


COURSE DATASHEET

COURSE TITLE	6.1- Principle of photovoltaic (PV) cells and the different PV cell technologies
COURSE PLATFORM	Moodle
COURSE WEB	ECoVEM - Programme ERASMUS+ INES - Institut National de l'Énergie Solaire (ines-solaire.org)
ACCESS INFORMATION	On-site training. Custom-made module-based program (can be combined with courses 6.2 and 6.3). Trainees must contact INES training department through course web link in order to define the program according to their skills, needs and time availability.
PROVIDER INSTITUTION	INES Formation
PROVIDER CONTACT	<i>name:</i> LELIEVRE J-F <i>email:</i> jf.lelievre@ines-solaire.org
TEACHERS	<i>T1-</i> LELIEVRE Jean-François <i>T2-</i> <i>T3-</i>
TYPE OF COURSE	<input type="checkbox"/> On-line (stand-alone) <input type="checkbox"/> On-line (tutored) <input type="checkbox"/> Visio <input type="checkbox"/> Work-based training <input checked="" type="checkbox"/> On-site training <input type="checkbox"/> Hybrid on-site/on-line <input checked="" type="checkbox"/> Other (specify): CEA-INES research laboratories tour + INES-PFE pedagogical platform tour
DATES EXPECTED OPENING	06/2022
DATES AVAILABILITY	<input type="checkbox"/> 365 days accessible <input checked="" type="checkbox"/> Other (specify): according to trainers' availabilities and trainees' demand
WORKLOAD STUDENT (in hours)	7 to 14 (according to desired technical level and optional research labs and pedagogical platform tours)
TYPE OF TRAINING	<input checked="" type="checkbox"/> Initial VET <input checked="" type="checkbox"/> Continuous VET <input type="checkbox"/> Work-based training
EQF LEVELS	<input type="checkbox"/> EQF 3 <input type="checkbox"/> EQF 4 <input checked="" type="checkbox"/> EQF 5 <input checked="" type="checkbox"/> EQF 6 <input checked="" type="checkbox"/> EQF 7 <input type="checkbox"/> EQF 8
LANGUAGES	<input checked="" type="checkbox"/> English <input checked="" type="checkbox"/> Others (specify):French.....
MAIN SUBJECT	<input type="checkbox"/> Design and manufacture of PCB <input type="checkbox"/> Microelectronics packaging technologies <input type="checkbox"/> Integrated circuits design <input type="checkbox"/> System design <input type="checkbox"/> Fundamentals of microelectronics manufacturing <input checked="" type="checkbox"/> Microelectronics for a greener economy <input type="checkbox"/> Key competences and skills <input type="checkbox"/> Other (specify):

COURSE DESCRIPTION	Solar photovoltaic (PV) energy will become in a mid-term scale one of the World main energy sources while industrial production shall come back to Europe in a short-term scale. In this context and in order to integrate this sector at the cutting edge of technology, it is important to have an expert knowledge on Energy, electricity and photovoltaic markets, while understanding the basics of PV cell and module science, technologies and fabrication process.	
KEYWORDS	<i>KW1- Photovoltaics</i> <i>KW2- Electricity and photovoltaic markets</i> <i>KW3- Microelectronics for photovoltaic applications</i>	
LEARNING OBJECTIVES	<i>LO1-</i> Understand the photovoltaic principle as well as the opportunities and limitations of PV technology <i>LO2-</i> Identify the different PV cell technologies and the general trends and technological innovations in PV <i>LO3-</i> Apprehend the different microelectronic tools used for the fabrication of standard PV cells and modules	
PREREQUISITES	<i>P1-</i> Basics in energy <i>P2-</i> Basics in electricity <i>P3-</i> Basics in physics of materials and microelectronics	
LEARNING OUTCOMES	<i>Knowledge:</i>	<i>K1-</i> Overview of PV industrial sector status and PV applications <i>K2-</i> Overview of PV cell and module technologies <i>K3-</i> Overview of PV cell and module fabrication process, characterization
	<i>Skills:</i>	<i>S1-</i> Master the operating principle of PV and the different PV cell technologies <i>S2-</i> Identify trends and technological innovations in PV <i>S3-</i> Understand the different stages of manufacturing standard PV cells and modules, as well as their characterization
	<i>Responsibility and Autonomy:</i>	<i>C1-</i> Ease with interacting with interlocutors who do not master solar technologies <i>C2-</i> Proactivity in orienting technological solutions
MODULES	<i>Module1</i>	<i>Title:</i> Photovoltaic electricity market status
		<i>Description:</i> Energy, electricity, renewable electricity and photovoltaic markets Description of photovoltaic installations and overview of applications Life cycle assessment, recycling, carbon footprint and circular economy
	<i>Module2</i>	<i>Title:</i> Basic Physics of photovoltaic cell
		<i>Description:</i> Semiconductors properties, p-n junction and photovoltaic cell Outstanding characteristics and limits of crystalline silicon for PV

