reflect on responsibility issues during the

innovation process, learn best practice examples and work out creative solutions to build greater trust in the science through research. On completion of this workshop students will be able to: understand the different aspects of responsibility in innovation processes and research projects (ethics, public engagement, public outreach....), be familiar with a toolkit of resources and guidelines to implement RRI in their research, apply different concepts of RRI to increase the social impact of their research, discuss different examples of good practice in responsible research and inspirational ways of increasing the dialogue with the society.

#### 4.2.3.1 The Structure

Topic	Learning outcomes	Learning Materials
Understanding Responsibility in research and Innovation	Examine the concept of responsibility in research and innovation	Learning material 1: lecture by instructor - slides Learning material 2: interactive discussions (partly based on video material) Learning material 3: card-based engagement exercise Learning Material 4: selected papers
	Asses how to involve stakeholders in an innovation process	Learning Material 1: lectures by instructor: slides Learning material 2: interactive discussions (partly based on video material) Learning material 3: card-based engagement exercise
	Discuss the social impact of research and innovation	Learning Material 1: lectures by the instructor – slides Learning Material 2: interactive discussions (partly based on video material) Learning Material 4: selected papers
	Propose ways to improve the alignment of research with societal needs	Learning Material 1: lecture slides Learning Material 5: case study discussion or problem-based learning activity (in the specific context of the energy transition, optional)
	Discuss “responsibility” in a case study	Learning Material 1: lecture slides Learning Material 4: selected papers Learning Material 5: case study discussion or problem-based learning activity (in the specific context of the energy transition, optional)

#### 4.2.3.2 The Materials

Learning Material 1	
Short description or summary	Lecture slides “Understanding Responsibility in Research and Innovation”. The slides comprise information about basic concepts in the area of responsible research and information, guidelines to discuss the social

Learning Material 1	
	impact of research, guidelines to work on own case study, and a compilation of open-source resources.
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Post-Doc researchers (optional: research and science managers and stakeholders from the industry cooperating with the university in research projects)</li> </ul>
Format and/or link to the material	PowerPoint presentation including relevant links to open source material in <a href="http://https://rwth-aachen.sciebo.de/s/oQA228U0ltNIOYI">http://https://rwth-aachen.sciebo.de/s/oQA228U0ltNIOYI</a>
Author & organisation	Ana de la Varga, RWTH Aachen
Material Type	Lecture Notes
Level of Completion (%)	90%

Learning Material 2	
Short description or summary	Open source videos to initiate different discussion on topics related to the concepts of Responsibility in Research and Innovation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Post-Doc researchers (optional: research and science managers and stakeholders from the industry cooperating with the university in research projects)</li> </ul>
Format and/or link to the material	Open-source video <a href="https://www.youtube.com/watch?v=E0MMcj09gP8&amp;feature=youtu.be">https://www.youtube.com/watch?v=E0MMcj09gP8&amp;feature=youtu.be</a>
Author & organisation	HEIRRI (heirri.eu) , RRI-Tools (rri-tools.eu)
Material Type	Homework/Assignment
Level of Completion (%)	100%

Learning Material 3	
Short description or summary	Open source card games to initiate different discussion on topics related to the concepts of Responsibility in Research and Innovation
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>

Learning Material 3	
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Post-Doc researchers (optional: research and science managers and stakeholders from the industry cooperating with the university in research projects)</li> </ul>
Format and/or link to the material	PowerPoint presentation including relevant links to open-source material in <a href="https://rwth-aachen.sciebo.de/s/oQA228U0ItNIOYI">https://rwth-aachen.sciebo.de/s/oQA228U0ItNIOYI</a>
Author & organisation	Ana de la Varga (RWTH Aachen) , HEIRRI (heirri.eu)
Material Type	Game
Level of Completion (%)	100%

Learning Material 4	
Short description or summary	Compilation of selected papers and relevant literature
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• PhD/Post-Doc researchers (optional: research and science managers and stakeholders from the industry cooperating with the university in research projects)</li> </ul>
Format and/or link to the material	List of selected papers: <a href="https://rwth-aachen.sciebo.de/s/oQA228U0ItNIOYI">https://rwth-aachen.sciebo.de/s/oQA228U0ItNIOYI</a>
Author & organisation	Ana de la Varga (RWTH Aachen)
Material Type	Reading
Level of Completion (%)	90

Learning Material 5	
Short description or summary	Case study discussion or problem-based learning activity (in the specific context of the energy transition, optional) Guidelines to develop the case by the students will be included in Material 1.
Targeted EQF level	<ul style="list-style-type: none"> <li>• 7-8</li> </ul>

Learning Material 5	
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>PhD/Post-Doc researchers (optional: research and science managers and stakeholders from the industry cooperating with the university in research projects)</li> </ul>
Format and/or link to the material	PowerPoint presentation including relevant links to open-source material in <a href="https://rwth-aachen.sciebo.de/s/oQA228U0ItNIOYI">https://rwth-aachen.sciebo.de/s/oQA228U0ItNIOYI</a>
Author & organisation	Ana de la Varga, RWTH Aachen
Material Type	Lecture Notes
Level of Completion (%)	90%

#### 4.2.3.3 The implementation

The seminar will be delivered at the Human Technology Centre of the RWTH Aachen University for a group of up to 20 PhD Students, PostDoc researchers, Young Research Group Leaders, and possibly research and science managers or partners from industrial R&D departments.

### 4.2.4 Economics of energy sources and the optimal integration of renewable energies and energy conservation measures

#### 4.2.4.1 The Structure

Topic	Learning outcomes	Learning Materials
Economics of energy sources and the optimal integration of renewable energy and energy efficiency measures	Explain and analyze the different forms of energy: Primary energy sources and Energy vectors  Define Energy Efficiency and identify main Energy Efficient Technologies and Best Practice	Learning Material 1
	Analyze the EU Energy Efficiency, Energy Performance of Building, Renewable Energy and Electricity Directives	Learning Material 1
	Understanding the "fundamentals" of economics of energy  Identify the Economics of Renewable Energy Mix and Energy Efficiency  Learning about the successful integration of renewable sources in different sectors	Learning Material 1  Learning Material 2

	Apply methods to determine comparative “Levelized cost of energy” for various technologies on a €/MWh basis and perform sensitivity analysis.	
	Understanding the most significant criticalities and the constraints affecting the organizational structures and the functioning of the energy markets	Learning Material 1 Learning Material 2
	Identify and analyze factors influencing the dynamics of energy transition: cost reduction of RE&EE technologies, Internalising Externalities and Non-Energy Benefits	Learning Material 1 Learning Material 2
	Ability to assess the potential for Energy Efficiency and to internalize the environmental externalities	Learning Material 1 Learning Material 2
	Ability to use the principles and methodologies of energy-economy-environment modelling in his professional activity.	Learning Material 1 Learning Material 2

#### 4.2.4.2 The Materials

Learning Material 1	Basics of energy efficiency, renewable energy and related relevant legislations
Short description or summary	<p><b>Presentation through PowerPoint slides and recorded, or transcription of training/educational speech will be used to cover in detail the following topics:</b></p> <ul style="list-style-type: none"> <li>• Basic terminology and definitions of energy: different forms of energy, Units of measurements and conversion factors.</li> <li>• Energy efficiency concepts and measures: Efficient technologies and best practices for residential, tertiary and industrial sectors.</li> <li>• Renewable Energy sources: Basic concept and main characteristics of various RES (Biomass, Hydropower, Wind, Direct Solar Energy, Geothermal Energy). Net Energy, Intermittency, Capital Intensity</li> <li>• Energy Efficiency Directive. Calculation of energy efficiency indicators. Fields of implementation. Expected results and benefits.</li> <li>• Connected directives EED Directive, EPBD Directive, Electricity Directive, EMAS.</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted learning/ delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• Seminar</li> </ul>

