Ref. Ares(2025)4546975 - 06/06/2025

D5.2b

Training programmes, storyboards and materials

skillbill

SKILL TO BOOST INNOVATION & PROFESSIONAL FULFILLMENT IN A SUSTAINABLE ECONOMY

Sinergie

23 / 05 / 2024

Funded by the European Union

PROJECT INFORMATION

PROGRAMME	Horizon Europe
TOPIC	HORIZON-CL5-2021-D3-02-02
TYPE OF ACTION	HORIZON Coordination and Support Actions
PROJECT NUMBER	101075587
START DAY	1 September 2022
DURATION	36 months

DOCUMENT INFORMATION

TITLE	Training Programmes, storyboards and materials (final version)
WORK PACKAGE	WP5
TASK	T5.2.2, T5.2.3
AUTHORS (Organisation)	Giovanni Pede (SINERGIE), Angelo Montanari (SINERGIE), Santeri Saarinen (METROPOLIA), Simona Baldovskà (PEDAL), Stanislava Druskova (PEDAL)
REVIEWERS	A.Kalaouzi, G. Efraimidis, G. Tsogas (Q-PLAN), E.G.Facci, A. Rosati (AzzeroCO2)
DATE	22/05/2025

DISSEMINATION LEVEL

PU	Public, fully open	x
SEN	Sensitive, limited under the conditions of the Grant Agreement	
Classified R-UE/EU-R	EU RESTRICTED under the Commission Decision No2015/444	
Classified C-UE/EU-C	EU CONFIDENTIAL under the Commission Decision No2015/444	
Classified S-UE/EU-S	EU SECRET under the Commission Decision No2015/444	

DOCUMENT HISTORY

VERSION	DATE	CHANGES	RESPONSIBLE PARTNER
1.0	15/12/2023	Notification	SINERGIE
1.01	19/12/2023	Layout, content	SINERGIE (upon feedback by Q-PLAN)
2.0	22/12/2023	Content Systematised	SINERGIE (upon feedback by White Research and PEDAL Consulting)
2.01	26/02/2024	Finalization of the Instructional Design and update of table of lessons content	SINERGIE (upon feedback by AzzeroCO2)
3	11/04/2025	Inclusion of new courses	SINERGIE, MET
4	22/05/2025	Finalisation of the deliverable + review	SINERGIE, PEDAL, Q-PLAN, A0

TABLE OF CONTENTS

ABBREVIATIONS

ADDIE	Methodology encompassing Analysis, Design, Development, Implementation, and Evaluation
AR	Augmented Reality
EM	Energy Manager
EnPI	Energy Performance Indicator
EQF	European Qualification Framework
HVAC	Heating, Ventilation, Air Conditioning
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
PA	Public Administration
RES	Renewable Energy Sources
SB	Storyboard
STEM	Science, Technology, Engineering and Mathematics
UI	User Interface
TBA	To Be Announced
VET	Vocational Education & Training
VR	Virtual Reality
WP	Work Package
XR	Extended Reality
PV	Photovoltaic Panels

Executive Summary

Deliverable D5.2b presents the final outcomes of Task 5.2 under Work Package 5 (WP5) of the SKILLBILL project, which focuses on skilling, reskilling, and upskilling in the renewable energy sector through Vocational Education and Training (VET). It encompasses the design and implementation of training schemes, instructional frameworks, and learning materials developed to support energy transition competencies, particularly targeting technicians and public administration staff.

The deliverable is structured into three main components:

1. **Training Schemes for PA and Technicians** (Task 5.2.1):

   Based on the needs analysis from Task 5.1, tailored training programs were developed for two professional profiles: Energy Managers and Photovoltaic (PV) Technicians. These schemes outline specific competencies, learning outcomes, and modular structures, with a strong emphasis on blended learning models and soft skills integration.

2. **Instructional Design** (Task 5.2.2):

   Storyboards were designed to support the learning journey through both traditional and digital means, incorporating mobile-accessible Augmented Reality (AR) simulations. The instructional design aligns with the ADDIE framework to ensure pedagogical coherence and technological feasibility.

3. **Content Design** (Task 5.2.3):

   Detailed course materials were created in collaboration with subcontractors and academic partners, including interactive AR experiences. Two immersive tools—a mobile simulator for energy audits and another for PV panel installation—were developed to enhance hands-on learning in a virtual environment.

The deliverable culminates in a comprehensive, multilingual training program implemented in various formats across multiple countries. These include synchronous and asynchronous sessions, gamified content, and AR-enhanced modules to maximize accessibility, engagement, and real-world applicability. The result is a scalable, inclusive training model that aligns with EU directives, promotes gender equity in STEM, and responds directly to workforce needs in the renewable energy domain.

1. INTRODUCTION

1.1 SKILLBILL's Project and Goals

SKILLBILL, a Horizon Europe-funded initiative spanning 36 months, endeavours to catalyse innovation and professional fulfilment in a sustainable economy. The primary objective is to establish a robust foundation for the accelerated deployment of renewable energy sources (RES). This multifaceted project engages stakeholders across various levels, propagates scientific culture, and empowers a diverse workforce through skill enhancement.

1.1.1 *Core Principles*

The underlying principles driving SKILLBILL are:

Dissemination at Different Levels: ensuring that knowledge is shared at various levels.

Training a Diverse Workforce: tailoring knowledge to train a specified number of workers.

Increasing Awareness on RES: making knowledge instrumental in raising awareness about Renewable Energy Sources.

Promoting Social Inclusivity: contributing to a more social and inclusive Europe.

1.1.2 *Pathways for Motivation and Involvement*

SKILLBILL aims to create pathways that motivate and involve individuals in RES, irrespective of their initial education or job position. Leveraging the technological potential of RES involves generating interest in the business and employing clear, accessible approaches such as tools and learning modules featuring user-friendly language.

1.1.3 *Concrete Actions*

SKILLBILL proposes concrete actions to accelerate the deployment of renewable energy:

Engaging Stakeholder Community: Through a Stakeholder Joint Initiative, organizing working groups focused on different thematic technologies. This initiative aims to steer the development of sustainable technologies and foster discussions on technology drivers and regulatory recommendations with ultimate goal to translate technological advances into new education/training needs .

Knowledge Sharing and Peer Learning: Utilizing a dedicated Green Portal to disseminate validated material on RES. The portal includes educational videos, interviews, training lectures, and open discussion forums. A Scientific Advisory Board ensures the quality of the material, allowing partners, users, citizens, students, and technology providers to contribute.

Skilling, Upskilling, and Reskilling: Launching education programmes targeting different user groups:

- Young People (adults): Interested in acquiring RES skills for career and professional development.
- Adults: Particularly those unemployed or at risk of job loss, seeking to acquire new competences to stay competitive.

Employed Individuals: Including public administration technicians and RES professionals, looking to update competences for career advancement.

1.1.4 *Facilitating Education Programmes*

SKILLBILL employs flexible provision methods, including modular courses and distance learning, supported by new technologies such as virtual reality. A dedicated e-learning platform enhances accessibility, facilitating the participation of diverse individuals in SKILLBILL education programmes.

1.2 Focus on WP5 "Skilling, reskilling and upskilling: Vocational Education and Training"

SINERGIE takes the lead in Work Package 5 (WP5) titled "Skilling, reskilling and upskilling: vocational education and training," a pivotal component extending from the project's inception to Month 33, nearing to project end.

This WP harbours ambitious objectives at the European Union (EU) level, striving to accomplish two Significant Objectives (SOs):

- SO4: Formulating a technical, practical, and enduring Vocational Education Training (VET) program focused on Renewable Energy Sources (RES).

- SO5: Diminishing the gender gap prevalent in Science, Technology, Engineering, Mathematics (STEM).

In essence, WP5 involves the execution of the SKILLBILL training program and content meticulously tailored for adult learners and professionals. The training actions will be meticulously developed employing the ADDIE methodology, encompassing Analysis, Design, Development, Implementation, and Evaluation.

The leading Partner in WP5 will orchestrate the design of training curricula, scrutinizing interactions with the e-learning platform, the learning experience, and content, all rooted in a comprehensive analysis of the needs and requirements of potential users. The outcomes of this analysis will be intricately woven into the digital environment designated for delivering the training.

WP5 unfolds through a well-structured array of tasks and subtasks:

T5.1 "Segmentation and Training Needs Analysis": Delving into the intricacies of this task, Chapter 3 of the Deliverable provides a more exhaustive exploration.

T5.2 "Curriculum and Content Design":

- T5.2.1 "Training schemes for PA and technicians": Building upon the results of T5.1, this subtask will delineate the programs and methodologies for the training courses, elucidating the training objectives for each course.
- T5.2.2 "Instructional design": This task aims to leverage storyboard design to define users' journeys, their interactions within the platform, and the design of digital learning materials.
- T5.2.3 "Content design": Encompassing the implementation of training materials and support within the platform.

T5.3 "Piloting and Validation of Training Courses":

- T5.3.1 "Train the trainers": In this subtask, trainers will be meticulously selected for each Partner country, introduced to the project's scope, and familiarized with the optimal utilization of the training material through specific training sessions.
- T5.3.2 "Replication": This involves potential adaptations, coordination of translations, and the replication of the course in non-partner countries.
- T5.3.3 "Monitoring and evaluation": Rigorous monitoring of training activities will be ongoing, with data collection crucial for assessing criteria such as the usability of digital tools, the evaluation of the learning experience, teaching performance of trainers, user satisfaction, and the overall evaluation of the course, platform, and contents.

2. Task 5.1

2.1 Task Goals

The primary objective of Task 5.1 (T5.1) is to meticulously identify and delineate the distinct user segments slated to be the focal point of the forthcoming training courses. Within the ambit of each identified segment, a comprehensive analysis of training requirements will be conducted, delving into the realms of extant and anticipated skill sets, burgeoning needs on the horizon, proficiency in leveraging digital media, and overarching expectations associated with the courses. Beyond serving as a foundational resource for shaping the contours of the training initiatives, this in-depth analysis furnishes pivotal benchmark data instrumental in gauging the efficacy of the overall project and appraising the calibre of the courses and accompanying materials engendered through this multifaceted endeavour.

2.2 Methods

2.2.1 *Interviews*

The integration of information derived from raw, anonymized results of partner-conducted interviews, collected as part of the broader T2.1 initiative, is a deliberate effort to augment the discussion's completeness and reliability. This move emphasizes the importance of grounding discussions in factual statements from stakeholders. The results can be summarised as follows:

2.2.1.1 Obstacles to RES Development

Two formidable barriers identified universally across the board impede the progress of Renewable Energy Sources (RES) technology and related jobs: a pervasive lack of awareness and a resistant public attitude, encapsulated in the “Not In My Backyard (NIMBY)” phenomenon. Despite RES's growing popularity, there exists a notable gap in disseminating information about incentives, training opportunities, and future labour market developments. The NIMBY sentiment, notably against wind blades, poses challenges to RES programs. However, considering RES's potential as a significant job creator, strategic communication and training programs become crucial.

2.2.1.2 SKILLBILL’S Training Courses

Key components influencing the effectiveness and marketability of SKILLBILL’s training courses include identifying target users, outlining motivational factors, and crafting a suitable delivery methodology. The interviews underscore the pivotal role of these elements in shaping the success of the training initiatives.

2.2.1.3 Target Users

Balancing social aspirations for greater inclusion with practical limitations is crucial when defining target users. While there is room for increased female participation, the diversity and technical nature of RES fields necessitate specialization. Target groups should be broad, encompassing both employed and unemployed individuals, with defined minimum requirements for technical courses.

2.2.1.4 Motivational Factors

Anticipated job opportunities in RES underscore the need for targeted strategies to address the industry's demand and workforce shortage imbalance. Effective communication of motivational factors, including free courses with career-enhancing potential, is vital. Leveraging the "green" nature of courses can be a strategy to attract female participants, as data shows that females tend to be more inclined towards environmental protection, alongside structuring courses with flexibility for working parents.

2.2.1.5 Delivery Methodology

Constructing an impactful and time-worthy training methodology involves considering various facets. The surge in digital, online training solutions post-Covid-19 is acknowledged, highlighting benefits such as accessibility, flexibility, and interactivity. The qualities of trainers, including empathy and the ability to make courses informative and enjoyable, are emphasized. Practical, hands-on activities are deemed essential for a well-rounded training experience, with unanimous favour not leaning towards fully digitalized courses without direct human contact.

2.2.2 *Workshops*

The two Focus Groups were part of the tools devised to collect data during Task 5. They were initially planned to include separate sessions for the Private Sector and Private Administration. Challenges in involving the members of the latter led to the Public Administration Focus Group being transformed into a smaller DELPHI, detailed in Paragraph 2.2.3. Both the Private Sector Focus Group and the PA Delphi were conducted in March 2023.

2.2.2.1 Structure of the Focus Groups

The "Private Sector" Focus Group lasted around 60 minutes, involving a limited number of participants capped at 12. Two Sinergie team members facilitated the session, guided by predetermined questions covering Training Content, Methodology, Critical Points, Risks, and Opportunities. A PowerPoint presentation summarized the project's key aspects, aiding discussions.

2.2.2.2 Key points

TRAINING CONTENT: A consensus emerged for blended learning, combining theoretical instruction with practical experience. In-person training was favoured for engagement, but online distance learning, including Virtual Reality (VR), was acknowledged for flexibility. VR's benefits were recognized, but physical infrastructures for VR simulations were suggested.

DELIVERY METHOD: A consensus emerged for blended learning, combining theoretical instruction with practical experience. In-person training was favoured for engagement, but online distance learning, including Virtual Reality (VR), was acknowledged for flexibility. VR's benefits were recognized, but physical infrastructures for VR simulations were suggested.

TRAINEES' AGE RANGE: The discussion highlighted considerations about the age groups most and least interested in the program, acknowledging the need for practical criteria in participant selection.

BARRIERS: Identified barriers to acquiring new skills in the RES domain included a lack of technical knowledge, while the panel emphasized the importance of soft skills and a flexible mindset.

Course Effectiveness: Participants stressed the effectiveness of a course through practical, hands-on experiences, interactive learning tools, and the creation of an archive for training material.

TARGETS: The necessity for inclusion was acknowledged, but the consensus leaned toward narrowing down target groups based on practical criteria. Two main categories of potential stakeholders were identified, encompassing those directly involved in practical operations and those overseeing them.

COURSE CONTENT: Four major content categories were agreed upon: soft skills, project management, legal/regulatory framework knowledge, and technical skills depending on RES industries. The transversal nature of soft skills was underscored.

MAKING THE PROPOSAL ATTRACTIVE: Key motivating factors for participation included employment prospects, competitive salaries, networking opportunities, eco-friendliness, and the quality and fun of training courses.

2.2.3 *Delphi*

To make up for the missing P.A. Focus Group, which could not be organised due to the insufficient numbers of engaged stakeholders, we submitted a questionnaire to the available ones. The questionnaire was articulated in four parts:

1. Training content
2. Methodology
3. Critical Points
4. Risks and opportunities

The questionnaires were then elaborated using the Delphi method.

The Delphi method[1] is based on the principle that forecasts from a structured group of individuals are more accurate than those from unstructured groups. The experts answer questionnaires in two

[1] BROWN, Bernice B. *DELPHI PROCESS: A Methodology Used for the Elicitation of Opinions of Experts* , The RAND Corporation, Santa Monica, California, 1968

or more rounds. After each round, a facilitator provides an anonymised summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Thus, experts are encouraged to revise their earlier answers in light of the replies of other members of their panel. The process ends when consensus is reached on the results produced by each round, and the mean scores of the final rounds decree the outcome.

Results from the questionnaires and the relative responses can be summarised as follows:

METHODOLOGY: Respondents stressed the need to balance the flexibility of online training with the benefit of practical, hands on experience. Some of them also pointed out that the availability of extra content in the form of a digital repository could be an added value to the training courses. Some others indicated that they, while endorsing the use of digital technology for logistical reasons, they would still favour the use of some sort of physical training material, such as a book, for very specific topics like regulations.

Respondents agreed across the board on the necessity to employ multimedia tools both for on-site and online lessons. None expressed perplexity with regards to the use of VR, albeit none of them has any pre-existing experience with the technology. With regards of computer literacy requirement, the respondents found that basic knowledge of common items like internet browser and programmes like MS Word should be sufficient to follow the courses.

CRITICAL POINTS: Most respondents identified the age range of the participants that could be most interested in attending the course as people in their 30s and 40s, and at least legal age.

With regards to the previous knowledge, one responded mentioned that local regulations should be considered when planning the courses, as some of them mandate having graduated in certain subjects of having attended certain schools to perform certain jobs. In Finland, for example, people can’t work as electricians unless they have graduated from a high-school that guarantees training in the related subjects.

RISKS AND OPPORTUNITIES: The respondents identified three main potential barriers to the fruition of the course.

- The first is that technical jobs in RES which involve working outside entail a certain degree of physical activity, and are typically performed by people who can meet the minimum physical requirements set by the law.

-The second is fitting the course into one’s work-life balance. This issue requires careful consideration in light of the fact it can wield a particularly powerful impact on female attendance, as a consequence of the fact that women are more likely to take up roles as caregiving roles in addition to their professional commitments . Flexible, distance learning technology can be used to mitigate this factor to some extent.

-The third potential difficulty is a lack of sufficient motivation on the side of the course attendees.

With regards to the time-worthiness of the course, the majority of the respondents agreed that it stems from course’s practical usefulness, in its being immediately applicable to solve problems that participants might face at work.

The respondents agreed that the necessity to comply to local regulations and the perspective of accessing the labour market after attending the course.

While finding expectations rather self-evident, namely learning new skills and perfecting those already possessed, the respondents determined that offering high-quality courses will be important to ensuring meeting the participants' expectations

2.3 Conclusions

The following conclusions are drawn from the extensive discussions in Paragraphs 3.2.2 (Interviews), 3.2.3 (Focus Groups), and 3.2.4 (Delphi round). of Deliverable 5.1 *Report on Needs Analysis*

2.3.1 *Target Groups*

Identification of target groups should prioritize inclusivity, aiming to address the predominant male orientation in the Energy Sector, particularly in Renewable Energy Sources (RES). Greater female involvement is not only ethical but also widens the talent pool. The SKILLBILL course holds significant potential for those seeking re-entry into the labour market. The recommendation is to select a limited number of industries, envisioning two levels in the training courses: practical and supervisory. Physical requirements and an age range of 30s and 40s were noted, with no age-based restrictions.

2.3.2 *Training Methodology*

The training methodology must embody flexibility, ensuring compatibility with participants' work-life balance, particularly crucial for female participation. E-learning is favoured for its flexibility, accessibility, and potential for gamification to enhance motivation. While e-learning provides flexibility, participants stressed the importance of in-person activities, hands-on experiences, and the potential of Virtual Reality (VR) in bridging theory and practice.

2.3.3 *Training Content*

Differentiated content for Field Agent and Overseer courses was recommended, with a common focus on transversal soft skills. The overlap of content between areas was considered beneficial, providing a holistic learning experience. Key considerations include practical utility, high-quality design and information, provision for hands-on experience or VR simulations, and the incorporation of practical examples and case studies.

2.3.4 *Driving Factors*

Motivation emerges as a critical driving factor for SKILLBILL course participation. Factors contributing to motivation include the overall course quality, professionalism of trainers, and effective communication of course characteristics and benefits. Job perspectives, environmental impact, potential qualifications, and the flexibility of course delivery were highlighted as significant selling points to attract participants.

3. TASK 5.2

3.1 Overview

Task 5.2 is structured into three subtasks, each contributing to the comprehensive development of training courses within the SKILLBILL project.

3.1.1 *Task 5.2.1 Training Schemes for PA and Technicians*

Objective: Define training course programs based on Task 5.1 results, outlining competencies, knowledge, skills, and learning outcomes. Establish clear training objectives, teaching programs, and potential formal certifications.

Outcome: Design of training curricula specifying competencies, learning objectives, expected results, job processes, and training contents for different segments (PA and technicians).

3.1.2 *Task 5.2.2 Instructional Design*

Objective: Develop the user journey (learning experience) and interactions with the platform and digital learning materials. Create storyboards to guide the development of learning materials and support their integration into the digital environment.

Role of Subcontractor: Subcontracting for instructional design expertise, leveraging AR and instructional design software and hardware. Focus on defining user interactions and experiences, setting the stage for content development in Task 5.2.3.

3.1.3 *Task 5.2.3 Content Design*

Objective: Implement training materials for classroom teaching and asynchronous e-learning. Develop storyboards outlining the user experience and interactions with VR/AR simulators.

Collaboration with Subcontractor: SINERGIE's subcontractor directly supports MET in content development based on their requests. The collaboration is crucial due to SINERGIE's lack of internal digital production skills.

Working Dynamics within WP5:

SINERGIE'S APPROACH

Subcontracts tasks that require specialized digital learning skills, partnering with external bodies possessing VR and instructional design tools.

RATIONALE FOR SUBCONTRACTING

- Specialized Skills: Subcontracting is based on the need for technical skills and specialization in e-learning project design.

- Technology Access: Externalizing tasks ensures access to specific software and tools required for instructional design and content development.

SUBCONTRACTOR'S ROLE

Contributes technical skills and specific software, enriching the consortium's capabilities and technologies.

MET'S LEADERSHIP

While MET leads content design, SINERGIE's subcontractor intervenes to enhance development based on specific requests, addressing localization needs.

OVERALL GOAL

Achieve an effective and enriched consortium by combining diverse skills and technologies, ensuring the successful implementation and testing of SKILLBILL training programs in the VET sector.

3.2 Task 5.2.1 Training scheme for PA and technicians

Task 5.2.1 will result in the production of 2 outcomes: an Energy Manager course and a Photovoltaic Operator course. Given the significant difference in scope and content, each course will be preceded by a dedicated Training of the Trainers. Details on each of the courses are displayed in the table below. Considerable effort was devoted to content optimisation to allow for interoperability of content whenever possible, particularly with regards to the Soft Skills module, which was identified as the de-facto *fil rouge* between the Energy Manager and the Photovoltaic course.

In drafting and compounding the content of the course, the following definitions from the European Qualifications Framework (EQF) have been adopted:

COMPETENCY: that which is needed to perform one's professional function well

KNOWLEDGE: that which is known, either theoretically or factually

SKILL: that which can be used to find a cognitive and / practical solution to a problem. Skill can be cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments).

COMPETENCE: the autonomous application of knowledge and skills

The table below illustrates the basic structure of the course, in which the global Competency is articulated in Knowledge, Skills

Table 1 - Competency Structure

		Competency		
Module	**Title**	**Knowledge**	**Skills**	**Competence**
Module 1	Module title	that which is known, either theoretically or factually, as a result of attending this module	that which can be used to find a cognitive and / practical solution to a problem	the autonomous application of knowledge and skills acquired through this module
Module 2	Module title	that which is known, either theoretically or factually, as a result of attending this module	that which can be used to find a cognitive and / practical solution to a problem	the autonomous application of knowledge and skills acquired through this module

The following table describes the delivered VET courses in SKILLBILL. The first family of courses includes an Energy Manager course and the relative Training of the Trainers. The second family of courses includes a Photovoltaic course and the relative Training of the Trainers.

The table includes replications in Italy and Slovakia. Different format has been adopted for the courses.

Table 2 - VET Courses Families

Course number	Slated date	Title	Target audience	Number of hours	Delivery mode	Delivery language	Topics
1	February 2024	Energy Manager - Training of the Trainers	Selected professionals matching the relative description	2	Online synchronous	English	Energy management training contents: how to use them in training activities; how to use storyboards to replicate SKILLBILL courses; how to use the AR energy audit simulator
2	April 2024	Energy Manager	Technicians	8	Blended (6 hours asynchronous + 2 hours online synchronous (AR Experience)	English	Energy Manager Profile RES technology Economy, finance and energy management Audit – AR Experience Soft Skills
3	December 2024	Training of the Trainers	Selected professionals matching the relative description	2	Online synchronous with AR experience	English	Delivery of quality online training of Photovoltaic technologies AR experience: installation of PV panels
4	February – June 2025	Photovoltaic Panels (2 intakes): feb + apr	Technicians	8	Online asynchronous with AR experience	English	Introduction; Fundamentals and theory of PV; Power electronics; Balance of the system; Panels

							installation; AR experience: installation of PV panels
5	December 2024	Replication of ToT (both EM + PV)	Trainers and training project designers from accredited VET bodies of Emilia-Romagna	4	Online synchronous with AR experience	Italian	Introduction to the SKILL BILL project; type of contents created; using storyboards; gamification to train technicians on RES
6	December 2024	Replication of ToT (both EM + PV)	Trainers and training project designers from accredited VET bodies of Lazio	4	Online synchronous with AR experience	Italian	Introduction to the SKILLBILL project; type of contents created; using storyboards; gamification to train technicians on RES
7	February – June 2025	Energy Manager - Training of the Trainers (round 2)	Energy Managers and trainers interested in becoming trainers on RES and Energy management	2	Online asynchronous with AR experience	English	Energy management training contents: how to use them in training activities; how to use storyboards to replicate SKILL BILL courses; how to use the AR energy audit simulator
8	March – June 2025	Energy Manager	Technicians	8	Online asynchronous with AR experience	English	Energy Manager Profile RES technology Economy, finance and energy management Audit – AR Experience Soft Skills Live lesson of round 1 on energy audit turned into an energy
9	March – June 2025	Photovoltaic Training of trainers	Technicians interested in becoming trainers on RES and Energy management	2	Online asynchronous with AR experience	English	Newly recorded video-lessons, including how to use skill bill contents, storyboards and AR simulator in training

							activities and how to create a lesson plan
10	April-May 2025	Photovoltaic Panels installation	Students of Matej Bel University in Banská Bystrica + Gymnázium Fiľakovo (2 editions)	8	On site + online asynchronous with AR experience	Slovak	Introduction to the SKILL BILL project; type of contents created; using storyboards; gamification to train technicians on RES
11	May 2025 (a second edition is foreseen in June 2025)	“Management dell’Energia” (technical course including both EM+PV materials)	Professionals (reskilling/upskilling), unemployed and university students	16	Online synchronous with 2 AR experiences	Italian	Selection of EM (energy audit principles) and PV modules (installation) + usage of both AR simulators

3.2.1 *Energy Manager*

The rationale behind offering an Energy Manager VET course is a direct product of the results of Needs Analysis performed in Task 5.1, which can be summarised as follows:

3.2.1.1 Target groups

The identification of target groups should take the following principles into account:

Inclusivity: the Energy Sector in general is still predominantly male-oriented, and RES as no exception. Greater female involvement is desirable not only on ethical grounds, but also as a way of expanding the talent pool to be tapped into. A SKILLBILL course could be significantly beneficial for those seeking to re-enter the labour market.

Pragmatism: the variety and complexity of the RES field means that it is not feasible to train everyone to do everything. A small number of industries should be selected and courses planned accordingly. Participants in the Focus Group concurred on the need to envisage at least two levels in the training courses: the more practical ones, that would require some sort of pre-existing knowledge or training to conform to national regulations, and those designed to train the personnel who will oversee and / direct the operations of those work on the ground. People without pre-existing technical skills to conduct practical activities on the ground could more easily fit in the latter category.

Some participants in the Delphi round remarked that physical requirements should be considered when setting the parameters for accessing the courses for those performing hands-on activities in the field, as these professions are typically more physically demanding than desk jobs. They also identified people in their 30s and 40s, and at least legal age, as potentially more probably interested in the courses. However, no age-based restrictions will be embedded in the courses. , with the exception of those mandated by the law of the land.

3.2.1.2 Training methodology

The definition of the training methodology and the appropriate tools to bring it to fruition must reflect the following elements:

Flexibility: the courses' set-up needs to be sufficiently flexible to allow those people who would attend it while also having a job to fit it into their work-life balance. This is especially important to boost female participation because of the added complexity deriving from the responsibilities of those who are also home-makers and/or parents. For this reason, the consensus is that e-learning would be the best option.

Accessibility: lessons and didactic materials should be readily and easily accessible, preferably in digital form. A dedicated digital repository has also been mentioned as a valuable resource.

Engagement: there is a broad consensus across the board on motivation being a critical factor in ensuring the success of the course and its time-worthiness. The training methodology should therefore be conducive of a strong motivation across a given time-span. One of the ways in which this can be achieved is embedding some level of gamification into the training methodology, so that the content is not just interesting, but also fun to acquire.

Several participants in the Focus Group and the interviews pointed out that for a course to be truly effective theoretical instruction must be complemented by hands-on experience in the field. Some advocated field trips and visits to actual facilities as excellent opportunities to ask real questions. Others suggested that the use of VR could help bridge the gap between theory and practice, and it could be used to train people how to react appropriately to a determined set of problems in a completely safe environment.

Other participants with trainer's background opined that while the flexibility afforded by e-learning technology is key to ensure participation, trainees have a tendency of being more active during in-person activities, and that cooperation and interaction between them holds great didactic potential, and recommended building some level of peer-interaction into the training methodology.

3.2.1.3 Training content

Following the discussion on Target Groups detailed in Paragraph 3.3.3, participants in the Focus Group agreed on the need to differentiate the training content for those who will take the Field Agent-oriented courses and those who would take the Overseer courses.

However, participants also agreed that at least one module in each area should be dedicated to transversal soft-skills, with particular attention to communication, negotiation, conflict resolution.

They also agreed that the two areas need not be completely different and unrelated. Content overlapping to some degree could be mutually beneficial: engineers for example could benefit from exposure to the more practical aspects of PV panel installing, and vice-versa manual workers could take advantage of some elements of project management.

Therefore, they envisaged two different areas sharing an overarching module on Soft Skills, and a number of modules the majority of which would be specific to a given area, with provisions for overlapping where appropriate and potentially beneficial.

Additional considerations include:

- The training content should be selected and organised to ensure that is practically useful.
- Content should be high quality in both design and information
- Practical examples and case studies should be provided to clarify the course's perceived utility and value.
- Provision should be made for hands-on experience, either directly or in the form of VR simulations.

3.2.1.4 Driving factors

Participants in the Focus Group, Delphi round and Interviews all share the view that motivation is a major driving factor towards participating in a SKILLBILL course. Motivation can be built and maintained through a combination of factors:

- The overall quality of the course
- The ability and professionalism of trainers
- Effective communication of the courses' characteristics and benefits.

With regards to communicating the "selling points" of the SKILLBILL courses, participants in the Focus Groups and the interviews suggested the following:

Job perspectives: given the projected growth of the RES field and the subsequent creation of jobs, trainees can expect to access more easily the labour market with the skills and knowledge acquired with the SKILLBILL courses.

Green: by working in the RES after attending a SKILLBILL course, the trainees could contribute to impacting the environment positively. A growing body of contemporary research reports a consistent, cross-cultural gender-based difference in men's and women's attitude towards environmental topics, with the latter being more interested in fighting climate change and displaying a higher degree of negative emotions towards it compared to the former[2]. This could be leveraged as a drive for a greater inclusion of female workers.

Qualification: attending the course could result in a useful qualification, if such provisions are made beforehand with the competent authorities.

Flexibility: the course can be taken at one's pace taking full advantage of digital learning environments, allowing potential participants to integrate the course into their work-life balance.

The programme is articulated in a Training of the Trainers course and an Energy Manager Course proper. Participants in the Training of the Trainers course will become able to offer the Energy Manager course themselves. Both courses feature an especially-developed, browser-launched game accessible via smartphone, enriched by an AR experience.

3.2.1.5 Training of the Trainers

Broadly speaking, the ideal Trainer has a strong background in Renewable Energy Resources, has a good understanding of the EU-mandate regulations, and an equally good understanding of his/her own country's regulation. He/she is also interested in performing energy audits, and teaching others how to. The course is aimed at familiarising Trainers with the AR experience featured in the Energy Manager course, and with some of the latest best practices in distance learning teaching.

A synthetic description of the Knowledge, Skills, and Competence of the course is displayed in the table below:

[2] https://climatecommunication.yale.edu/publications/gender-differences-in-public-understanding-of-climate-change/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9266259/

https://www.cambridge.org/core/journals/american-political-science-review/article/facing-change-gender-and-climate-change-attitudes-worldwide/38688C0CA6DF889475FDB52C06DD7FF9

Table 3 - Energy Manager Training of the Trainers Competency Matrix

		Competency		
Module	**Title**	**Knowledge**	**Skills**	**Competence**
Module 1	Training of the Trainers	The trainer knows and understands the content of the Energy Manager course, including the game and embedded AR experience's characteristics, gameplay, and the learning goals.	The trainer can use the game and AR Experience to good effect to offer the Energy Manager course.	The trainer can deploy the Energy Manager course with regards to both the theoretical/notional content and its AR experience.

Participants' response will be collected via a dedicated survey, and the information extracted to identify possible ameliorations for successive iterations of the course.

The following pages display the material designed for the recruitment operations which, at the time of the writing of this Deliverable, are effectively ongoing

ARE YOU OUR TRAINER?

skillbill
SKILL TO BOOST INNOVATION & PROFESSIONAL FULFILLMENT IN A SUSTAINABLE ECONOMY

TRAINING OF THE TRAINERS

Energy Managers for Renewable Energy Sources are vital for **optimising** green energy usage and **reducing** carbon footprint. They strategise, monitor, and ensure efficient renewable energy utilisation, advancing sustainability goals. In a world focused on clean energy, these professionals play a pivotal role in shaping a **sustainable future**. But they need to be **trained**.

