Digital Training Manual

1.Introduction: SING for GREEN integrates sustainability into Additive Manufacturing (AM) curricula. This manual guides trainers to the **pedagogical methodologies**, materials and **best practices** useful for the use of the materials and the delivery of the course, as designed by the SING for GREEN consortium. The course aims at supporting professionals, educators and students in AM, including those in design, engineering and sustainability sectors.

2.Trainee Pre-requisite Knowledge Requirements: Basic knowledge of engineering, manufacturing, and CAD. Familiarity with AM technologies, material science, optimization, sustainability, and engineering software are beneficial. Prior exposure to design methodologies, structural analysis, and LCA aids in advanced topics.

3.Course Structure: The training program consists of two core Competence Units (CUs):

i. **CU-A: Additive Manufacturing Life Cycle Assessment and Sustainability** (7 hours; workload: 14 hours): CU-A serves as the introductory unit, covering fundamental sustainability tools, business case studies, and two case studies depicting the effect of sustainability analysis for various manufacturing processes.

ii. **CUB: Sustainability-Driven Design Strategies** in AM (14 hours; workload: 28 hours): CU-B builds on CU-A, focusing on advanced AM design methodologies such as topology optimization, generative design, part consolidation, and lattice structures.

CU-A and CU-B are complementary but independent: learners can specialize in either sustainability assessments (CU-A) or advanced AM design (CU-B) as needed.

4.Course Content Delivery: The training follows a structured sequence, introducing theory before moving to practical applications. It includes step-by-step guidance on software tools for topology optimization, generative design, and sustainability assessments. It can be delivered in-person, online, and hybrid. In-person sessions are best supported using physical materials, live software demonstrations, and group exercises. Synchronous virtual sessions should include screen-sharing, tutorial demonstrations, and open discussions. Hybrid delivery combines both approaches, using online content for flexibility and in-person workshops for hands-on engagement.

5.Curriculum Overview and Resources:

Topic	Material	Further Resources
CUA: Additive Manufacturing Life Cycle Assessment and Sustainability	• Presentations & Lecture Notes on sustainability concepts, LCA methodologies, and databases • Case Studies comparing AM and traditional manufacturing • Recorded Lectures & Videos explaining sustainability in AM • Interactive Exercise using LCA tools	• LCA Tools: SimaPro, GaBi, OpenLCA (official documentation and tutorials) • Research Papers on sustainable AM design • Industry Reports on sustainability in AM (e.g., from ASTM, ISO, EWF)
CUB: Sustainability-Driven Design Strategies in AM	• Software Tutorials for topology optimization (Altair Inspire, ANSYS, Autodesk Fusion 360) • Simulation Tools & CAD Models for generative design and part consolidation • Interactive Worksheets & Exercises for hands-on learning • Case Studies from aerospace, automotive, and biomedical applications.	• AM Software Documentation (Fusion 360, ANSYS, Topology, Materialise Magics) • Scientific Articles on advanced AM design and optimization • Industry Best Practices for implementing AM in manufacturing.

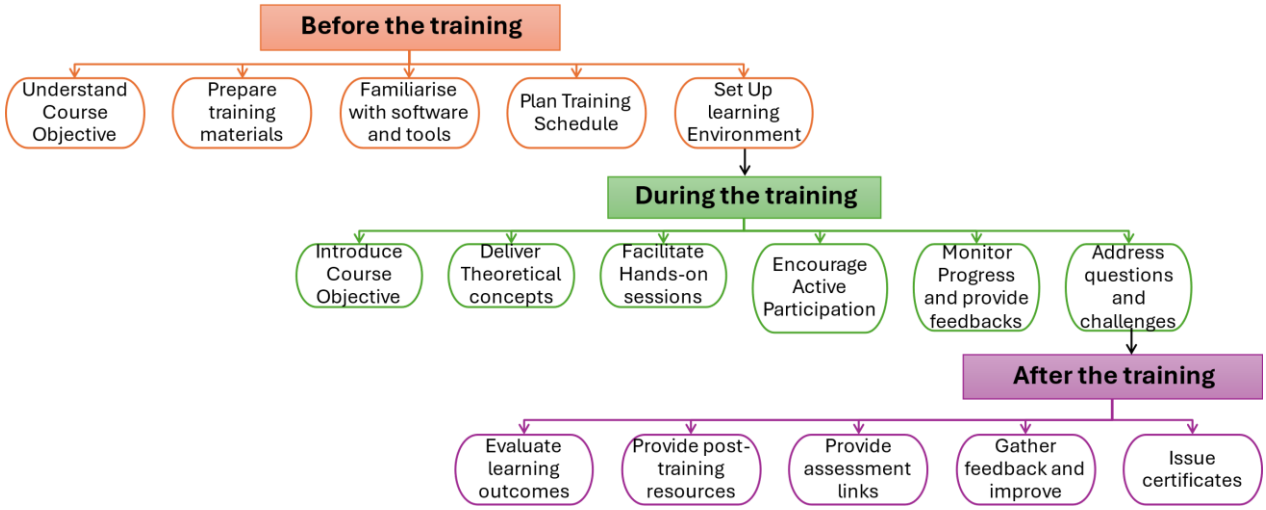
6. Use of Teaching Materials and Learning Platform: Utilize presentations, videos, simulation tools and sustainability databases to enhance learning. Provide clear instructions for accessing and navigating online learning platforms (if applicable). Ensure trainees are familiar with software tools required for design and analysis.

In the context of the pilot training implemented during the project, the following guidelines apply:

7. Trainer-Trainee Responsibilities, Assessment and Evaluation: Trainers must maintain accurate attendance (minimum 60%) and engagement records, support trainees in overcoming challenges. Trainers must ensure participants complete their within one week of the CU(s) delivery. Each CU has separate assessments and certification, awarded upon achieving at least 60% of the grades. Participants who do not pass the assessment can retake the exam after a defined period (e.g., 1 week), with a maximum of three reassessments.

8. Post Training Activities: Ensure all participants complete the required assessments before certification. Provide trainees with post-training resources for continuous learning and professional growth.

9. Suggested Teaching and Learning Journey



Innovative Learning and Teaching Pedagogy

Methodology	Purpose and impact	How?	Where in the Curriculum?
Case-Based Learning	Encourage critical thinking; integrate technical and sustainability considerations	Create real-world scenarios where learners navigate sustainability trade-offs in design choices	CUA Business case studies, Case Studies
Learning by Doing	Supports hands-on learners; deepens tool mastery	Include simulation and AM software walkthroughs	CUB Topology optimization, Part consolidation
Problem-Based Learning	Develops problem-solving and foster independence and applied problem-solving	Present structured problems with multiple possible solutions	CUA Business case studies, Case Studies
Critical Knowledge Construction	Encourages analysis and evaluation	Case-based learning and comparisons	CUA Case Studies, CUB
Technology-Enhanced Learning	Improves engagement, interactivity, and real-world tool familiarity	Use interactive and digital tools to enhance learning experiences using CAD, simulations and blended learning	CUB Generative Design, Topology Optimization & Lattice Structures