Learning Material 1	Basics of energy efficiency, renewable energy and related relevant legislations
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, postgraduate students, Participants from Industry (e.g. Engineers, Energy Manager, Certified Experts on Energy Management, High-level staff)</li> </ul>
Format and link to the material (if publicly available)	PowerPoint Presentation EU Legislation Portal ( <a href="https://eur-lex.europa.eu/homepage.html">https://eur-lex.europa.eu/homepage.html</a> )
Author & organisation	Walter Mario Cariani, LS, Italy
Material Type	Lesson
Level of Completion (%)	60

Learning Material 2	Fundamental of renewable energy economics with practical exercise
Short description or summary	<p><b>Presentation through PowerPoint slides and recorded, or transcription of training/educational speech will be used to cover in detail the following topics:</b></p> <ul style="list-style-type: none"> <li>Structure of supply tariff for electricity and natural gas to end-users</li> <li>Economic indicators (e.g. Payback Time, Net Present Value, Internal Rate of Return) to assess the cost-effectiveness of various energy investments. Implementation of sensitive analysis</li> <li>Market Competition - Renewables vs Fossil Fuels</li> <li>Current Levelized cost of various (conventional and renewable) generation technologies (LCOE): methods to determine them.</li> <li>Marginal costs (MC) of different renewable energies and comparison with the marginal cost of Energy Efficiency Implementation Measures</li> <li>Externality Cost of Various Electricity Generating Methods: a preliminary quantitative assessment to internalizing externalities</li> <li>Policies for Economically Accelerating the Energy Transition to Renewables</li> <li>Exercise about Cost-Benefits analysis of Renewable Projects</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted learning/ delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>Seminar</li> </ul>

Learning Material 2	Fundamental of renewable energy economics with practical exercise
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, postgraduate students, Engineers, Participants from Industry (e.g. Energy Manager, Production Manager, High-level Staff, Experts on Energy Management)</li> </ul>
Format and link to the material (if publicly available)	PowerPoint Presentation EU Legislation Portal ( <a href="https://eur-lex.europa.eu/homepage.html">https://eur-lex.europa.eu/homepage.html</a> )
Author & organisation	Walter Mario Cariani, LS, Italy
Material Type	Lesson
Level of Completion (%)	60

#### 4.2.4.3 The implementation

This course will be offered as a seminar programme in the form of a slide presentation and MOOC (see 4.3.9)

### 4.2.5 Behavioural change as a powerful drive to minimize the energy consumption while providing the same level of energy service

#### 4.2.5.1 The Structure

Topic	Learning outcomes	Learning Materials
Behavioural change as a powerful drive to minimize the energy consumption while providing the same level of energy service	Overview energy use and analyze energy-related human behaviour  Understanding the relationships between human behaviour and energy consumption  Analyzing the impact of behavioural change on energy consumption	Learning Material 1
	Identify the barriers hindering the behavioural change  Recognize human-related factors (e.g. motivation, perception, learning, and attitude or belief system) that need to be addressed to change consumer behaviour	Learning Material 1
	Ability to use the principles and methodologies of behavioural sciences for designing projects and programs aimed at promoting energy efficiency and energy saving	Learning Material 1 Learning Material 2 Learning Material 3



	<p>Explain behavioural economics and cognitive bias</p> <p>Public policy and behaviour change</p> <p>Identify effective and reliable ways to measure the change in energy use</p>	
	<p>Analyze the EU Energy Efficiency, Energy Performance of Building, Renewable Energy and Electricity Directives</p> <p>Understanding how a well-informed consumer can make more environmental-friendly (conscious) investment decisions</p> <p>Encouraging uptake and proper use of RE&amp;EE technologies</p>	Learning Material 3

#### 4.2.5.2 The Materials

Learning Material 1	Relation between human behaviour and energy consumption, basics of behavioural change theories
Short description or summary	<p><b>Presentation through PowerPoint slides and recorded, or transcription of training/educational speech will be used to cover in detail the following topics:</b></p> <ul style="list-style-type: none"> <li>• The relationships between energy consumption and human behaviour</li> <li>• Behavioural change in the use of energy: technological, social and behavioural impacts on EE; Behavioural economics and cognitive bias</li> <li>• The potential of behavioural change for the environment</li> <li>• The basic principles of behaviour modification</li> <li>• The barriers to behavioural change</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• seminar</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers, Energy Manager, Certified Experts on Energy Management</li> </ul>
Format and link to the material (if publicly available)	PowerPoint Presentation
Author & organisation	Antonio Disi ENEA, Italy
Material Type	Lesson

Learning Material 1	Relation between human behaviour and energy consumption, basics of behavioural change theories
Level of Completion (%)	30

Learning Material 2	Behaviour change for energy conservation: practical guide and case studies
Short description or summary	<p><b>Presentation through PowerPoint slides and recorded, or transcription of training/educational speech will be used to cover in detail the following topics:</b></p> <ul style="list-style-type: none"> <li>- Practical Guide to Programs and Projects development <ul style="list-style-type: none"> <li>▪ Orientation to the problem and definition of the objectives</li> <li>▪ Analysis of determinants and target groups</li> <li>▪ Design of behavioural change measures</li> <li>▪ Implementation of identified measures</li> <li>▪ Measurement and evaluation of intermediate and final objectives</li> <li>▪ Monitoring: measurement and evaluation of the persistence of the message</li> </ul> </li> <li>- Case Studies <ul style="list-style-type: none"> <li>▪ Best practices</li> <li>▪ Adopt Technological and Behavioral Energy Savings Measures</li> <li>▪ Quantitative analysis and evaluations</li> </ul> </li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>● 6-8</li> </ul>
The targeted learning/delivery mode	<ul style="list-style-type: none"> <li>● seminar</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>● Pre-graduate students, post-graduate students, Engineers, Energy Manager, Certified Experts on Energy Management</li> </ul>
Format and link to the material (if publicly available)	PowerPoint Presentation video
Author & organisation	Antonio Disi ENEA, Rino Romani LS, Italy
Material Type	Lesson
Level of Completion (%)	30

Learning Material 3	Behavioural change and related relevant legislations
Short description or summary	<p><b>Presentation through PowerPoint slides and recorded, or transcription of training/educational speech will be used to cover in detail the following topics:</b></p> <ul style="list-style-type: none"> <li>• Renewable Energy sources: Basic concept and main characteristics of various RES (Biomass, Hydropower, Wind, Direct Solar Energy, Geothermal Energy). Net Energy, Intermittency, Capital Intensity</li> <li>• Energy Efficiency Directive: expected results and benefits a better informed final costumer (through the provision of individual smart meters. Appropriate advice and information on the actual time of use accurate billing information based on actual consumption the possibility of easy access to complementary information on historical consumption, allowing detailed self-checks).</li> <li>• Connected directives EED Directive, EPBD Directive, Electricity Directive.</li> <li>• Instruments and policies to promote behavioural change: (i) fiscal incentives; (ii) access to finance, grants or subsidies; (iii) information provision; (iv) exemplary projects; (v) workplace activities;</li> <li>• Ways and means to engage consumers and consumer organisations during the possible roll-out of smart meters through the communication of (i) cost-effective and easy-to-achieve changes in energy use; (ii) information on energy efficiency measures</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted learning/delivery mode	<ul style="list-style-type: none"> <li>• Seminar</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers, Energy Manager, Certified Experts on Energy Management</li> </ul>
Format and link to the material	PowerPoint Presentation
Author & organisation	Antonio Disi ENEA, Rino Romani LS, Italy
Material Type	Lesson
Level of Completion (%)	30