Will you be part of the challenge?

- if you have a solid **background** in Renewable Energy Sources, and you're prepared to discuss the basics of the most prevalent RES
- if you have a good understanding of **EU regulations**, and you are proficient in your own country's legislation
- if you're interested in Auditing procedures and / Plant Management

get in touch with us, and become the next **Trainer** in the SKILLBILL Programme.

EREF · Metropolia · Università degli Studi della Tuscia · Utrecht University · AzzeroCO2 · PEDAL Consulting · Q-PLAN International · White Research · Sinergie

Funded by the European Union

HORIZON-CL5-2021-D3-02-02

skillbill

SKILL TO BOOST INNOVATION & PROFESSIONAL FULFILLMENT IN A SUSTAINABLE ECONOMY

1 Background info

This Training of the Trainers for Energy Manager courses is part of SKILL BILL, a ground-breaking project funded by the European Union to promote skill, reskill and upskill the workforce.

Participants will receive theoretical knowledge and first-hand experience of cutting-edge AR technology in the field of Energy Manager courses.

This course is the first step in fulfilling SKILL BILL's pledge to provide quality and inclusive access to RES technology-related skills to the workforce of today and tomorrow.

2 Trainer's profile

1. You've got a solid background in Renewable Energy Sources, and you're prepared to discuss the basics of the most prevalent RE
2. You've got a good understanding of EU regulations, and you are proficient in your own country legislation
3. You're interested in Auditing procedures and / Plant Management

3 Roles & responsibilities

Learning how to deliver effective energy management training programmes

Gaining expertise in relevant software and AR experience specifically designed for this course

4 Effort and timing

the trainer training programme takes place in a two-hour synchronous session offered online. Upon completion, you will be able to use the provided materials and the VR/AR to offer courses yourself.

5 Support and resources

Your point of reference will be Sinergie soc.cons. a r.l., a VET Provider with years of experience in European and Energy-related projects. You can contact us at formazione@sinergie-italia.com. All the resources and materials of the course will be made available digitally.

6 Costs

the training is offered completely free of charge

7 Declaration of Interest/Acceptance

See document attached

This Terms of Reference outlines the expectations, responsibilities, and support provided to the Energy Management Trainer during their training program. It is essential for both the trainer and the organization to work collaboratively to ensure a successful training journey.

USE QR CODES BELOW

CONSENT FORM

DECLARATION OF INTEREST

Funded by the European Union

HORIZON-CL5-2021-D3-02-02

3.2.1.6 Energy Manager Course

The Energy Manager course aims at filling the gap in the availability of well-trained, qualified professionals with the right combination of theoretical knowledge and practical skills.

The course has been set up to be taken completely online, with the intent to capitalise on the flexibility of e-learning and thus providing opportunities to all participants to study at their own pace. This is particularly important to facilitate the enrolment of women, both those in paid employment and home-makers.

STRUCTURE

The course encompasses 5 different modules:

1. Professional profile and regulations
2. RES technologies
3. Economics, finance, and energy management systems
4. Energy Audit simulation (theory and AR experience)
5. Soft skills

Details of each course Knowledge and Skills are available in the Energy Manager Competency Matrix displayed in the following page.

FEEDBACK AND ASSESSMENT

Retention of the theoretical aspects of the course will be evaluated by means of a specifically-designed test that participants will sit asynchronously online at the end of each module. Additionally, participants will sit a final test comprising content from all modules upon completion of the course, in identical fashion.

Feedback will be collected by means of a brief online survey at the end of the course. The aforementioned feedback will be utilised to extract lessons learnt and proposals for possible ameliorations during the successive iterations of the course.

Table 4 - Energy Manager Competency Matrix

		Competency		
Module	**Title**	**Knowledge**	**Skills**	**Competence**
Module 1	Professional profile and regulations	The EM knows and understands the general legal framework at a European level, as well as the specific his/her relevant national legislation	The EM is able to make use of the theoretical knowledge of the legal framework a European and National level to identify and plan steps to ensure compliance	The EM can effectively manage the legal aspects of RES energy management by deploying theoretical knowledge combined with the skill to apply it practically.
Module 2	RES technologies	The EM knows the basic characteristics, advantages, and disadvantages of the main RES technologies	The EM is able to conceptualise solutions to problems based on a combination of RES technology characteristics and applications	The EM possesses theoretical knowledge of the main RES technologies and their practical applications
Module 3	Economics, finance and energy management system	The EM knows and understands the ISO 500001:2018, ISO 14000 characteristics and applications, in addition LCA and Integrated Management Systems	The EM can effectively apply his knowledge and expertise to devise and implement result-oriented actions relative to Energy Management	The EM can act in the capacity of Energy Manager and is able to design suitable, workable solution based on the theoretical foundation of Energy Management, LCA and IMS.
Module 4	Energy Audit Simulation (theory + AR simulation)	The EM knows the basic principles the underscore the performance of an Energy Audit	The EM is able to adapt to a variety of situational occurrences that may arise during the performance of the Energy Audit	The EM can perform an Energy Audit in both is technical and interactional aspects
Module 5	Soft Skills	The EM is privy of the fundamentals of effective communication and problem-solving	The EM can communicate timely and effectively to mediate conflicts and identify suitable, satisfactory solutions	The EM is able to apply his theoretical and practical knowledge of communication’s best practices to mediation and problem-solving activities

The following table offers a detailed breakdown of the content of each of the modules making up the Energy Manager Course

Table 5 - Energy Manager Course Syllabus

		Content
Module	**Title**	**Details**
Module 1	Professional profile and regulations	1. Origins 2. Profile of the Energy Manager 3. Energy Manager Vs Energy Management Expert 4. Energy Management Systems 5. Energy Manager Framework 6. Spire Programme and Teacher's Project
Module 2	RES technologies	1. Solar Energy 2. Wind Energy 3. Hydropower 4. Geothermal Energy 5. Biomass Energy 6. Tidal Energy 7. Ocean Thermal Energy 8. Hydrogen Energy
Module 3	Economics, finance and energy management system	**1. UNI 50001:218** 1.1 Implementation 1.2 Objectives 1.3 Energy Policy 1.4 Planning 1.5 Energy Analysis 1.6 Indicators 1.7 Enactment and Operations 1.8 Communication 1.9 Documentation 1.10 Operational Control **2. INTEGRATED MANAGEMENT SYSTEMS** 2.1 Objectives 2.2 Impact on Environment 2.3 Design & Acquisition 2.4 Verification 2.5 Advantages **3. LCA & ISO 14000** 3.1 Definition of Life Cycle Assessment 3.2 Purpose 3.3 Key points 3.4 Advantages 3.5 The ISO 14000 standard **4. LEAN PRODUCTION & LEAN MANAGEMENT** 4.1 Definition 4.2 Origins 4.3 Prerequisites 4.4 Principles

		4.5 The wastes 4.6 “Just in time” 4.7 Principles of the Toyota Way
Module 4	Audit Simulation (theory + AR simulation)	1. Principles of Energy Audit 2. AR Experience
Module 5	Soft Skills	**1. COMMUNICATION** 1.1 Definition 1.2 Communicative Process 1.3 Functions **2. TYPES OF COMMUNICATION** 2.1 Modes of Communication 2.2 Directions 2.3 Styles **3. ASSERTIVENESS** 3.1 Definition 3.2 Praxis **4.COMMUNICATION TRAPS** 5.Examples

This table describes the time allocation for each module of the Energy Manager Course.

Table 6 - Energy Management Course Time Allocation

Module	Topic	Delivery	Mode	Hours
I	Professional profile and regulations	Online	Asynchronous	1
II	RES Technologies	Online	Asynchronous	2
III	Economics, finance and energy management systems	Online	Asynchronous	2
IV	Audit Simulation (theory + AR simulation)	Online	Synchronous	2
V	Soft Skills	Online	Asynchronous	1
Total				8

3.2.2 *Photovoltaic Panels*

The Photovoltaic Panels Course and its relative Training of the Trainers were developed after the realisation of the first round of Energy Manager courses. PV courses includes, as for the EM, Training of trainers' courses and the technical courses for PV installers. The AR experience is focused on

Table 7 - Photovoltaic Panels Course Content

Module	Title	Content
1	Fundamentals of PV	The Terminology of PV A Brief History of PV
2	The Solar Resource	Introduction: The Sun The Solar Spectrum Components of Solar Radiation Estimation of PV Power Production
3	The Working Principle of Solar Cells	Light Absorption and the Photovoltaic Effect Doping of Semiconductors and pn-Junctions Working principles of Solar Cells
4	IV-curves and Equivalent Circuit Model	Introduction: The IV-curve The Maximum Power Point The Non-ideal Diode Equation
5	Series/Parallel Connections and Shading	Electrical Cell Interconnection Mismatch Losses and Bypass Diodes Module Shading
6	Module Design and Fabrication	Module Components Module Fabrication Process Module Design Guidelines and Qualification Tests Cell Cutting Advanced Module Designs
7	Extracting Energy from a PV Panel	PV Power Characteristics PV loading techniques Maximum power point tracking
8	PV Power Conversion	Power Converters in PV Applications DC-DC Converters PV Inverters Efficiency of power converters PV inverter types Interfacing PV Systems with the Electric Grid

3.2.2.1 Training of the Trainers

Broadly speaking, the ideal Trainer has a solid background in Photovoltaic Systems and Renewable Energy Technologies, with a strong grasp of both EU-level directives and national regulations related to solar energy. He/she is experienced in the design, installation, and performance assessment of PV systems, and is passionate about sharing this knowledge with others. The course is designed to familiarise Trainers with the technical, theoretical, and practical aspects of photovoltaic panels, while also introducing them to the use of AR tools and innovative methods for effective distance learning delivery.

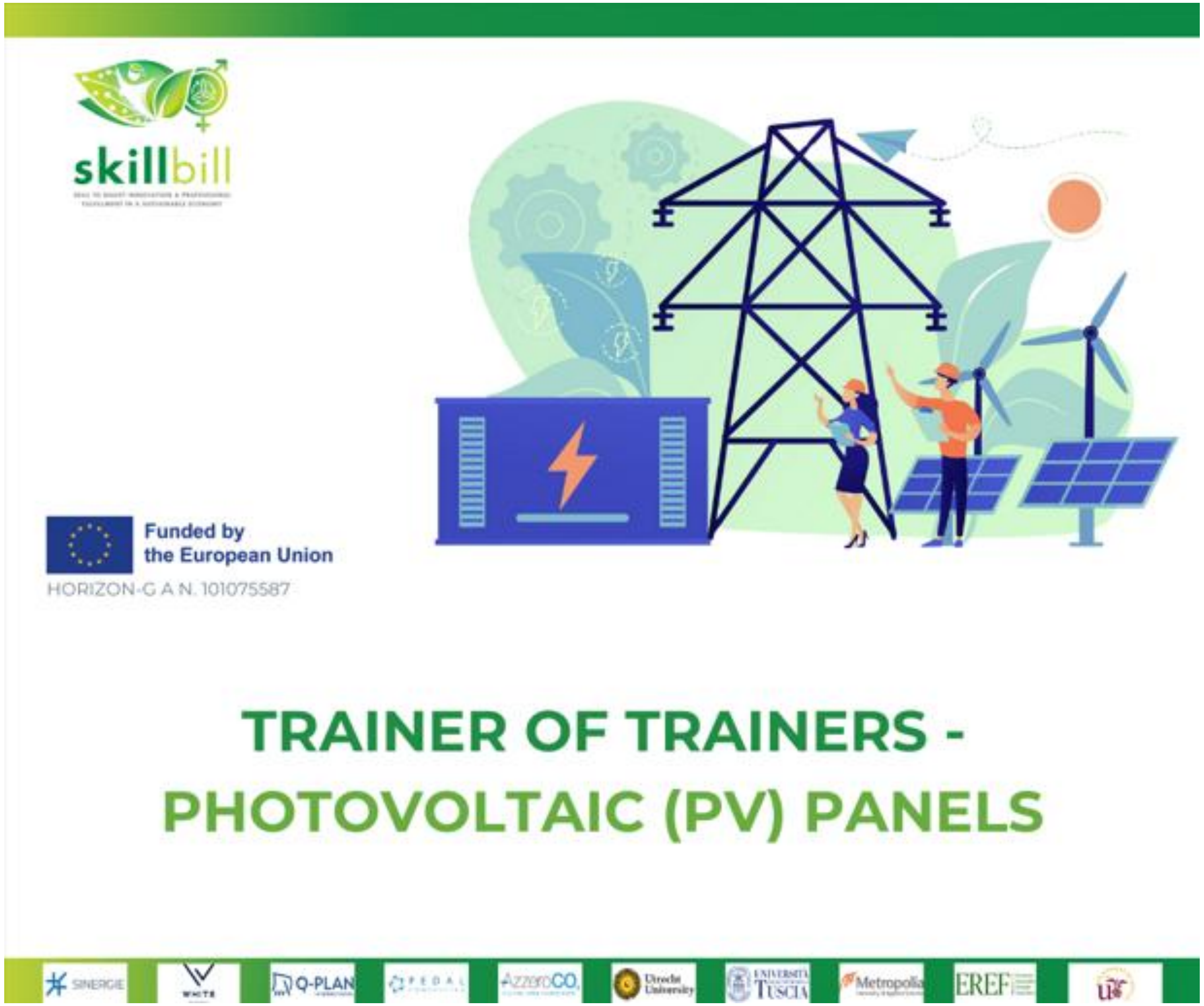
A synthetic description of the Knowledge, Skills, and Competence of the course is displayed in the table below:

Table 8 - PV Training of the Trainers Competency Matrix

		Competency		
Module	**Title**	**Knowledge**	**Skills**	**Competence**
Module 1	Training of the Trainers	The trainer knows and understands the content of the Photovoltaic Panels course, including theoretical foundations, system components, and installation practices, as well as the features and learning goals of the embedded AR experience.	The trainer can use the AR experience and supporting digital tools effectively to teach the PV Panels course content.	The trainer can deliver the PV Panels course, covering both the theoretical and practical aspects, using AR and other interactive teaching methods.

Participants' response will be collected via a dedicated survey, and the information extracted to identify possible ameliorations for successive iterations of the course.

The following pages display the material designed for the recruitment operations which, at the time of the writing of this Deliverable, are effectively ongoing


skillbill
Funded by
the European Union
HORIZON-G A N. 101075587
TRAINER OF TRAINERS -
PHOTOVOLTAIC (PV) PANELS

Funded by the European Union
HORIZON-G A N. 101075587

1 BACKGROUND INFO

This Training of the Trainers for Photovoltaic Panels courses is part of **SkillBill**, a ground-breaking project funded by the European Union to promote skill, reskill and upskill the workforce.
Participants will receive theoretical knowledge and firsthand experience of energyu, power and efficiency as well as the terminology used when speaking of photovolaic panels.
This course is the first step in fulfilling SKILL BILL's pledge to provide quality and inclusive access to RES technology-related skills to the workforce of today and tomorrow.

2 TRAINER'S PROFILE

1. You've got a solid background in Renewable Energy Sources, and you're prepared to discuss the basics of the most prevalent **RE**
2. You've got a good understanding of EU regulations, and you are proficient in your own country legislation
3. You're interested in Auditing procedures and / Plant Management

3 EFFORT AND TIMING

the trainer training programme takes place in a **two-hour asynchronous (self paced)** session offered online. Upon completion, you will be able to use the provided materials.

4 SUPPORT AND RESOURCES

Your point of reference will be Sinergie soc.cons. a r.l., a VET Provider with years of experience in European and Energy-related projects. You can contact us at innovazione@sinergie-italia.com. All the resources and materials of the course will be made available digitally.

5 COSTS

the training is offered completely free of charge

3.2.2.2 Photovoltaic Panels Course

The Photovoltaic Panels course aims to address the shortage of well-trained, skilled technicians equipped with both solid theoretical understanding and practical competence in PV systems. Designed to be delivered entirely online, the course leverages the flexibility of e-learning to make training accessible to a wider audience, enabling participants to progress at their own pace. This approach is especially valuable in encouraging the participation of women, including those currently employed and those managing household responsibilities.

STRUCTURE

The course encompasses 6 different modules:

1. Introduction to Photovoltaics
2. PV Fundamentals
3. Solar Energy and PV Theory
4. Power Electronics in PV Systems
5. Balance of System (BoS) Components
6. PV Installation Practices

Details of each course Knowledge and Skills are available in the PV Competency Matrix displayed in the following page.

FEEDBACK AND ASSESSMENT

Retention of the theoretical aspects of the course will be evaluated by means of a specifically-designed test that participants will sit asynchronously online at the end of each module. Additionally, participants will sit a final test comprising content from all modules upon completion of the course, in identical fashion.

Feedback will be collected by means of a brief online survey at the end of the course. The aforementioned feedback will be utilised to extract lessons learnt and proposals for possible ameliorations during the successive iterations of the course.

Table 9 - PV Competency Matrix

		Competency		
Module	Title	Knowledge	Skills	Competence
Module 1	Introduction to Photovoltaics	The learner understands basic energy concepts, PV terminology, historical development, and the role of PV in modern energy systems.	The learner can contextualize PV technology and explain its relevance, evolution, and core terms.	The learner can clearly describe the role, development, and potential of PV systems within the broader renewable energy landscape.
Module 2	PV Fundamentals	The learner knows the core electrical concepts, types of energy, power, efficiency, and key cost/efficiency metrics (e.g., LCOE).	The learner can interpret and use PV terminology and performance data.	The learner can evaluate and compare basic PV system characteristics using relevant technical and economic indicators.
Module 3	Solar Energy and PV Theory	The learner understands solar radiation, atmospheric impact, semiconductor physics, p-n junctions, I-V curves, and MPP concepts.	The learner can analyse solar irradiance, assess PV panel behaviour, and estimate output based on environmental conditions.	The learner can assess PV panel performance and design based on scientific and environmental factors.
Module 4	Power Electronics in PV	The learner knows principles of MPPT, inverters, DC-DC converters, and power management techniques in PV systems.	The learner can apply concepts like MPPT, converter sizing, and identify inverter types suitable for system configurations.	The learner can optimize PV system performance using appropriate power electronics solutions for both grid-tied and off-grid setups.
Module 5	Balance of System Components	The learner understands electrical and mechanical BoS components, including wiring, protection, mounting, and safety protocols.	The learner can select and configure BoS elements suited to different environments and installations.	The learner can ensure a reliable, safe, and compliant PV system design using appropriate BoS configurations.
Module 6	PV Installation Practices	The learner knows installation steps, safety precautions, electrical connections, grounding, maintenance, and cleaning requirements.	The learner can perform or supervise safe and correct installation and maintenance procedures.	The learner can install, inspect, and maintain PV systems in accordance with technical standards and safety regulations.

The following table offers a detailed breakdown of the content of each of the modules making up the PV Course

Table 10 - PV Course Syllabus

		Content
Module	**Title**	**Details**
Module 1	Introduction to Photovoltaics	1. Course Overview and Objectives 2. Energy, Power, and Efficiency 3. PV Terminology 4. History of PV 5. LCOE 6. PV Adoption Context
Module 2	PV Fundamentals	1. Types of Energy 2. Power and Energy Units 3. Electrical Energy Concepts 4. Efficiency Comparisons 5. Market Trends 6. PV System Types
Module 3	Solar Energy and PV Theory	1. Solar Radiation and the Sun 2. Solar Spectrum and Atmosphere 3. Air Mass and Insolation 4. Semiconductor Physics 5. I-V Curve and MPP 6. Panel Efficiency
Module 4	Power Electronics in PV Systems	1. Kirchhoff's Laws 2. PV Connections (Series/Parallel) 3. MPPT Methods (P&O, IncCond, CV) 4. DC-DC Converters 5. Inverter Types 6. Conversion Efficiency
Module 5	Balance of System Components	1. Electrical BoS: Wiring and Protection 2. Mechanical BoS: Mounting Systems 3. Wind and Snow Loads 4. Environmental Stressors 5. Safety Measures
Module 6	PV Installation Practices	1. Installation Safety 2. Storage and Handling 3. Wiring and Grounding 4. Mounting Techniques 5. Shading and Layout 6. Cleaning and Maintenance

This table describes the time allocation for each module of the PV Course.

Table 11 - PV Course Time Allocation

Module	Topic	Delivery	Mode	Hours
I	Introduction to Photovoltaics	Online	Asynchronous	1
II	PV Fundamentals	Online	Asynchronous	1
III	Solar Energy and PV Theory	Online	Asynchronous	1
IV	Power Electronics in PV Systems	Online	Asynchronous	1.5
V	Balance of System Components	Online	Asynchronous	1.5
VI	PV Installation Practices	Online	Asynchronous	2
Total				8

3.3 Task 5.2.2 Instructional Design

Sinergie contributes to this part of the project by realising the Instructional design of the AR experience for the Energy Manager Course, and by penning the content of the Photovoltaic Panels course.

3.3.1 *Energy Manager*

Originally conceived as full VR experience requiring VR visors, this part of the Energy Manager VET course has been re-conceptualised as a mobile-based AR experience embedded in a game.

The reasons behind this decision are traceable to:

- A logistical assessment
- A cost-benefit analysis

Utilising VR visors would have required not only the purchase or rent the equipment itself, but also to ensure the availability of suitable rooms to conduct training sessions safely, as full VR visors effectively block the user's vision when active. In addition, the use of VR visors might have resulted in an impairment of the replication activities: visors would have had to be shipped to partners, thus incurring in shipping and insurance costs, and limiting availability to only one partner at a time. By transforming the visor-based experience into a mobile-based, game-embedded AR experience, it is possible to contain costs and maximise availability while maintaining good levels of engagement and learning value.

3.3.2 *Content*

An instructional design map detailing the content of modules has been developed. While still subject to adjustments during the content development, the ID MAP (Table 8) offers an overview of topics the trainers will be deal with during the vocational training. Detailed descriptions of modules 1, 2, 3 and 5 are provided in the subsequent tables.

Table 12 - Energy Manager Game and AR Experience ID Map

1. Introduction: gaining the interest, opening the module smoothly while giving the opening information	
	1.1 Let's start!
	1.2 Learning Objectives - Target Audience - Requisites
	1.3 Context of Training
	1.4 Course Map
2. Energy Manager Job Profile	
	2.1 Learning Objectives
	2.2 The professional profile of the Energy Manager
	2.3 The role of the Energy Manager within an organization
	2.4 Areas of intervention of the energy manager
	2.5 The Energy Manager on the European scenario
	2.6 A Case Study: the European Project MAESTRI
3. An overview of RES technologies	
	3.1 Learning Objectives
	3.2 Basic concepts of Energy, power and efficiency
	3.3 Solar energy and PV
	3.4 Wind Energy
	3.5 Hydropower
	3.6 Biomasses
	3.7 Geothermal
4. How companies are organized and the Energy manager role	
	4.1 Learning Objectives
	4.2 The foundations of corporate economy
	4.3 Company organization and functions

	4.4 The PDCA or plan–do–check–act management method
	4.5 Quality management and ISO9001 standards
5. Energy Audit and International regulations and standards	
	5.1 Learning Objectives
	5.2 Standards Overview
	5.3 The Integrated Management System
	5.4 ISO14001 standard
	5.5 Life Cycle Assessment
	5.6 ISO 50001 standard
	5.7 Lean Management
	5.8 VR Example of how to perform an EA
6. Energy Manager hard and soft skills	
	6.1 Learning Objectives
	6.1 Hard and soft skills
	6.2 Energy diagnosis
	6.3 Overview of interventions
	6.4 Project Management
	6.5 Communication: a soft skill for everyone
7. Final Assessment	
	7.1 Introduction
	7.2 Knowledge Check
	7.3 Assessment Results
	7.4 Course Completion

3.3.2.1 Introduction

The following table offers a concise outline of the general characteristics of the Introduction section:

Duration	7' 15''
Characters	Karen, the Energy Manager coach Markus, the learner's alter ego
Notes	The environment could be a university classroom, the actor (or the avatar) will be in the centre and the room windows will be used to present the images described in the storyboard whenever they are 2D images or movies.

The following table contains a synthesis of the segments in which the Introduction section is organised.

Segment	Title	Word count	Expected Duration
1.1	Let's start!	233	1m. 45 sec.
1.2	Learning objectives, Target Audience, Requisites	405	2m. 42 sec.
1.3	Context of Training	242	1m. 30 sec.
1.4	Course Map	285	2m.

A detailed description of the content of the individual segments is available in the tables of the following pages.

1.1 LET'S START

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	[**Karen**] Hi, I am Karen and I will accompany you during this journey – a journey that has the potential to alter your career trajectory but can also contribute to change, at least somehow, the direction our world is heading to. I am very pleased to be your guide to a course that will equip you with the essentials to become proficient as Energy Manager.	Energy Manager	Evocative image related to the course. (eg. Energy-Management-1-768x432.jpg) The on-screen text appears with animation and increases in size
	[**Karen**] Energy management is a multidisciplinary field, so this course will cover technical, managerial, and communication aspects. By offering practical skills and knowledge, the course will effectively prepare you to become a competent Energy Manager who can contribute to sustainability and efficiency in various industries.	Multidisciplinary field Technical Managerial Communication aspects	Evocative image related to the course (e.g. paving-the-path-to-a-sustainable-future-1691419350-2473.jpg) Graphics to show a path. The on-screen text appears with animation and increases in size
	[Karen] The Energy Manager role emerged in response to increasing concerns about energy consumption, environmental sustainability, and the need for efficient energy utilization in various sectors, including industries, commercial buildings, and residential spaces. The figure of the Energy Manager was born in the USA at the time of the first oil crisis of 1973. In Italy it was already institutionalized by law 308/82, but with law 10/91 the energy manager role receives a new and stronger impulse. In fact, the "Manager for the conservation and rational use of energy what we call in short "Energy Manager" is now mandatory in Italy for industrial realities with consumptions exceeding 10,000 toe/year and for civil, tertiary and transport organizations that have a consumption higher than 1,000 toe/year.	Concerns about Energy consumption Environmental damage Long term sustainability	Image of oil crisis (e.g. oil_shock_1973_74_720x450.jpg) Show Italian flag and text "National perspective" Put an (i) icon beside "toe". Clicking on it will open a popup window with the text of the next row
	"toe" means "tons oil equivalent" As a reference, 1,000 toe correspond to approximately 1.2 million m^3 of natural gas or 5.3 million kWhe (kilowatt hours equivalent) in end uses.		

1.2 LEARNING OBJECTIVES, TARGET AUDIENCE, REQUISITES

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	[Markus - perplexed] I wonder if the Energy Manager is really needed… I am not sure it is so important, with so many other urgent problems we are facing… [Karen] In a world that's energy-hungry and is also rapidly evolving, the relevance of responsible energy management cannot be understated. We find ourselves at a juncture where our choices today shape the environment we pass on to generations ahead. This course isn't just a bunch of information; it's a pivotal step towards a more sustainable future.	Energy makes the world go around	Static pictures or better short movies of power plants with exhaust fumes photovoltaic plant cars in queue people going by bike Music from Liza Minnelli
	[Markus] Hmm, maybe you are right… tell me more about the course [Karen] Throughout this course, we'll learn the basics of energy management – from its core concepts to practical applications. The course will focus on management aspects more than on technical issues but nonetheless it will present the diverse tapestry of energy sources. Renewable energy, energy efficiency, and conservation practices will become familiar territory at the end of the course. [Markus] I'm not an engineer, I am just interested in energy saving from the management point of view! [Karen] From the technical point of view, high school knowledge of physics and chemistry are enough to let you understand the technical parts. We are aiming to give you a broader understanding of energy management that covers both technical and organizational issues. With a holistic approach to Energy Management, you will be able to involve the engineers with the right competences and	Basics of Energy Management Core concept Practical applications Renewable energy energy efficiency conservation practices HOLISTIC APPROACH	The texts will appear with animation on a background of pictures of renewable power plants (wind, solar)

	asks the correct – and meaningful – questions, as well to understand if the answers make sense in your context.		
	[Markus] That's make sense! But how about the different national approaches to Energy? I understand that the European countries do not apply the same rules and regulations… [Karen] You are right but remember that the European Union has been at the forefront of advocating sustainable practices and energy efficiency. Its directives serve as a beacon, guiding nations towards a greener and more sustainable future. This course is designed to adhere to the directives set forth by the European Union and to explore how they have been implemented at national level.	National approaches can differ The EU directives define the long-term strategy	Animation of EU countries flags that enter separately, but then position themselves over the map of EU initially with national boundaries that slowly disappear.
	[Karen] It's worth noting that the application of these directives in national contexts extends far beyond just compliance. It represents an opportunity for innovation, for the creation of solutions that are not only environmentally responsible but also economically viable. As aspiring Energy Managers, you will play a pivotal role in driving this change, in shaping the energy landscape of your respective nations.	Shape the energy landscape Shape the country landscape	Image: ec-socialmedia-fallback.png Markus and Karen smile to the learners

1.3 CONTEXT OF TRAINING

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	[Markus] Do you have any suggestion to expand my knowledge beyond this course boundaries? [Karen] You have plenty of options and they can suit nearly any inclination. On the technical side, you can deal with Engineering topics related to Energy, such as modelling and simulation, data analytics, Power Systems and Grid Integration, monitoring and control system. The field of Green Building and Architecture is a new one and very promising: from the research and development of new material for energy-efficient buildings and the the design of sustainable buildings to the certification of the building itself there is plenty of opportunities to work on. Still on the hard science side, you can deepen your knowledge about the different renewable power sources, such as wind, solar, biomasses, hydropower. If you are more inclined to business and management, you can devote yourself to Environmental management, that means dealing with Policy and Regulations, Impact Assessment and policies for Sustainable Development. In Business and Management there is a wide range of soft skills to be studied such as Communication, Negotiation or Project Management. If you are interested in economics, analysis of cost-benefit of environmental policies, or the definition of those policies can give you a lot of reward, as well as more specific but very important fields of study such as the analysis of Energy efficiency in supply chains.	01_03_related_topics.png	Picture rolls out gradually when the voiceover describes the different sections

1.4 COURSE MAP

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	This schema shows the course structure. Click on each section to display in detail its contents.	01_02 course map.png Click on the map for more info	Slide 1 – file pictures_schemas.pptx Course Map Clicking on each module displays the structure of each module
	This is the module you are currently looking at. It provides a general overview of the course and its content, to give you an idea of what you are requested to do and what do you expect to learn.	1.1 Let's start 1.2 Learning Objectives - Target Audience 1.3 Context of Training 1.4 Course Map	Clicking on each item of the course map opens a text block with the module content.
	In this module you will learn in detail what the role of Energy Manager involves. The module also contains a Case Study from a European project that will be you focus better them activities and functions.	2.1 Learning Objectives 2.2 The professional profile of the Energy Management Expert 2.3 The role of the Energy Management Expert within an organization 2.4 The Energy Management Expert on the European scenario 2.5 A Case Study: the European Project MAESTRI	Clicking on each item of the course map opens a text block with the module content.
	A sound understanding of renewable energy sources features and potential is important to achieve the targets of sustainability and cost reduction that are integral part of the EM job. This module is a not-too-technical refresher about some physical entities and describes the main features, advantages and criticalities of renewable energy sources.	3.1 Learning Objectives 3.2 Basic concepts of Energy, power and yield 3.3 Solar energy and PV 3.4 Wind Energy 3.5 Hydropower 3.6 Biomasses	Clicking on each item of the course map opens a text block with the module content.

		3.7 Geothermal	
	In this fourth module we tackle the Energy Manager role from a mora organizational point of view. Where is located the EM within a company? How are its competencies required within the company?	Learning Objectives 4.2 The foundations of corporate economy 4.3 Company organization and functions 4.4 The PDCA or plan–do–check–act management method 4.5 Quality management and ISO9001 standards	Clicking on each item of the course map opens a text block with the module content.
	The Energy Manager must keep in mind not only the physical and organizational constraints but the complex framework of international standards and directives to which it must comply. The module presents these standards in a clear and simple way, focusing on their relevance to the EM job.	5.1 Learning Objectives 5.2 Standards Overview 5.3 The Integrated Management System 5.4 ISO14001 standard 5.5 Life Cycle Assessment 5.6 ISO 50001 standard 5.7 Lean Management	Clicking on each item of the course map opens a text block with the module content.
	Being an EM means to be able to negotiate at different levels within and outside the organization it works in. The module describes the soft skills required and is aimed to promote further learning in order to acquire those skills that are critical for any energy management process.	6.1 Learning Objectives 6.1 Hard and soft skills 6.2 Energy diagnosis 6.3 Overview of interventions 6.4 Communication: a soft skill for everyone	Clicking on each item of the course map opens a text block with the module content.
	Eventually, you can prove yourself the level of knowledge acquired by this final assessment.	7.1 Introduction 7.2 Knowledge Check 7.3 Assessment Results 7.4 Course Completion	Clicking on each item of the course map opens a text block with the module content.
	[Karen] Thank you for your commitment to this journey. Together, let's navigate the intricate web of energy management, leveraging EU directives and national cases to forge a path towards a brighter and more sustainable future.		After the learner has explored the modules, the coach delivers this closing speech

3.3.2.2 Energy Manager Job Profile

The following table offers a concise outline of the general characteristics of the Energy Manager Job Profile section:

Duration	45' 55''
Characters	Karen, the Energy Manager coach Markus, the learner's alter ego
Notes	Module 2.2 is a module with the characters of Markus and Karen Modules 2.3, 2.4, 2.5 and 2.6 are based on 2D slides, some of them interactive. Module 2.6 includes 2 YouTube videos of the Maestri project.