MATERIALS			Characterization and key parameters of silicon solar cells
	<i>Module3</i>	<i>Title:</i>	The different PV cell technologies.
		<i>Description:</i>	<p>1st generation PV cells: crystalline silicon Mainstream PERC cell fabrication process Advanced concepts for Si PV cells Research routes and industrial trends</p> <p>2nd generation PV cells: low cost thin films</p> <p>3rd generation PV cells: high efficiency, concentration and space PV</p> <p>Emerging PV: the tremendous growth of Perovskite solar cells</p>
	<i>Module4</i>	<i>Title:</i>	PV module fabrication process and characterization
		<i>Description:</i>	<p>Architecture of standard PV modules</p> <p>Manufacturing process, technological innovations and industrial trends</p>
	<i>Module 5</i>	<i>Title:</i>	CEA-INES research laboratories tour
		<i>Description:</i>	<p>Silicon crystallization</p> <p>Fabrication and characterization of PV cells</p> <p>Fabrication, characterization and accelerated ageing of PV modules</p> <p>Outdoor research platform of PV systems</p>
	<i>Module 6</i>	<i>Title:</i>	INES-PFE pedagogical platform tour
		<i>Description:</i>	<p>Outdoor pedagogical platform of PV systems showing the different practical applications of PV</p> <p>Indoor pedagogical platform of PV systems (components, wiring, installation, safety...)</p>

	<input type="checkbox"/> <i>Podcasts</i>
EXTERNAL RESOURCES	<input checked="" type="checkbox"/> <i>Links to webs</i> <input type="checkbox"/> <i>Videos</i> <input type="checkbox"/> <i>Tutorials</i> <input checked="" type="checkbox"/> <i>Books/chapters</i> <input checked="" type="checkbox"/> <i>Journal articles/conference papers</i> <input type="checkbox"/> <i>Related/complementary modules/courses (links to other ECOVEM courses)</i> <input checked="" type="checkbox"/> <i>Other (Add as many lines as needed) exhibition of different generations of solar PV cells and modules + research samples</i>
ASSESSMENT AND EVALUATION (Each module should have its own evaluation as well as the whole course)	<p>Percentage of completion</p> <input type="checkbox"/> <i>Assessment based on completion materials (videos, quizzes, etc.)</i> <p>Auto-assessment tasks</p> <input checked="" type="checkbox"/> <i>Fixed quizzes</i> <input type="checkbox"/> <i>Adaptative quizzes</i> <input type="checkbox"/> <i>Drag and drop activities</i> <input type="checkbox"/> <i>Video-quizzes</i> <input type="checkbox"/> <i>Virtual simulators</i> <p>Peer assessment tasks</p> <input type="checkbox"/> <i>Assessment based on peer activities</i> <p>Self-assessment tasks</p> <input type="checkbox"/> <i>Essay based on topics and providing a document as solution</i> <input type="checkbox"/> <i>Laboratory practices - laboratory work</i> <input type="checkbox"/> <i>Assessment based on software simulation activities</i> <p>Teacher assessment tasks</p> <input checked="" type="checkbox"/> <i>On-site examination</i> <input type="checkbox"/> <i>On-line examination</i> <input type="checkbox"/> <i>Laboratory practices - laboratory work</i> <input type="checkbox"/> <i>Assessment based on software simulation activities</i>
HOME IMAGE OF THE COURSE (jpg or png)	 <p style="text-align: center;">Principle of PV cells and the different PV cell technologies</p>
INNOVATIVE LEARNING METHODOLOGIES (We included in the Project Proposal the Performance-centered	<input type="checkbox"/> <i>Performance-centered approach and Electronic Performance Support Systems</i> <input checked="" type="checkbox"/> <i>Innovation in instructional design</i> <input type="checkbox"/> <i>Project-Based Learning</i> <input type="checkbox"/> <i>Activity Based Learning</i>

<p>approach and gender and inclusive diversity)</p>	<ul style="list-style-type: none"> <input type="checkbox"/> <i>Simulation Based Learning</i> <input type="checkbox"/> <i>Remote and Virtual Laboratories</i> <input type="checkbox"/> <i>Blended Learning</i> <input type="checkbox"/> <i>Microlearning</i> <input type="checkbox"/> <i>Open educational resources (OER)</i>
<p>INTERNAL COMMENTS :</p>	<p>This course is modular and adjustable in terms of duration and technical level (EQF 5 to 7). The modules of courses 6.2 and 6.3 can be combined with this course according to trainees' skills and expectations</p>