## 4.3 MOOCs

### 4.3.1 Challenges and solutions in Future Power Networks

#### 4.3.1.1 The Structure:

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
List and explain the challenges in future power systems	Technical issues in power systems caused by distributed generation, power-electronic based grids, low-inertia systems, and other new technologies	Learning Material 1: Lecture Slides and Video: Today's and Tomorrow's Networks
Explain and analyse how new control techniques can be used for addressing the challenges	Methods for stabilizing low-inertia systems using RoCoF control  Maintaining stability using the concept Linear Swing Dynamics	Learning Material 2: Lecture Slides and Video: Linear Swing Dynamic: a new approach to frequency control  Learning Material 3: Lecture Slides and Video: New voltage control techniques  Learning Material 4: Lecture Slides and Video: Frequency Control & Stability in Future Power Electronics Networks (Workshop)  Learning Material 5: Lecture Slides and Video: Dynamic Voltage Stability (Workshop)
Explain how real-time simulations help in testing new solutions for future power systems	Commercial and customized simulation tools  Simulation tools for developing new control techniques for future power systems	Learning Material 6: Lecture Slides and Video: Introduction to real-time simulation tools
Explain how monitoring systems enable key functions in future power systems	Classical state-estimation  State-estimation as applied to distribution systems  Multi-area state estimation approaches	Learning Material 7: Lecture Slides and Video: Monitoring of Power Systems

#### 4.3.1.2 The Materials

Learning Material 1	
Short description or summary	Lecture Slides and Video: Today's and Tomorrow's Networks

Learning Material 1	
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://youtu.be/A_q9Bp6bo-I">https://youtu.be/A_q9Bp6bo-I</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture
Level of Completion (%)	95%

Learning Material 2	
Short description or summary	Lecture Slides and Video: Linear Swing Dynamic: a new approach to frequency control
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<a href="https://youtu.be/3iQESilmXIU">https://youtu.be/3iQESilmXIU</a>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 3	
Short description or summary	Lecture Slides and Video: New voltage control techniques
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>MOOC</li> </ul>

Learning Material 3	
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://youtu.be/6hv8jBniZ98">https://youtu.be/6hv8jBniZ98</a></li> </ul>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 4	
Short description or summary	Lecture Slides and Video: Frequency Control & Stability in Future Power Electronics Networks (Workshop)
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>MP4 File</li> </ul>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 5	
Short description or summary	Lecture Slides and Video: Dynamic Voltage Stability (Workshop)
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://youtu.be/3551IrXVxAE">https://youtu.be/3551IrXVxAE</a></li> </ul>

Learning Material 5	
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 6	
Short description or summary	Introduction to real-time simulation tools
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://youtu.be/l59JAR6llsM">https://youtu.be/l59JAR6llsM</a></li> </ul>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture
Level of Completion (%)	95%

Learning Material 7	
Short description or summary	Monitoring of Power Systems
Targeted EQF level	<ul style="list-style-type: none"> <li>7-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Industry and PhD/MSc students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://youtu.be/9bi2I7naFKQ">https://youtu.be/9bi2I7naFKQ</a></li> </ul>
Author & organisation	RWTH – Institute for Automation of Complex Power Systems
Material Type	Lecture

Learning Material 7	
Level of Completion (%)	95%

### 4.3.2 Innovation and Diversity in engineering

#### 4.3.2.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Explain and compare different gender and diversity approaches	Introduction of gender approaches Introduction of diversity approaches	Learning Material 1: Video lecture: Gender and diversity approaches  Learning Material 2: Exercise: Comparing different approaches based on literature
Discuss the context between diversity and innovation	Understand how diversity affects innovations	Learning Material 3: Video lecture: Innovation and diversity  Learning Material 4: Text work
Create transfer between stereotyping, labelling and social processes	Concept of stereotyping and labelling  Stereotyping and labelling in engineering	Learning Material 5: Video lecture: Innovation and ethics 1  Learning Material 6: Video lecture: Innovation and ethics 2
Identify and discuss the cultural aspects of gender and diversity as well as its impact on the career choice, the task selection and the quality of developed solutions, design, technologies and products	Engineering Education  Understanding who becomes an engineer  Engineering Culture	Learning Material 7: Video lecture: (Engineering) culture  Learning Material 8: Text work
Evaluate the complex impact of social aspects for learning and working in research, development and engineering	Overview of social aspects  Impact of social aspects in engineering	Learning Material 9: Video lecture: The impact of social aspects
Demonstrate to work self-organized and improve their presentation competence,	Presentation methods	Learning Material 10: Text work



Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
being able to work with the concepts of intersectionality (gender and diversity) as well as their ability to work in an interdisciplinary team	Group work in interdisciplinary teams	

#### 4.3.2.2 The Materials

Learning Material 1	Video lecture: Gender and diversity approaches
Short description or summary	Students will get an introduction in concepts of gender and diversity. Moreover, the video lecture introduces and explains the “Four Layers of Diversity Model” created by Gardenswartz & Rowe
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076</a></li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 2	Exercise: Comparing different approaches based on literature
Short description or summary	Students have to read the following text: Faulkner, W. (2007). Nuts and Bolts Gender-Troubled Engineering Identities. <i>Social Studies of Science</i> , 37 (3), p. 331-356. Afterwards, the students will answer a couple of questions about the text.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>

Learning Material 2	Exercise: Comparing different approaches based on literature
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>Faulkner, W. (2007). Nuts and Bolts Gender-Troubled Engineering Identities. <i>Social Studies of Science</i>, 37 (3), p. 331-356</li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Homework/Assignment
Level of Completion (%)	100%

Learning Material 3	Video lecture: Innovation and diversity
Short description or summary	The lecture will deal with the dimensions of innovation, according to Hauschildt et al. (2016).
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076</a></li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 4	Text work
Short description or summary	Students have to read different texts about the connection between diversity and innovation. Afterwards, they will answer a couple of questions.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>

Learning Material 4	Text work
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	The lecture slides contain the references of the different texts
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Reading
Level of Completion (%)	100%

Learning Material 5	Video lecture: Innovation and ethics 1
Short description or summary	The first part of the video lecture will explain the terms stereotyping and labelling, as well as the context between stereotyping and innovation. The second part will deal with engineering ethics. This includes defining general concepts on ethics and engineering ethics as well as the characterization of socially responsible engineers.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20program%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20program%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076</a></li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 6	Video lecture: Innovation and ethics 2
Short description or summary	This lecture will deal with the connection between ethical questions and innovation. Therefore, the lecture introduces and explains the “Responsible Research and Innovation” framework and focuses on social innovations.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>

Learning Material 6	Video lecture: Innovation and ethics 2
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076</a></li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 7	Video lecture: (Engineering) culture
Short description or summary	This lecture explains the term culture. Afterwards, we will focus on engineering culture, including engineering habitus and discussing differences in engineering education in different countries.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076</a></li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Lecture
Level of Completion (%)	50%

Learning Material 8	Text work
Short description or summary	The students have to read the following text: Hofstede, G. (2011). Dimensionalizing Cultures: The Hofstede Model in Context. <i>Online Readings in Psychology and Culture</i> , 2(1). <a href="https://doi.org/10.9707/2307-0919.1014">https://doi.org/10.9707/2307-0919.1014</a> Based on the text, the students will get a reflection question.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>Hofstede, G. (2011). Dimensionalizing Cultures: The Hofstede Model in Context. <i>Online Readings in Psychology and Culture</i>, 2(1). <a href="https://doi.org/10.9707/2307-0919.1014">https://doi.org/10.9707/2307-0919.1014</a></li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Reading
Level of Completion (%)	100%