The following table contains a synthesis of the segments in which the Energy Manager Job Profile section is organised.

Segment	Title	Word count	Expected Duration
2.1	Learning Objectives	240	1m. 30 sec.
2.2	The Professional Profile of the Energy Management Expert	1030	7m.
2.3	The Role of the Energy Manager within an Organisation	1100	7m. 30 sec.
2.4	Areas of Intervention of the Energy Manager	1239	8m. 15
2.5	The Energy Manager in the European Scenario	720	4m. 45 sec.
2.6	A case study: The European Project MAESTRI	196	16m. 55 sec.

A detailed description of the content of the individual segments is available in the tables of the following pages.

2.1 LEARNING OBJECTIVES

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	This lesson is composed of 6 modules. • The first two modules will explain in detail who the Energy Manager is, the requisites to become and Energy Manager and their activities. The modules also clarify the differences between Energy Manager and Energy Management Expert. • Module 2.3 will present different kind of organizations and the position of Energy Manager within these organization – it will give you an overview of hiring opportunities for Energy Managers. • Module 2.4 will describe in details the activities performed by the Energy Managers and their areas of intervention. • In module 2.5 you will find an example of National regulations that define the role, skills and knowledges required to an Energy Manager. The module describes shortly the Italian FIRE association. • The case study of module 2.6 will present the EU project Maestri and you will have the opportunity to watch two short videos about results attained by the project.	Summary 2.1 Learning Objectives 2.2 The professional profile of the Energy Manager 2.3 The role of the Energy Manager within an organization 2.4 Areas of intervention of the energy manager 2.5 The Energy Manager on the European scenario 2.6 A Case Study: the European Project MAESTRI	
	At the end of this module, you will be able to: Describe the profile of the Energy Manager Explain the differences between Energy Manager and Energy Management Expert List the types of organization where the Energy Manager can work with Describe the Energy Manager areas of intervention Be aware of national standards that certify the role of Energy Manager Point out the results of Maestri EU project about energy efficient use in the manufacturing industry	Same as narrated text	

2.2 THE PROFESSIONAL PROFILE OF THE ENERGY MANAGEMENT EXPERT

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	[**Markus**] Here we are in the Sevilla Airport! Quite modern, and very comfortable! The temperature here is 22 degrees, compared to the 41 degrees outside! [**Karen**] Yes, the airport was renovated in 1992 for the Expo by the architect Rafael Moneo who adopted stylistic features typical of Andalusian architecture. Keeping cool the air inside is a good challenge for the architects and engineers who cooperated to the project. These building, in the same way as commercial centres or office building, are really energy hungry. Not only for air conditioning and heating, but also for lighting, plumbing and so on. This is where the professional profile of the Energy Manager enters to play a role that is a very important one!	No text	Markus and Karen inside the Sevilla airport (pictures 3l-image-Seville-Airport.jpg and Seville_airport_departures.jpg
	[**Markus**] I would like to learn more about the job profile of the Energy Manager, but first I have a question about terminology. I heard both the terms “Energy Manager” and “Energy Management Expert”. Are these two roles the same or are they different? [**Karen**] You are right Markus, the terms "Energy Manager" and "Energy Management Expert" are related but can have slightly different connotations based on the context. [**Markus**] Would you mind telling me the differences? [**Karen**] An Energy Manager is a professional responsible for overseeing and optimizing energy consumption within a specific organization, facility, or sector. They focus primarily on managing energy usage, improving efficiency, and implementing strategies to reduce energy costs and environmental impact. “Energy Management Expert” is a broader term that encompasses professionals who have extensive knowledge, skills, and experience in the field of energy management.	Energy Manager Energy Management Expert Energy Manager professional responsible for overseeing and optimizing energy consumption within a specific organization, facility, or sector Energy Management Expert broader term for professionals who have extensive knowledge, skills, and experience in	The texts are show in synchrony with voiceover

	[**Markus**] If I understand correctly, the Energy Manager has role more operational, while the Energy Management Expert seems to be more general. [**Karen**] Yes, the Energy Managers work hands-on within the organization to identify energy-saving opportunities, plan and execute projects, and monitor energy performance. They often interact with various departments, employees, and stakeholders to promote energy efficiency practices and achieve sustainability goals. On the other side, the Energy management Expert often has an expertise that extends beyond a specific organization or facility. They may provide consulting, advising, and specialized services to multiple clients, industries, or sectors. Energy Management Experts may offer strategic guidance, conduct energy audits, develop energy policies, and provide solutions to improve energy efficiency and sustainability across various contexts. The profiles of the energy manager and that of the energy management expert overlaps at some extent, but the case may also occur in which an energy manager is not an Energy Management Expert or that, conversely, the Energy Management Expert is not an Energy Manager. [**Markus**] And this course is aimed to the profile of which? [**Karen**] The course is aimed to train Energy Manager, but nothing forbids that if you get more experience in this role, you could move subsequently to a consulting position that provide services to multiple clients.	the field of energy management	
	An Energy Manager is a professional responsible for overseeing and optimizing energy consumption within an organization or facility. They play a crucial role in reducing energy costs, improving energy efficiency, and promoting sustainable practices. Energy Managers are typically employed in various sectors, including industries, commercial buildings, government agencies, and institutions, where energy usage is a significant operational expense	Following text, with words emphasized An **Energy Manager** is a professional responsible for **overseeing and optimizing energy consumption** within an organization or facility. They play a crucial role in **reducing energy costs**, **improving energy**	Slide without actor. The voice is Karen's Picture of commercial centres, airports, large building, schools

		efficiency, and promoting **sustainable practices**. Energy Managers are typically employed in sectors where energy usage is a significant operational expense	
	Explore the key Differences between the role of Energy Managers and Energy Management Experts by clicking on each item.	Click on the differences to get more information. Scope of Work Level of Expertise Client Base Roles and Responsibilities Depth of Impact	Interactive slide – the user must click on the five items to get the detailed text Picture key differences.png
	Scope of Work Energy Managers typically work within a specific organization, focusing on implementing energy-saving strategies and projects for that entity. Energy Management Experts have a broader scope and may work as consultants, providing expert advice and solutions to multiple clients, industries, or sectors.	Same as narrated text	Voiceover reads the text
	Level of Expertise Energy Managers possess expertise in energy management within the specific context of their organization or facility. Energy Management Experts have a deep and broad understanding of energy management principles that can be applied across different scenarios.	Same as narrated text	Voiceover reads the text
	Client Base Energy Managers primarily serve their employing organization and focus on improving energy efficiency within that entity. Energy Management Experts may work with a diverse range of clients, including businesses, industries, governments, and institutions seeking energy management guidance.	Same as narrated text	Voiceover reads the text
	Roles and Responsibilities	Same as narrated text	Voiceover reads the text

	Energy Managers are responsible for hands-on management of energy consumption, projects, and initiatives within a specific organization. Energy Management Experts may be engaged in tasks such as energy auditing, policy development, regulatory compliance, technology evaluation, and strategic planning for various clients.		
	Depth of Impact Energy Managers have a direct impact on their organization's energy consumption, costs, and sustainability practices. Energy Management Experts can influence multiple organizations and sectors by providing insights, recommendations, and solutions to improve energy management practices.	Same as narrated text	Voiceover reads the text
	[**Markus**] Can an Energy Manager be an Energy management expert at the same time? [**Karen**] It is desirable, generally speaking, that an Energy Manager satisfies the requirements of the UNI CEI 11339 standard - we will see later what this means - regardless of whether or not they intend to be certified. However, there are situations, especially in large organizations, in which the Energy Manager should be a high-level manager to be able to effectively influence corporate decisions. In these circumstances it is likely that the role of Energy Management will be taken over by employees.	Can an Energy Manager be an Energy management expert at the same time?	Karen and Markus speak – balloons appear with the narrated text
	[**Markus**] So, could an Energy Manager not be an Energy Management Expert? [**Karen**] Yes, an Energy Manager can be appointed regardless of whether or not he has the characteristics required by the UNI CEI 11339 standard.	Could an Energy Manager not be an Energy Management Expert?	Karen and Markus speak – balloons appear with the narrated text
	[Markus] Do not tell me that an Energy Management Expert couldn't be an Energy Manager !? [**Karen**] Oh, yes, this another possibility. An Energy Management Expert might not necessarily hold the title of Energy Manager. This is because adherence to the requirements set forth in the certification and accreditation scheme for compliance with the UNI CEI 11339:2009 standard	Energy Management Expert couldn't be an Energy manager	Karen and Markus speak – balloons appear with the narrated text

	can be maintained even outside the appointment of the Energy Manager. For instance, consider the case of a freelance consultant who has conducted feasibility studies and energy audits and who has directly handled requests for incentives related to energy-efficient interventions. Another example could be a technician who is expert in equipment efficiency and maintenance in a particular sector (civil or industrial). This technician may have been directly responsible for implementing energy efficiency measures and renewable energy sources, as well as ensuring their optimal maintenance		

2.3 THE ROLE OF THE ENERGY MANAGER WITHIN AN ORGANISATION

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	An energy manager, as the term suggests, is a person who is tasked with managing energy within a company, a public body, or more generally, a structure. Their responsibilities include monitoring consumption, optimizing it, and promoting interventions aimed at energy efficiency and the use of renewable sources	Energy Manager Managing energy within a company, a public body, or more generally, a structure	Evocative image
	This translates into a distinct role based on the dimensional characteristics of the structure under consideration. Complex organizations Small companies or organization Residential buildings Click on the blocks to get more information	Complex organizations Small companies or organization Residential buildings Click on the blocks to get more information	Pictures of buildings belonging to the different types mentioned: Large office building / Hospital Manufacturing plant medium size Apartment building and small houses Organized in clickable blocks that link subsequent rows
	In **complex organizations**, the energy manager would ideally hold a managerial position, leading a group consisting mainly of technical professionals. In this scenario, the energy manager doesn't necessarily have to be a technician – at least in principle. They must primarily be a high-level manager, supported by skilled specialists, capable of exerting effective influence over the company's energy policies. Nevertheless, a technical background might still be preferable even under these circumstances.	Managerial role Technical background not required but preferable	Picture of Large office building / Hospital Cut out picture of a manager. Cut out picture of employees hierarchically linked to the manager
	In **small companies or organizations**, the role of Energy Manager is typically filled by an external consultant possessing technical skills. Within these structures, the managerial responsibilities are often minimal, if present at all. For example, tasks such as energy accounting and the preparation of feasibility studies generally fall within the purview of the professional.	External consultant Minimal involvement in internal company procedures	Picture of a manufacturing plant medium sized or small supermarket

	However, due to the external nature of the consultant's role, direct involvement in internal company procedures is unlikely. Nonetheless, the term 'Energy Manager' may still be applicable in such contexts.		
	In **residential buildings**, having a dedicated consultant is often not feasible due to the associated costs. This role can be fulfilled by support networks (such as consumer associations, energy centres, agencies, etc.) or by those responsible for issuing energy certifications. We are now more accurately addressing the role of an energy auditor rather than an energy manager, as the management aspect is completely absent.	No dedicated consultant Support networks More auditing than management	Picture of an apartment building or terraced houses
	The energy manager Verifies consumption through dedicated audits or, if available, by reviewing reports generated by remote management, remote control, and automation systems. Optimizes consumption by appropriately regulating systems and ensuring their efficient energy use. promotes energy saving behaviours among employees and/or occupants of the facility. Enhances their awareness of energy usage. proposes investments to improve energy savings in production processes.	verifies consumption. optimizes consumption. promotes energy saving. Enhances occupants' awareness of energy usage. proposes investments to improve energy savings.	Picture of devices for monitoring / auditing consumptions (e.g. e54-insulation-inspection-1200x628.jpg, EST-contabilizzatore-202r.jpg)
	There are other ways in which the Energy Manager intervention could be highly beneficial for the structure. By analysing the consumption data and patterns, the Energy Manager can promote an optimized use of electrical loads in order to avoid power peaks which involve higher costs.	optimized use of electrical loads avoid power peaks	Picture of peak shaving (eg. peak_shaving.png)
	The energy manager in these cases collaborates with the purchasing department in • Entering into the most convenient and best-suited contracts for electricity and other energy sources that meet the organization's needs • promoting the concept of green procurement • performing a Life Cycle Cost Analysis (LCCA) to select and purchasing machinery characterized by low energy consumption thereby reducing management costs	Best-suited contracts for energy sources Green procurement Life Cycle Cost Analysis (LCCA)	Evocative images

	An Energy manager needs also to communicate effectively with non-technical people other corporate functions Click on each item to learn more.	Communicate with non-technical people other corporate functions	Cut out figures of people representing the two categories. Links to the two following rows
	Non-technical people They could be decision-makers inside the company or colleagues in charge of other tasks. Dealing with these people requires the ability to explain technical concepts in simple terms and this relies mostly on personal qualities. Training on soft skills such as communication or negotiation could improve the capabilities of the Energy Manager		This text opens when clicking on “non-technical people”
	Other corporate functions Energy is intrinsically a horizontal theme, which involves many functions within a company and many different people: • who buys electricity and other fuels • who selects and request machinery and devices • who deals with system maintenance • who designs the buildings and facilities • who writes the tender specifications writers • and the legal departments, and many others. To deal with corporate functions requires the involvement and commitment of top management, who must create the conditions for the energy manager to be able to operate at their best and find the necessary collaboration. One way to answer this requirement is to adopt an energy management system, if possible, ISO 50001 certified.		This text opens when clicking on “other corporate functions”
	[**Karen**] From what you have seen so far, the ideal energy manager is a figure who must have solid foundations in energy, investment assessment and legislation and markets, possibly combined with communication skills. It is a non-trivial mix that can only be achieved over time, through experience and continuous updating.	Time experience continuous updating.	Karen who speaks to the learner. Picture of a would-be Energy Manager
	Here are some examples of different types of organizations and how the position of an Energy Manager fits within them: Manufacturing Company	Same as narrated text	Each item links to the following rows

	Commercial Building (Office Complex) Hospital or Healthcare Facility Educational Institution (University) Municipal Government Data Centre Retail Chain		
	Manufacturing Company In a manufacturing company, an Energy Manager's role would involve: Identifying energy-intensive processes and equipment. Conducting energy audits to identify areas for improvement. Implementing energy-efficient technologies and practices. Monitoring energy consumption in real-time to ensure optimal performance. Collaborating with production teams to align energy efficiency with production goals.		Picture of a manufacturing plant
	Commercial Building (Office Complex) In a commercial building setting, an Energy Manager's responsibilities would include: Analysing energy usage for lighting, HVAC, and other systems. Optimizing building controls for energy efficiency. Managing energy-efficient lighting and equipment upgrades. Implementing occupancy and daylight sensors to reduce unnecessary energy use. Educating occupants about energy-saving practices.		Picture of a commercial building (office or commercial centre)
	Hospital or Healthcare Facility Within a healthcare facility, an Energy Manager would be responsible for: Monitoring energy usage in medical equipment, lighting, and HVAC systems. Implementing energy-saving measures without compromising patient care. Ensuring compliance with healthcare regulations while improving efficiency. Overseeing waste management practices to minimize energy-intensive disposal methods.		Picture of a hospital

	Educational Institution (University) In an educational institution, an Energy Manager would be tasked with: Analysing energy use in classrooms, labs, and dormitories. Implementing energy-efficient lighting and HVAC systems. Promoting sustainability initiatives across campus. Collaborating with students and faculty to raise awareness about energy conservation.		Picture of a University
	Municipal Government Within a local government, an Energy Manager's role could involve: Developing and implementing energy-saving policies for public buildings. Managing energy use in street lighting, water treatment plants, and transportation systems. Pursuing grants and funding for energy efficiency projects. Collaborating with community stakeholders to promote sustainability.		Picture of a Public building
	Data Centre In a data centre, an Energy Manager's responsibilities would encompass: Monitoring energy consumption of servers, cooling systems, and backup generators. Implementing airflow management and cooling strategies to optimize efficiency. Exploring innovative technologies to reduce energy use in high-density computing environments. Ensuring consistent uptime while maximizing energy efficiency.		Picture of the interior of a data centre
	Retail Chain In a retail setting, an Energy Manager would focus on: Analysing energy consumption in lighting, HVAC, and refrigeration systems. Implementing energy-efficient lighting and equipment. Managing energy use across multiple store locations. Collaborating with store managers to implement consistent energy-saving practices.		Picture of a large supermarket

2.4 AREAS OF INTERVENTION OF THE ENERGY MANAGER

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	The areas of intervention of an energy manager are wide and diversified. For instance, the Energy Manager can be involved in the following activities – be aware that this list is not exhaustive! Energy diagnoses Energy performance indicator (EnPI) Consumption management and interventions Good practice Ad hoc projects Financial aspects Optimization of supplies Report Let's have a look in detail to each of these activities	The Energy Manager can be involved in the following activities Energy diagnoses Energy performance indicator (EnPI) Consumption management and interventions Good practice Ad hoc projects Financial aspects Optimization of supplies Report	Evocative image in background Text rolls out in synchro with voiceover
	Energy audits Energy diagnoses, or energy audits, are the first step of any efficiency initiative. Directive 2012/27/EU defines the audit as 'energy audit' means a systematic procedure with the purpose of obtaining adequate knowledge of the existing energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective energy savings opportunities, and reporting the findings" The initial energy diagnosis (or even a relatively simple analysis procedure for minor interventions) represents a proactive investment. It provides an overview of the current consumption landscape and lays the groundwork (procedural, IT, technical) for future diagnoses.	ENERGY AUDITS first step of any efficiency initiative. 'energy audit' means a systematic procedure with the purpose of obtaining adequate knowledge of the existing energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective energy savings	EM performing an Energy audit

	For instance, Italian regulations such as Article 8 of Legislative Decree 102/14 imposes a diagnosis obligation on large companies and energy-intensive companies.	opportunities, and reporting the findings (Directive 2012/27/EU) proactive investment lays the groundwork for future diagnoses.	
	Definition of Energy Performance Indicators (EnPI) An EnPI is defined as a measure or unit of energy performance as defined by the organization. It is quite a general definition. Let's see some examples: kWh consumed per site kWh per linear metre of product produced kWh per square meter of occupied office space kWh/m2 of illuminated surface kWh/bed in hospitals m3 of gas/water used in industrial processes An EnPI can be expressed by using a simple metric, ratio, or a model, depending on the nature of the activities being measured. It is critically important that the Energy Manager determines a suitable range of relevant EnPI's based on the results of the energy review. EnPI's analysis and monitoring will help the Energy Manager to demonstrate continual improvement in either efficiency, use and/or consumption. Defining the indicators involves a careful analysis of the production process and may require dedicated consumption measurement campaigns." The measurements can be derived from readings of existing instruments, or they might necessitate the installation of measuring devices, such as electrical power meters or flow rate gauges for various fluids. The specificity of the measurements to be taken can often require an investment to enhance the existing services within the plant or require the involvement of external companies. The indicators enable:	**Energy Performance Indicators (EnPI)** Examples of EnPI kWh consumed per site kWh per linear metre of product produced kWh per square meter of occupied office space kWh/m^2 of illuminated surface kWh/bed in hospitals m^3 of gas/water used in industrial processes Analysis of existing data Data collection campaigns designed on purpose The EnPI enable: a comparison of different activities from an energy perspective, the tracking of the effects of implemented interventions over time, allowing for comparisons of the organization with other similar structures, a comparison of an organization's data with	Picture e.g. energy-reporting-dashboard.jpg

	a comparison of different activities from an energy perspective, the tracking of the effects of implemented interventions over time, allowing for comparisons of the organization with other similar structures, - a comparison of an organization's data with data found in the literature.	data found in the literature.	
	Consumption management and interventions Through the analysis of consumption patterns and indicator trends, the Energy Manager will be able to suggest organizational changes related to the utilization of existing equipment. These interventions typically do not incur significant investment costs and are based on modifications in users' behaviours. The implementation of such changes necessitates a continuous effort to raise awareness among users. Additionally, the subsequent promotion and dissemination of the achieved outcomes are equally important. The achievement of appreciable results will be facilitated by the provision of possible incentives for operators based on the results achieved. The most suitable areas for carrying out these actions appear to be thermal power plants, room lighting, air exchange control.	**Consumption management and interventions** organizational changes related to the utilization of existing equipment No significant investment needed Require users' awareness	Pictures of thermal power plants, room lighting, air exchange control
	Implementation of good practices The Energy Manager is also responsible for defining a set of good procedures and best practices relating to the management methods, both in thermal and electrical plants and in the various user contexts, capable of avoiding unnecessary consumption and limiting inefficiencies. These practices require user training and information. Furthermore, the final balance by cost centres allows the management to set up rewarding systems of various types to encourage creative participation from the bottom up in the effort to improve efficiency.	set of good procedures and best practices to avoid unnecessary consumption and limit inefficiencies rewarding systems to encourage bottom-up participation	Evocative image e.g. implement_best_practices.jpg
	Ad hoc projects During the refurbishment of plants or departments, the Energy Manager can propose solutions appropriate for the evolving technologies and consider the collected energy indicators.	**Ad hoc projects** In case of refurbishment of plants or departments	Picture of insulated pipe conveying steam, or heat storage systems

	In some cases, it may be necessary to conduct energy measurement and diagnosis campaigns, potentially involving external expertise and resources to gather additional information. The identified solutions should be capable of aligning with the company's decision-making and entrepreneurial logic. Ad hoc projects could involve aspects such as renovating steam network insulation, utilizing recovered heat, implementing specialized energy storage systems, and establishing cogeneration consortium plants.	Consider new technologies / energy indicators Collect if needed more data	
	Financial aspects In formulating intervention proposals, the energy manager must always consider the economic and financial aspects alongside the technical ones, in close collaboration with the company management. It is advisable to analyse the existing financing possibilities deriving for example from local, regional, national and European Community grants and tenders. Various instruments are available to finance interventions to improve energy efficiency and renewable energy sources, such as white certificates, thermal account, tax deductions. A particularly incentive form is represented by the reinvestment in energy efficiency of a part of the results of the savings obtained from the optimized management.	**Financial aspects** Must consider the economic and financial aspects Access to local, regional, national and European Community grants and tenders Reinvest in energy efficiency part of the savings	Picture of money saved
	Optimization of supplies The Energy Manager will need to analyse the contractual and accounting documents of various energy supplies, verifying contractual parameters, the presence of any penalties, and discrepancies with the data in the literature. In the electricity sector, with the market opening up, new opportunities have arisen for consumer-customers who now have the choice of purchasing directly from new suppliers or joining purchasing consortia based on the size and type of their consumption. The preparation of periodic reports can help facilitate the adoption or planning of appropriate measures to modify supply conditions.	**Optimization of supplies** analyse contractual and accounting documents of energy vendors purchase from new suppliers or join purchasing consortia Periodic reports	Picture of power line and transformers

	Report The generation of reports constitutes a crucial component of the Energy Manager's role. These reports play a fundamental role in communicating the outcomes of the undertaken initiatives to the entire organization, spanning all hierarchical levels. By emphasizing the economic advantages and showcasing the implementation of effective practices, the value of the energy manager's role within the organization can be convincingly demonstrated.	**Report** A crucial component Communicating the outcomes to all organization's hierarchical levels	
	Among the tasks of the Energy Manager, communication activities cannot be underestimated. The Energy Manager must raise awareness among employees, especially those involved in the management and maintenance of thermal power stations and electrical systems. However, communication towards employees who are merely users is equally important, as they can significantly influence changes in consumption patterns. Involvement can range from simply informing employees about proposed/implemented changes to actively involving them in data collection phases. This can include, for instance, the installation of new monitoring equipment.	communication activities toward employees involved in management and maintenance of thermal power stations and electrical systems toward employees who are merely users	Texts with arrows pointing to two groups of employees
	Equally important is the action of interfacing with the various organization's functions. This requires a different approach if you are internal to the structure you are an external consultant Click on the two items to get more information	interfacing with the various organization's functions. internal to the structure external consultant Click on the two items to get more information	Text with two options that links next rows
	internal to the structure If you are part of the internal structure, it's important to establish contacts with administrative managers responsible for accounting and financial statements. This will provide you with the necessary understanding of the current situation. Additionally, you should engage with decision-makers regarding investments. This will help you grasp the company's guidelines and strategies for utilizing its resources		Pop-up text

	If you're an external consultant, it's important to have a solid understanding of the internal production processes, the relevant managers, and the organizational procedures. Additionally, you'll need to establish communication channels with the administrative heads to access information and data. Most importantly, you should collaborate with the management to determine the strategies that will be implemented and reach an agreement on the policies governing internal relations."		Pop-up text

2.5 THE ENERGY MANAGER ON THE EUROPEAN SCENARIO

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	The activity of Energy Manager requires particular experience and constant regulatory, theoretical and technological updating that companies, especially medium/small ones, cannot support with the internal personnel. Italian legislation already introduced the issues of energy saving and efficient use of energy with Law 308/82. Law 10/91 introduces the person responsible for the conservation and rational use of energy (or Energy Manager), who becomes mandatory in all companies and institutions characterized by annual energy consumption higher than a certain primary energy consumption (expressed in TOE - Tonnes of Oil Equivalent). In particular, the obligation to appoint an Energy Manager (annual) is triggered if consumption exceeds: 1,000 toe/year for service sector and public administration entities 10,000 toe/year for companies in the industrial sector Approximately 1,000 toe correspond to 1.2 million m^3 of natural gas or 4.5 million kWh.	NATIONAL CASE – The Energy manager in Italy Mandatory for companies and institutions characterized by annual energy consumption higher than 1,000 toe/year for service sector and public administration entities 10,000 toe/year for companies in the industrial sector	Reference to https://www.gazzettaufficiale.it/eli/id/1982/06/07/082U0308/sg Italian flag
	In 2009, the UNI CEI 11339 standard titled “Energy management - Energy Manager Experts. General requirements for qualification” has outlined a new professional figure, qualified and certified: the Expert in Energy Management (EGE). This certified profile conforms to the most recent European Directives which require a more efficient use of energy resources.	UNI CEI 11339 standard Expert in Energy Management (EGE)	Logo UNI CEI

	The figure of the Energy Management Expert has a very high level of professionalism, with managerial, technical, economic-financial, legislative and communication skills, capable of supporting company decision-makers or their supervisors at an analytical level, in the policies and in energy-related stocks		
	Here there is a list of the competences required as stated by the UNI CEI standard: Expertise in traditional and innovative technologies on energy efficiency and use of renewable sources. Expertise in the environmental implications of energy use, national and international policies and implementation mechanisms. Detailed expertise in the electricity and gas market, of the players involved in the market itself, of the type of supply offers, of the contractual forms, of the current tariffs and prices. Expertise in project economic evaluation methodologies, investment profitability, funding sources, financing instruments ("project financing" and TPF – "Third Party Financing"), as well as project risk assessment. Expertise in techniques for evaluating achievable and achieved energy savings. Expertise in the contractual arrangements for the purchase of goods and services, with particular reference to interventions aimed at energy requalification also in outsourcing mode. Expertise in the basics of business organization, management and budget control, analytical accounting, project management. Expertise in legislation and technical regulations, in the fields of energy, the environment and safety.		Evocative images of renewable source, electricity and gas, some spreadsheet for economic analysis, screenshot of EnPI
	The skills to be mastered by an Expert in Energy Management should be Energy and economic development Energy and environment	Same as narrated text	Arrange the texts in a graphical schema

	The energy market Legislation: legal, fiscal, sector technical Economy and finance Contract law Company organization and management Energy management Energy accounting Programming and control Maintenance organizational procedures Project management Business planning Risk analysis Tasks and functions of the EEM Reporting and communication Teamwork		
	FIRE (Federazione Italiana per l'Efficienza Energetica, Italian Federation for energy efficiency) was founded in 1987 by ENEA (the Italian national agency for new technologies, energy and sustainable economic development) and two energy manager associations. FIRE is an independent non-profit organisation, whose purpose is to promote sustainability and the efficient use of energy. FIRE members can be persons or organizations and they represents all the energy sector: energy efficiency technologies producers, power producers, distributors, ESCOs, large and medium enterprises, universities and research centres, energy managers and energy professionals. Such a wide range of members typologies guarantees that FIRE approach to energy efficiency and energy productivity is holistic and not sectorial. Since 1992 FIRE manages the Italian energy manager network on behalf of the Ministry of	The FIRE Association Founded in 1987 independent non-profit organization holistic approach to energy efficiency and energy productivity SECEM is a FIRE internal structure dedicated to the certification of the skills of the experts in energy management	FIRE logo logoFIRE.jpg Link to FIRE Site https://fire-italia.org/fire-in-english/

	Economic Development. FIRE promotes their role through various initiatives. In 2008 FIRE launched SECEM, an internal structure dedicated to the certification of the skills of the experts in energy management in accordance with the UNI CEI 11339:2009 Italian standard. SECEM was accredited in 2012 according to the ISO 17024 international standard.	SECEM was accredited in 2012 according to ISO 17024 standard	
	FIRE: Creates surveys and carries on research and market studies on various topics linked with the energy market. Organizes training courses with different levels of in-depth analysis. The considered topics cover all the aspects of energy management. Participates to EU-funded projects such as Save, Intelligent Energy, South Eastern Europe, Leonardo, Life+, Horizon 2020 dealing with many aspects related to energy efficiency (policy, technologies, economy and finance, contracting, dissemination and training, etc.). Publishes a fortnightly newsletter and the quarterly magazine “Gestione Energia”. Organizes conferences and workshops.	FIRE Creates surveys and carries on research and market studies Organizes training courses Participates to EU-funded projects Publishes a fortnightly newsletter and the magazine “Gestione Energia”. Organizes conferences and workshops.	Evocative image of courses Link to FIRE Site https://fire-italia.org/fire-in-english/

2.6 A CASE STUDY: THE EUROPEAN PROJECT "MAESTRI"

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	The MAESTRI project aims to advance the sustainability of European manufacturing and process industries. This is done by providing a management system in the form of a flexible and scalable platform, and to guide and simplify the implementation of an innovative approach, the Total Efficiency Framework. The overall aim of this framework is to encourage a culture of improvement within process industries by assisting the decision-making process, supporting the development of improvement strategies and helping define the priorities to improve the company's environmental and economic performance. Its development and validation will be achieved through application in four real industrial settings across a variety of activity sectors.		
	Among the many results brought by Maestri project there is **Eco Orbit View**, a method designed to establish a connection between business and environmental aspects in order to select improvements that are beneficial for both of them simultaneously	**Eco Orbit View** Watch the video	Embed the video from the YouTube channel Video must be seen completely in order to proceed in the course. (8' 03'') https://youtu.be/6_2aXJ_ZTIw (English version)
	Another interesting result from Maestri project is **Eco Lean Management Board**, a method created for visualisation and management of crucial business and environmental aspects for different organizational levels.	**Eco Lean Management Board** Watch the video	Embed the video from the YouTube channel Video must be seen completely in order to proceed in the course. (8' 49'') https://youtu.be/bYvy456cNx8 (English version)
	If you are interested in other resources generated within the Maestri project, please access the download section of Maestri website at this address https://maestri-spire.eu/downloads/		

3.3.2.3 An overview of RES technologies

The following table offers a concise outline of the general characteristics of the *An Overview of the RES Technology* section:

Duration	1h 14’ 20’’
Characters	Karen, the Energy Manager coach Markus, the learner’s alter ego
Notes	

The following table contains a synthesis of the segments in which the *An Overview of the RES Technology* section is organised.

Segment	Title	Word count	Expected Duration
3.1	Learning Objectives	176	1 m. 10 sec.
3.2	Basic Concepts of Energy, Power and Efficiency	3140	21 m.
3.3	Solar Energy and PV	1920	12 m. 50 sec.
3.4	Wind Energy	1400	9 m. 20 sec.
3.5	Hydroelectric Power Plants	1535	16 min.
3.6	Biomasses	366	2m. 30 sec.
3.7	Geothermal	1708	11m. 30 sec.

A detailed description of the content of the individual segments is available in the tables of the following pages.