Learning Material 9	Video lecture: The impact of social aspects
Short description or summary	This lecture serves as a summary of the previous contents. We will especially focus on the effects of not considering social aspects in engineering.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li><a href="https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076">https://newrepository.atosresearch.eu/index.php/apps/files/?dir=/ASSET/Work%20Packages/WP3%20Energy%20transition%20programs%20preparation/Learning%20Materials/RWTH/Innovation%20and%20Diversity%20in%20engineering&amp;fileid=292076</a></li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Lecture
Level of Completion (%)	40%

Learning Material 10	Text work
Short description or summary	Within the course, the students will read various scientific texts and acquire reading skills. In addition, students can discuss the different texts of the course in smaller groups and thus gain experience in group work.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-7</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Online (MOOC)</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Engineering students</li> </ul>
Format and/or link to the material	<ul style="list-style-type: none"> <li>The lecture slides contain the references of the different texts</li> </ul>
Author & organisation	Research Group Gender and Diversity in Engineering RWTH Aachen University
Material Type	Reading
Level of Completion (%)	100%

### 4.3.3 Renewable Energy Technologies

#### 4.3.3.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Describe fundamentals and main characteristics of renewable energy sources and technologies and their differences compared to fossil fuels.	Understand the working principle of renewable energy technologies.	Lecture (MOOC) and notes
Evaluate the effects that current energy systems based on fossil fuels have over the environment and the advantages of renewable energy sources.	Evaluate the advantages of renewable energies with respect to fossil fuels.	Lecture (MOOC) and notes

Compare different renewable energy technologies and choose the most appropriate based on local conditions.	Understand the main technical characteristics of renewable energy technologies and evaluate their suitability to a given application.	Lecture (MOOC) and notes
Perform simple energy, environmental and techno-economical assessments of renewable energy systems.	Evaluate renewable energy systems from energy, economic and environmental viewpoints.	Lecture (MOOC) and notes
Design, at least at a preliminary level, renewable/hybrid energy systems.	Understand and apply the basic design principles of renewable energy technologies.	Lecture (MOOC) and notes
Discuss how to use local energy sources to improve the sustainability of energy-related activities.	Evaluate the impact related to the use of local, renewable energy sources.	Lecture (MOOC) and notes

#### 4.3.3.2 The Materials

Learning Material 1	
Short description or summary	<p>Introduction: energy transition and the role of renewable energy technologies.</p> <ul style="list-style-type: none"> <li>• Classification and availability of energy sources</li> <li>• Integration of renewable energy technologies</li> <li>• Introduction to the technical and economic analysis of energy systems</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Free access MOOC through the platform EMMA</li> <li>• Email for students' support</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Class students</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	Francesco Calise, Massimo Dentice d'Accadia, Maria Vicidomini, - University of Naples
Material Type	Lecture

Learning Material 1	
Level of Completion (%)	

Learning Material 2	
Short description or summary	Solar energy: availability <ul style="list-style-type: none"> <li>• Basic principles of solar energy collection</li> <li>• Overview of solar energy technologies</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Free access MOOC through the platform EMMA</li> <li>• Email for students' support</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Class students</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	Francesco Calise, Massimo Dentice d'Accadia, Maria Vicidomini, - University of Naples
Material Type	Lecture
Level of Completion (%)	

Learning Material 3	
Short description or summary	Solar thermal systems <ul style="list-style-type: none"> <li>• Overview of solar thermal systems</li> <li>• Performance of solar thermal collectors and systems</li> <li>• Advances in solar thermal technologies</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Free access MOOC through the platform EMMA</li> <li>• Email for students' support</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Class students</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	Francesco Calise, Massimo Dentice d'Accadia, Maria Vicidomini, - University of Naples
Material Type	Lecture
Level of Completion (%)	



Learning Material 4	
Short description or summary	Photovoltaic and Concentrated Solar Power systems <ul style="list-style-type: none"> <li>• Overview of solar power technologies</li> <li>• PhotoVoltaic systems (PV)</li> <li>• Concentrating Solar Power systems (CSP)</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Free access MOOC through the platform EMMA</li> <li>• Email for students' support</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Class students</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	Francesco Calise, Massimo Dentice d'Accadia, Maria Vicidomini, - University of Naples
Material Type	Lecture
Level of Completion (%)	

Learning Material 5	
Short description or summary	Wind energy <ul style="list-style-type: none"> <li>• Wind power conversion</li> <li>• Technical and economic assessment of wind power systems</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Free access MOOC through the platform EMMA</li> <li>• Email for students' support</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Class students</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	Francesco Calise, Massimo Dentice d'Accadia, Maria Vicidomini, - University of Naples
Material Type	Lecture
Level of Completion (%)	

Learning Material 6	
Short description or summary	Hydropower <ul style="list-style-type: none"> <li>• Hydroelectric conversion</li> <li>• Technical and economic assessment of hydropower systems</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Free access MOOC through the platform EMMA</li> <li>• Email for students' support</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Class students</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	Francesco Calise, Massimo Dentice d'Accadia, Maria Vicidomini, - University of Naples
Material Type	Lecture
Level of Completion (%)	

Learning Material 7	
Short description or summary	Geothermal energy <ul style="list-style-type: none"> <li>• Geothermal resource and systems</li> <li>• Technical and economic assessment of geothermal energy systems</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Free access MOOC through the platform EMMA</li> <li>• Email for students' support</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Class students</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	Francesco Calise, Massimo Dentice d'Accadia, Maria Vicidomini, - University of Naples
Material Type	Lecture
Level of Completion (%)	

Learning Material 8	
Short description or summary	Biomass energy <ul style="list-style-type: none"> <li>• Introduction to biomass energy</li> <li>• Biomass-to-energy conversion</li> <li>• Technical and economic assessment of biomass energy systems</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Free access MOOC through the platform EMMA</li> <li>• Email for students' support</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Class students</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	Francesco Calise, Massimo Dentice d'Accadia, Maria Vicidomini, - University of Naples
Material Type	Lecture
Level of Completion (%)	

#### 4.3.4 Electric heat pumps in the energy transition framework

##### 4.3.4.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Analyse the potential use of the electrical heat pump technology	Compare the heat pump technology to other options for heating and cooling of buildings in the energy transition framework / describe the rationale behind the use of heat pump coupled to renewable energy sources	Learning material 1: Lecture (MOOC) and Lecture Notes  Learning material 2: Lecture (MOOC) and Lecture Notes  Learning material 3: Lecture (MOOC) and Lecture Notes
Describe heating and cooling load profiles	Analyse and compare typical load profiles for different types of buildings and climate both during summer and winter conditions.	Learning material 4: Lecture (MOOC) and Lecture Notes

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
		<p>Learning material 5: Lecture (MOOC) and Lecture Notes</p> <p>Learning material 6: Lecture (MOOC) and Lecture Notes</p>
Compute primary energy consumption and environmental impact	Do calculations of energy consumption and environmental impact during simple situations where the load is known of energy	<p>Learning material 7: Lecture (MOOC) and Lecture Notes</p> <p>Learning material 8: Lecture (MOOC) and Lecture Notes</p>
Describe the heat pump working principle	describe the heat pump working principle and the variation of the performance under variable boundary conditions	<p>Learning material 9: Lecture (MOOC) and Lecture Notes</p> <p>Learning material 10: Lecture (MOOC) and Lecture Notes</p>
Illustrate different technologies	Know the schematics and compare different technologies based on the final user needs (high-performance chiller systems, multiple unit direct expansion systems, systems working with natural fluids)	<p>Learning material 11: Lecture (MOOC) and Lecture Notes</p> <p>Learning material 12: Lecture (MOOC) and Lecture Notes</p> <p>Learning material 13: Lecture (MOOC) and Lecture Notes</p>
Compute the performance of a heat pump according to standards	Do simple calculations of seasonal performance indicators for a heat pump once known the map of performance under different conditions, following the standards	<p>Learning material 14: Lecture (MOOC) and Lecture Notes</p> <p>Learning material 15: Lecture (MOOC) and Lecture Notes</p>
Size a heat pump and run simulations	Size a heat pump and read critically the results of a dynamic simulation	Learning material 16: Lecture (MOOC) and Lecture Notes