3.1 BASIC CONCEPTS OF ENERGY, POWER AND EFFICIENCY

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
	This lesson is composed by 6 modules. The first module is aimed to refresh some basic concepts about energy, power and efficiency. It will explain in plain terms these physical entities the Energy Manager must be able to handle with confidence. The following modules present the main features of Renewable Energy Sources, from Solar energy and Photovoltaic panels to wind energy, hydroelectric power plants, biomasses and geothermal energy. For each power source is supplied a description and are described advantages and drawbacks from the environmental and economic point of view of its usage.	3.1 Learning Objectives 3.2 Basic concepts of Energy, power and efficiency 3.3 Solar energy and PV 3.4 Wind Energy 3.5 Hydropower 3.6 Biomasses 3.7 Geothermal	
	At the end of this module, you will be able to: Describe what energy, power and efficiency are and why they are important for an Energy Manager; Present the advantages of each renewable power source but also the potential problems that could arise from its usage; Evaluate the lifespan of each energy source and understand what the energy balance is for each of them	Same as narrated text	

3.2 LEARNING OBJECTIVES

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
	[Karen] A good Energy Manager must have some technical background, at least to understand the basic concepts that lay behind its activity. Let's start from the beginning, from the same word "energy" [Markus, drinking an energy drink] I am plenty of energy! [Karen, disappointed] ok, let's things straight!		Karen and Markus in a relaxed environment – in a public park
ENERGY	In physics, **energy** is the quantitative property that designates the capacity for doing work or cause a change such as causing objects to move, generating heat, or initiating chemical reactions. Energy exists in different forms, each characterized by its distinct properties and the role it plays in interactions between matter and forces. The word "energy" comes from Ancient Greek ἐνέργεια (enérgeia) 'activity'. From a mechanical point of view, energy is defined as the product of force applied by the displacement generated.	**energy** the capacity for doing work or cause a change Energy exists in different forms In mechanics energy is the product of force applied by the displacement generated	
	[**Markus**] Can you give me some examples? [**Karen**] If a person, let's say Lisa, who weighs 65 kilograms, rises 2 meters on a staircase, she gets some energy. This energy is due to her positions: she had to exert a force against the gravity to rise on the staircase and this was done for 2 meters.		Picture 3_2_energy.jpg
	[**Markus**] And how can I measure Lisa's energy? [**Karen**] The unit of measurement for energy in the International System of Units (SI) is the joule (J). Lisa has displaced her weight exerting a force of 65 kg x 9,8 m/s2 = 637 Newton for 2 meters. Her energy is now 1.274 J		Picture 3_2_energy.jpg
	[**Markus**] Wow, seems a lot of energy! She has to eat a lot to get this energy!		

	[Karen] Actually, food contains much more energy! A biscuit has an energy content of 110.000 Joules! Theoretically, she could climb a hill 170 meters high!		
	Question Karen said “theoretically” that means that, in practice, a single biscuit is not enough to climb the hill. In your opinion, why? Lisa needs energy for other functions as well, such as digesting the biscuit, keep her body warm, let the blood circulate in the body; Lisa doesn’t convert all the biscuit energy into muscular energy – some is wasted. Both the previous answers Karen is wrong – A biscuit has enough energy to let Lisa climb the hill! Feedback answer 1 That’s correct but you should also consider that not all the biscuit energy is converted into muscular force – part of it is not assimilated by Lisa’s body and therefore is wasted. Feedback answer 2 That’s correct but you should also consider that part of the biscuit energy is used for other purposes by Lisa’s body, such as digesting the biscuit, keep her body warm, let the blood circulate in the body. Not all the biscuit energy is converted into muscular force. Feedback answer 3 That’s correct. Not all the biscuit energy is converted into muscular force: part of it is not assimilated by Lisa’s body and therefore is wasted. Another part of the biscuit energy is used for other purposes by Lisa’s body, such as digesting the biscuit, keep her body warm, let the blood circulate in the body. Feedback answer 4 No, Karen is right. The computation is just theoric. In practice, not all the biscuit energy is converted into muscular force: part of it is not assimilated by Lisa’s body and therefore is wasted. Another part of the biscuit energy is used for other purposes by Lisa’s body, such as digesting the biscuit, keep her body warm, let the blood circulate in the body.	Same as narrated text	Feedback is shown and narrated when the user makes a selection and presses the Confirm button

	[**Markus**] But on the biscuit wrapping I see, beside a figure in kJ, also a number in calories. What does it mean? [**Karen**] Markus, this is not a course on diet and food! However, your question arises an important point that every Energy Manager should know: the conversion among different measurement units for energy.		Picture of a biscuit pack with the dietary information well visible
	The Joule is the measurement unit in the International System (SI), but there are many other units used to express energy such as Ergs Calories British thermal units kilowatt-hours kilocalories It is easy to convert one unit into another if you know the correct conversion factor. Click on each item of the schema to get more information	Units to express energy Ergs Calories British thermal units kilowatt-hours kilocalories Click on each item to get more information	Graphic schema showing the different units Clicking on the schema item the user displays the pop-up messages of the following 5 rows
	Erg The erg is a unit of energy equal to 10^{-7} joules (100 nJ). It originated in the Centimetre–gram–second system of units (CGS). It has the symbol erg. The erg is not an SI unit. The erg has not been a valid unit since 1 January 1978 when the European Economic Community ratified a directive of 1971 that implemented the International System (SI) as agreed by the General Conference of Weights and Measures.	1 erg = 10^{-7} joules This unit is used in astrophysics For instance, the solar luminosity is expressed in erg/s	Picture of the solar surface by telescope
	Calorie two main definitions of "calorie" are in wide use: they differ by a multiplication factor of 1000. The **large calorie**, food calorie, dietary calorie, or **kilogram calorie** was originally defined as the amount of heat needed to raise the temperature of one kilogram of water by one degree Celsius. The **small calorie** or **gram calorie** was defined as the amount of heat needed to cause the same increase in one gram of water Thus, 1 large calorie is equal to 1000 small calories.	1 calorie = amount of heat needed to cause the increase of temperature of 1 degree in one gram of water 1 large calorie (1kcal) is equal to 1000 small calories (cal) 1 calorie = 4.184 J	

	For our job of Energy Manager the word calorie and its symbol usually refer to the small unit; the large one being called kilocalorie. One calorie is equal to exactly 4.184 J		
	British thermal unit The British thermal unit (BTU or Btu) is a measure of heat, which is a form of energy. It was originally defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. One BTU equals about 1,055 J. In the United States the price of natural gas is quoted in dollars per the amount of natural gas that would give 1 million BTUs (1 "MMBtu") of heat energy if burned.	1 BTU = amount of heat required to raise the temperature of one pound of water by 1 degree Fahrenheit 1 BTU = 1,055 J	
	kWh A kilowatt-hour (unit symbol: kW·h commonly written as kWh) is a non-SI unit of energy. It derives from the product of one kilowatt of power for one hour. It is equivalent to 3.6 megajoules (MJ) in SI units. Kilowatt-hours are a common billing unit for electrical energy supplied by electric utilities. Metric prefixes are used for multiples and submultiples of the basic unit, the watt-hour.	1 kWh = one kilowatt of power for one hour 1 kWh = 3.6 MJ	
	The conservation principle The principle of conservation of energy states that energy cannot be created or destroyed; it can only be converted from one form to another. This principle is encapsulated in the law of conservation of energy, a cornerstone of physics that has been rigorously tested and confirmed through countless experiments. The transformation of energy from one form to another is at the basis of our technology: every time something happens, it’s because energy is converted from one form to a different form.	**The conservation principle** energy cannot be created or destroyed but only transformed	
	The energy can have many different forms. The table here shows some of them and a short description for each of them. Kinetic Energy Potential Energy		Graphic schema wit texts Clicking on them opens a popup with more info (following7 rows)

	Thermal Energy Chemical Energy Electrical Energy Nuclear Energy Electromagnetic Energy Click on each item to get more information		
	Kinetic Energy: This type of energy is associated with the motion of an object. The faster an object moves and the greater its mass, the more kinetic energy it possesses.		Racing cars or motorbikes
	Potential Energy: Potential energy is stored energy that an object possesses due to its position or configuration in a system. Examples include gravitational potential energy, which depends on an object's height in a gravitational field, and elastic potential energy, present in objects like compressed springs.		Picture of a waterfall
	Thermal Energy: Also known as heat energy, thermal energy is the energy associated with the motion of particles within a substance. It determines the temperature of a material and can be transferred from one object to another through processes like conduction, convection, and radiation.		Picture of a hot iron
	Chemical Energy: This energy is stored in the bonds between atoms and molecules within a substance. It can be released or absorbed during chemical reactions, such as combustion or photosynthesis.		Boxes of explosives and some sugar cubes
	Electrical Energy: Associated with the movement of electric charges, electrical energy powers a wide range of devices and systems, from electronics to power grids.		Lightning
	Nuclear Energy: This potent energy form resides in the nucleus of atoms. It is released through nuclear reactions, such as nuclear fission (splitting) or fusion (combining) of atomic nuclei.		Nuclear power plant
	Electromagnetic Energy: This energy is carried by electromagnetic waves, including visible light, radio waves, microwaves, and more. Electromagnetic energy plays a crucial role in the transmission of energy from the Sun to Earth.		Laser beam
	[**Markus**] So, you say that energy conversion is feasible and at the basis of our technology. But is it relevant for me as an Energy Manager?	Explore the pictures in this page to get more information on how energy is converted from one form to another.	Graphic schema with small images depicting the different type of plants.

	[**Karen**] Markus you are not yet an Energy Manager! But understanding the energy conversion is important because it involves other basic concepts we will explore shortly, power and efficiency. Explore the pictures in this page to get more information on how energy is converted from one form to another.		For renewable these will be the same images to be used later.
	In a hydroelectric power plant, water from a reservoir flows down through turbines due to gravity. The potential energy of the elevated water is converted into mechanical energy as the turbines spin. These turbines are connected to generators, which convert the mechanical energy into electrical energy.	**Hydroelectric Power Generation** Potential Energy (Gravitational) → Mechanical Energy → Electrical Energy	Plant schema or picture
	Solar panels consist of photovoltaic cells that contain semiconductor materials. When sunlight (composed of photons) strikes these cells, it excites electrons in the material, generating a flow of electricity. This process directly converts solar energy into electrical energy.	**Solar Panels** Energy Conversion: Solar Energy (Light) → Electrical Energy	Plant schema or picture
	In an internal combustion engine, like those found in cars, a mixture of fuel (such as gasoline) and air is ignited. This chemical reaction releases energy in the form of heat. The heat causes the gases to expand rapidly, driving pistons. The mechanical motion of the pistons is then converted into rotational motion to drive the vehicle	**Combustion Engines (Internal Combustion Engine)** Energy Conversion: Chemical Energy (Fuel) → Thermal Energy → Mechanical Energy	Plant schema or picture
	Wind turbines have blades that are turned by the force of the wind. The kinetic energy of the moving air is transferred to the spinning blades, causing them to rotate. This rotational motion drives a generator, which converts the mechanical energy into electrical energy.	**Wind Turbines** Energy Conversion: Kinetic Energy (Wind) → Mechanical Energy → Electrical Energy	Plant schema or picture
	In nuclear power plants, nuclear fission reactions release an immense amount of heat. This thermal energy is used to heat water and produce steam, which drives turbines. The turbines are connected to generators that convert the mechanical energy from the turbines into electrical energy.	**Nuclear Power Generation** Energy Conversion: Nuclear Energy (Fission) → Thermal Energy → Mechanical Energy → Electrical Energy	Plant schema or picture
	Batteries store chemical energy. When a circuit is closed, a chemical reaction occurs within the battery that releases electrons, creating a flow of electricity. This electrical energy can then be used to power various devices, from smartphones to laptops.	**Battery-Powered Devices** Energy Conversion: Chemical Energy (Stored in Battery) → Electrical Energy	Plant schema or picture

	Geothermal power plants tap into the Earth's internal heat. Water is pumped into hot underground reservoirs and turns into steam due to the high temperatures. The steam is then used to drive turbines, which generate mechanical energy that is subsequently converted into electrical energy	**Geothermal Power Generation** Energy Conversion: Thermal Energy (Heat from Earth's Interior) → Mechanical Energy → Electrical Energy	Plant schema or picture
	The conversion tool of Google is a powerful way to perform energy conversion quickly and easily. Just digit in the search bar of Google "convert joule to calories" for instance and the tools is displayed. You can change the energy measurement units and the values and get the conversion done immediately. Feel free to play with the converter to get a grasp of the order of magnitude of different energy units	It's your turn! Using the conversion tool of Google answer the following questions: How many Joules are equivalent to 33.5 kcal? How many kilojoule are equivalent to 5 kWh? How many BTU are equivalent to 5 kWh?	Interactive slide. The narrated text must be available also by clicking on a page link "How to convert energy units using Google" The page will contain 3 questions. To answer the question, the user must type into a text field the right value. Below the answers 140164 J 18000 kJ 17060,7 BTU
POWER	[Markus] You mentioned power… isn't it the same as energy? [Karen] In the common language the two concepts of power and energy are often confused- They are strictly related, but time makes the difference!		
	Power expresses the rate at which energy is transferred or transformed. It represents the measure of how quickly work is done or how rapidly energy is converted from one form to another. The concept of power is essential for understanding the dynamic aspect of energy interactions and the efficiency of various processes. Power (P) is defined as the amount of energy (E) transferred or transformed per unit of time (t): Power = Energy \ Time If you measure energy in Joule and time in seconds, the unit of measure of power is Watt.		
	[**Markus**] You are telling me that power quantifies how fast energy is used or produced.		

	A higher power value implies that energy is being converted at a faster rate and conversely, a lower power value indicates a slower energy transformation process. [**Karen**] Perfect, you got the idea. Power finds applications in various fields, from engineering to everyday life. For instance, in the context of electrical appliances, power consumption is a crucial consideration to ensure efficient energy usage. In the world of machines and engines, power output determines their performance capabilities. Understanding power allows us to optimize processes, design efficient systems, and make informed decisions about energy utilization.		
UNITS OF POWER	The unit of measurement of power, watt, is a small unit not suited for power plants. To express the power of equipment that ranges from a dishwasher to a nuclear plant normally units of measurement that are multiple of watts are used. **Kilowatt (kW)** Kilowatts are used to measure the power consumption of appliances, electrical devices, and the output of power plants. 1 kilowatt = 1000 watts **Megawatt (MW)** It's often used to measure the output of large power plants, industrial machinery, and energy consumption on a larger scale. 1 megawatt = 1000 kilowatts = 1,000,000 watts **Gigawatt (GW)** It's used to describe the power output of very large power plants, complex industrial processes, and large-scale energy generation. 1 gigawatt = 1000 megawatts = 1,000,000,000 watts	**Kilowatt (kW)** 1 kilowatt = 1000 watts **Megawatt (MW)** 1 megawatt = 1000 kilowatts = 1,000,000 watts **Gigawatt (GW)** 1 gigawatt = 1000 megawatts = 1,000,000,000 watts	Picture of a dishwasher, data centre and power plant
	[**Markus**] Mmm… when I bought my Moto Guzzi V7 Stone nobody told me about watts or kilowatt, they told me it has a power of 65 CV… what does it mean? [Karen] CV stands for “Cavallo Vapore” in Italian. In English it’s HP, that stands for HorsePower.		

	Horsepower is a unit of power traditionally used in mechanical engineering and automotive applications. It was originally defined to compare the power of steam engines to the work done by horses. One mechanical horsepower is approximately equivalent to 746 watts. Your Moto Guzzi therefore has a power of 48 kW. [**Markus**] Thanks for the conversion!		
	[**Karen**] Beside energy and power, another important parameter to be considered when speaking of energy management, that is efficiency. Efficiency is a central concept for an Energy Manager because most of its activities deal with increasing efficiency of devices or processes.		
	Efficiency, from a general point of view, refers to the effectiveness with which a physical system or process converts input resources into useful output, achieving its intended goal while minimizing waste, losses, or undesirable effects. It quantifies how well a system utilizes its inputs to produce the desired results. Efficiency is a crucial concept across various domains of science, engineering, economics, and even everyday life. Efficiency is always a ratio, that can be expressed as a percentage and its values range from 0 (null efficiency) to 1 (maximum efficiency), or from 0% to 100%. Efficiency = (Useful Output) / (Input Resources) You will never get from a closed physical system more output than the input!	Efficiency effectiveness with which a physical system or process converts input resources into useful output Efficiency = (Useful Output) / (Input Resources)	
	Efficiency can be improved acting on: **Minimization of Losses**. Efficient systems aim to minimize wastage, losses, or dissipation of resources during the conversion process. In other words, they strive to extract the maximum benefit from the available inputs. **Optimal Resource Utilization** Efficient systems use resources optimally, avoiding overconsumption or excessive use of inputs. They find the balance between achieving the desired outcome and conserving resources.	Improve efficiency Minimization of Losses. Optimal Resource Utilization. Performance Enhancement	

	Performance Enhancement Improving efficiency often leads to improved system performance, as less input is needed to achieve the same or even better output. This can result in cost savings, reduced environmental impact, and enhanced reliability.		
	Efficiency in the Conversion of Heat to Mechanical Energy The conversion of heat into mechanical energy lies at the heart of numerous industrial applications, from power generation to transportation systems. The efficiency of this conversion plays a crucial role in determining the overall effectiveness and sustainability of these processes. For a heat engine, thermal efficiency is the ratio of the net work output to the heat input; in the case of a heat pump, thermal efficiency (known as the coefficient of performance) is the ratio of net heat output (for heating), or the net heat removed (for cooling) to the energy input (external work). When converting heat to mechanical energy, the primary challenge is to extract as much useful work as possible from the heat source, which is often a high-temperature reservoir. This conversion is governed by the second law of thermodynamics, specifically the concept of Carnot efficiency. .	**Efficiency in the Conversion of Heat to Mechanical Energy** heat engine thermal efficiency = net work output / heat input heat pump thermal efficiency or COP (coefficient of performance) = net heat output / energy input (external work) – for heating thermal efficiency or COP = net heat removed / energy input (external work) - for cooling	
	For a device that converts energy from another form into thermal energy (such as an electric heater, boiler, or furnace), the thermal efficiency is the ratio between the thermal energy in output and the energy in input. A boiler that produces 210 kW output for each 300 kW of heat-equivalent input has a thermal efficiency that is 210/300 = 0.70, or 70%. If for instance you burn methane, only 70% of the heat generated actually contributes to the produce hot water. The remaining 30% is lost to the environment. An electric resistance heater has a thermal efficiency close to 100%. When comparing heating units, such as a highly efficient electric resistance heater to a 70% efficient natural gas-fueled furnace, an economic analysis is needed to determine the most cost-effective choice.		Picture of a boiler and schema of energy used /lost

	Cooling systems, such as air conditioning (HVAC) units and heat pumps, play a pivotal role in maintaining comfortable indoor environments and facilitating various industrial processes. These systems operate based on thermodynamic principles, with efficiency being a key parameter that governs their performance and energy consumption. Cooling systems utilize a cycle known as the refrigeration cycle, which involves the transfer of heat from a cooler space (indoors) to a warmer space (outdoors). This cycle relies on the principles of heat transfer, compression, and expansion of refrigerants to achieve its cooling effect. The efficiency of cooling systems is often quantified using the coefficient of performance (COP). For a heat pump or cooling system, the COP is defined as the ratio of the desired cooling effect (heat removed from the indoor space) to the energy input required to achieve that effect. COP = Desired Cooling Effect / Energy Input The higher the COP, the more efficiently the cooling system can achieve the desired cooling effect using a given amount of energy. This parameter is a critical measure of efficiency, as it directly relates the cooling achieved to the energy consumed.	Efficiency of Cooling Systems Cooling HVAC units and heat pumps Transfer heat form lower temperature to higher temperature This is not a spontaneous process and requires energy The coefficient of performance (COP) measures the efficiency of these systems COP = Desired Cooling Effect / Energy Input	Picture of a heat pump and schema of heat transfer
	Here there are some typical efficiency ranges for various types of machines: Gasoline-powered automobile engine: 20% - 30% efficiency Diesel engine (automobiles and trucks): 30% - 40% efficiency Large marine diesel engines: 40% - 50% efficiency Aircraft jet engines: 30% - 40% efficiency Conventional steam power plants: 30% - 40% efficiency (can be higher with advanced technology) Large hydroelectric power plants: 80% - 90% efficiency (conversion of mechanical energy to electrical energy) Modern onshore wind turbines: 30% - 50% efficiency (conversion of wind energy to electrical energy) Commercial photovoltaic solar panels: 15% - 20% efficiency (conversion of sunlight to electrical energy) Electric motors (varies widely depending on type and load): 70% - 95% efficiency	Here there are various types of machines: Click on them to get information about their efficiency	Picture of the device mentioned. Pointing on each of them shows the information about efficiency

3.3 SOLAR ENERGY AND PV

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
INTRODUCTION	The Sun is an incredibly powerful source of energy that emits in space any direction. A small portion of this energy output is collected by the Earth located 150 million kilometers away from the Sun. The solar constant is the amount of solar energy received per unit area at the average distance between the Earth and the Sun. It is used to estimate the amount of solar energy that reaches the outer atmosphere of Earth and is approximately 1361 W/m². This value is at the outer atmosphere of Earth, about 600 km from the surface. The actual amount of solar energy that reaches the surface of the Earth depends on various factors, including the angle of sunlight, atmospheric absorption, and Earth's reflectivity. The annual global solar energy absorption of the Earth is about 173,000 terawatts (TW), where 1 TW = 10^{12} watts. It is an enormous amount of energy, by far greater than the energy currently used by the 8 billion of humans. Solar energy as one of the most abundant and environmentally friendly sources of power available to humanity and therefore solar power has gained immense attention and significance in addressing the world's growing energy demands while mitigating the adverse effects of climate change.	Introduction to Solar Energy solar constant = 1361 W/m². annual global solar energy absorption of the Earth = about 173,000 terawatt	Picture of Sun – Earth showing the fraction of energy intercepted by Earth
	One of the primary methods of capturing solar energy is through photovoltaic (PV) technology, commonly known as solar panels. These panels consist of interconnected solar cells made from semiconductor materials.	Photovoltaic panels – direct production of electricity Concentrated Solar Power (CSP) –high temperature heat for electricity production	Pictures of PB panels, CSP central and thermal solar panels

	When sunlight strikes these cells, it triggers a process called the photovoltaic effect, which releases electrons and generates a flow of electricity. This electricity can be used to power homes, businesses, and even entire communities, offering a clean and renewable alternative to fossil fuels. Solar energy adoption extends beyond electricity generation. Solar thermal systems harness the sun's heat to produce steam, which can drive turbines for electricity production or be used directly for applications like water heating and space heating. Furthermore, concentrated solar power (CSP) technology utilizes mirrors or lenses to focus sunlight onto a small area, producing high temperatures that can also be used for electricity generation. The appeal of solar energy lies not only in its potential to reduce greenhouse gas emissions and combat climate change but also in its role as a decentralized energy source. Solar installations can be deployed at various scales, from individual rooftop systems to large-scale solar farms. This decentralization enhances energy security, resilience, and accessibility for diverse communities.	Solar thermal systems –low temperature heat for water and space heating	
	The solar energy that reaches the Earth is the basis of many remarkable phenomena. Sun energy really power nearly everything happens on Earth, from wind to rain, from wave to life. Here are some key points about the amount of solar energy and its interactions with Earth: **Atmospheric Absorption and Scattering** Not all the solar energy that reaches Earth's outer atmosphere makes it to the surface. Earth's atmosphere absorbs and scatters a portion of the incoming sunlight. Some wavelengths, such as ultraviolet (UV) and most X-rays and gamma rays, could be harmful to life and are absorbed by the atmosphere. A significant portion of solar energy is reflected back into space by Earth's surface, clouds, and the atmosphere. The	SOLAR BALANCE **Atmospheric Absorption and Scattering** **Solar energy is the primary driver of weather** **Solar energy for sustaining life**	Picture earth_energy_budget.jpeg

	amount of reflected energy depends on surface type (land, water, ice), cloud cover, and atmospheric conditions. Part of the energy received is also emitted into outer space as thermal radiation. Greenhouse gases limit the amount of thermal radiation dispersed and help keeping the planet warm. Earth's energy budget involves a balance between incoming solar radiation and outgoing thermal radiation. Any imbalance in this budget can lead to changes in global temperature and climate patterns, which has important implications for the planet's ecosystems and the well-being of its inhabitants. **Solar energy is the primary driver of weather** The solar energy that is not reflected is absorbed by Earth's surface, oceans, and atmosphere. This absorbed energy is a primary driver of Earth's climate and weather patterns. Differential heating of the Earth's surface causes variations in temperature and pressure, which in turn create wind patterns. Similarly, solar energy heats the ocean's surface, leading to the formation of ocean currents that redistribute heat around the planet. **Solar energy for sustaining life** Solar energy is crucial for the process of photosynthesis in plants, which converts sunlight into chemical energy stored as glucose. This process forms the basis of the food chain, as plants are consumed by herbivores and then by carnivores. Additionally, solar energy is stored in the biomass of living organisms through the food they consume.		
	Photovoltaic (PV) panels, also known as solar panels, are a promising source of renewable energy. PV is the most installed RES worldwide due to the availability of the resource, short installation time and relatively low cost. They offer a multitude of advantages that position solar energy as a key player in the transition to a cleaner and more sustainable energy future. Their environmental benefits, cost savings, energy independence, and versatility make them a valuable investment for individuals, businesses, and communities seeking to harness the power of the sun. Their main advantages are:	Solar Photovoltaic Panel main advantages Reduced Environmental Impact Low Operating and Maintenance Costs Scalability and Versatility Remote Power Generation Click on each item to get more information	Picture of PV Items link to following 4 rows

	Reduced Environmental Impact Low Operating and Maintenance Costs Scalability and Versatility Remote Power Generation Click on each item to get more information		
	Reduced Environmental Impact Solar panels generate electricity by converting sunlight directly into electrical energy. This process is clean and does not produce greenhouse gases or other harmful emissions, making solar power a sustainable and environmentally friendly energy source, at least during their operation.		
	Low Operating and Maintenance Costs Solar panels have relatively low operating and maintenance costs. Once installed, they require minimal maintenance, usually limited to periodic cleaning and ensuring they are free from shading. They have no moving parts, reducing the risk of mechanical breakdowns		
	Scalability and Versatility Solar panels can be installed on various scales, from individual residential rooftops to large-scale solar farms. They are versatile and can be integrated into buildings, homes, and even portable applications like solar-powered chargers and devices.		
	Remote Power Generation Solar panels enable power generation in remote or off-grid locations where traditional electricity sources might be unavailable or expensive to install. This is particularly beneficial for providing electricity to rural communities or isolated installations.		
	Photovoltaic (PV) panels offer numerous benefits but they also come with some drawbacks and limitations that should be considered in their deployment and use. Sunlight availability and conversion efficiency Initial costs and investments required Space Requirements Environmental Impact of Manufacturing and disposal		Picture of PV Items link to following 4 rows

	Sunlight availability and conversion efficiency Photovoltaic panels generate electricity directly from sunlight. This means that their output is highly dependent on weather conditions, time of day, and geographic location. Cloudy days, nighttime, and seasonal changes in day length and sun position will result in reduced energy generation. The amount of electricity of a solar panel suffers of two major problems: **Intermittence** = alternance day/night (on/off; fully predictable) **Variability** = fluctuations of production intra-day and day-to-day (forecast accuracy < 100%) For these reasons the Capacity Factor (CF) is an important parameter to be evaluated as the ratio between the amount of energy actually produced and the product of the PV panels nameplate power by the time you want to span. CF = Actual energy produced (kWh) / nominal power (kW) $*$ Time (h) The efficiency of PV panels, which refers to the amount of sunlight they convert into electricity, varies based on technology and quality. Technological evolution led to a significant increase in solar panel efficiency, that is currently between 15% and 20% for commercial panels. This means that a portion between 85% and 80% of sunlight does not get converted into usable energy. Energy storage solutions, like batteries, are often required to mitigate the intermittence but can be applied only to a local scale and are quite expensive, significantly impacting on initial investments required.	Sunlight availability and conversion efficiency **Intermittence** = alternance day/night (on/off; fully predictable) **Variability** = fluctuations of production intra-day and day-to-day (forecast accuracy < 100%) Efficiency of commercial panels = 15-20% Capacity factor = CF = Actual energy produced (kWh) / nominal power (kW) $*$ Time (h)	
	Initial costs and investments required. The upfront cost of purchasing and installing PV panels can be relatively high, including expenses for solar panels, inverters, mounting systems, and installation labor. While the cost of solar technology has decreased over the years, the initial investment can still be a barrier for some individuals, businesses, or governments.	Initial costs and investments required.	

	Adding a storage system worsen the economic balance due to the high cost of batteries and their limited lifetime.		
	Space Requirements Solar energy is a distributed energy source and therefore PV panels require significant space to collect it. To generate 1 MW of energy a surface of one hectare (100 meters x 100 meters) is required. Photovoltaic panels due to their flexibility and scalability however can be easily installed in surfaces that are used for other purposes, such as rooftops of existing building, parking, industrial plants. Rooftop installations however can be constrained by available area and orientation. The appearance of PV panels installed on top of buildings – especially if historical or ancient - can be seen as unattractive or may not fit the architectural style of certain structures. Panel extensions can also affect the landscape by their intrusiveness	Space Requirements one hectare = 1 MW Aesthetic Considerations On buildings On landscape	Picture of panels on building Extension of panels
	Environmental Impact of Manufacturing and disposal The production of PV panels involves energy-intensive processes, including the mining of raw materials, manufacturing, and transportation. The energy payback period is the time it takes for a PV panel to generate as much energy as was used in its production. While this period has been decreasing due to technological advancements, it's still a consideration in terms of the overall environmental impact of the panel's lifecycle. Panel disposal also should be considered when evaluating the economics. While solar energy is clean during operation, the environmental impact of panel production should be considered.	Environmental Impact of Manufacturing and disposal Silicon production is energy intensive Disposal of panels and supporting structures should be evaluated	
	Maintenance and Longevity While PV panels require generally low maintenance, but anyway they still require periodic cleaning and inspection. Dust, debris, shading, and extreme weather conditions can affect their performance over time.	Maintenance and Longevity low maintenance periodic cleaning and inspection affected by dust, debris, shading, weather phenomena such as hail or snow	Panels affected by hail (e.g. damaged_panels.jpeg)

	Panel lifetime is estimated in 25 to 30 years and this should be considered for cost analysis and long-term planning.	Estimated lifetime 25 to 30 yrs.	
	The energy balance of solar panels refers to the comparison between the total energy used in the production and manufacturing of the panels and the total energy produced by those panels during their operational lifetime. This balance is often expressed as the Energy Pay Back Time" (EPBT) or "energy return on investment" and is an important metric to understand the environmental impact and sustainability of solar panel technologies. The energy balance calculation takes into account various factors, including the energy required for raw material extraction, manufacturing processes, transportation, installation, and maintenance of the solar panels. It is then compared to the energy output of the panels over their operational lifespan, considering factors like solar insolation (amount of sunlight), system efficiency, and degradation of panel performance over time. A positive energy balance indicates that the solar panels have produced more energy over their lifetime than the energy that went into their production. In other words, the panels have "paid back" the energy invested in their creation and continue to contribute clean energy to the grid. A shorter energy payback time is generally preferable, as it indicates a quicker return on the energy investment. Over the past few decades, improvements in solar panel efficiency and manufacturing processes have led to significant reductions in energy payback times. In many cases, modern solar panels can achieve energy payback times of just a few years, which means they generate more energy during their operational lifetime than the energy used to manufacture them. It's important to note that the energy balance can vary based on factors such as the type of solar panel technology (e.g., monocrystalline, polycrystalline, thin-film), the location of installation (solar insolation levels), the energy mix used for manufacturing, and the recycling or end-of-life considerations for the panels.	The EPBT for France Note how the figures change going from the sunny south to the north, where there are more clouds and rain and where there is less sunlight	Picture EPBT

3.4 WIND ENERGY

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
	Wind energy has emerged as a prominent and sustainable source of electricity generation in our quest for cleaner and more environmentally friendly power options. At the forefront of harnessing this renewable resource are wind turbines – towering structures adorned with large rotating blades that transform the kinetic energy of moving air into usable electrical power. Wind turbine power generation exemplifies the marriage of modern engineering and age-old natural forces, offering a promising solution to our global energy needs while reducing our carbon footprint.	Introduction to Wind Turbine Power Generation	Picture of a wind turbine (modern) and a Dutch windmill
	Wind turbines operate on a simple yet powerful principle: capturing the energy inherent in wind motion. As wind flows over the turbine's blades, it imparts a force that sets them in motion. This mechanical energy is then transferred through a gearbox to a generator, where it is converted into electrical energy. This process showcases the efficient transformation of kinetic energy – energy of motion – into a form that can power our homes, businesses, and industries.	Harnessing the Power of Moving Air	Schema e.g Operating-principle-of-the-wind-turbine
	The power you could get form a wind turbine is: Proportional to the cube of wind speed. If the speed of wind doubles, the power increases 8 times! The consequence: look per areas with very strong winds! Is directly proportional to the surface of the rotor area, that means in practice to the length of rotor blades. Use the biggest rotor you can allow! The density of air is also important for the power generated: the colder the air the higher its density and therefore the higher the power generated.	Proportional to the cube of wind speed Directly proportional to the surface of the rotor area directly proportional to the air density	Picture “wind rotor Peinke”