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
		Learning material 17: Lecture (MOOC) and Lecture Notes
List technologies for heat storage with heat pumps	Describe the basics of thermal energy storage technologies for heat carriers at low and medium temperatures. Describe the options for heat storage application at a district scale	Learning material 11: Lecture (MOOC) and Lecture Notes  Learning material 12: Lecture (MOOC) and Lecture Notes  Learning material 13: Lecture (MOOC) and Lecture Notes
Describe best practices for application in complex systems	Describe different options of heat pump integration in complex systems based on heating/cooling load peaks compared to total power needs	Learning material 14: Lecture (MOOC) and Lecture Notes  Learning material 15: Lecture (MOOC) and Lecture Notes

#### 4.3.4.2 The Materials

Learning Material 1	
Short description or summary	Classification of energy sources and their description. Classification of end uses and their description. The role of electric heat pumps in the Italian and European total energy consumption with projections to 2030 scenario.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the EMMA platform</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Citizens, Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes

Learning Material 1	
Level of Completion (%)	90%

Learning Material 2	
Short description or summary	World policies for the energy transition: Brazil, China, India, Europe and USA strategies for heat pumps diffusion and penetration in energy transition framework. Heat pumps diffusion and their market in Italy and Europe.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Citizens, Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes, Data Set
Level of Completion (%)	90%

Learning Material 3	
Short description or summary	Classification of electric heat pumps and their application. Basic principles for heating, cooling and sanitary hot water and examples of their applications. Special applications for heat pumps: industrial sector, district heating and smart city.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Citizens, Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes

Level of Completion (%)	90%
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Learning Material 4	
Short description or summary	Description of the different building categories and the methods to calculate heating and cooling load needs.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	70%

Learning Material 5	
Short description or summary	Definitions of climate zones according to EU regulations and typical winter and summer load profiles
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	70%

Learning Material 6	
Short description or summary	Example of a load profile for a case study
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes, Case Study
Level of Completion (%)	70%

Learning Material 7	
Short description or summary	Description of the methods to calculate the energy consumption and the environmental impact
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	60%

Learning Material 8	
Short description or summary	Energetic and environmental impact comparison between a heat pump and a burner during the heating season based on the basic calculations
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>



Learning Material 8	
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	60%

Learning Material 9	
Short description or summary	Working principle for vapour compression systems and technical limits for operation
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	50%

Learning Material 10	
Short description or summary	Energetic and environmental impact comparison between a heat pump and a burner during the heating season based on the basic calculations introduced before
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>

Learning Material 10	
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	50%

Learning Material 11	
Short description or summary	Description of the technology related to the water chillers, with some information about the actual performance and technological limits
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	50%

Learning Material 12	
Short description or summary	Description of the technology related to systems with multiple units operating with direct expansion, with some information about the actual performance and technological limits
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>

Learning Material 12	
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	40%

Learning Material 13	
Short description or summary	Description of the technology related to heat pumps operating with natural fluids, with some information about the actual performance and technological limits
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	40%

Learning Material 14	
Short description or summary	Description of the regulations and standards which establish the method to be applied to calculate the performance indicators
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	

Learning Material 14	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	40%

Learning Material 15	
Short description or summary	Application of the standards to the case study in order to calculate the SCOP indicator
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	40%

Learning Material 16	
Short description or summary	Criterion to size the system for a defined load
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	30%

Learning Material 17	
Short description or summary	Examples of maps of performance. Example of the use of the maps in a dynamic simulator with a discussion about the results
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Mechanical engineering students, people from the industry</li> </ul>
Format and/or link to the material	<a href="https://platform.europeanmoocs.eu/">https://platform.europeanmoocs.eu/</a>
Author & organisation	
Material Type	Lecture (MOOC) and Lecture Notes
Level of Completion (%)	30%

#### 4.3.5 Green professionalization and ethics

##### 4.3.5.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Recall the sociological terminology about the role of professionals and expert knowledge in society	Understand the social construction of competencies fields of jurisdiction in order to: 1 – question the social “power” of experts and professionals; 2 – investigate how professional ethics and social legitimation are interrelate in contexts of socio-technical transition.	Seminar slides selected papers
Describe the professionalization process of the “green-collars”	Understand the nexus between energy transition and emerging socio-technical skills. Understand the role of the “green collars” in the environmental disputes related to the energy transition.	Seminar slides and selected paper
Identify and recognize empirical experiences of green professionalization	Acquire basic methodological notions of the sociological research in order to retrace empirical experiences of green professionalization	Seminar slides and selected paper

## 4.3.5.2 The Materials

Learning Material 1-3	
Short description or summary	The aim is to offer to the student's examples of how the social actors mentioned in the presentation and the previous unit depict: a) the social and environmental worth of the green jobs, b) their role in the energy transition process.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face to Face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Students class</li> </ul>
Format and/or link to the material	<p><u>National Geographic article</u> about “11 of the Fastest Growing Green Jobs”<a href="https://www.nationalgeographic.com/environment/sustainable-earth/11-of-the-fastest-growing-green-jobs/">https://www.nationalgeographic.com/environment/sustainable-earth/11-of-the-fastest-growing-green-jobs/</a></p> <p><u>Video n. 1</u> Green jobs facing environmental urgencies. The ethics of the green economy? The point of view of the International Labour Organization (ILO).<a href="https://www.youtube.com/watch?v=NrNQzCjI8A4">https://www.youtube.com/watch?v=NrNQzCjI8A4</a></p> <p><u>Video n.2</u> Engineers, high education, new challenges of energy transitions. The point of view of the University of Aberdeen MSc Programme Coordinator (Engineering curriculum). <a href="https://www.youtube.com/watch?v=tpgTsgWA0Lw">https://www.youtube.com/watch?v=tpgTsgWA0Lw</a></p> <p><u>Video n.3</u> Architects and the planning of sustainable places for the future. The point of view of one of India's pioneering green architects.<a href="https://www.youtube.com/watch?v=9klc9BLqtGw">https://www.youtube.com/watch?v=9klc9BLqtGw</a></p> <p><u>Reading 1</u> Environmental economy - statistics on employment and growth<a href="https://ec.europa.eu/eurostat/statistics-explained/pdfscache/41606.pdf">https://ec.europa.eu/eurostat/statistics-explained/pdfscache/41606.pdf</a></p> <p><u>Reading 2</u> Professionalism: Value and ideology, Julia Evetts (University of Nottingham) <a href="http://www.sagepub.net/isa/resources/pdf/Professionalism.pdf">http://www.sagepub.net/isa/resources/pdf/Professionalism.pdf</a></p>
Author & organisation	Dario Minervini, University of Naples Federico II
Material Type	Lecture
Level of Completion (%)	

### 4.3.6 Corporate Communication and Corporate Social Responsibility

#### 4.3.6.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Acquiring the basic knowledge on the relationship between corporate communication, organizational features and social values.	<p>Ability to recognize the differences between organizational forms in industrial and post-industrial society</p> <p>Understanding the organisational principles of the different ways of coordinating corporate activities</p> <p>Being able to define the meaning and usefulness of Corporate Social Responsibility</p> <p>Acquisition of the basic notions of corporate communication with respect to social, organizational and social responsibility contexts.</p>	Seminar slides and selected paper(s), reading – learning material 1-3.
Understanding the role of consumption and the consumer in contemporary society and business communication, as well as acquiring the basic knowledge in the definition of the communication plan with particular attention to energy companies.	<p>The relevance of proactive, smart &amp; critical consumption in contemporary society (e.g., the socio-environmental issues)</p> <p>Basic knowledge to understand and define communication plan activities</p> <p>Differenced and similarities of energy corporate communication strategies</p>	Seminar slides and selected paper(s), reading – learning material 4-6.
Final task. A short document about a communication plan proposed by students.	Evidencing that student learned the basic concepts of the course	Final task – learning material 7

#### 4.3.6.2 The Materials

Learning Material 1-3	
Short description or summary	During the course period, slides and access open materials (in pdf or doc format) will be available.