	A rotor with a blade 63 meters long can produce about 5-6 MW		
	Wind energy is much more concentrated than solar energy and therefore wind turbines have a relatively small land footprint compared to some other power generation methods, making them particularly suitable for repurposing existing spaces. Wind turbines can be found in a range of settings, from remote wind farms to urban rooftops. Their designs have evolved to suit varying wind speeds and conditions, making wind energy a versatile option for regions with varying climates. The most productive setting for wind farm is offshore, where there are no obstacles to air flow and in location where the wind are strong and reasonably constants. In some countries wind farm are installed inland, along mountain ridges where the wind is generated by the region orography.	Wind energy – more concentrated than solar -> reduced land footprint Range of settings available Can be installed Offshore Inland	Picture of offshore and inland wind farms
	One of the main advantages of wind turbines is their relative simplicity: the blades are connected to a nacelle that contains all the equipment required to produce electricity, without further conversion. Wind farm do not produce any greenhouse gas emissions or air pollutants during operation nor use water or other coolants. Once wind turbines are installed, their operating and maintenance costs are relatively low compared to conventional power plants.	Direct conversion from mechanical energy to electrical energy -> high efficiency Clean operation Low maintenance costs	Schema of nacelle
	Wind projects can be developed relatively quickly compared to traditional power plants. This makes wind energy a flexible solution for addressing immediate energy needs and responding to changing demand. Ongoing advancements in wind turbine design and technology are leading to increased efficiency, improved performance, and reduced costs, making wind energy more competitive in the energy market. Electric energy produced from wind is one of the cheapest among renewable power sources and compares very favorably with fossil fuel power plants that rely on much more mature technologies.	Quick deployment Flexible solution Reduced cost of electrical energy produced	Ref. https://www.ise.fraunhofer.de/en/publications/studies/cost-of-electricity.html
	While wind turbines offer numerous advantages as a renewable energy source, they also come with certain drawbacks and challenges.	Intermittency Weather conditions	Picture damaged wind-turbine

	Wind energy is highly dependent on wind speed and consistency. Wind patterns can vary significantly over time and location, leading to fluctuations in energy production. Calm periods with low wind speeds or extended calm spells can result in reduced energy generation, which can affect the reliability of wind power as a consistent energy source. There could be also small-scale intermittency. These are fast and local changes of wind power going from no wind to very strong wind gusts that may seriously damage the wind turbines. Turbines have optimal wind speed ranges for operation, and extreme wind conditions, such as high winds and gusts, may require the turbines to be shut down to prevent damage.	calm spells – no production strong gusts - damages to wind turbines	
	Wind farms often need to be located in remote areas with strong and consistent winds and the transmission of the generated electricity to the main power grid could require the construction of new transmission lines. The intermittent nature of wind energy production necessitates solutions for energy storage or backup power sources to maintain a steady and reliable electricity supply. The upfront investment required to design, manufacture, and install wind turbines and associated infrastructure can be substantial. While the long-term operational costs are relatively low, the initial capital costs can pose financial barriers, particularly for smaller-scale projects. Integrating variable wind energy into existing power grids requires careful management to balance supply and demand. The development of smart grids allows to integrate wind energy much more easily than in the past into the current mix of power sources.	Technological challenges Remote location of wind farms – need for building transmission infrastructures Intermittency need for energy storage systems. Need for sophisticated smart grids to balance load and production	Picture of offshore wind-turbine
	Large wind turbines can be visually obtrusive, altering the landscape and affecting the aesthetics of natural and rural areas. Moreover, some people find the noise generated by wind turbines, such as the whooshing sound of rotating blades, to be disruptive, particularly when turbines are situated close to residential areas. Wind turbines can also pose risks to birds and bats. Collisions with turbine blades can lead to fatalities, particularly for species that fly at low altitudes or during migration.		Landscape with wind turbines Statistical data about birds death causes birds_killed_by_15195.jpeg (source https://www.statista.com/chart/15

	While modern designs often incorporate measures to mitigate such impacts, the potential for negative effects on local wildlife remains a concern. Wind farms require the construction and maintenance of access roads, transmission lines, and other infrastructure that can impact natural ecosystems and land use. Although wind energy enjoys broad public support due to its environmental benefits and potential to contribute to a sustainable energy future, some wind energy projects face opposition from local communities due to concerns about visual impact, noise, or other perceived drawbacks. This NIMBY (Not In My Backyard) syndrome can lead to delays or cancellations of projects, hindering the expansion of wind energy.		195/wind-turbines-are-not-killing-fields-for-birds/)
	Evaluating the energy balance of wind turbines involves comparing the total energy produced by a wind turbine over its operational lifetime with the energy required for its manufacturing, transportation, installation, maintenance, and decommissioning. This assessment provides insights into the net energy benefit and environmental impact of wind energy. The energy balance can vary depending on factors such as the turbine's size, location, design, and the energy mix used for manufacturing and construction. However, studies have generally shown that wind turbines have a positive energy balance, meaning they produce more energy over their lifetime than what was invested in their production and operation. Energy Invested (Embodied Energy). This is the energy required to deploy a wind turbine Manufacturing Transportation Installation Maintenance Decommissioning Energy Produced This is the energy produced during the wind turbine lifespan Wind turbines generate electricity over their operational lifespan, which is typically around 20 to 25 years. The amount of energy produced depends on factors such as wind speed, turbine efficiency, and maintenance practices.	Energy balance = Energy produced – Energy invested Energy Invested (Embodied Energy). This is the energy required to deploy a wind turbine Manufacturing Transportation Installation Maintenance Decommissioning Click on items to get more information Energy Produced This is the energy produced during the wind turbine lifespan (20-25 years)	Clicking on the items show the info of the following 5 rows Manufacturing Transportation Installation Maintenance Decommissioning

	Studies that have conducted life cycle assessments (LCAs) of wind turbines have found that the energy payback period – the time it takes for a turbine to generate as much energy as was invested in its manufacturing and operation – is relatively short, often less than a year or two. This means that wind turbines typically produce several times more energy than is required for their entire lifecycle. It's important to note that these assessments might vary based on location, technology advancements, and the energy mix used in manufacturing. Additionally, ongoing improvements in turbine design and manufacturing processes are likely to further enhance the positive energy balance of wind turbines. In conclusion, the energy balance of wind turbines is generally positive, with the energy produced over their operational lifetime exceeding the energy invested in their manufacturing, transportation, installation, maintenance, and decommissioning.		
	Manufacturing The production of wind turbine components (blades, tower, nacelle, generator, etc.) requires energy. This includes material extraction, processing, fabrication, and assembly.		
	Transportation Transporting the components to the installation site requires energy, especially for large components that may need to be transported long distances.		
	Installation Erecting the turbine, including the construction of access roads and foundations, requires energy.		
	Maintenance Regular maintenance and occasional component replacements are needed over the turbine's operational lifetime. These activities require energy for labor, equipment, and transportation.		
	Decommissioning At the end of a turbine's life, decommissioning involves dismantling, removing, and potentially recycling or disposing of components.		

3.5 HYDROELECTRIC POWER PLANTS

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
	A hydropower plant is a facility that generates electricity by utilizing the kinetic energy of flowing water to turn turbines, which in turn drive generators to produce electricity. This renewable energy source is harnessed from various water bodies such as rivers, dams, or reservoirs, and it plays a significant role in global electricity production. Hydropower facilities range in size from large power plants, which supply many consumers with electricity, to small and even 'micro' plants, which are operated by individuals for their own energy needs or to sell power to utilities. Large Hydropower - Facilities that have a capacity of more than 30 megawatts (MW). Small Hydropower - projects that generate between 100 kilowatts and 10 MW. Micro Hydropower - plants with a capacity of up to 100 kilowatts. A small or micro hydroelectric power system can produce enough electricity for a single home, farm, ranch, or village.		Pictures of hydroelectric power plants of various size
	The plant size affects its structure and characteristics. Large Plants They have a higher capacity to generate electricity. They often involve the construction of significant infrastructure, including dams, reservoirs, and complex water diversion systems. Small Plants They have a lower capacity and are typically built on smaller water bodies, such as rivers or streams. They generate less electricity compared to large plants. Smaller plants require less extensive infrastructure, usually involving intake structures and smaller penstocks.	Same as narrated text	Graphical comparison of the two types of plants

	There are three types of hydropower facilities: impoundment diversion pumped storage Some hydropower plants use dams and some do not. Click on the images to display in detail each type		Source https://www.energy.gov/eere/water/types-hydropower-plants three thumbnails of different plant types
	Impoundment The most common type of hydroelectric power plant is an impoundment facility. An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released to meet changing electricity needs or other needs, such as flood control, recreation, fish passage, and other environmental and water quality needs. Click on the picture to get more information		
	Diversion A diversion, sometimes called a “run-of-river” facility, channels a portion of a river through a canal and/or a penstock to utilize the natural decline of the river bed elevation to produce energy. A penstock is a closed conduit that channels the flow of water to turbines with water flow regulated by gates, valves, and turbines. A diversion may not require the use of a dam. Click on the picture to get more information		
	PUMPED STORAGE Another type of hydropower, called pumped storage hydropower, or PSH, works like a giant battery. A PSH facility is able to store the electricity generated by other power sources, like solar, wind, and nuclear, for later use. These facilities store energy by pumping water from a reservoir at a lower elevation to a reservoir at a higher elevation. When the demand for electricity is low, a PSH facility stores energy by pumping water from the lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir and turns a turbine, generating electricity.		

	Water Source The key element of any hydropower plant is a reliable water source, which could be a river, a dammed reservoir, or a natural waterfall.		
	Intake Structure This is where water is diverted from the water source into the plant. The design of the intake structure varies based on the plant's size and location. The water intake is controlled by a mobile gate and a trash rack prevents the access to large debris, such as logs.		
	Penstock A penstock is a large pipe or conduit that carries the diverted water from the intake to the turbine's blades. The force of the flowing water propels the turbine.		
	Turbine The turbine is the heart of the hydropower plant. As the high-speed water flows through the turbine's blades, it causes them to spin. This kinetic energy is then transferred to the generator.		
	Generator Connected to the turbine, the generator converts the mechanical energy from the spinning turbine into electrical energy.		
	Transmission Lines The generated electricity is then transformed to the suited voltage and transmitted through power lines to homes, businesses, and industries, providing a source of reliable and clean energy.		
	Hydropower plants, whether large or small, offer numerous advantages as a renewable energy source. These advantages stem from their ability to harness the energy of flowing water to generate electricity in an efficient and sustainable manner. Here are some of the key advantages of large Hydropower Plants High Energy Output – they can generate significant amounts of electricity, providing a reliable source of baseload power to meet the demands of large populations and industries. Energy Storage – they can function as energy storage systems by adjusting the flow of water through turbines based on electricity		Picture of large hydroelectric plant

	demand. Excess electricity can be used to pump water back into the reservoir, effectively storing energy for later use. Flood Control - Large dams associated with hydropower plants can regulate water flow, reducing the risk of flooding downstream during periods of heavy rainfall. Water Supply- the reservoirs created by large dams can serve as water storage for various purposes, including irrigation, drinking water supply, and industrial use.		
	Small hydropower plants offer the advantage of local energy generation and can be easily scaled based on local energy needs, making them adaptable to different community sizes and electricity demands. They can be installed in remote or rural areas, providing localized power generation for communities that may not have access to larger grids. Compared to large dams, small hydropower plants often have a lower environmental footprint, causing less disruption to ecosystems and aquatic habitats. The production and use of the electrical energy in the same area reduces the need for extensive long-distance transmission, minimizing energy losses during distribution.		Picture of a small hydropower plant
	Both large and small hydropower plants have environmental impacts, although the scale and extent of these impacts can vary. The construction of large dams and reservoirs can result in significant ecological disruption, including habitat loss, altered water flow, and changes in water temperature that affect aquatic life. Human life can also be significantly altered: large dam projects can lead to the displacement of communities, as the creation of reservoirs can submerge homes, farmlands, and cultural sites. Even though smaller in scale, small hydropower plants can still disrupt local ecosystems and aquatic habitats, modifying fish migration routes. This affects not only the fish populations but also the overall health of river ecosystems. Reservoirs can trap sediment that would naturally flow downstream, potentially leading to erosion downstream. The nutrients and the organic matter transported in the sediment are blocked upstream and therefore the river ecosystems can be heavily affected.	Environmental impact ecological disruption displacement of communities trap sediment	Picture on sediment

	Even if hydropower plant does not emit greenhouse gases during their operation, they can release methane, a potent greenhouse gas, due to the decomposition of submerged organic matter in reservoirs.		
	Watch this short video on sediments and dams (6’ 03’’)	Video	https://www.youtube.com/watch?v=HQ-Y8ClEpgw
	The large plants initial costs are huge. The construction of large dams and associated infrastructure requires significant upfront investment, and the return on investment may take years to realize. Not to be overlooked is the weight of water in large reservoirs can induce seismic activity in some cases, leading to concerns about the safety of nearby communities. There are also a number of very serious accidents reported in the past with thousands of victims related to large dams. The Vajont reservoir is located in northern Italy. On 9 October 1963, during initial filling, a landslide caused a megatsunami in the lake in which 50 million of cubic meters of water overtopped the dam in a wave of 250 m, which brought massive flooding and destruction to the Piave Valley below, leading to the destruction of several villages and towns, causing an estimated 1,900 to 2,500 deaths	Large investments required Potential accidents related to reservoirs	Picture of Vajont reservoir
	Smaller plants are not exempt from other drawbacks due to their intrinsic characteristics. The usage of small rivers and the lack of reservoirs could make smaller plant prone to changes in water flow, which can result in intermittent power generation. This can be a challenge for maintaining a consistent power supply. The lack of Integration into existing electricity grids makes intermittence a major challenge, particularly in regions with weak infrastructure. While smaller in scale, these plants still require land for infrastructure, potentially competing with other land uses such as agriculture or conservation.		
	The lifespan of a hydropower plant can vary depending on factors such as the type of plant, the quality of construction, maintenance practices, technological advancements, and changes in regulations or environmental conditions. However, in general,		

	hydropower plants are known for having relatively long lifespans compared to many other types of power generation facilities. Large hydropower plants, such as those built with substantial infrastructure like dams and reservoirs, are often designed and built to last for several decades. They can have operational lifespans ranging from 50 to 100 years or more, assuming they receive proper maintenance and upgrades as needed. Small hydropower plants, which are generally less complex and have smaller infrastructure requirements, also have relatively long lifespans. Similar to large plants, their operational lifespan can range from 30 to 80 years or more, again depending on factors like maintenance and technological advancements.		
	Further readings https://ec.europa.eu/research-and-innovation/en/projects/success-stories/all/making-sustainable-hydropower-reality https://en.wikipedia.org/wiki/Gleno_Dam https://en.wikipedia.org/wiki/Grand_Ethiopian_Renaissance_Dam		

3.3.2.3.6 BIOMASSES

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
INTRODUCTION	Biomass power plants mimic what in Natura happens as the ordinary cycle of life and energy: to get energy from decaying organic substances. Biomass power plants operate on a concept deeply rooted in nature: the conversion of organic matter into energy. Biomass materials, ranging from crop residues and forestry byproducts to municipal solid waste and dedicated energy crops, contain stored energy in the form of carbon compounds. Biomass power plants encompass various technological pathways, each suited to different biomass sources and energy needs. **Direct combustion** involves burning biomass materials to produce heat, which drives turbines or engines to generate electricity. **Gasification**, on the other hand, transforms biomass into a synthetic gas (syngas) that can be burned for heat or used to produce electricity. **Biochemical processes**, such as anaerobic digestion, harness microbial activity to generate biogas from organic waste. Biomass is really a renewable energy source because it is derived from organic materials that can be continuously replenished through natural processes. Biomass power plants can utilize agricultural residues, wood waste, forestry byproducts, and even organic waste from municipalities and industries. By converting these materials into energy, biomass power plants contribute to waste reduction and minimize the need for landfill disposal, thereby addressing waste management challenges.	Energy from biomasses – what life does since its inception on Earth conversion of organic matter into energy. Direct combustion Gasification Anaerobic digestion	Biomass plant image

	Biomass power plants can provide stable and dispatchable electricity supply since they can be operated continuously, unlike some intermittent renewable sources like solar and wind. This makes them valuable for grid stability and addressing fluctuations in energy demand. Biomass is often sourced locally, reducing dependence on imported fossil fuels and in many cases transportation costs. This enhances energy security by utilizing local resources, which can help stabilize energy prices and reduce vulnerability to international energy market fluctuations. Unlike fossil fuels, which are finite and contribute to greenhouse gas emissions, biomass is considered carbon-neutral during normal operation because the carbon dioxide released during combustion is offset by the carbon dioxide absorbed during the growth of plants. This can contribute to mitigating climate change by reducing the overall concentration of greenhouse gases. Of course, building a biomass power plant is in itself not a carbon-neutral activity because energy is required in the manufacturing, transportation, installation, control and maintenance of the power plant.	Biomass power plants = a stable and dispatchable electricity supply Biomass is sourced locally Biomass power plant operation is carbon-neutral The carbon dioxide emitted is the carbon dioxide captured by biomass during its production	
	Proper sourcing and management of biomass feedstock are essential to ensure the long-term environmental benefits of biomass energy. On the bright side certain energy crops can be cultivated on marginal lands that are not suitable for traditional agriculture. This minimizes competition with food production and optimizes land use for energy generation. On the other side expanding biomass cultivation for energy purposes can lead to changes in land use, including deforestation and conversion of natural habitats to biomass plantations. This can have negative environmental and social implications, including loss of biodiversity and displacement of local communities.	Challenges and Considerations Use of marginal lands Poor land practices	Picture of deforestation
	Biomass can directly or indirectly be converted into biofuels which can be of solid, liquid or gaseous forms. Currently, over 85% of biomass energy is consumed as solid fuels for cooking, heating and lighting, often with low efficiency.	Biomass into Biofuel	

	Traditional bioenergy (fuel wood, charcoal which can only deliver heat) dominate bioenergy consumption in developing countries. Advances in combustion and gasification technologies have improved the efficiency of biomass power plants, reducing emissions and increasing energy output. Biomass feedstock varies in composition and moisture content, which can impact combustion efficiency and emissions. Co-firing biomass with coal in existing coal-fired power plants is another option to transition toward cleaner energy sources.	Over 85% of biomass energy is consumed as solid fuels Efficient combustion and emissions control are essential to mitigate air pollution and ensure environmental compliance	
	While biomass energy is often considered carbon-neutral due to the absorption of carbon dioxide (CO2) during plant growth, the actual emissions depend on factors such as feedstock type, processing, and transportation. Inefficient combustion or incomplete combustion of biomass can release pollutants and CO2, affecting air quality and the net carbon neutrality of the process. Biomass combustion can release pollutants such as particulate matter, volatile organic compounds (VOCs), and nitrogen oxides (NOx), which can contribute to poor air quality and respiratory issues. Implementing effective emission control technologies is crucial to mitigate these impacts	Biomasses and the air quality	
	The transportation of bulky biomass feedstock to the power plant can incur energy and environmental costs, particularly if long distances are involved. These transportation-related emissions and energy requirements must be factored into the overall energy balance. Combustion of biomass produces ash and residues that need proper management and disposal. Poor ash management can lead to environmental contamination and pose challenges in terms of storage and disposal methods.		
	In some cases, government incentives or subsidies for biomass energy production can create competition for biomass feedstock, leading to increased demand and potential conflicts with other uses such as food production. Establishing biomass power plants requires investment in infrastructure, technology, and supply chains. The economic viability of these projects can be affected by fluctuating		

	feedstock prices, energy market conditions, and regulatory policies.		
	The energy balance is calculated by comparing the total energy output (heat, power, or biofuels) over the operational lifetime of the biomass plant with the total energy input required for feedstock production, transportation, and processing. If the energy output is greater than the energy input, the biomass plant has a net energy gain. Conversely, if the energy input exceeds the energy output, the plant may have a net energy loss. A positive net energy gain indicates that the biomass plant is producing more usable energy than what is invested in its production and operation. This evaluation is crucial to determine the net energy gain or loss from using biomass as a renewable energy source. Energy Inputs Feedstock Cultivation Feedstock Transportation Processing and Conversion Energy Outputs Heat and Power Generation Biofuels Production. Click on the items to get more information	energy balance = Energy outputs – energy inputs Energy Inputs Feedstock Cultivation Feedstock Transportation Processing and Conversion Energy Outputs Heat and Power Generation Biofuels Production. Click on the items to get more information	
	However, the specifics of the energy balance can vary significantly depending on factors such as feedstock type, plant efficiency, agricultural practices, and processing methods. Different biomass feedstocks have varying energy balances due to differences in energy content, growth rates, and cultivation practices. Advanced processing technologies can significantly improve the efficiency of energy conversion, affecting the overall energy balance. Local conditions such as climate, soil quality, and agricultural practices influence feedstock yields and energy inputs. In some cases, well-managed biomass operations can achieve a positive net energy gain, while in others, the balance may be closer to neutral.		

	To accurately evaluate the energy balance, a comprehensive life cycle analysis considering all stages of feedstock production, transportation, processing, and energy conversion is necessary. Furthermore, the energy balance isn't the only consideration when assessing biomass energy. Environmental impacts, carbon emissions, land use, and sustainability aspects also play a critical role in determining the overall viability and benefits of using biomass as an energy source.		
	Feedstock Cultivation The energy required for growing, cultivating, and harvesting the biomass feedstock (e.g., crops, wood, agricultural residues). This includes fuel for tractors, irrigation, fertilizers, and pesticides.		
	Feedstock Transportation Energy needed to transport the feedstock from the cultivation site to the processing plant.		
	Processing and Conversion The energy consumed during the conversion of biomass to usable energy, which involves processes such as combustion, gasification, or anaerobic digestion.		
	Heat and Power Generation The energy produced in the form of heat and electricity from the combustion or gasification of biomass. This energy can be used for electricity generation, heating, or combined heat and power (CHP) applications.		
	Biofuels Production In the case of biofuels like ethanol or biodiesel, the energy contained in the final fuel product that can be used for transportation.		

3.3.2.3.7 GEOTHERMAL

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
INTRODUCTION	Amidst the pursuit of sustainable energy solutions, geothermal power plants have emerged as a remarkable example of harnessing the Earth's natural heat to generate clean and renewable electricity. Geothermal power plants transform the planet's natural warmth into a consistent and reliable energy source. Beneath the Earth's crust, temperatures rise due to the planet's primordial heat and the natural decay of radioactive isotopes. Geothermal energy harnesses this heat through a process that involves drilling wells into subsurface reservoirs of hot water or steam. As these fluids rise to the surface, they release their thermal energy, which is then converted into electricity. Italy was the first country to develop geothermal power commercially in 1914 at Larderello. This was followed by plants at Wairakei, New Zealand in 1958 and at the Geysers in California in 1960. The U.S. currently leads the world in geothermal power generation with a total of 2850 MW produced from 203 different plants located in California, Nevada, Utah and Hawaii.		
	Geothermal power plants come in several configurations, each designed to suit the characteristics of the resource and the surrounding geography. The three main types are: **Dry Steam Plants** **Flash Steam Plants** **Binary Cycle Plants**.	Diverse Plant Configurations Dry Steam Plants Flash Steam Plants Binary Cycle Plants. Click on the items to get more information	Source graphics from U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy
	Dry Steam Plants These plants use high-temperature steam directly from the Earth to drive turbines, generating electricity. This is the oldest type of geothermal power plant. It was first used at Lardarello in Italy in 1904 in an experimental plant and	**Dry Steam Plants**	Picture drysteam

	commercially since 1914. Steam technology is used today at The Geysers in northern California, the world's largest single source of geothermal electricity. These plants emit only excess steam and very minor amounts of gases.		
	Flash Steam Plants Hydrothermal fluids above 182°C can be used in flash plants to make electricity. In these plants, high-pressure hot water is extracted from the reservoir and sprayed into a tank held at a much lower pressure than the fluid, causing some of the fluid to rapidly vaporize, or "flash." The vapor then drives a turbine, which drives a generator. If any liquid remains in the tank, it can be flashed again in a second tank (double flash) to extract even more energy.	**Flash Steam Plants**	Picture flashplant
	Binary Cycle Plants Most geothermal areas contain moderate-temperature water (below 200°C). Energy is extracted from these fluids in binary-cycle power plants. These plants use a secondary working fluid with a lower boiling point than water. Hot geothermal fluid pass through a heat exchanger where it heats the secondary (hence, "binary") and causes the secondary fluid to flash to vapor, which then drives the turbines. Because this is a closed-loop system, virtually nothing is emitted to the atmosphere. Moderate-temperature water is by far the more common geothermal resource, and most geothermal power plants in the future will be binary-cycle plants. Currently, off-the-shelf binary equipment is available in modules of 200 to 1,000 kW.	**Binary Cycle Plants**	Picture binaryplant.gif Source http://digitallib.oit.edu/digital/collection/geoheat 894040.pdf
	Although geothermal power is not confined to regions with active volcanic activity, they rely on specific geological conditions. Geothermal power plants require access to high-temperature geothermal reservoirs, at least 200 °C, which are not uniformly distributed across the globe. As a result, geothermal power plants are confined to regions with suitable geological features, limiting their global applicability.	Where are located use geothermal plants? high-temperature geothermal reservoirs > 200 °C	https://en.wikipedia.org/wiki/List_of_geothermal_power_stations https://www.sciencedirect.com/science/article/pii/S0959652620319211?via%3Dihub

	Unlike some other renewable sources like solar and wind, geothermal energy is available around the clock, irrespective of weather conditions, reducing the need for backup power sources to manage intermittency.		https://www.cnr.it/en/news/9450 Picture globalmap-0.jpg
	Geothermal power plants do not use fossil fuels and therefore produces minimal greenhouse gas emissions. They can still have environmental impacts due to the release of trace gases and potentially harmful elements from geothermal fluids. Geothermal power plants require land for infrastructure, such as well drilling, power generation facilities, and transmission lines. Water is often used to extract heat from the reservoir or as a cooling vector and can be depleted or polluted if not managed properly. The management of wastewater from the plants, often rich of chemicals extracted from the thermal fluids, can pose local environmental challenges. The construction and drilling costs of geothermal power plants can be relatively high due to the specialized equipment and geological exploration required. This initial investment can act as a barrier to entry, especially for smaller-scale projects or in regions where financial resources are limited. In areas with high geothermal activity, such as geysers and hot springs, the construction of power plants might interfere with natural surface manifestations. Altering these features could have cultural, tourism-related, or even environmental implications.	Environmental and economic concerns	Picture Sonoma_Plant_at_The_Geysers_4778.png
	Geothermal energy relies on the heat within the Earth's core continuously generated by natural processes. In theory, this energy source is a long-term and sustainable one that is not subject to depletion on a time scale of millions of years. However, on a local scale, prolonged extraction of heat from a geothermal reservoir can lead to a decline in its temperature and overall resource depletion.	Renewable and Sustainable long-term and sustainable energy source available around the clock, not depending on weather conditions	

	Over time, the rate at which heat is replenished naturally may be slower than the rate at which it is extracted, leading to a reduction in power output.		
	Geothermal power plants tend to have long operational lifetimes, often exceeding 30 years or more. They still require regular maintenance. Equipment corrosion and scaling due to mineral deposits in geothermal fluids can affect plant performance and require costly repairs. Some geothermal reservoirs offer the potential for combined heat and power (cogeneration) applications. This means that in addition to electricity, geothermal plants can provide a source of heat for direct use in industries, greenhouses, and district heating systems.	Long operational lifetime Cogen opportunities = electricity and heat	
	Evaluating the energy balance for geothermal power plants involves comparing the total energy produced over the plant's operational lifetime to the energy inputs required for various stages of its life cycle, including construction, operation, and maintenance. Energy Inputs Construction Operation and Maintenance Energy Outputs Electricity Heat from cogeneration Click on the items to get more information	Net Energy Production = energy produced - energy inputs Energy Inputs Construction Operation and Maintenance Energy Outputs Electricity Heat from cogeneration Click on the items to get more information	
	Construction The energy required for constructing geothermal power plants includes manufacturing materials, assembling components, and building infrastructure. This includes drilling wells, installing turbines, and constructing transmission lines. Energy inputs during construction depend on the scale of the project and the technologies used.	Construction	
	Operation and Maintenance Geothermal power plants have relatively low ongoing energy inputs during their operational phase. These include electricity for pump systems (in some cases), maintenance of equipment, and personnel for plant operation.	Operation and Maintenance	

	Electricity Generation This energy output is the primary purpose of the plant and constitutes the main benefit of geothermal energy. The amount of electricity generated depends on factors such as the plant's capacity, efficiency, and resource availability.	Electricity Generation	
	There is a particular – and more widespread – energy source that can be classified as “geothermal”: heat pumps. Heat pumps, including geothermal heat pumps, are systems designed to transfer heat from one place to another for the purpose of heating or cooling. There is a distinction between the two in terms of how they operate and the heat sources they utilize: **Geothermal Power Plants** Geothermal power plants are facilities that tap into the Earth's natural heat reservoirs, typically found at significant depths beneath the Earth's surface. These power plants use the Earth's internal heat to generate electricity. The heat extracted from the Earth's interior is used to drive turbines, which in turn generate electricity. This process falls under the category of electricity generation. **Heat Pumps (Geothermal Heat Pumps)** Heat pumps, including geothermal heat pumps, are systems designed to transfer heat from one place to another for the purpose of heating or cooling. Geothermal heat pumps utilize the relatively stable temperature of the Earth's subsurface as a heat source or sink, depending on whether the system is in heating or cooling mode. They don't generate electricity directly; instead, they provide space heating or cooling for buildings by extracting heat from the ground during heating mode or releasing heat into the ground during cooling mode. Geothermal heat pumps are often referred to as ground-source heat pumps or geothermal HVAC systems. While both geothermal power plants and heat pumps involve the utilization of the Earth's heat, the key distinction lies in their primary purpose and the scale of operation: Geothermal Power Plants generate primarily electricity	Heat pumps are Geothermal power sources? Geothermal Power Plants generate primarily electricity large-scale facilities Heat pumps transfer heat from one environment to another small scale systems	

	large-scale facilities Heat pumps transfer heat from one environment to another small scale systems		
	Let’s have a look to heat pumps in detail. At the heart of a heat pump's operation lies the concept of heat transfer, driven by the movement of thermal energy from areas of low temperature to areas of high temperature. This process is achieved through the use of a refrigerant, a substance with a low boiling point that can change between liquid and gas states. By exploiting this change in state, heat pumps can transfer heat energy efficiently. They can work both in Heating mode Cooling mode Click on items to get more information		
	Heating Mode In heating mode, a heat pump extracts heat energy from the external environment, even in colder conditions, and transfers it indoors to warm up the space. This ability to extract heat from a low-temperature source and deliver it to a higher-temperature area is what sets heat pumps apart from traditional heaters, which generate heat through more energy-intensive methods.	Heating Mode	
	Cooling Mode Heat pumps can also operate in reverse to provide cooling. By absorbing heat from the indoor environment and releasing it outdoors, they effectively cool interior spaces. This makes heat pumps dual-purpose systems capable of maintaining comfortable temperatures throughout the year.	Cooling Mode	
	Various types of heat pumps cater to different needs. Air-source heat pumps draw heat from the outdoor air, while ground-source (geothermal) heat pumps use the relatively stable temperature of the Earth's subsurface. Water-source heat pumps extract heat from water bodies such as lakes or rivers. Each type has its own advantages based on factors like climate, space availability, and efficiency.	Types of Heat Pumps Depending on the heat source or sink Air Ground Water	

	Heat pumps are renowned for their remarkable energy efficiency. Rather than generating heat through combustion or electrical resistance, they simply move heat from one place to another, consuming less energy in the process. This efficiency translates into reduced utility bills and lower carbon emissions, contributing to sustainability and reduced environmental impact. Heat pumps find applications in a diverse range of settings. They are commonly used for residential heating and cooling, but their benefits extend to commercial buildings, industrial processes, swimming pools, and more. They are integral to efforts to achieve energy-efficient buildings and reduce greenhouse gas emissions.		

3.3.2.4 How Companies are Organised and the Energy Manager Role

The following table provides a list of the planned content for this section:

Segment	Title	Duration
4.1	Learning Objectives	1 min
4.2	The foundations of Corporate Economy	5 min
4.3	Company Organisation and Functions	11 min., 15 secs.
4.4	The PDCA or plan-do-check-act management method	11 min., 10 secs.
4.5	Quality Management and ISO9001 standards	13 min., 40 secs

Details are provided in the tables of the following pages.