Learning Material 1-3	
	Through this document, the student will be able to improve his/her knowledge on the lesson topics.
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Interactions among MOOC platform</li> <li>email and telco for discussion and students support.</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Class students</li> </ul>
Format and/or link to the material	<p>Unit lesson slides: 3 pdf files on the website of the MOOC course</p> <p>Free access pdf 1: "Globalization and postmodern values."</p> <p>Free access pdf 2: "Organizational communication for organizational climate and quality service in Academic libraries."</p> <p>Free access pdf 3: "Corporate Social Responsibility."</p>
Author & organisation	Ivano Scotti, University of Naples
Material Type	Lecture
Level of Completion (%)	

Learning Material 4-6	
Short description or summary	<p>During the course period, slides and access open materials (in pdf or doc format) will be available.</p> <p>Through this document, the student will be able to improve his/her knowledge on the lesson topics.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Interactions among MOOC platform</li> <li>email and telco for discussion and students support.</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Class students</li> </ul>
Format and/or link to the material	<p>Unit lesson slides: 3 pdf files on the website of the MOOC course</p> <p>Free access pdf 4: "Prosumer communities and relationships in smart grids."</p> <p>Free access pdf 5: "Designing a strategic communication plan."</p> <p>Free access pdf 6: "E-Marketing by energy companies."</p>
Author & organisation	Ivano Scotti, University of Naples
Material Type	Lecture



Learning Material 4-6	
Level of Completion (%)	

Learning Material 7	
Short description or summary	
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Interactions among MOOC platform</li> <li>email and telco for discussion and students support.</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Class students</li> </ul>
Format and/or link to the material	<p>Slide with instruction for the final task</p> <p>Links to commercials of energy companies as an example of communication strategy</p>
Author & organisation	Ivano Scotti, University of Naples
Material Type	Assessment
Level of Completion (%)	

#### 4.3.7 A holistic approach for Energy Transition: territory, networks, and sustainability

##### 4.3.7.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Clarifying the meaning and implications of Energy Transition	<p>Understand the social construction of Energy Transition from the:</p> <ul style="list-style-type: none"> <li>territorial perspective;</li> <li>social perspective;</li> <li>environmental perspective.</li> </ul>	Study materials: lecture slides and suggested readings (book chapters, research papers, scientific essay)
Identifying the meaning and implication of Sustainable planning of Energy Transition	<p>Understand the concept of sustainability and participatory planning.</p> <p>Understand the implications in terms of cooperation/conflict using case studies.</p>	Study materials: lecture slides and suggested readings (book chapters, research papers, scientific essays)

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Recognising Social Network Analysis as a tool of Participatory Planning	<p>Acquire basic notions of theoretical and methodological approach of the Social Network Analysis, specifically in order to identify:</p> <ul style="list-style-type: none"> <li>• network as a tool of participatory planning;</li> <li>• role, skills and weight of the brokers.</li> </ul>	Study materials: lecture slides and suggested readings (book chapters, research papers, scientific essays)

#### 4.3.7.2 The Materials

Learning Material 1-3	
Short description or summary	<p>Understand the “social construction” of Energy Transition in order to cultures, practices, and perceptions;</p> <p>Understand the concept of sustainability and participatory planning</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• student class</li> </ul>
Format and/or link to the material	<p>Free access pdf 1: Is climate morality the answer? Preconditions affecting the motivation to decrease private car use - Alfred Andersson</p> <p>Free access pdf 2: Exploring blockchain for the energy transition: Opportunities and challenges based on a case study in Japan - A. Ahl a,*, M. Yarime b,e,f, M. Goto a, Shauhrat S. Chopra c, Nallapaneni Manoj. Kumar c, K. Tanaka d, D. Sagawa d</p> <p>Free access pdf 3: The Important Difference between Change and Transition - Jeff Bracken Bracken &amp; Associates</p>
Author & organisation	Anna Maria Zaccaria, University of Naples Federico II
Material Type	Lecture
Level of Completion (%)	

Learning Material 4-6	
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Short description or summary	<p>Understand the implications of Energy Transition in terms of cooperation/conflict using case studies.</p> <p>To acquire basic notions of the theoretical and methodological approach of the Social Network Analysis, specifically in order to identify social networks as a tool of cooperation/conflict dynamics</p> <p>Acquire basic notions of the theoretical and methodological approach of the Social Network Analysis, specifically in order to identify the role, skills and weight of the brokers.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Face-to-face</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Students class</li> </ul>
Format and/or link to the material	<p>Free access pdf 1: Network Analysis in the Social Sciences</p> <p>Free access pdf 2: “INTRODUCTIONTOSOCIALNETWORKANALYSIS “</p>
Author & organisation	Anna Maria Zaccaria, University of Naples Federico II
Material Type	Lecture
Level of Completion (%)	

#### 4.3.8 Train the trainer

##### 4.3.8.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Identify the meaning of vocational education.	Understand the principles of vocational education, and the value for the participants. The importance of clarification of the learning goals to the trainees, and explore how to encourage active participation.	Study materials: video presentation 1 (MOOC), lecture notes and quiz.
Clarify the elements of vocational training.	Knowledge of the definition of vocational training, categorization of the learning stages, and scrutiny of the purposes of adult learning.	Study materials: video presentation 2 (MOOC), lecture notes and quiz.

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Recognizing the aims and objectives of vocational training.	Understanding the categorization as well as the importance of setting course aims.	Study materials: video presentation 3 (MOOC), lecture notes and quiz.
Ability to structure a complete training course	Explanation of the structural elements of a course. Identification of different trainee characteristics, learning content design, and adaptation of training techniques and tools.	Study materials: video presentation 4 (MOOC), lecture notes and quiz.
Acquisition of audience communication skills	Identification of the communication process elements. Demonstration of communication elements impact.	Study materials: video presentation 5 (MOOC), lecture notes and quiz.
Enhancement of audience management techniques	Analysis of the motives that enhance active participation during a course. Recognition and anticipation of anticipate audience tension, proper response and engagement techniques in the learning environment.	Study materials: video presentation 6 (MOOC), lecture notes and quiz.
Ability to execute a training session	Analysis of the microteaching elements and incorporation in teaching methods.	Study materials: video presentation 7 (MOOC), lecture notes and quiz.

#### 4.3.8.2 The Materials

Learning Material 1-3	
Short description or summary	<p>Understand the principles of vocational education, and the value for the participants. The importance of clarification of the learning goals to the trainees and explore how to encourage active participation.</p> <p>Knowledge of the definition of vocational training, categorization of the learning stages, and scrutiny of the purposes of adult learning.</p> <p>Understanding the categorization as well as the importance of setting course aims.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Students and Vocational trainers</li> </ul>

Learning Material 1-3	
Format and/or link to the material	Unit lesson slides: 1 pdf per unit through the platform EMMA (total of 3 units.)
Author & organisation	Nikos Agiotis, OTEAcademy
Material Type	Lecture (MOOC), Lecture Notes and quiz
Level of Completion (%)	80%

Learning Material 4-7	
Short description or summary	<p>Explanation of the structural elements of a course. Identification of different trainee characteristics, learning content design, and adaptation of training techniques and tools.</p> <p>Identification of the communication process elements. Demonstration of communication elements impact.</p> <p>Analysis of the motives that enhance active participation during a course. Recognition and anticipation of anticipate audience tension, proper response and engagement techniques in the learning environment.</p> <p>Analysis of the microteaching elements and incorporation in teaching methods.</p>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted delivery mode.	<ul style="list-style-type: none"> <li>Free access MOOC through the platform EMMA</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Students and Vocational trainers</li> </ul>
Format and/or link to the material	Unit lesson slides: 1 pdf per unit through the platform EMMA (total of 4 units.)
Author & organisation	Nikos Agiotis, OTEAcademy
Material Type	Lecture (MOOC), Lecture Notes, and quiz
Level of Completion (%)	80%

#### 4.3.9 Economics of energy sources and the optimal integration of renewable energies and energy conservation measures

##### 4.3.9.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Explain and analyze the different forms of energy: Primary energy sources and Energy vectors	Introduction to the different forms of energy sources and energy vectors  Understand the evolution over the time of relationships between economic development and energy sources utilised	Learning Material 1: – Seminar slides – Selected papers
Understand Energy Efficiency and Renewable Energy  Analyse the main Energy Efficient and Renewables Energy Technologies: Best Practices	Understand the meaning of Energy Efficiency, learn how Energy Efficiency can be measured and how the deployment of Energy Efficient Technologies and Best Practices may reduce energy consumption and related environmental impact  Learn the main features of currently available Renewables Energy Technologies (RETs)	Learning Material 1: – Seminar slides – Selected papers
Understand the EU Energy Efficiency, Energy Performance of Building, Renewable Energy and Electricity Directives	Acquire knowledge and understand E.U. Directives which establish a common framework of measures for the promotion of Energy Efficiency and Renewables within the Union in order to ensure the achievement of the Union's targets on energy efficiency and RES to 2020 and 2030 horizon and to pave the way for further future improvements.	Learning Material 1: – Seminar slides – Selected papers
Understand the "fundamentals" of economics of energy	Analyse the Economics of Renewable Energy Mix and Energy Efficiency  Learning about the successful integration of renewable sources in different sectors  Apply methods to determine comparative "Levelized cost of energy" for various technologies on a €/MWh basis and perform sensitivity analysis.	Learning Material 1, Learning Material 2: – Seminar slides – Selected papers
Analyse the main factors affecting the dynamics of the Energy Transition	Identify and analyze factors influencing the dynamics of energy transition: cost reduction of RE&EE technologies, Internalising Externalities and Non-Energy Benefits	Learning Material 1, Learning Material 2: – Seminar slides – Selected papers
Explain and discuss the potential for Energy Efficiency. Explain the impact of externalities on Energy Transition process	Ability to discuss the potential for Energy Efficiency in end-use sectors  Learning how policies aimed to internalize the environmental externalities of energy use can speed up the Energy Transition	Learning Material 1, Learning Material 2: – Seminar slides – Selected papers
Make Cost-Benefit Analysis exercises of	Ability to perform an economic and financial analysis through an exercise addressed to evaluate	Learning Material 1,

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Renewable Energy Projects	and select the most cost-effective RE project between two alternative options.	Learning Material 2: – Seminar slides – Selected papers

#### 4.3.9.2 The Materials

Learning Material 1	Basics of energy efficiency, renewable energy and related relevant legislations
Short description or summary	<p>Presentation through PowerPoint slides and recording, or transcription of training/educational speech will be used to cover in detail the following topics:</p> <ul style="list-style-type: none"> <li>• Basic terminology and definitions of energy: different forms of energy, Units of measurements and conversion factors.</li> <li>• Energy efficiency concepts and measures: Efficient technologies and best practices for residential, tertiary and industrial sectors.</li> <li>• Renewable Energy sources: Basic concept and main characteristics of various RES (Biomass, Hydropower, Wind, Direct Solar Energy, Geothermal Energy). Net Energy, Intermittency, Capital Intensity</li> <li>• Energy Efficiency Directive. Calculation of energy efficiency indicators. Fields of implementation. Expected results and benefits.</li> <li>• Connected directives EED Directive, EPBD Directive, Electricity Directive, EMAS.</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted learning/ delivery mode (e.g. face to face, online, blended etc.	<ul style="list-style-type: none"> <li>• MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, postgraduate students, Participants from Industry (e.g. Engineers, Energy Manager, Certified Experts on Energy Management, High-level staff)</li> </ul>
Format and link to the material (if publicly available)	<p>Video</p> <p>EU Legislation Portal (<a href="https://eur-lex.europa.eu/homepage.html">https://eur-lex.europa.eu/homepage.html</a>)</p>
Author & organisation	Walter Mario Cariani, LS, Italy
Material Type	Lesson

Learning Material 1	Basics of energy efficiency, renewable energy and related relevant legislations
Level of Completion (%)	60

Learning Material 2	Fundamental of renewable energy economics with practical exercise
Short description or summary	<p>Presentation through PowerPoint slides and recording, or transcription of training/educational speech will be used to cover in detail the following topics:</p> <ul style="list-style-type: none"> <li>• Structure of supply tariff for electricity and natural gas to end-users</li> <li>• Economic indicators (e.g. Payback Time, Net Present Value, Internal Rate of Return) to assess the cost-effectiveness of various energy investments. Implementation of sensitive analysis</li> <li>• Market Competition - Renewables vs Fossil Fuels</li> <li>• Current levelized cost of various (conventional and renewable) generation technologies (LCOE): methods to determine them.</li> <li>• Marginal costs (MC) of different renewable energies and comparison with the marginal cost of Energy Efficiency Implementation Measures</li> <li>• Externality Cost of Various Electricity Generating Methods: a preliminary quantitative assessment to internalizing externalities</li> <li>• Policies for Economically Accelerating the Energy Transition to Renewables</li> <li>• Exercise about Cost-Benefits analysis of Renewable Projects</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted learning/delivery mode	<ul style="list-style-type: none"> <li>• MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, postgraduate students, Engineers, Participants from Industry (e.g. Energy Manager, Production Manager, High-level Staff, Experts on Energy Management)</li> </ul>
Format and link to the material (if publicly available)	<p>PowerPoint Presentation</p> <p>EU Legislation Portal (<a href="https://eur-lex.europa.eu/homepage.html">https://eur-lex.europa.eu/homepage.html</a>)</p>
Author & organisation	Walter Mario Cariani, LS, Italy
Material Type	Lesson
Level of Completion (%)	60



#### 4.3.9.3 The implementation

This course will be also offered as a short seminar programme in the form of a slide presentation.