4.1 LEARNING OBJECTIVES

ScreenTitle /Number	Audio Narration	On-screen text	Media Files / Visual Instructions/Developer Notes
	This lesson is composed by 5 modules. The first module you are reading explains the lesson structure. Module 2 describes the basics of a company structure, and Module 3 delves into the organization and functions of companies. Module 4 describe the application of the PDCA management method to Energy management system, Module 5 examines the ISO 9001:2015 standard and the effects of a Quality Management Systems on a company organization and its benefits.		
	At the end of this module, you will be able to: • Describe company's structure and organization. • List the different kinds of companies. • Describe how to apply the PDCA management method. • Apply the SWOT methodology to Energy Management Point out ISO 9001 benefits and also identify some criticism	Same as narrated text	

4.2 THE FOUNDATIONS OF CORPORATE ECONOMY

ScreenTitle /Number	Audio Narration	On-screen text	Media Files / Visual Instructions/Developer Notes
1	What is a company? A company is a formal and organized entity formed by individuals or groups with the primary purpose of conducting business activities. It serves as a legal and operational framework that allows individuals, shareholders, or stakeholders to collaborate in pursuit of specific objectives. Companies can vary in size, structure, and industry, encompassing everything from small local businesses to multinational corporations. According to the definition given by economist Gino Zappa, a company is "economic institution designed to last over time, which orders and carries out activities to satisfy human needs and does so in a coordinated way, to produce, procure or consume economic resources". Let's focus on some of the most relevant features of this definition.	Company formal and organized entity with the purpose to conduct business activities	Picture of companies of various size
2	The key words of this definition are: • Economic institution that acts in a coordinated way. • Acting in an economic context. Designed to last over time.	**economic institution designed to last over time**, which orders and carries out activities to satisfy human needs and does so in a **coordinated way**, to produce, procure or consume **economic resources**	The sentence is highlighted in synchro with voiceover

3	Human existence is characterized by the continuous presence of needs. Needs determine the desire to find goods and services suitable for eliminating, alleviating, or preventing the state of discomfort. Goods and services can only be obtained through a production process. Consumption is the act suitable for satisfying the need. Production and consumption are the two phases of economic activity. The company is the entity that carries out economic activity.	Same as text	Schema of the process that involves • Human existence • Needs • Goods and services • Production / Consumption Economic activity - Company
4	Companies can be classified as • Companies that produce goods or services but that rely on other companies to supply these goods or services to consumers. • Companies that supply to consumers goods or services they do not produce by themselves but purchase from other companies. Companies that at some extent both produce and distribute goods and services to consumers	Taxonomy of companies • Production only • Distribution only Production / distribution mixed	Schema showing the structure
5	Companies can also be categorized as Public companies – or state-owned companies Private companies – or companies whose property is controlled by individuals or other companies. Non-profit companies – whose objective is to offer pro-bono services or good, aiming to cover costs but without generating any profit	Companies • Public companies • Private companies Non-profit companies	Schema showing the structure

6	The fundamental characteristics of modern companies are: 1. Stable organization - the company is established to last over time 2. Availability of people and assets to conduct of business activity. There must be a close coordination between people and assets, thus allowing the continuous creation of economic value.	Companies • Stable organization Availability of people and assets	Schema showing the structure
7	Companies are made by persons who cooperate to the resources transformation to produce goods and services. Persons • Invest money and generate the risk capital to finance the company Contribute with their activity to the company objectives	Persons • Supply money (capital) Supply work (manager, employees, workers)	Schema showing the structure
8	Companies are affected by Economic Environment and Social Environment The company is an open system that interacts with the external environment. The interactions ensure a continuous flow of materials, information, capital, which cause the company's tendency to adapt to ongoing changes.	Companies are affected by • Economic Environment • Social Environment From / To the Environment a continuous flow of materials, information, capital, energy	
9	Energy is a fundamental component for the company life in order to • Assure a suitable environment for employees		

	and workers • Enable transformation of resources into good • Transport persons, assets, good in and out the company		
10	Energy is not just a utility for companies, but it is a critical factor for • operational efficiency • cost structure • environmental strategy • reliability • innovation capacity • compliance with regulations global scalability.	• operational efficiency • cost structure • environmental strategy • reliability • innovation capacity • compliance with regulations global scalability.	
11	Operational Efficiency Energy powers machinery, equipment, and technology that are fundamental for daily operations in almost every industry. Without energy, production lines, computers, and other essential tools cannot function.	Same as spoken text	
12	Cost Management Energy costs can be a significant part of a company's operating expenses. Efficient energy use can help in reducing these costs, while inefficient use or high energy prices can negatively impact profitability.	Same as spoken text	
13	Sustainability and Environmental Impact Companies are increasingly recognizing the importance of sustainable energy use both for environmental reasons and for meeting consumer expectations. Using	Same as spoken text	

	renewable energy sources or adopting energy-efficient practices can reduce a company's carbon footprint and enhance its public image.		
14	Reliability and Business Continuity Consistent and reliable energy supply is crucial to avoid disruptions in business operations. Power outages or instabilities in energy supply can lead to significant losses in production and revenue.	Same as spoken text	
15	Innovation and Competitive Advantage Companies that invest in innovative energy technologies can gain a competitive edge. This could be through improved efficiency, lower costs, or by offering greener products and services that appeal to environmentally conscious consumers.	Same as spoken text	
16	Regulatory Compliance Many countries have regulations regarding energy efficiency and emissions. Companies need to use energy in a way that complies with these laws to avoid legal penalties and maintain their license to operate.	Same as spoken text	
17	Globalization and Scalability For companies looking to expand or operate globally, understanding and adapting to different energy landscapes (such as availability, types, and costs of energy) in various regions is essential for successful scalability.	Same as spoken text	

4.3 COMPANY ORGANISATION AND FUNCTIONS

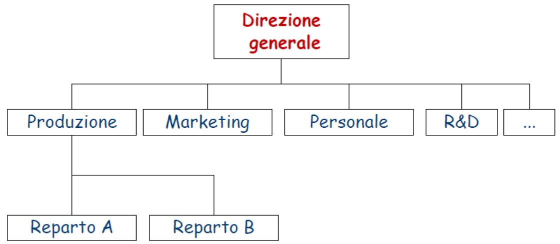
ScreenTitle /Number	Audio Narration	On-screen text	Media Files / Visual Instructions/Developer Notes
	The **company organization** analyzes and uses the most economically advantageous combinations of available resources, in terms of both human labor and material resources. Within the company, the organization must prepare the **production factors** by combining them in the most effective and efficient way possible. **Effectiveness**: ability to achieve a pre-established objective; effectiveness can be computed as the ratio between the objective set and the one achieved **Efficiency**: the ways in which the objective is achieved, comparing the economics of the means used and the costs incurred	**Company organization** combinations of available resources Production factors Effectiveness Efficiency	
	The various decisions taken regarding organization define the **organizational structure**, which determines the distribution of tasks and responsibilities among the people working in the company. The organizational structure depends on the size of the company, the sector in which it operates, and the technology used	The organizational structure depends on the **size** of the company. the **sector** in which it operates. the **technology** used.	
	To correctly analyze the organizational structure of a company you must examine the corporate functions and the departments where these functions are implemented, as well as the relationships established between the various departments.	organizational structure of a company • functions • departments • relationships among	

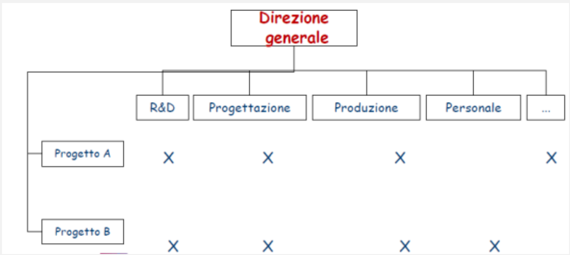
	A company function is a set of activities of the same nature, aimed at achieving the company objective There are: • Primary functions • Support functions Infrastructural functions	departments A company function is a set of activities of the same nature, aimed at achieving the company objective	
	Primary functions directly concern the creation of the product and its sale. They include: • Logistics • Production Marketing and Sales	Primary functions • Logistics • Production Marketing and Sales	
	Logistics Deals with the integrated management of problems related to transport, packaging and the material administration of stocks of raw materials, goods and finished products		
	Production deals with organizing and coordinating the use of production factors, to carry out the material transformation of goods or to transfer them in time and space		
	Marketing and Sales Marketing takes the form of a series of strategies that the company implements to increase sales and influence consumer choices; Sales are closely linked to marketing and seeks the solution to operational problems related to the marketing and distribution of goods and products		

	The **support functions** are functions that support the main ones, they provide the knowledge and resources, material and human, necessary to carry out the productive activity. They include: • Procurement • HR (Human Resources) Research and Development	**Support functions** • Procurement • HR (Human Resources) Research and Development	
	Procurement Deals with the purchase of the goods necessary for the company's activity		
	HR (Human Resources) The staff who manages relationships with workers and employees		
	Research and Development Includes finalized design activities to the diversification of production, to qualitative improvement, to the diversification and improvement of production processes		
	The infrastructural functions have impact on the entire company structure. They include: • the Finance Function • the Accounting Function • the General Management Function the Control Function		
	A **company department** is made up of one or more people operating in a well-identified area of activity, who are entrusted with the execution of certain tasks and are granted certain decision-making powers.		

	In any company you can recognize three layers • Strategic • Intermediate Operational	three layers • Strategic • Intermediate Operational	Pyramid structure
	The **strategic layer** has maximum decision-making powers. To this layer belong people who have responsibility for the organization. Among its duties • to develop company strategies • to manage the company's relationships with the external environment • to supervise company activity		Pyramid structure
	Between the top and the operational layers there is the **intermediate layer** which has the task of transmitting and ensuring that the orders of the strategic layer are carried out by the operational layer. It has decision-making powers limited to the delegation granted to it by the strategic summit.		Pyramid structure
	At the bottom we find the **operational layer** with little decision-making autonomy and made up of the people who physically carry out the activities linked to generate the goods and services that the company sells.		Pyramid structure
	The **company coordination mechanisms** are the rules that manage the transmission of orders, circulation of information and control for the physical execution of the directives among the layers. Information is news that can circulate between people of the same layer or between people of different layers		

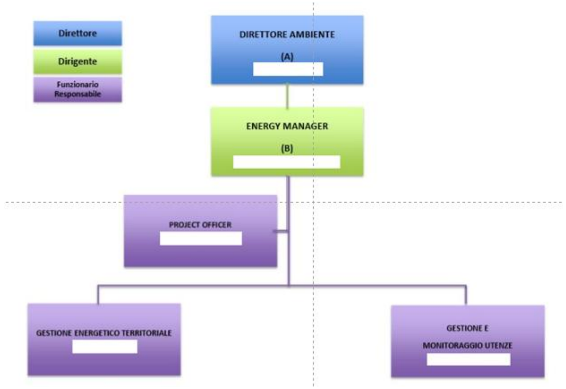
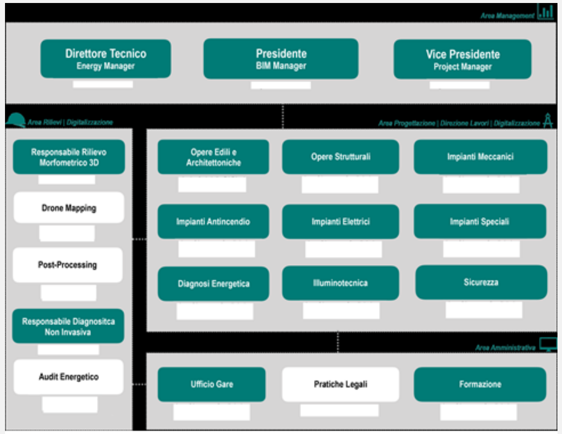
	The methods of transmitting orders are determined by the **management style** that can be: **Authoritarian**: it is based on the centralization of decision-making power in the hands of the strategic top. **Participatory**: based on the delegation of decision-making power and the empowerment of employees, to stimulate collaboration, creativity, and personal skills		
	The **organizational chart** is a graphic representation that visualizes the organizational structure of a company. It gives immediate perception of the articulations and subdivisions to which the different bodies correspond, with their hierarchical positions and their functional relationships.		
	There are different Organizational Models that translates into different organizational charts • Basic structure • Functional model • Multifunctional model • Organization by Business Units Matrix organizations		
	Basic structure The management function is carried out by a single person which is generally identified with the entrepreneur. Rigid hierarchical relationships are established between strategic management and the operational level and the intermediate layer is absent.		

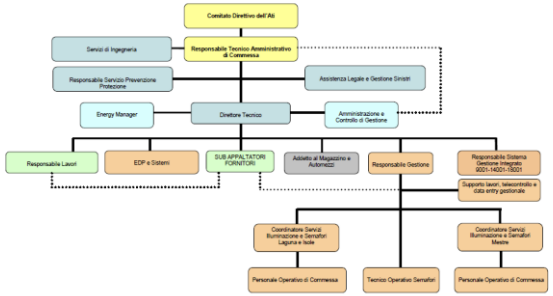
	The structure is very flat, with a direct link from the entrepreneur with each of the employees. This structure can be applied only when the number of employees is very small.		
	Functional model The main characteristic is the construction of organizational structures on the macro functions into which the company is divided. Unlike the basic structure, in the functional structure there are intermediate line managers to whom the owner or partners delegate some responsibilities.		
	Multifunctional model The criterion of subdivision by functions is applied several times. This model offers some **advantages**: it is efficient, because minimizes the resources to be used and is suitable for companies with single-product strategies. It has also some disadvantages, because makes difficult to manage a variety of products with different production and marketing characteristics. This model is not suitable to develop strategies that can be shared among departments and the lack of direct relation between profitability and responsibility of each department hinders an accurate company management.		
	Organization by Business Units (BU) This structure is characterized by the division of work based on specialization by business, product or market.		

	The General Management deals with the development of overall strategies. The Central Staff (Finance, Personnel, ...) supports both the DG and the underlying divisions. The Operational Units have executive tasks within a specific area. The BUs are characterized by the fact that the respective managers are delegated to manage the unit as if it were a company.		
	This model applies positively when the Business Units are actually independent and the relationships between the Units are such that the consolidated additional income is still positive, without internal competition. The model requires that the decentralization from the DG to the Business Units is real and effective. The main advantage is the objective-oriented attitude this model fosters; each Unit manager acts as an entrepreneur and is fully responsible of the BU success. It could lead, as a drawback, to some loss of efficiency.		
	Matrix organization This organizational model combines elements of the Business Units model and the Functional model. The company is organized by Units but at the same time implements a subdivision of company personnel by function. It is a structure where authority, skills and responsibilities are intertwined both vertically and horizontally		

	It is suitable for companies that work on order to ensure at the same time the coordination of the activities necessary for the realization of the project under the pre-established conditions and the efficiency induced by the concentration of resources in the same functional department, In matrix structures there are two groups of managers: • functional managers, who take care of the effective and efficient execution of a certain function regardless of the projects; project managers who coordinate the specific project and assume responsibility.		
	Where is the energy manager located in the company organization? In medium and large organizations, the energy manager may be responsible for the company's **Energy Management System** (or **EMS**), as defined by the international standard ISO 50001 published in 2011. An EMS expands the role of the energy manager and it increases effectiveness, as it inserts it into a defined corporate energy policy, with explicit quantitative objectives, and extends its area of activity to all company functions, through specific procedures.		
	An EMS works according to the so-called **PDCA** (**plan-do-check-act**) or Deming cycle: • an **energy analysis** is carried out and the company's energy efficiency improvements are verified; • the management draws up a **company energy policy**, setting quantitative savings		

	objectives to be achieved within a certain time frame (these targets can be established freely by the organization and do not necessarily depend on the achievable potential); • a **company management system** is developed, with the help of external consultants, which indicates the detailed procedures aimed at achieving the set objectives, and a manager of the SGE is appointed (generally the energy manager); • a **monitoring system** is developed, preferably based on a remote management, remote control or automation system, which will serve to collect and analyze data on consumption (and not only) in order to ensure the achievement of targets; • the planned **efficiency measures** are implemented; • the **outcome of the actions undertaken** is monitored; company policy or internal procedures are eventually **corrected** if the results are not in line with expectations.		
	In short, operations are planned, actions are implemented, the results are verified and then a decision is made whether to modify the objectives or the organization to achieve the maximum result. From a company's point of view, the ideal situation to ensure correct energy management with a view to competitiveness, as well as reducing costs and emissions, is to achieve an **ISO 50001 certification**, placing a valid energy manager as head of the EMS.		

	Data collected over many years have widely demonstrated that the adoption of an EMS generates improvements in performance over time. Moreover, in the industrial sector, after a few years, energy tends to be considered as one of the levers of production processes leading to their optimization and benefits that go beyond the simple reduction of consumption.		
	The schema shows the organizational chart of a Public structure – the Genoa Municipality in Italy. Here the Energy Manager has a Manager role and refers to the Head of the Environment Division of the Municipality.		
	In this private company, with a matrix organization, the Technical Director has also the responsibilities of Energy Manager and he/she is at the same level of President and Vice-president.		 ESEMPIO DI SOC. PRIVATA

	The Energy Manager is in staff to the Technical Director in the multifunctional chart of this company Consortium.		 ESEMPIO DI SOC.CONSORTILE/CONSORZIO AZIENDE

4.4 THE EMS AND THE APPLICATION OF PDCA management method

ScreenTitle /Number	Type	Description	Text	Media Files / Visual Instructions/Developer Notes
	What is "environmental policy"? A company's environmental policy represents that part of the company policy that deals with environmental activities and interactions with the environment. The fundamental principles are: • Compliance with environmental laws • The minimization of environmental risks The reduction of consumption and waste			
	The implement its environmental policy the company must reduce: • consumption of raw materials; • energy consumption (electricity, methane gas, LPG, etc.); • quantity of waste produced. This translates into two main objectives: • consume less; produce less waste			

	In order to achieve these objectives, the company must have a, Environmental Management System or EMS The EMS is the set of interrelated elements to establish an environmental policy and to manage company's interactions with the environment.			
	The international standards that apply to EMS and to which companies can comply with on a voluntary basis are: • ISO 14001:2015 • ISO 9001:2015 • EMAS ISO 50001:2018			
	The ISO 50001:2011 global energy management standard, modeled after the ISO 9001 Quality Management and ISO 14001 Environmental Management Standards, supports process manufacturers and producers to use energy more efficiently. The ISO 50001 process follows the same PDCA approach as these other ISO standards and provides a framework to: • Develop a policy for more efficient use of energy • Fix targets and objectives to			

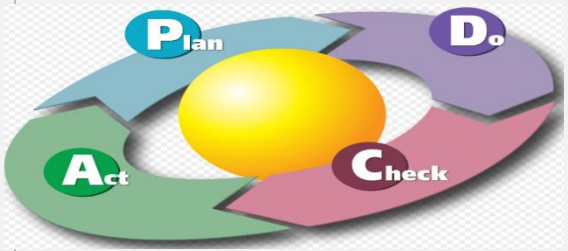
	meet the policy • Use data to better understand and make decisions about energy use • Measure the results • Review how well the policy works, and Continually improve energy management.			
	The EMS identifies environmental aspects related to • activity, • products, • services, of the company that have a significant impact on the environment			
	How to implement an EMS • **Initial environmental analysis** (initial analysis of aspects and impacts); • **Environmental policy** (general objectives of action with toward the environment); • **Environmental program** (description of the measures adopted to achieve environmental objectives); • **Part of the management system** (structure, planning, responsibility, practices, procedures, processes and resources that allow the development of environmental policy and	• **Initial environmental analysis** • **Environmental policy** • **Environmental program** • **Part of the management system** • **Internal environmental audit and management review** **Environmental declaration**		

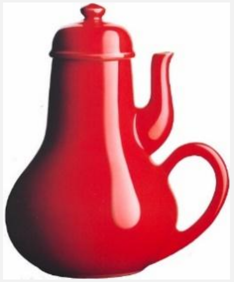
	consequently environmental efficiency); • **Internal environmental audit and management review** (systematic, documented and periodic evaluation of the organization's environmental performance and EMS) **Environmental declaration** (for EMAS): contains information on the organization's EMS and is targeted to the public.			
	What is the EMS for? • Support for local environmental policies and improvement of relations with the territory • Transparency and effectiveness land and resource management • Continuous improvement of environmental impact reduction • Systematic evaluation the effectiveness of the EMS itself • Improvement of active participation, training and communication both inside and outside the organization. • Adoption of a clear environmental policy will well-defined improvement objectives.			

	Integrated management of the territory in cooperation with the Municipality and also with other actors, both public and private.			
	Environmental management systems are usually implemented by a single entity or company, but there are experiences that involved different entities, for instance industrial districts. The EMS manager draws up the documents, and namely the EMS Manual, and takes care of its dissemination and application. The company owner approves the documents developed and oversees the EMS evaluation.			
	The EMS Manual is made by four sections 1. **Introduction** Defines the type of company dealing in particular with the environmental organization and its environmental policy; contains a paragraph with the definitions and abbreviations used; 2. **Environmental management system**: describes the 5 functions that compose it; 3. **Evaluation of the environmental management**			

	system: describes the to periodic tests the EMS is subjected to; **Attachments**: Describes how to operate in relation to the 5 EMS functions.			
	The EMS has five main functions: • Training • Communication • Documentation; • Operational control; Management of environmental non-compliances			
	How complex and detailed must an EMS be? The amount of documentation and dedicated resources depend on several variables: • the field of application of the system, • the size of the organization, the type of business, products and services			
	From the EMS - through the study of the Environmental Indicators company-specific - it is possible to build an **Environmental Plan**. The Environmental Plan is a set of environmental indicator scores combined with the environmental intervention to be implemented and			

	the environmental objective to be achieved. The **Environmental Plan** ranks the activities to be carried out based on the **intervention priorities**. When this ranking is integrated with **costs** and **times** estimates for the execution of these activities the result is the **Environmental Program**.			
	The PDSA Cycle (Plan-Do-Study-Act) is a systematic process for gaining valuable learning and knowledge for the continual improvement of a product, process, or service. Also known as the Deming Wheel, or Deming Cycle, this integrated learning - improvement model was first introduced to Dr. Deming by his mentor, Walter Shewhart of the famous Bell Laboratories in New York.			
	Continuous improvement is the goal that every company tries to achieve every day, but for many it remains an abstract concept. To achieve a continuous level of improvement the "perfect project			

	manager" must adopt a plan to follow, evaluate and implement to solve the problems she/he faces.			
	The Deming cycle is a problem-solving method for identifying why a process or product does not meet expectations, developing hypotheses about possible changes and testing their effectiveness in a continuous loop. It is based on 4 successive steps and is a model that provides continuous and repeated improvements for the optimization of processes and the improvement of quality and efficiency.			
	The Deming cycle is also called the PDCA method due to the four phases that compose it: • **Plan** set the objectives and define the processes required to deliver results that comply with the organization's environmental policy; • **Do** implement the processes as planned; • **Check** monitor and measure processes with respect to environmental policy, objectives and targets, legal requirements and other requirements and report the			

	results; **Act** define and implement actions to continuously improve the performance of the Environmental Management System.			
	Listen to this speech by Ian Bradbury of Deming Institute		From YouTube (7 min 48 sec) https://youtu.be/dgazCOz_IIY	
	Deming's cycle can be applied to any activity, production cycles and different types of organization, for problem solving and for the improvement of any production and operational process. It is an indispensable tool for remedying the most frequent project management errors.		Picture of a project management error 	
	The PDCA method – Pro and Cons **Advantages** The Deming cycle is a tool for introducing improvements in a sustainable and thoughtful way. Instead of rushing and forcing a change in usual procedures, we proceed in small steps and always under close observation. **Disadvantages** You need to invest a lot of time in planning, since the Deming wheel does not provide quick solutions to problems.			

	Let's see an example of PDCA method application. The management of a furniture factory wants to increase the production of cabinets. It is found that all the parts of the wardrobe are assembled quickly, with the exception of the round feet, which always take more time. To speed up this part of the process the Deming method should help.			
	During the design phase (**Plan**) it is found that the lathe used to produce the round objects is prone to many errors. Defective supports have to be disposed of quite frequently and this slows down the production chain and leads to additional expenses. The plan is therefore to purchase a more modern machine, but starting with just one to test its effectiveness, instead of replacing all the machines at once. In the second phase (**Do**) the new lathe is tested. Products made with the new lathe are monitored for a month while the old machines run the mass production. Managers can verify whether it is really worth investing in the new machinery.			

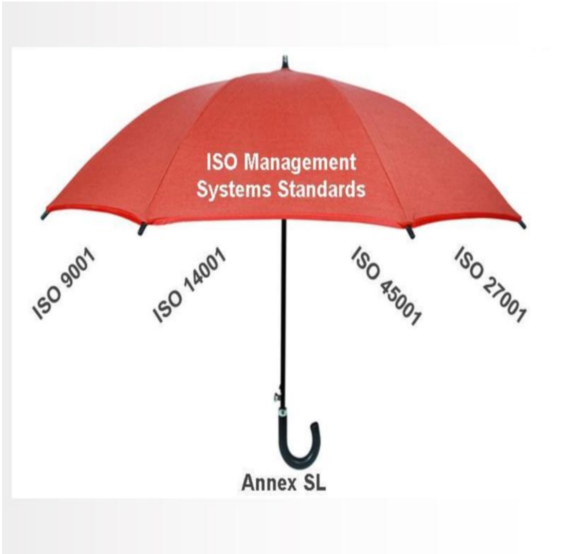
	Although the production error had been removed, the production speed had not increased at all. In the third phase (**Check**) this problem is analyzed and it is recognized that employees are so used to the old machinery that they still struggle to use the new one as efficiently. Therefore the plan will be modified and fully implemented in the final phase (**Act**). All lathes will now be replaced and at the same time employees will receive detailed instructions on the new equipment. This significantly speeds up furniture production and reduces waste to a minimum. The company now sets the new production speed as standard.			
	The Energy manager should leverage the PDCA method to keep the continuous improvement cycle going over time with committed resources and oversight.			
	Plan During the plan phase of the cycle, an energy officer and an energy team should be appointed and the organization needs to formulate the energy policy in form of a written statement, which contains the intent and direction of energy policy.			

	This energy policy should be clearly communicated within the organization. The energy team driving this continuous improvement cycle is the connection between management and employees. In this phase, the organization has to identify the significant energy uses and prioritize the opportunities for energy performance improvement.			
	Do The stated objectives and processes are now introduced and implemented. Top management assures that resources are made available and responsibilities determined. Plant staff and other participants must be aware and capable of carrying out their energy management responsibilities. The implementation of the energy management system starts.			
	Check An energy management system requires a process for compliance and valuation of energy-related objectives. An internal audit can help to verify that the energy management			

	system is functioning properly and generating the planned results. The processes are monitored with regard to legal and other requirements (customer requirements, internal policies) as well as to the goals of the organization's energy management program. The results are documented and reported to top management.			
	Act Top management prepares a written valuation based on the internal audit. This document is called the management review. The results will be evaluated on their performance level. If required, corrective or preventive actions can be initiated. Energy-relevant processes are optimized and new strategic goals are derived.			
	A good primer on how to plan and execute an energy management project can be found in Sam Thiara podcast. The podcast stresses the importance of getting the benchmarks and		Link to page with podcast https://www.emersonautomationexperts.com/2019/industry/podcast-howto-approach-energy-management-projects/	

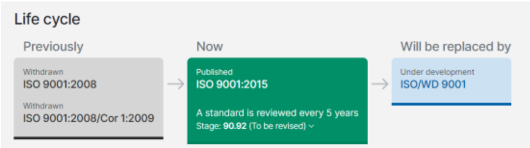
	baseline performance established early in the planning. These benchmarks and baselines are helpful not only in project justification and return on investment post project, but also help to justify the ongoing support required to maintain the savings over time			

4.5 THE QUALITY MANAGEMENT AND ISO 9001 STANDARDS

ScreenTitle /Number	Type	Description	Text	Media Files / Visual Instructions/Developer Notes
	This video from ISO Central Secretariat in Geneva, Switzerland, offers a quick introduction to ISO 9001:2015 standard and its meaning.		YouTube video https://youtu.be/O5T4H8K_rwQ?feature=shared Duration: 5 in 19 sec	
	The ISO 9000 family is a set of five quality management systems standards issued by ISO (International Organization for Standardization). These standards help organizations to ensure they meet customer and other stakeholder needs within statutory and regulatory requirements related to a product or service. ISO 9000 deals with the fundamentals of Quality Management Standards including the seven quality management principles that underlie the family of standards. ISO 9001 is the standard we are most interested in for the purpose of this course, and it deals with the		sistema_norme.png  	

	requirements that organizations wishing to meet the standard must fulfill.			
	A bit of history ISO 9000 was first published in 1987 by ISO and it was based on the British Standards BS 5750 series of standards. Large organizations that supplied government procurement agencies often had to comply with a variety of quality assurance requirements for each contract awarded. Eventually, industries adopted ISO 9000 instead of forcing contractors to adopt multiple—and often similar—requirements.			
	The adoption of ISO9000 standard can bring a wide range of benefits to companies: • **Customer confidence** The standard ensures that organizations have robust quality control processes in place, leading to increased customer trust and satisfaction. • **Effective complaint resolution** ISO 9001 offers guidelines for resolving customer complaints efficiently, contributing to timely and			

	satisfactory problem-solving. • **Process improvement** The standard helps identify and eliminate inefficiencies, reduce waste, streamline operations, and promote informed decision-making, resulting in cost savings and better outcomes. **Ongoing optimization** Regular audits and reviews encouraged by ISO 9001 enable organizations to continually refine their quality management systems, stay competitive, and achieve long-term success.			
	Criticisms of ISO 9001 certification There also some criticisms of ISO 9000 and 9001. One of the most common deals with the amount of money, time, and paperwork required for a complete implementation, and later when needed, ISO 9001 certification. Dalgleish in an article titled "Probing the Limits – ISO 9000: More Hindrance Than Help" published on Quality Magazine, cites the "inordinate and often unnecessary paperwork burden" of ISO, and says that "quality managers feel that			

	ISO's overhead and paperwork are excessive and extremely inefficient". It must be noted however that the level of minimum documentation has been greatly reduced, going from ISO 9001:2000 to ISO 9001:2015.			
	The ISO9001 standard is continuously updated; the issue year is stated together with the standard name, separated by a colon. The version ISO9001:2008 is now withdrawn and the current major version is ISO9001:2015. This version undergoes a minor review every 5 years and now the minor version is 90.92. It will be withdrawn in 2025 when a new major version, now under development, will be released.		life_cycle.png  	
	Version IOS9001:2015 focuses on seven Quality Management Principles • **Customer focus** • **Leadership** • **Engagement of people** • **Process approach** • **Improvement** • **Evidence-based decision making** **Relationship management**			

	Customer focus Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations.			
	Leadership Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.			
	Engagement of people People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.			
	Process approach A desired result is achieved more efficiently when activities and related resources are managed as a process.			
	Improvement Improvement of the organization's overall performance should be a permanent objective of the organization.			
	Evidence-based decision making Effective decisions are based on the analysis of data and information.			

	Relationship management An organization and its external providers (suppliers, contractors, service providers) are interdependent and a mutually beneficial relationship enhances the ability of both to create value.			
	The ISO9001:2015 version is less prescriptive than its predecessors and focuses on **performance**. This was achieved by combining the process approach with **risk-based thinking**, and employing the **Plan-Do-Check-Act** cycle at all levels in the organization.		Risks.png 	
	ISO9001:2015 key changes • High-Level Structure of 10 clauses is implemented. Now all new management system standards released by ISO will have this high-level structure • Greater emphasis on building a management system suited to each organization's particular needs • A requirement that those at the top of an organization be involved and accountable, aligning quality with wider			

	business strategy • Risk-based thinking throughout the standard makes the whole management system a preventive tool and encourages continuous improvement • Less prescriptive requirements for documentation: the organization can now decide, in addition to the mandatory documents and records, what documented information it needs and in what format it should be • Alignment with other key management system standards through the use of a common structure and core text • Inclusion of Knowledge Management principles • Quality Manual & Management representative (MR) are no longer mandatory			
	Risk-based thinking has been given a far more prominent role in the ISO 9001:2015 standard than it's received in the past. Here are the steps to deal with risk in any business		risk-reward-in-ISO.webp	

	• Identify the risks and opportunities • Plan your response • Integrate the response into your quality management system (QMS) Evaluate effectiveness		 	
	Identify the Risks and Opportunities There are two distinct kinds of risk that a company may encounter: external and internal. External risk is risk incurred from the environment in which the company operates. These can be legal, regulatory, financial, and cultural risks. Internal risk is risk incurred from within an organization. This can be caused by an organization's structure, resource deficiencies or allocation, and hierarchy. Risk and opportunity need to be determined within the context of the business, something that will lead to different definitions of each term for different organizations.		risk_diagram.png  	

	Additionally, in many cases, risk will also bring opportunity. Companies need to properly assess where risk ends and opportunity begins, and how they can reduce one while capitalizing on the other.			
	Plan Your Response Companies are required to develop a plan for addressing the risk and opportunities they have identified. A company will need to do an in-depth assessment of the possible risks for this part. How likely are these risks? How disruptive would they be if they were to happen? What amount of resources is your company willing to dedicate to mitigating these risks? Similarly, what is the potential for capitalizing on the opportunities? Can their likelihood be increased while mitigating the risk? Is the potential risk worth incurring for a chance at capitalizing on the opportunity? Once these assessments have been made, an organization can develop a plan for addressing the risks and opportunities based on their stated strategies for both. Without properly assessing their attitude to risk, an		As above	

	organization cannot properly plan to either mitigate it or capitalize on the opportunities it presents. These plans need to be clearly laid out, with a plan for documenting the process and keep clear records on it.			
	Integrate the Response into Your Quality Management System (QMS) This step requires a company to insert the plan they have developed for addressing risk and opportunity into the greater framework of the QMS that they already have in place. The plan needs to allow for the rest of a company's QMS to remain seamless. As a standard that emphasizes universal application, the nature of ISO 9001 will require that the process developed for addressing risk and opportunity be compatible with all other procedures in the company.		As above	
	Evaluate Effectiveness This step in the process is also in lockstep with the core principles of the ISO 9001 standard; proper documentation and record keeping processes will need to be put in place.		As above	

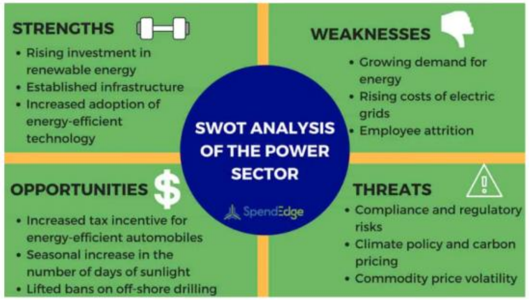
	The company must record the outcomes and measure the effectiveness of their efforts. It is crucial to develop a comprehensive assessment of the company's willingness to take on risk and pursue potential opportunities. Without a detailed understanding of the company's aims in regard to both risk and opportunity, it will be all but impossible to properly assess the effectiveness of the process that's been implemented. As with any procedure in a company operating under ISO 9001 standards, this step allows for the constant scanning of potential inefficiencies that can be improved upon. It should be noted that context is also a key factor in any risk assessment process. Risk at one juncture of the process might look different than the same risk at another juncture. This is why having a comprehensive strategy for risk assessment is critical. Preparing for and thinking about all the possibilities will help better prepare your company.			
	Risk can be both mitigated and leveraged into opportunity.		risk-assessment.webp	

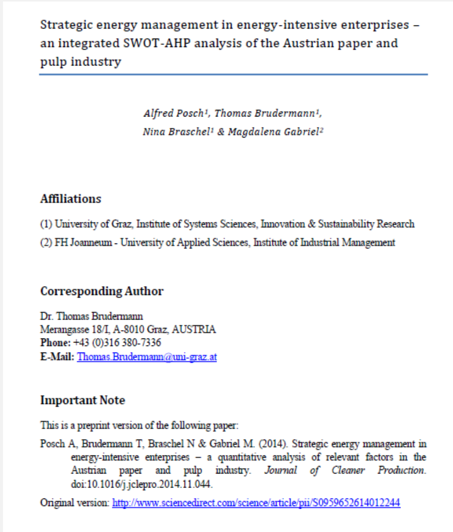
	In the past, the ISO 9001 system treated risk as a separate component to quality management, focusing on prevention instead. In the 2015 update, the idea of risk-based thinking is meant to be addressed with a more systematic approach. While risk-based thinking will sound like a new concept, its already something that most people engage with on a day-to-day basis. Any individual who is asked to make decision in their day to day life, i.e. everyone, is constantly weighing the risks associated with those decisions and working to mitigate that risk. The idea behind the 2015 update is to infuse that thought process into the entire quality management system. To make risk assessment a main component of the process at each level of the system.			
	Where Does Risk Assessment Appear In ISO 9001? In the ISO 9001:2015 update, risk assessment appears in two main ways: • leadership directives planning.			

	Leadership Directives As with anything that goes on in a company, leadership will play an out-sized role in the implementation of a quality management system. Because of this, an organization's leaders will need to be properly versed in the concept of risk-based thinking. As the primary decision makers in an organization, leaders will already have a general awareness of risk-based thinking and probably already use it to some extent in their day to day activities. By focusing on leadership directives, the standard is putting an emphasis on how these directives can and should be influenced by a risk-based approach. This shift replaces an emphasis on preventive measures in previous versions of the standard.			
	Planning The planning section is where the preventive action is removed from the old standard and replaced with an emphasis on managing risks and opportunities at every step of the process. This is another example of the standard asking organizations to			

	approach risk and opportunity in the same way they would approach any other problem that needed to be solved. The standard is not asking companies to go out and add new steps to their current quality management systems. Instead, the standard is asking for a more risk-based approach to every step and process in the system. This will look different for each company that applies the standard to their processes.			
	The Benefits of Risk-Based Thinking Risk-based thinking helps to highlight and add to many of the benefits that a good quality management system will bring to an organization. These benefits include: • improved governance • improved work environment • improved compliance practices improved customer satisfaction			
	An organization's risks depend on the context in which it operates. Risk management is the key to achieving goals and consistently		overcome_risks.png	

	delivering valuable products or services to customers.			
	The schema shows the relationships among risks and opportunities within the company context		schema_risks_opportunities.png 	
	SWOT analysis is a strategic planning and strategic management technique. The name is an acronym for the four components the technique examines: • Strengths: characteristics of the business or project that give it an advantage over others • Weaknesses: characteristics		SWOT_en.svg.png	

	that place the business or project at a disadvantage relative to others • Opportunities: elements in the environment that the business or project could exploit to its advantage • Threats: elements in the environment that could cause trouble for the business or project Results of the assessment are often presented in the form of a matrix, or simply as paragraphs.			
	An example of SWOT analysis applied to the energy sector is shown in the picture. You can use the SWOT technique to analyze the energy mix used by a company to better understand the alternatives available to minimize risks and maximize opportunities.		swot_analysis_of_the_YfXWO-1024x576.jpg.webp 	
	The article you can find here is a further example of SWOT analysis applied to an energy intensive industry and demonstrate the use of		Article to be linked. Strategic energy management in energy-intensive enterprises an integrated SWOT-AHP analysis of the Austrian paper and pulp industry.pdf	

	such analysis for a strategic management of energy.		Image : article_front_page.png  **Strategic energy management in energy-intensive enterprises – an integrated SWOT-AHP analysis of the Austrian paper and pulp industry** *Alfred Posch[1], Thomas Brudermann[1],* *Nina Braschel[1] & Magdalena Gabriel[2]* **Affiliations** (1) University of Graz, Institute of Systems Sciences, Innovation & Sustainability Research (2) FH Joanneum - University of Applied Sciences, Institute of Industrial Management **Corresponding Author** Dr. Thomas Brudermann Merangasse 18/I, A-8010 Graz, AUSTRIA **Phone:** +43 (0)316 380-7336 **E-Mail:** Thomas.Brudermann@uni-graz.at **Important Note** This is a preprint version of the following paper: Posch A, Brudermann T, Braschel N & Gabriel M. (2014). Strategic energy management in energy-intensive enterprises – a quantitative analysis of relevant factors in the Austrian paper and pulp industry. *Journal of Cleaner Production*. doi:10.1016/j.jclepro.2014.11.044. Original version: http://www.sciencedirect.com/science/article/pii/S0959652614012244	

3.3.2.5 Energy Audit Game

The following table provides an overview of the content of the Energy Audit Game and related AR Experience.

<table>
<tr><td>Setting</td><td colspan="2">ACME – A Company Manufacturing Everything</td></tr>
<tr><td>Characters</td><td colspan="2">The player avatar, the player can choose between:
Karen
Markus
Mr. Knowles, the receptionist
Mrs. Clearwaters, the ACME Managing director.
Mr. Unter, ACME Facility Manager.
Mrs. Pennysaving, ACME Purchasing Department manager.
Mr. Strongfellow, HR manager.
Mrs. Shortarm, the employee who mentions something regarding the lights.
Mr. Thawingbud, the employee who says a remark about cooling system.
Mrs. Houlihan, the employee who makes a comment about the heating system.</td></tr>
<tr><td>Environments</td><td colspan="2">ACME HQ building external
ACME Lobby
ACME Managing director office
ACME standard offices (where other persons are met)
ACME building systems rooms in the basement</td></tr>
<tr><td>Notes on user interface</td><td colspan="2">Interface with buttons to control the avatar should be clearly visible, to avoid the use of keyboard keys for movement. The same buttons will be used in mobile applications to move the avatars.

The user could turn on/off the audio voiceover for NPCs. In both cases the message delivered by NPC will be shown in a balloon.</td></tr>
<tr><td rowspan="4">Event types</td><td>INFO</td><td>some information displayed on screen, not linked to NPCs</td></tr>
<tr><td>ACTION</td><td>something the player does and acts on the avatar</td></tr>
<tr><td>Notebook ACTION</td><td>an action that changes the notebook content (Notebook is displayed)</td></tr>
<tr><td>NPC INFO</td><td>text show in the balloon of a Non-Playable Character (available as voiceover as well)</td></tr>
</table>

This table provides a concise description of the content of this Section.

Segment	Title	Expected Duration
5.1	Learning Objectives	1 m.
5.2	Standards Overview	5 m.
5.3	The Integrated Management System	8 m.
5.4	ISO 140001 Standard	12 m.
5.5	Life Cycle Assessment	8 m.
5.6	ISO 50001 Standard	12 m.
5.7	Lean Management	8 m.

A detailed description of the content is available in the tables of the following pages.

5.1 LEVEL 0 – COVER AND INTRODUCTION

ScreenTitle /Number	Type	Description	Text	Media Files / Visual Instructions/Developer Notes
0.1	INFO	Graphic cover of game – first screen displayed to user	Energy Auditor Challenge Transforming Buildings for a Greener Tomorrow	Engaging graphic animation with jingle The title is displayed with animation
0.2	INFO	The page describes the scope of the game and the rules of engagement.	Game scope In this game you are an energy auditor who will perform an energy audit at ACME Inc, a medium sized manufacturing company and eventually deliver advice and directions to improve company efficiency and reduce energy consumptions. To fulfil your mission you will interview people, collect information and evidences, inspect company facilities. During these activities you will fill in your notebook with information needed to deliver to ACME the energy report. Press START to begin to play	Text on screen with graphic background. Voiceover that reads the text
0.3	ACTION	Avatar selection	Select your avatar for the game	Two characters, Karen and Markus, are shown on screen. The user must select either one or the other to proceed. The avatar will be controlled by the user
0.4	NPC INFO	Avatar selection	I will support you during the game. You can ask me suggestions, advice and even some help if you are not sure what to do.	The avatar not selected will become an NPC with the role of sidekick. The text is the feedback by the avatar which was not selected.
0.5	INFO	Pop up text	Your mission 1/2 The energy audit is process that rolls out in different phases and helps organizations to reveal potential for significant savings. During the audit first of all we have to assess where, when, why and how energy is being used.	Button Continue shows text 2/2

			This is your job today: you must visit ACME Inc and collect these data. Then you will analyse this information to identify where and how ACME can improve its efficiency, reduce its energy costs and greenhouse gas emissions. Finally, it is very important to verify the effectiveness of the energy-efficiency brought in by the projects implemented.	
0.6	INFO	Pop up text	Your mission 2/2 You are free to choose where to go and which items to collect. Each item will provide a bit of information about ACME. However, be cautious of useless or fake information. You should apply critical thinking to select the information you need.	Button Continue closes the pop-up Button Previous shows text 1/2
0.7	ACTION	Selected avatar in front of the building. The building has the company name on it	Enter the building	The user moves the avatar who enters the building

5.2 LEVEL 1 – ACCESS TO ACME

ScreenTitle /Number		Description	Text	Media Files / Visual Instructions/Developer Notes
1.1	ACTION	The avatar inside the lobby with a staircase leading to upper floor (must convey the idea of power and wealth because it leads to General manager office) Elevator door with panel “To production plant” a receptionist desk a desk with some leaflets on it door with the panel “Toilets”	Labels on doors “To offices” (Beside the elevator) “To production plant” (on a door) Reception (close to reception desk) Company information (close to leaflets) Panel with “General Manager” wrote on it and an arrow that points upstairs at the stairs bottom. “Toilet” (on a door)	the user can move the avatar toward any of A-F elements the sidekick avatar moves accordingly
1.2	NPC ACTION	Choice A – row 1.1 toward general manager office	Receptionist blocks the access and says “Sorry sir/madam, but you have to announce yourself before getting to General Manager”	Penalty = -50 The receptionist moves in front of the staircase and blocks the access. You are again in the middle of the hall
1.3	NPC INFO	Choice B – row 1.1 toward elevator	Receptionist says “Sorry sir/madam, but you have to register yourself before accessing the offices”	Penalty = -30 You are again in the middle of the hall
1.4	NPC INFO	Choice C – row 1.1 toward production plant	Receptionist says “Sorry sir/madam, Production plant access is restricted. You must be accompanied by an ACME employee”	Penalty = -30 You are again in the middle of the hall
1.5	NPC MSF	Choice C – row 1.1 Sidekick comments	Remember that our mission is limited to office building energy audit. We should restrict our analysis to this building – production building will be dealt with later.	
1.6	NPC INFO	Choice D – row 1.1 toward receptionist	[receptionist balloon] How can I help you?	Score = +50

1.7	ACTION	You answer the receptionist by choosing one of the options	My name is Karen / Markus and I am here to conduct an energy audit of your company. I would like to meet the general manager to visit the production plant to go to the toilet to visit your offices	The user can click/touch one of the 4 choices (choices order is random) The user must select one option to proceed. Feedback is generated for each choice
1.8	NPC INFO	Choice I row 1.7	[receptionist balloon] Just a minute, I'll check if Mrs. Clearwaters can receive you.	Score = +50
1.9	NPC INFO	Sidekick says	[popup text] Good choice! Even if the audit was scheduled and you are waited for, it is always a good move to sum up the audit purpose with top management to be sure you have their endorsement.	
1.10	Notebook ACTION		[text on Notebook with check mark] General Manager kick off meeting	
1.11	NPC INFO	Choice II row 1.7	[receptionist balloon] Production plant access is restricted. You must be accompanied by an ACME employee.	Penalty = -10
1.12	NPC INFO	Sidekick says	[popup text] Good choice! Even if the audit was scheduled and you are waited for, it is always a good move to sum up the audit purpose with top management to be sure you have their endorsement. Contact the general manager first!	You dismiss the info text and return to the main hall with choices still visible
1.13	NPC INFO	Choice III row 1.7	[receptionist balloon] Please.	Receptionist waves toward the toilet door
1.14	Notebook ACTION	Feedback III Choice F - row 1.1	[text on Notebook with check mark] Control water consumption Control lights usage	Score = + 30 You enter the toilet and you see no one is present. lights are on. there is a tap with running water. You return to the main hall with choices still visible

1.15	NPC INFO	Choice IV row 1.7	[receptionist balloon] Sorry, but you are not allowed to be wandering the building without authorization.	
1.16	NPC INFO	Sidekick says	[popup text] During the audit you must respect the company internal rules and prescriptions. Even if the audit was scheduled and you are waited for, it is always a good move to sum up the audit purpose with top management to be sure you have their endorsement. Contact the general manager first!	You dismiss the info text and return to the main hall with choices still visible
1.17	INFO	Choice E – row 1.1	[Leaflet text] ACME company cares of you and the Planet! We have just launched an application for your mobile phone to help you share your car with colleagues when getting to and from the office! Register for free on the intranet and find your mate(s) for sharing your travel! It will be fun, you will save money and reduce your carbon footprint.	Score ?= +30 You pick up a leaflet and the text is shown on screen
1.18	NPC INFO	Sidekick says	[popup text] Good move, it is always useful to get some more information on the company you are visiting!	

5.3 LEVEL 2 – MEETING WITH MRS. CLEARWATERS

ScreenTitle /Number		Description	Text	Media Files / Visual Instructions/Developer Notes
2.1	ACTION	The avatar inside the lobby with a staircase leading to upper floor (must convey the idea of power and wealth because it leads to General manager office) Elevator door with panel “To production plant” a receptionist desk a desk with some leaflets on it door with the panel “Toilets”	Labels on doors “To offices” (Beside the elevator) “To production plant” (on a door) Reception (close to reception desk) Company information (close to leaflets) Panel with “General Manager” wrote on it and an arrow that points upstairs at the stairs bottom. “Toilet” (on a door)	the user can move the avatar toward any of A-F elements the sidekick avatar moves accordingly
2.2	NPC ACTION	Choice A – row 1.1 toward general manager office	Receptionist blocks the access and says “Sorry sir/madam, but you have to announce yourself before getting to General Manager”	Penalty = -50 The receptionist moves in front of the staircase and blocks the access. You are again in the middle of the hall
2.3	NPC INFO	Choice B – row 1.1 toward elevator	Receptionist says “Sorry sir/madam, but you have to register yourself before accessing the offices”	Penalty = -30 You are again in the middle of the hall

2.4	NPC INFO	Choice C – row 1.1 toward production plant	Receptionist says “Sorry sir/madam, Production plant access is restricted. You must be accompanied by an ACME employee”	Penalty = -30 You are again in the middle of the hall
2.5	NPC MSF	Choice C – row 1.1 Sidekick comments	Remember that our mission is limited to office building energy audit. We should restrict our analysis to this building – production building will be dealt with later.	
2.6	NPC INFO	Choice D – row 1.1 toward receptionist	[receptionist balloon] How can I help you?	Score = +50
2.7	ACTION	You answer the receptionist by choosing one of the options	My name is Karen / Markus and I am here to conduct an energy audit of your company. I would like to meet the general manager to visit the production plant to go to the toilet to visit your offices	The user can click/touch one of the 4 choices (choices order is random) The user must select one option to proceed. Feedback is generated for each choice
2.8	NPC INFO	Choice I row 1.7	[receptionist balloon] Just a minute, I’ll check if Mrs. Clearwaters can receive you.	Score = +50
2.9	NPC INFO	Sidekick says	[popup text] Good choice! Even if the audit was scheduled and you are waited for, it is always a good move to sum up the audit purpose with top management to be sure you have their endorsement.	
2.10	Notebook ACTION		[text on Notebook with check mark] General Manager kick off meeting	

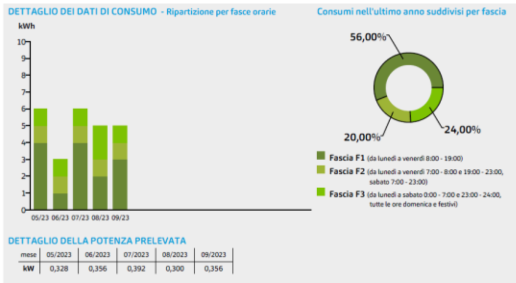
2.11	NPC INFO	Choice II row 1.7	[receptionist balloon] Production plant access is restricted. You must be accompanied by an ACME employee.	Penalty = -10
2.12	NPC INFO	Sidekick says	[popup text] Good choice! Even if the audit was scheduled and you are waited for, it is always a good move to sum up the audit purpose with top management to be sure you have their endorsement. Contact the general manager first!	You dismiss the info text and return to the main hall with choices still visible
2.13	NPC INFO	Choice III row 1.7	[receptionist balloon] Please.	Receptionist waves toward the toilet door

5.4 LEVEL 3 – MEETING WIITH MR. UNTER, ACME FACILITY MANAGER

ScreenTitle /Number		Description	Text	Media Files / Visual Instructions/Developer Notes
3.14	ACTION	The avatar inside the lobby with a staircase leading to upper floor (must convey the idea of power and wealth because it leads to General manager office) Elevator door with panel “To production plant” a receptionist desk a desk with some leaflets on it door with the panel “Toilets”	Labels on doors “To offices” (Beside the elevator) “To production plant” (on a door) Reception (close to reception desk) Company information (close to leaflets) Panel with “General Manager” wrote on it and an arrow that points upstairs at the stairs bottom. “Toilet” (on a door)	The elements already used / visited are marked with a green checkmark The avatar can choose them again, but no points are credited.
3.15	INFO	Row 3.1 - Choice B – Elevator	[Labels inside the elevator] Facility Management Division Purchasing Department HR Division Administration Engineering Basement (Building services)	The avatar enters the elevator cabin. There are floor pushbuttons labeled as follow: Facility Management Division Purchasing Department HR Division Offices Production

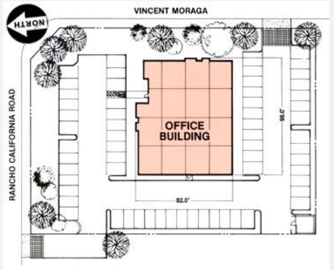
				Basement
3.16	ACTION	Row 3.2 - Choice A - Facility Management Division		Elevator movement (animation?) – whirring sound – elevator stops at the floor and door opens.
3.17	NPC INFO	The Facility Management manager is in front of the elevator waiting for you	[Mr. Unter] Welcome Markus and Karin! Let's go to my office where you can find all the documentation you need. I will be very glad to answer all your questions!	
3.18	NPC INFO	The sidekick avatar remembers you some background information	Conducting an energy audit for an office building requires a comprehensive understanding of the building's operations, systems, and energy consumption patterns. When meeting the facility manager, you'll want to gather as much information as possible to effectively assess the building's energy consumption and identifying potential opportunities for improvement. The facility manager will be a valuable ally in this process, so it's crucial to establish a good working relationship and open lines of communication	The avatar can dismiss the info by clicking a button or turning elsewhere.
3.19		The avatar in Mr. Unter office. There are some active objects in the office: Energy bills on the desk A folder marked "Building renovation plan" An advertising leaflet about Photovoltaic Solar Panels	Please feel free to look at available documents here around and to ask me any question.	The avatar can touch the objects and gets some information from them. Touching the Facility manager opens a popup with some questions

		Building floor plans open on the desk		
3.20	ACTION	Touch the Facility manager to ask a question. A popup opens with question text and options	Mr. Unter, I would ask you The permission to inspect the offices and the building services. A brief overview of the building. If you are married and if you have any children.	The avatar touches the Facility manager to open the popup and then chooses an option
3.21	NPC INFO	Row 3.7 – Choice A The sidekick displays these info	[first message] I think that it will be better to get some background information about the building itself before visiting the offices and the building services. [second message] Yes, I think it is a good idea to have a look to our offices and building services. Please use the elevator to move to the floors you wish to visit.	The first message is displayed when option B hasn't yet been selected and no objects (see row 3.6) have been touched. The second message is displayed when option B was selected. When the message is dismissed the avatar moves in front of the elevator, enter the elevator cabin and presses one of the pushbuttons – go to row 3.23
3.22	NPC INFO	Row 3.7 – Choice B Mr. Unter answers	Glad you asked! The building was built in the early '60 without too much attention to energy consumptions. It has three floors, plus the basement where are hosted the building services. The surface is 800 square meters for each floor, that is to say the total surface available to employees is 2.400 square meters.	Score = + 50 points

3.23	Notebook ACTION		[text on Notebook with check mark] Building dates back to ‘60 Surface 2.400 sqm	
3.24	NPC INFO	Row 3.7 – Choice C The sidekick displays these info	I understand your desire to get into good relationship with the Facility manager, but asking such a personal and not business-related info at our first meeting is perhaps inappropriate.	
3.25	INFO	Row 3.6 – Choice A Energy bills		Score = + 50 points The avatar touches the energy bills and they are displayed on screen. There is a “Next page” icon of energy bill. *The picture shows the consumption distribution at different hours of the day. Consumption during the night hours is quite high because the heating and lights are not turned off*
3.26	NPC INFO	Sidekick comments the energy bill	Hmm, it looks like energy consumption during the night hours are not negligible, as they should be. Maybe this could be an improvement area	
3.27	Notebook ACTION		[text on Notebook with check mark] Check occupancy patterns	

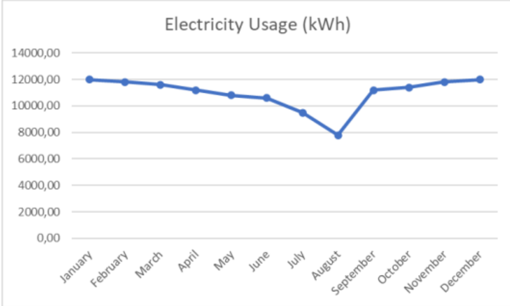
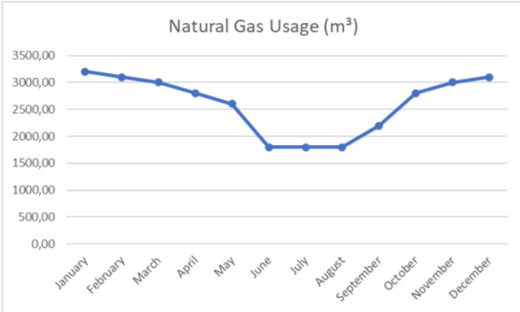
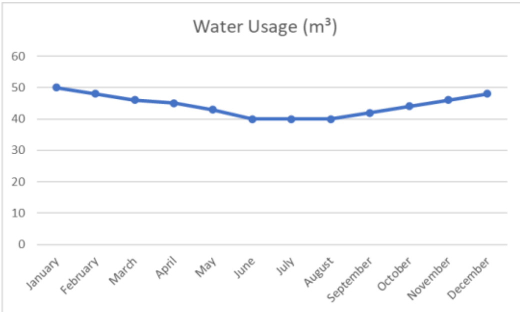
<table>
<tr>
<td>3.28</td>
<td>INFO</td>
<td>Row 3.6 – Choice A
Energy bills</td>
<td>
MIX OF PRIMARY ENERGY SOURCES
The Energy Services Manager (GSE) has published, as provided by the decree of the Minister of Economic Development on July 31, 2009, the composition of the initial national energy mix of electricity fed into the grid and the energy mix used for the production of electricity sold by A2A Energia in the Free Market, in the Gradual Safeguard Service and in the Safeguard Service related to the years 2021 and 2022 as follows:
<table>
<tr><td></td><td colspan="2">Composition of the energy mix used for the production of electricity fed by A2A Energia SpA ***</td><td colspan="2">Composition of the initial national mix used for the production of electricity fed into the Italian electric system**</td></tr>
<tr><td>Primary sources used</td><td>Year 2022*</td><td>Year 2021</td><td>Year 2022*</td><td>Year 2021</td></tr>
<tr><td>Renewable sources</td><td>48.88%</td><td>43.40%</td><td>36.84%</td><td>42.80%</td></tr>
<tr><td>Coal</td><td>9.85%</td><td>8.07%</td><td>9.43%</td><td>5.03%</td></tr>
<tr><td>Natural gas</td><td>34.62%</td><td>40.28%</td><td>46.92%</td><td>48.01%</td></tr>
<tr><td>Oil</td><td>1.51%</td><td>0.87%</td><td>2.01%</td><td>0.89%</td></tr>
<tr><td>Nuclear</td><td>1.55%</td><td>4.37%</td><td>0%</td><td>0%</td></tr>
<tr><td>Other sources</td><td>3.59%</td><td>3.00%</td><td>4.80%</td><td>3.27%</td></tr>
</table>
MIX DELLE FONTI ENERGETICHE PRIMARIE
Il Gestore dei Servizi Energetici (GSE) ha pubblicato, come previsto dal decreto del Ministro dello Sviluppo Economico del 31 luglio 2009, la composizione del mix energetico iniziale nazionale dell'energia elettrica immessa in rete e il mix energetico utilizzato per la produzione dell'energia elettrica venduta da A2A Energia nel Mercato Libero, nel servizio di Tutele Graduali e nel Servizio di Salvaguardia relativi agli anni 2021 e 2022 di seguito riportati:
<table>
<tr><td></td><td colspan="2">Composizione del mix energetico utilizzato per la produzione dell'energia elettrica immessa da A2A Energia SpA ***</td><td colspan="2">Composizione del mix iniziale nazionale utilizzato per la produzione dell'energia elettrica immessa nel sistema elettrico italiano**</td></tr>
<tr><td>Fonti primarie utilizzate</td><td>Anno 2022*</td><td>Anno 2021</td><td>Anno 2022*</td><td>Anno 2021</td></tr>
<tr><td>- Fonti rinnovabili</td><td>48,88%</td><td>43,40%</td><td>36,84%</td><td>42,80%</td></tr>
<tr><td>- Carbone</td><td>9,85%</td><td>8,07%</td><td>9,43%</td><td>5,03%</td></tr>
<tr><td>- Gas naturale</td><td>34,62%</td><td>40,28%</td><td>46,92%</td><td>48,01%</td></tr>
<tr><td>- Prodotti petroliferi</td><td>1,51%</td><td>0,87%</td><td>2,01%</td><td>0,89%</td></tr>
<tr><td>- Nucleare</td><td>1,55%</td><td>4,37%</td><td>0%</td><td>0%</td></tr>
<tr><td>- Altre fonti</td><td>3,59%</td><td>3,00%</td><td>4,80%</td><td>3,27%</td></tr>
</table>
* Si specifica che il mix energetico per l'anno 2022 è un dato pre-consuntivo.
</td>
<td>Score = + 50 points
The avatar clicks on the “Next page” icon of energy bill of row 3.12
The MIX of primary energy sources is shown
(available as screenshot in Italian in image mix_energy_sources_IT.png and in English in MIX OF PRIMARY ENERGY SOURCES.docx)</td>
</tr>
<tr>
<td>3.29</td>
<td>NPC
INFO</td>
<td>Sidekick comments the energy bill (page 2)</td>
<td>The energy mix of the current supplier seems better than the national average about the use of renewable energies.</td>
<td></td>
</tr>
<tr>
<td>3.30</td>
<td>Notebook
ACTION</td>
<td></td>
<td>[text on Notebook with check mark]
Ask to Purchasing Department a vendors’ comparison</td>
<td></td>
</tr>
<tr>
<td>3.31</td>
<td>NPC
INFO</td>
<td>Row 3.6 – Choice B
Building renovation plan</td>
<td>[Mr. Unter]
Ah, yeah, you noticed that document!
We are thinking about some interventions to better insulate the building, but the project is on hold due to the high costs.
Mrs. Clearwaters is not sure if the investment is worth the savings and the payback time. Neither I nor Mrs. Pennysaving of Purchasing are able to do such an evaluation!
Maybe the costs could be reduced if we insulate only some parts of the building, but which one?</td>
<td>Score = + 50 points
The avatar touches the folder and the Facility Manager explains</td>
</tr>
</table>

3.32	Notebook ACTION		[text on Notebook with check mark] Perform a check of the building by IR camera to identify hot spots Propose a ROI analysis of building insulation	
3.33	NPC INFO	Row 3.6 – Choice C PV panels leaflet	[Mr. Unter] I am receiving tons of these advertising, but I tell you, it's only marketing to sell their panels! The solar panels cannot be beneficial for us – we use a lot of electrical energy for internal lighting and the building roof is too small for those panels. One of them can only produce 350 W!	Score = + 50 points The avatar touches the leaflet, and the Facility Manager explains
	NPC INFO	Sidekick comments Mr. Unter words	Mr. Unter seems to be informed about photovoltaic, and apparently he has already done some technical evaluation. However, maybe he didn't thought about some game-changing approaches, such as installing LED lighting fixtures or using the parking lot for installing solar panels,	
3.34	Notebook ACTION		[text on Notebook with check mark] Check current lighting fixtures and energy consumption. Evaluate PV panel installation places alternative to roof.	
3.35	NPC INFO	Row 3.6 – Choice D Building floor plans	[Mr. Unter] The building has three floors, plus the basement where are hosted the building services. The surface is 800 square meters for each floor, that is to say the total surface available to employees is 2.400 square meters. There is a large parking lot for visitors' and employees' cars.	Score = + 50 points The avatar touches the floor plan and the Facility Manager explains

				
3.36	ACTION	Row 3.8 – Choice A Visit offices and building services	[Labels inside the elevator] Facility Management Division Purchasing Department HR Division Administration Engineering Basement (Building services)	The avatar enters the elevator cabin. There are floor pushbuttons with labels (see list on left)
3.37	NPC INFO	Row 3.23 – Choice A Sidekick suggestion	Maybe you forgot, but you have just visited the Facility Manager!	Back to row 3.23 – elevator cabin
		Row 3.23 – Other choices	Row 3.23 – Choice B – jumps to Level 4 Row 3.23 – Choice C – jumps to Level 5 Row 3.23 – Choice D – jumps to Level 7 (Heating and Cooling) Row 3.23 – Choice E – jumps to Level 8 (Lighting) Row 3.23 – Choice F – jumps to Level 7 (Heating)	

5.5 LEVEL 4 – MEETING WITH MRS. PENNYSAVING, ACME PURCHASING DEPARTMENT MANAGER

ScreenTitle /Number		Description	Text	Media Files / Visual Instructions/Developer Notes
4.1	ACTION	The avatar in the elevator presses pushbutton marked "Purchasing"		The elevator moves, doors open, and Mrs. Pennysaving greets you
4.2	NPC INFO	Mrs. Pennysaving greets you	I am glad you are here! Keeping costs under control is my job and mission, and energy costs are roaring these times!	There is an icon (for instance a question mark) close to the NPC. Touching this icon, you can ask a question.
4.3	ACTION	Pop up window with three questions Can you provide the past 12 months of utility bills (electricity, natural gas, water)? Are there any significant fluctuations in utility costs over the past few years? Are there any specific areas within the building with exceptionally high energy consumption?	Can you provide the past 12 months of utility bills (electricity, natural gas, water)? Are there any significant fluctuations in utility costs over the past few years? Are there any specific areas within the building with exceptionally high energy consumption?	You can touch any question to collect information
4.4	NPC INFO	Row 4.3 – Choice A	[Mrs. Pennysaving] Oh yes! Let's have a look to the trends in **electricity**, **gas** and **water** consumptions in the last year.	Score = +50 The three graphs can be displayed by touching the texts in bold File water-gas-electricity.xlsx

			  	
4.5	NPC INFO	Sidekick says	Well, the trends show a normal decrease during summer period, when people occupancy is reduced.	
4.6	Notebook ACTION		[text on Notebook with check mark] Install Centralized Lighting and Heating Control	
4.7	NPC INFO	Row 4.3 – Choice B	[Mrs. Pennysaving] Yes, energy costs increased as you well know.	

			We changed vendors to leverage the price battle and we succeeded in keeping costs at the lowest level possible.	
4.8	NPC INFO	Sidekick says	It seems that the purchasing department knows their job quite well and applies a wise policy of vendor selection and rotation to keep prices at bay.	
4.9	NPC INFO	Row 4.3 – Choice C	[Mrs. Pennysaving] Hmm, actually I do not know. I just receive the bills that cover the whole building consumption. Maybe Mr. Unter can answer this question. Let's call him!	
4.10	NPC INFO	Mrs. Pennysaving on the phone calls Mr. Unter	[Mrs. Pennysaving] Mr. Unter, can you join us? They are asking me a question I am not prepared to answer.	
4.11	ACTION	Mr. Unter appears. The question text is shown	Are there any specific areas within the building with exceptionally high energy consumption?	
4.12	NPC INFO		[Mr. Unter] I cannot answer this question because we do not have installed Thermal Energy Meters. When I proposed to install them, Mrs. Pennysaving rejected the project because it was too expensive. I would like to have more analytical information about energy consumption of each department, I think it could help us to significantly reduce costs.	
4.13	Notebook ACTION		[text on Notebook with check mark] Evaluate ROI of Thermal Energy Meters	
4.14	ACTION	The avatar thanks and returns toward the elevator	Thank you very much for these useful information	The avatar enters the elevator and presses a pushbutton.