#### 4.3.10 Behavioural change as a powerful drive to minimize the energy consumption while providing the same level of energy service

##### 4.3.10.1 The Structure

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Analyzing the impact of behavioural change on energy consumption	Overview energy use and analyze energy-related human behaviour  Understanding the relationships between human behaviour and energy consumption	Learning Material 1: – Slides – Readings list
Identify the barriers hindering the behavioural change	Recognize human-related factors (e.g. motivation, perception, learning, and attitude or belief system) that need to be addressed to change consumer behaviour	Learning Material 1: – Slides
Describe the basics of behavioural change theories and related methodologies. Explain behavioural economics and cognitive bias	Ability to use the principles and methodologies of behavioural sciences for designing projects and programs aimed at promoting energy efficiency and energy saving  Identify effective and reliable ways to measure the change in energy use	Learning Material 1, Learning Material 2: – Slides – Readings list
Analyze Public policy and behaviour change	Examine the EU Energy Efficiency, Energy Performance of Building, Renewable Energy and Electricity Directives  Understanding how a well-informed consumer can make more environmental-friendly (conscious) investment decisions  Encouraging uptake and proper use of RE&EE technologies	Learning Material 3: – Slides – Readings list

##### 4.3.10.2 The Materials

Learning Material 1	Relation between human behaviour and energy consumption, basics of behavioural change theories
Short description or summary	<p>Presentation through PowerPoint slides and recording, or transcription of training/educational speech will be used to cover in detail the following topics:</p> <ul style="list-style-type: none"> <li>• The relationships between energy consumption and human behaviour</li> <li>• Behavioural change in the use of energy: technological, social and behavioural impacts on EE; Behavioural economics and cognitive bias</li> </ul>

Learning Material 1	Relation between human behaviour and energy consumption, basics of behavioural change theories
	<ul style="list-style-type: none"> <li>• The potential of behavioural change for the environment</li> <li>• The basic principles of behaviour modification</li> <li>• The barriers to behavioural change</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>
The targeted delivery mode	<ul style="list-style-type: none"> <li>• MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>• Pre-graduate students, post-graduate students, Engineers, Energy Manager, Certified Experts on Energy Management</li> </ul>
Format and link to the material (if publicly available)	<ul style="list-style-type: none"> <li>• Video</li> <li>• slides</li> </ul>
Author & organisation	Antonio Disi ENEA, Italy
Material Type	Lesson
Level of Completion (%)	30

Learning Material 2	Behaviour change for energy conservation: practical guide and case studies
Short description or summary	<p>Presentation through PowerPoint slides and recording, or transcription of training/educational speech will be used to cover in detail the following topics:</p> <ul style="list-style-type: none"> <li>- Practical Guide to Programs and Projects development <ul style="list-style-type: none"> <li>▪ Orientation to the problem and definition of the objectives</li> <li>▪ Analysis of determinants and target groups</li> <li>▪ Design of behavioural change measures</li> <li>▪ Implementation of identified measures</li> <li>▪ Measurement and evaluation of intermediate and final objectives</li> <li>▪ Monitoring: measurement and evaluation of the persistence of the message</li> </ul> </li> <li>- Case Studies <ul style="list-style-type: none"> <li>▪ Best practices</li> <li>▪ Adopt Technological and Behavioral Energy Savings Measures</li> <li>▪ Quantitative analysis and evaluations</li> </ul> </li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>• 6-8</li> </ul>

Learning Material 2	Behaviour change for energy conservation: practical guide and case studies
The targeted learning/delivery mode	<ul style="list-style-type: none"> <li>MOOC</li> </ul>
The targeted audiences	<ul style="list-style-type: none"> <li>Pre-graduate students, post-graduate students, Engineers, Energy Manager, Certified Experts on Energy Management</li> </ul>
Format and link to the material (if publicly available)	Video slides
Author & organisation	Antonio Disi ENEA, Rino Romani LS, Italy
Material Type	Lesson
Level of Completion (%)	30

Learning Material 3	Behavioural change and related relevant legislations
Short description or summary	<p>Presentation through PowerPoint slides and recording, or transcription of training/educational speech will be used to cover in detail the following topics:</p> <ul style="list-style-type: none"> <li>Renewable Energy sources: Basic concept and main characteristics of various RES (Biomass, Hydropower, Wind, Direct Solar Energy, Geothermal Energy). Net Energy, Intermittency, Capital Intensity</li> <li>Energy Efficiency Directive: expected results and benefits a better informed final costumer (through the provision of individual smart meters. Appropriate advice and information on the actual time of use accurate billing information based on actual consumption the possibility of easy access to complementary information on historical consumption, allowing detailed self-checks).</li> <li>Connected directives EED Directive, EPBD Directive, Electricity Directive.</li> <li>Instruments and policies to promote behavioural change: (i) fiscal incentives; (ii) access to finance, grants or subsidies; (iii) information provision; (iv) exemplary projects; (v) workplace activities;</li> <li>Ways and means to engage consumers and consumer organisations during the possible roll-out of smart meters through the communication of (i) cost-effective and easy-to-achieve changes in energy use; (ii) information on energy efficiency measures</li> </ul>
Targeted EQF level	<ul style="list-style-type: none"> <li>6-8</li> </ul>
The targeted learning/delivery mode	<ul style="list-style-type: none"> <li>MOOC</li> </ul>

Learning Material 3	Behavioural change and related relevant legislations
The targeted audiences	<ul style="list-style-type: none"><li>• Pre-graduate students, post-graduate students, Engineers, Energy Manager, Certified Experts on Energy Management</li></ul>
Format and link to the material	Video PowerPoint Presentation slides
Author & organisation	Antonio Disi ENEA, Rino Romani LS, Italy
Material Type	Lesson
Level of Completion (%)	30

## 5. Conclusion

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This deliverable presents the description of the materials for ASSET programmes (short-programmes, seminars and MOOCs) and their updated learning graph instances. These materials will be updated as the project progresses and as the courses are delivered. The final versions of the materials will be shared with the public by the end of December 2020. Learning graph instances and material are framed in a way that has already facilitated the identification of the contents to be re-used within the consortium in the timeframe of the project. This first step demonstrates that broader and more articulated re-use for interdisciplinary courses and on-demand educational offers.

## 6. References

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- [1] Wilbert Tarnate, Ferdinanda Ponci, et al., (2019), D2.3: Learning goals catalogue for the energy sector, ASSET, <https://energytransition.academy/deliverable/D2.3>
- [2] Mashood Nasir, et. Al, (2020), D4.2: Educational Programmes Deployment Plan, ASSET.

## Annex A: Guidelines for Copyrights

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### *General Guideline*

Google images. In order to find out if a google image has copyright, there are several options:

1. Advanced search settings for google images. Inside this area (Advanced search), you can filter the images you need according to the rights of use (filter so they can be used or shared freely in this case).
2. Check the terms of use where you found the image. Normally it is at the bottom of the website.
3. Use a free download images website such as Pixabay, Gratisography, Everystockphoto, Unsplash, Freeimages, Pxhere or Wikimedia (read the terms and conditions of the image you download).
4. If you need to be sure that the image you are going to use will not give you problems with your copyright on the Internet, the best thing to do is to go to the Creative Commons image search engine (CC Search (Creative Commons Image Search)).

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<https://www.stm-assoc.org/intellectual-property/permissions/permissions-guidelines/>

Reports. Review the terms of use of the website or contact if needed the agency who made the report via email.

### *Specific cases*

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## Annex B: Guidelines for developing reusable materials

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The guidelines below are based on Chapter 6 of the user guide for the Sharable Content Object Reference Model (SCORM). [https://adlnet.gov/assets/uploads/SCORM\\_Users\\_Guide\\_for\\_ISDs.pdf](https://adlnet.gov/assets/uploads/SCORM_Users_Guide_for_ISDs.pdf)

(Note: SCORM is a collection of E-learning standards for learning management systems.)

Guidelines:

1. **Granular Size:** A more granular content is more reusable. Thus, the materials should be as small as possible. However, do not make it too small that cannot be used to achieve the learning outcome for your target audience.
2. **Context Neutral Content:** Context Neutral Content means that the content can be detached from material and still be considered complete. Some relevant practices for creating context neutral content are as follows:
  - a. Separate the needed context-specific content into another slide/page/unit in the material.
  - b. Don't refer to things that might change like course numbers, lesson numbers, or people's names – like "For tech support, contact Mike Smith."
  - c. Consider the stability of Internet hyperlinks before you include them.
  - d. Avoid references to previous course material and to specific features. For example, use "PHP is an effective way to create web applications" not "The Acme IT Department uses PHP to create web applications because it is so effective."
  - e. Context across a material can be created with voice narrations, independent of the visuals.