5.6 LEVEL 5 – MEETING WITH MRS. STRONGFELLOW, HR MANAGER

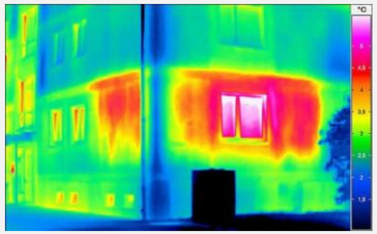
ScreenTitle /Number		Description	Text	Media Files / Visual Instructions/Developer Notes
5.1	ACTION	The avatar in the elevator presses pushbutton marked "HR Department"		The elevator moves, doors open, and Mr. Strongfellow greets the avatar.
5.2	NPC INFO	Mr. Strongfellow greets you. Face is not happy	[Mr. Strongfellow] I don't understand what I have to do with energy consumption or saving! Anyway, if you want to ask any question, I am here to help you, of course within the limits of employees' privacy.	The conversation takes place in the HR manager office or with the background of an open space with employees working
5.3	NPC INFO	Sidekick says	When conducting an energy audit in an office building, it's essential to gather information from various stakeholders, including the HR manager, to gain a comprehensive understanding of energy costs and identify potential energy-saving opportunities.	After this introduction, questions listed at row 5.4 are displayed
5.4	NPC INFO	Sidekick says	Here are some questions you can ask the HR manager: What are the office's operating hours, and are there any variations throughout the year? Are there any employee engagement programs or initiatives related to energy conservation? Do employees have control over lighting and temperature settings in their workspaces?	The list of questions stays open (or if it is too cumbersome can be shrunk and expanded at will)
5.5	ACTION	Row 5.4 – Choice A	[Mr. Strongfellow] We run normal office hours, from 9.30 to 17.30, with no shift. However, it is not uncommon that some employees stay longer hours, particularly in the Engineering Department, when we have to close a project on a tight schedule. Recently we adopted remote working, and sometimes the offices are nearly empty – people like to work from home when it is very cold outside!	
5.6	NPC INFO	Sidekick says	When the occupancy pattern is not stable, but could vary, it is a good idea to have some method to allow users to	

			manage energy usage and to define company policies for energy saving.	
5.7	Notebook ACTION		[text on Notebook with check mark] Occupancy pattern could vary a lot	
5.8	ACTION	Row 5.4 – Choice B	[Mr. Strongfellow] Yes! One year ago, we put in the noticeboards on each floor a communication by the General Manager about energy savings. Frankly speaking, I do not think it impacted too much – nobody read it!	
5.9	NPC INFO	Sidekick says	Communications on topics such as energy saving need to be impactful and frequent, to keep the attention high. It could be useful to define a publishing plan for monthly messages by email, possibly based on some storytelling or recurring characters.	
5.10	Notebook ACTION		[text on Notebook with check mark] Energy saving communication plan	
5.11	ACTION	Row 5.4 – Choice C	[Mr. Strongfellow] Oh, yes! They can turn on and off lights in the office. However, we do not allow them to act on heating – it will be a mess! The heating is activated at 8.00 in the morning and turned off completely at 18.00.	
5.12	NPC INFO	Sidekick says	Hmm, if people stay long hours and the heating is turned off at 18.00, I guess in winter they should find offices quite uncomfortable….	
5.13	Notebook ACTION		[text on Notebook with check mark] Flexible control of lighting and heating	
5.14	NPC INFO	The HR manager dismisses the avatar and says	[Mr. Strongfellow] So, dear Markus / Karin, as you can see, we already did whatever is possible to reduce energy consumptions and costs in our company. I do not see how you could improve the excellent work done by me and my colleagues.	
5.15	ACTION	The avatar thanks and returns toward the elevator	You are right, mine it's a tough job. Thank you very much for this useful information.	The avatar enters the elevator and presses a pushbutton.

5.7 LEVEL 6 – BUILDING INSULTATION (FACILITY MANAGER)

ScreenTitle /Number		Description	Text	Media Files / Visual Instructions/Developer Notes
6.1	ACTION	The avatar talks with the sidekick	We should also evaluate the building itself to assess its insulation. What can we do?	
6.2	NPC INFO	Sidekick proposes some alternatives	In my opinion we could ask the HR manager to tell us about building insulation. the Facility Manager to come with us in a building tour to assess its status and describe interventions done, if any Pick up an employee and talk about the building insulation in front of a good coffee	The avatar should touch one of the options and get corresponding feedback
6.3	NPC INFO	Row 6.2 - Choice A Sidekick comments the choice	I do not think it is a good choice. The HR manager doesn't know anything about the technical details of building insulation, and we need some facts and figures	When the feedback is dismissed, the questions of row 6.2 are displayed again
6.4	NPC INFO	Row 6.2 - Choice C Sidekick comments the choice	Hmm, not a good choice in my opinion. What do you think a randomly chosen employee knows about the technical details of building insulation? We need some facts and figures!	When the feedback is dismissed, the questions of row 6.2 are displayed again
6.5	NPC INFO	Row 6.2 - Choice B	Yes, the Facility Manager should be able to give us all the required information and perhaps can come with us in a tour of the building to assess its status	
6.6	NPC INFO	Avatar and sidekick meet the Facility Manager	[Mr. Unter – Facility Manager] If you want to get some info on the building insulation, I am the right person, sure. Let's go to inspect the building together.	
6.7	ACTION	The Facility Manager invites the avatar to touch each element to "inspect" it. The selection takes the avatar to one of the following rows.	Touch the elements you want to inspect: Exterior Walls Attic or Roof Windows Infrared Imaging Occupant comfort	Each element is shown on the screen with the help of an icon or a small drawing.

6.8	NPC INFO	Row 6.7 – Choice A Sidekick says	You must inspect the exterior walls for any visible gaps, cracks, or openings that may allow air infiltration. Also, check for signs of insulation, such as wall thickness and the presence of insulation material.	When the sidekick comment is dismissed, the following comment by avatar is displayed
6.9	ACTION	The avatar says	On the visual inspection the walls do not show any damage, look well maintained and painted recently. Mr. Unter, can you tell me something about any recent intervention on building?	
6.10	NPC INFO	Mr. Unter answers the avatar question	[Mr. Unter] Three years ago, we have fully insulated the building using high density fiberglass batts, 1 inch thick, with a nominal thermal resistance of 0.82.	
6.11	NPC INFO	Sidekick says	The thermal resistance of the insulation material, also called R-value, is a measure of how well the building resist to the thermal exchanges with the surrounding environment. A higher R-value indicates better insulation performance, and 0.82 is quite a high value. Fiberglass is also a fire-resistant material.	
6.12	Notebook ACTION		[text on Notebook with check mark] Building is well insulated with fire resistant material that do not pose problems in case of fire	
6.13	ACTION	Row 6.7 – Choice B Avatar says	Mr. Unter, can we visit the building attic?	
6.14	NPC INFO	Mr. Unter answers	[Mr. Unter] No problem. However, the building is terraced, and it has no attic.	
6.15	ACTION	Mr. Unter, avatar and sidekick on the building terrace. There are no PV solar panels but there are three large thermal solar panels. Avatar asks to Mr. Unter	This is a large dispersion surface. I see that there are no photovoltaic solar panels but there are thermal panels. Can you explain these choices, Mr. Unter?	
6.16	NPC INFO	Mr. Unter says	[Mr. Unter] The terrace was fully insulated when we did the building insulation three years ago and now the heat exchanges with exterior are really reduced.	

			We thought about installing solar panels, but the costs were too high. We opted for thermal panels that let us save some gas for heating water for sanitary purposes.	
6.17	Notebook ACTION		[text on Notebook with check mark] Terrace is properly insulated. No PV solar panels Production of hot water with thermal solar panels	
6.18	NPC INFO	Row 6.7 – Choice C Sidekick says	You must examine the condition of windows and doors for gaps or leaks around frames, seals, and weatherstrips. Assess the type and quality of glazing used in windows	
6.19	NPC INFO	A close up of the window frame is displayed and Mr. Unter describes the intervention	[Mr. Unter] We replaced all – or nearly all - the window frames with new ones made in PVC with thermal cut. They close very well, now there are no gaps or air leaks. All windows have double glazing.	Close up of window frame 
6.20	Notebook ACTION		[text on Notebook with check mark] Windows replaced with new ones. Double glazes on windows.	
6.21	NPC INFO	Row 6.7 – Choice D Sidekick says	Infrared thermography is a method that allow detection of temperature differences that may indicate insulation problems, such as missing or damaged insulation.	
6.22	ACTION	Avatar asks to Mr. Unter	Have you ever done a thermography inspection of the building?	
6.23	NPC INFO	Mr., Unter answers	[Mr. Unter] Yes, we did last week and this is a picture we got. It seems there is a problem…	
6.24	NPC INFO	Sidekick says	The picture clearly shows that two windows are not insulated satisfactorily. Some intervention is required to correct the problem.	

			But was the thermography done on the whole building?	
6.25	Notebook ACTION		[text on Notebook with check mark] Check the thermography done and possibly run another set of pictures	
6.26	ACTION	Row 6.7 – Choice E Sidekick says	Eventually, is the building occupant comfort we are trying to maximize, together with a cost reduction. Let's hear from the occupants to gather feedback on temperature comfort and any areas where they experience drafts or discomfort!	
6.27	ACTION	The image shows the office with some employees working. You can touch one of them and the character gets on the forefront and speaks	Three years ago, working in winter was a nightmare. If your desk was close to a window you had to wear your overcoat when sitting. Since the building was renovated and the new windows installed, comfort improved a lot. However, the doors often stay open, and drafts enter, causing a lot of discomfort!	Touch one of the employees to trigger dialogue
6.28	Notebook ACTION		[text on Notebook with check mark] Install automatic door closer	
	ACTION	The avatar thanks Mr. Unter and returns in the lobby	Thank you very much for this precious information about building insulation. We will use them in our energy audit.	The avatar enters the elevator and presses a pushbutton.

5.8 LEVEL 7 – HVAC PLANT (ADMINISTRATION)

ScreenTitle /Number		Description	Text	Media Files / Visual Instructions/Developer Notes
7.1	ACTION	The avatar talks with the sidekick	I would ask the Facility Manager some information about the heating plant, but I need to know the opinion of employees about their comfort. Let's go to the Administration department and talk with someone who works there.	The avatar enters the elevator cabin.
7.2	ACTION		[Labels inside the elevator] Facility Management Division Purchasing Department HR Division Administration Engineering Basement (Building services)	The avatar presses the pushbutton labelled "Administration".
7.3	ACTION	The avatar reaches the Administration floor. There are at least two employees working at their desk and a fan coil visible. The avatar can touch: Employee A Employee B The fan coil		The avatar touches an employee and asks a question or touches the fan coil and gets a close-up picture of the device
7.4	ACTION	Row 7.3 – Choice A Avatar speaks	How do evaluate the comfort of this office' Is the temperature right for you?	Score = +50
7.5	NPC INFO	Mr. Thawingbud answers	[Mr. Thawingbud] Heating is fine, but the air conditioned… it's terrible! I always get a cold when they start the office refreshment – or should I say the office freezing?	

			We cannot control the temperature and the fan runs always at maximum speed. I have to wear a wool jumper in July to avoid getting ill.	
7.6	NPC INFO	Mrs. Houlihan another employee intervenes	[Mrs. Houlihan] You are right, in summer the air conditioning runs at full speed, but I suspect that if you could control the HVAC system, you will set the temperature to 35 °C	
7.7	NPC INFO	Sidekick says	Setting the right temperature is a problem everywhere. People have different perceptions of temperature and what is comfortable for someone isn't for someone else. Remember however that reducing humidity improves tolerance towards higher temperatures, which require less energy to maintain.	
7.8	ACTION	Sidekick asks a question	What do you suggest? Install a thermostat for every office so that each one can set the preferred temperature. Buy portable air conditioners that everyone can set to the preferred temperature. Set the plant to an average temperature that maximizes comfort to most of the employees and at the same time reduces energy consumption.	
7.9	ACTION	Row 7.8 – Choice A Sidekick says	Why do you think that people working in the same will agree on the same temperature? The thermostat will be acted upon continuously to change the temperature without increasing the employee's comfort.	
7.10	ACTION	Row 7.8 – Choice B Sidekick says	This is possibly the worst solution you could choose! Think about the costs and the energy waste by many air conditioners competing one with the other!	
7.11	ACTION	Row 7.8 – Choice C Sidekick says	By this solution you get just an "average" comfort and satisfaction, but it is the most sensible solution.	
7.12	NPC INFO	Sidekick says	Maybe a good communication plan that explains the company energy policies could make more acceptable the HVAC settings.	
7.13	Notebook ACTION		[text on Notebook with check mark] Suggest a communication plan for HVAC settings	
7.14	ACTION	Row 7.3 – Choice B Avatar speaks	What about heating? What do you think about winter season comfort?	Score = +50

7.15	NPC INFO	The employee (Mrs. Houlihan) answers the question	Oh, winter heating is fine! The only problem in winter is the tap water in the toilets. It is so hot, it can scald! And it is even impossible to mix water, there are two separate taps for hot and cold water.	
7.16	NPC INFO	Sidekick says	Possibly the setting for hot water is too high – the problem is only during winter because in summer water is heated by thermal solar panels and never reaches too high temperatures.	
7.17	Notebook ACTION		[text on Notebook with check mark] Install taps with mixer. Change the hot water upper temperature setting.	
	INFO	Row 7.3 – Choice B Fan coil details		Score = +50 An enlarged view of the fan coil is shown. See picture fan-coil-aermec-omnia-ul-36s-universal-fan-coil-unit-without-controls-ul36s.jpg
	NPC INFO	Sidekick says	This fan coil has no local controls, and its settings must be configured at a central level or using a remote control.	
7.18	NPC INFO	Sidekick says	We still do not have information about HVAC plant. To whom do we have to ask: The Facility manager The Maintenance Engineer The Purchasing Department manager	
7.19	ACTION	Row 7.18 – Choice B Sidekick says	The Maintenance Engineer surely has the technical information we need but perhaps he lacks the wider vision of the Facility Manager	Penalty = -10 The question remains visible
7.20	ACTION	Row 7.18 – Choice C Sidekick says	The Purchasing Department manager knows all the details about costs and model, but maybe they do not have the technical information we need	Penalty = -10 The question remains visible
7.21	ACTION	Row 7.18 – Choice A Sidekick says	The Facility Manager is the right person to give us all the information we need. I have arranged a meeting with him in the basement, where are located the building plants.	Score = +50 The avatar moves toward the elevator
7.22	ACTION		[Labels inside the elevator] Facility Management Division Purchasing Department HR Division	The avatar presses the pushbutton labelled Basement (Building services).

			Administration Engineering Basement (Building services)	
7.23	INFO	The avatar meets the Facility Manager in the basement. The environment contains the following items (as icons or menu) Air handlers Boilers Chillers Water pumps Main distribution piping and valves	Air handlers Boilers Chillers Water pumps Main distribution piping and valves	Picture in background Mechanical_room.jpg The avatar can touch each one of the elements and the Facility Manager supplies more information about the piece of equipment.
7.24	ACTION	Row 7.23 – Choice A Sidekick says	When inspecting an air handler, what do you have to check? Mark all the options that you consider correct. Condition and cleanliness of air filters. When filters were replaced or cleaned last time. Verify insulation around the air handler for damage or deterioration. Check for air leaks around the air handler and its connections.	Score = +50 for each option checked
7.25	NPC INFO	Sidekick says	Well, all these controls are important to guarantee proper and efficient operation of the air handlers.	
7.26	Notebook ACTION		[text on Notebook with check mark] Verify maintenance schedule for air handlers	
7.27	ACTION	Row 7.23 – Choice B Avatar asks the Facility Manager	Boilers are used to heat the fluid used by the HVAC plant. Is the boiler installed here a condensation boiler?	
7.28	NPC INFO	Facility manager answers	Yes, we have replaced the old boiler with a new model of condensation boiler just three years ago. Why do you ask?	
7.29	ACTION	Sidekick says	What do you answer to Facility Manager question? Just to know, my cousin sells boilers. Because condensation boilers are more efficient, and I am glad you choose this kind of boiler.	

			Because condensation boilers are less efficient, and I would like to know why you choose this kind of boiler	
7.30	NPC INFO	Row 7.29 – Choice A Sidekick says	Not a good answer, even if we set aside the drop in professionalism speaking of your cousin…	
7.31	NPC INFO	Row 7.29 – Choice B Sidekick says	Good answer, the higher efficiency of condensation boilers is a strong argument for replacement of old boilers with this new kind.	
7.32	NPC INFO	Row 7.29 – Choice B Sidekick says	Not a good answer. The higher efficiency of condensation boilers is a strong argument for replacement of old boilers with this new kind.	
7.33	Notebook ACTION		[text on Notebook with check mark] Check the model and type of boilers	
7.34	ACTION	Row 7.29 – Choice C Sidekick says	Which of these features of the chiller will you check to guarantee the maximum efficiency? The outside painting must be bright and without rust. Monitor the condenser water temperature to ensure it is optimized for heat rejection. Determine the chiller's efficiency rating, typically represented as the Coefficient of Performance (COP) or Energy Efficiency Ratio (EER).	
7.35	NPC INFO	Row 7.34 – Choice A	Although a well-kept appearance of the device indicates good maintenance, it does not significantly affect efficiency.	Penalty = -10
7.36	NPC INFO	Row 7.34 – Choice B	The correct setpoints adjustment for water temperature is important to optimize chillers' efficiency.	Score = +50
7.37	Notebook ACTION		[text on Notebook with check mark] Check chillers' setpoints	
7.38	NPC INFO	Row 7.34 – Choice C	Getting these values and comparing them to the manufacturer's specifications and industry standards lets you benchmark the equipment efficiency and identify possible improvements.	
7.39	Notebook ACTION		[text on Notebook with check mark] Constantly check device efficiency and consumptions	
7.40	ACTION	Row 7.29 – Choice D Avatar asks to Facility Manager	Have you installed any system to control pumps efficiency?	Score = +50
7.41	NPC INFO	Mr. Unter answers	[Mr. Unter] We have equipped all pumps with variable speed drives (VSDs) that allow for adjusting pump speeds based on demand.	

			AS you know, VSDs can significantly improve energy efficiency by matching pump output to actual needs.	
7.42	Notebook ACTION		[text on Notebook with check mark] Water pumps are equipped with Variable Speed Drives.	
7.43	ACTION	Row 7.29 – Choice E Avatar looks around and sees tubes with bad insulation		Score = +50 Picture damaged_pipe_insulation.jpg
7.44	NPC INFO	Sidekick says	If the pipe insulation is missing or damaged, the efficiency of the whole system is affected by unwanted heat exchanges.	
7.45	NPC INFO	Mr. Unter says	[Mr. Unter] Now we can we return to the offices floor.	
7.46	ACTION	The avatar thanks Mr. Unter and returns in the lobby	Thank you very much for the visit of building systems, they are very important for our energy audit.	The avatar enters the elevator and presses a pushbutton.

5.9 LEVEL 8 – LIGHTING (ENGINEERING)

ScreenTitle /Number		Description	Text	Media Files / Visual Instructions/Developer Notes
8.1	INFO	The avatar could arrive at this level only after talking to Mrs. Clearwaters (level 2)	[Labels inside the elevator] Facility Management Division Purchasing Department HR Division Administration Engineering Basement (Building services)	The avatar enters the elevator cabin. To reach this level must press button E
8.2	ACTION	The avatar enters an office with several desks and some employees. Two of them are active areas (points E and F below). Items that can be touched to activate an action: Ceiling lighting fixtures using fluorescent lamps old type (38 mm) Table lamp on desk using halogen bulb. Storeroom for documents, door partially open, light inside on Mobile phone power supply connected to a wall socket without phone connected. Mrs. Shortarm (an employee) Mr. Longfellow (an employee)		The avatar can touch any of the item to get more information and fill in the notebook

8.3	INFO	Row 8.2 – Choice A Ceiling lighting fixtures using fluorescent lamps old type. Close up of the fixture to show the fluorescent tubes of old type		
8.4	NPC INFO	Row 8.2 – Choice A Sidekick says	The older tubes, called T12 with a diameter or 38 mm, were developed during the '30 of last century and are now abandoned. Other tubes of smaller diameter, such as T8, are now in use. Remember that compared to fluorescent bulbs, LED lights are up to 80% more efficient. Unlike fluorescent lights, LED lights convert 95% of their energy into light and only 5% is wasted as heat	Score = +50
8.5	Notebook ACTION		[text on Notebook with check mark] Replace fluorescent tubes with LED	
8.6	NPC INFO	Row 8.2 – Choice B Sidekick says	Halogen lights emit about 16-24 lumens per watt, whereas LED lights emit about 80-100 lumens per watt. That means that you'll get a much higher brightness level from LEDs than halogens—even if you use a less-powerful bulb	Score = +50
8.7	Notebook ACTION		[text on Notebook with check mark] Replace halogen lamp with LED. Check if that person needs an extra light. Maybe it would be enough to change desk orientation	
8.8	INFO	Row 8.2 – Choice C Enter the storeroom (no windows, light is on, nobody inside, look at light switch)		
8.9	NPC INFO	Row 8.2 – Choice C Sidekick says	The light in this room is always on, because people enter or exit the storeroom carrying loads, have their hands full and they do not care to turn lights off	Score = +50

8.10	Notebook ACTION		[text on Notebook with check mark] Add an IR detector to control lights on/off	
8.11	NPC INFO	Row 8.2 – Choice D Close up of the mobile phone power supply connected to a wall socket without phone connected		Score = +50
8.12	NPC INFO	Row 8.2 – Choice D Sidekick says	Though no power is being supplied to the phone since it is not plugged in, some power is used to do the conversion to the low voltage value and therefore some power is dissipated. It is a very low consumption, but it's anyway useless and could be easily avoided.	Score = +50
8.13	Notebook ACTION		[text on Notebook with check mark] Issue an internal communication about low load consumptions OR do nothing, it is not worth the energy spent on email for communication!	
8.14	NPC INFO	Row 8.2 – Choice E Mrs. Shortarm The person rises from desk and talks to the avatar	So, you are inspecting the building to reduce consumptions! We really need to do something against energy waste! I work long hours here, you know, and every evening I have to turn off lights on all the floor, because nobody else cares! But I care! And I turn off EVERY light!	Score = +50
8.15	Notebook ACTION		[text on Notebook with check mark] Install Centralized Lighting Control	
8.16	NPC INFO	Row 8.2 – Choice E Mr. Longfellow The person rises from desk and talks to the avatar	Speaking of energy consumption, have a look to our toilets! The hand dryer we have are prehistoric! Maybe they were used by some T-rex! I guess that replacing them with paper towels will be a great benefit for the planet.	Score = +50
8.17	NPC INFO	Row 8.2 – Choice E Sidekick says	The topic is controversial. From many studies it seems that the overall energy consumption by paper towels is a little higher than more recent hand dryers, but if the hand dryer is old and not too efficient, the paper towel is better (source 1) From the hygienic point of view, it is likely that paper towels work better because they physically remove bacteria from the hands, whereas hot air dryers and jet air dryers cannot. (source 2)	

8.18	INFO	The avatar returns to elevator, enter the cabin and choses a different floor	[Labels inside the elevator] Facility Management Division Purchasing Department HR Division Administration Engineering Basement (Building services)	The avatar enters the elevator cabin. Floors already visited are marked with a green checkmark
	NPC INFO	Row 8.18 – Choice E Sidekick suggestion	Maybe you forgot, but you have just visited the Engineering Department!	Back to row 8.18 – elevator cabin
		Row 8.18 – Other choices	Choice A – jumps to Level 4 Choice B – jumps to Level 4 Choice C – jumps to Level 5 Choice D – jumps to Level 7 (Heating and Cooling) Choice F – jumps to Level 7 (Heating)	

The last two levels have been planned, and at the time of the writing of this deliverable are being translated into the level of detail of the previous 8 levels

5.10 LEVEL 9 – DATA ANALYSIS

Segment	Topic
9.1	Bills review and build-up of historical series
9.2	Comparison of different years and looking for explanation of energy use changes (fake data from 2018 to 2023 showing the pandemic lock downs, the increase of energy use in 2022 but also the incidence of remote working)
9.3	Constraints on some interventions (e.g., change of window frames that will imply to disruption of normal activities)
9.4	Summary of Data Collected: • No RES in use • Heating plant of old type • Window frames damaged and leaking

5.11 LEVEL 10 – IDENTIFY ENERGY MANAGEMENT OPPORTUNITIES.

Segment	Topic
10.1	Selecting the intervention based on a cost / benefit scheme
10.2	Each intervention is explained, and its cost and benefit are shown: A. Attic insulation B. Internal insulation of perimeter walls C. Windows frame replacement D. Building automation and control system E. Condensing boiler F. Thermostatic valves on heating units G. Replacement of existing lamps with LED units H. Presence detectors in the toilets I. Photovoltaic panels J. Thermal solar panels for hot water production K. Consumption monitoring
10.3	Explanation of the difference between interfering and non-interfering interventions. (A, B, E and F are interfering, G and J are non-interfering)
10.4	Description of the cost/benefit analysis performed using a simulation model.
10.5	Consumptions comparison before and after the interventions according to the simulation model and forecast both the savings and the improvement of building energy ranking (for instance from Class G, 205 kWh/m^{2}year, to Class D, 71 kWh/m^{2}year.
10.6	Use of Thermal Energy Meters (4.11) is not justified because the building is occupied by a single company.

3.3.2.6 Energy Manager Hard Skills and Soft Skills

This section provides a detailed description of the Soft Skills Module.

The following table provides a list of the planned content for this section, while the specifics of the single units are provided in the following pages.

Segment	Title	Expected Duration
6.1	Learning Objectives	1 min
6.2	Hard and soft skills - Introduction	12 min, 20 secs.
6.3	How to perform an Energy Audit	15 min, 30 secs.
6.4	Project Management	7 min, 15 secs.
6.5	Communication: a soft skill for everyone	27 min. 52 secs.

6.1 LEARNING OBJECTIVES

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	This lesson is composed by 5 modules. The first module summarizes the topics of the lesson. The second module explains the differences between hard and soft skills, with a focus on the abilities of the energy manager. The third module describes how to conduct an energy audit. The fourth module delves into the meaning of project management, and the last module provides a comprehensive overview of communication types and characteristics.		
2	At the end of this module, you will be able to: • Describe energy manager's hard and soft skills. • Explain the skills required for an energy manager. • List the necessary steps to perform a quality energy audit. • Describe the main phases of the project management process. • Be aware of the difference among communication mode, direction and style. Point out the barriers to communication and how to avoid communication traps.	Same as narrated text	

6.2 Introduction

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	A skill is an ability or expertise that allows an individual to perform a specific task, job, or activity effectively and efficiently. Skills are typically developed through training, education, practice, and experience, and they can encompass a wide range of capabilities, from technical and physical skills to cognitive and interpersonal abilities. Skills enable individuals to achieve goals, solve problems, and excel in various aspects of life, including work, hobbies, and daily activities.		
2	Hard and soft skills are two categories of skills that people possess, and they play different roles in the workplace and in various aspects of life		
3	**Hard Skills:** Hard skills, also known as technical skills or technical competencies, are specific, teachable abilities or knowledge that are typically acquired through formal education, training programs, or on-the-job experience. These skills are often quantifiable and can be measured or tested. Hard skills are usually job-specific and are essential for performing tasks and functions within a particular field.		
4	Here are some examples of hard skills: • Programming: Knowing how to write code in programming languages		

	like Python, Java, or C++. • Accounting: Proficiency in using financial software like QuickBooks or knowledge of Generally Accepted Accounting Principles (GAAP). • Data Analysis: Skills in data manipulation, statistical analysis, and using tools like Microsoft Excel, SQL, or data visualization tools like Tableau. • Mechanical Engineering: Expertise in CAD (Computer-Aided Design) software for designing machines and structures. Medical Procedures: Performing surgical techniques, diagnosing diseases, and administering medications, all of which require specialized training and knowledge.		
5	An energy manager is responsible for optimizing energy usage and efficiency within an organization or facility. This role involves a combination of technical and analytical skills to reduce energy consumption, lower costs, and minimize environmental impact.		
6	Here are some hard skills required for an energy manager: • Energy Auditing • Data Analysis • Energy Conservation Technologies • Regulatory Compliance • Energy Management Systems (EMS) • Financial Analysis • Renewable Energy Integration • Energy Procurement • Energy Conservation Measures (ECMs) • Environmental Impact Assessment • Project Management		

	Communication and Reporting		
7	**Energy Auditing** Conducting thorough energy audits to assess the current energy consumption patterns and identify areas for improvement. This involves data collection, analysis, and the use of specialized software tools.		
8	**Data Analysis** Proficiency in data analysis software, such as Microsoft Excel or dedicated energy management software, to interpret energy consumption data, identify trends, and make informed decisions based on data-driven insights.		
9	**Energy Conservation Technologies** Knowledge of various energy-efficient technologies and systems, including HVAC (Heating, Ventilation, and Air Conditioning) systems, lighting controls, building automation systems, and renewable energy sources like solar panels and wind turbines.		
10	**Regulatory Compliance** Understanding and staying up-to-date with energy-related regulations, codes, and standards relevant to the industry and region where the organization operates. This includes knowledge of programs like ENERGY STAR, LEED (Leadership in Energy and Environmental Design), and local building codes.		
11	**Energy Management Systems (EMS)** Familiarity with EMS software and hardware used to monitor and control energy usage in real-time.		

	This includes the ability to set up and configure these systems for optimal performance.		
12	**Energy Auditing** Conducting thorough energy audits to assess the current energy consumption patterns and identify areas for improvement. This involves data collection, analysis, and the use of specialized software tools.		
13	**Financial Analysis** Competence in conducting cost-benefit analyses and ROI (Return on Investment) calculations for energy-saving projects and initiatives. This includes calculating payback periods and assessing the financial feasibility of energy efficiency upgrades.		
14	**Renewable Energy Integration** Understanding the integration of renewable energy sources into the organization's energy portfolio, including the technical aspects of solar, wind, or other renewable energy systems.		
15	**Energy Procurement** Knowledge of energy markets, procurement strategies, and negotiation skills for securing favorable energy supply contracts and tariffs.		
16	**Energy Conservation Measures (ECMs)** Familiarity with a variety of ECMs, such as insulation improvements, lighting retrofits, and energy-efficient equipment upgrades, and the ability to prioritize and implement them.		

17	**Environmental Impact Assessment** The ability to assess the environmental impact of energy usage and the implementation of energy efficiency projects, including calculating carbon emissions reductions.		
18	**Project Management** Skills in project planning, execution, and monitoring, as energy managers often oversee the implementation of energy-saving projects and initiatives.		
19	**Communication and Reporting** Effective communication skills to convey energy-saving recommendations, progress, and results to various stakeholders within the organization, including management, employees, and regulatory authorities.		
20	**Hard Skills – Energy Manager** These hard skills are essential for an energy manager to effectively analyze, plan, implement, and monitor energy management strategies that reduce energy consumption, improve sustainability, and save costs for their organization. Additionally, staying updated with the latest advancements in energy-efficient technologies and sustainable practices is crucial for success in this role.		
21	**Soft Skills** Soft skills, often referred to as interpersonal skills or people skills, are personal attributes, traits, and abilities that influence how individuals interact with others, work in teams, and handle various situations.		

	These skills are generally not tied to a specific job or profession and are valuable across different fields and in daily life. Soft skills are essential for effective communication, collaboration, and personal development.		
22	Here are some examples of soft skills: • Communication • Leadership • Problem-Solving • Adaptability Teamwork		
23	**Soft Skills – Energy Manager** Soft skills are equally as important as technical skills for an energy manager. These skills enable them to engage with stakeholders, drive change, and effectively manage energy conservation efforts within an organization.		
24	**Communication Skills** These skills include the ability to express ideas clearly, actively listen, and convey information effectively, both in written and verbal forms. • **Effective Communication** Energy managers must communicate their plans, recommendations, and strategies to a wide range of stakeholders, including executives, employees, and suppliers. Clear and concise communication is essential for gaining support and buy-in for energy conservation initiatives.		

	Interpersonal Skills Building positive relationships with colleagues, team members, and external partners is crucial. Energy managers often collaborate with various departments and need to be able to work effectively with people from diverse backgrounds and roles.		
25	**Leadership and Influencing Skills:** The capacity to motivate, inspire, and guide others to achieve common goals and objectives is very important for Energy Managers that often work in teams with people from different departments and without a strong hierarchical dependence. • **Leadership** Energy managers need to lead by example and inspire others to follow energy-efficient practices. They should be able to set goals, motivate teams, and drive change within an organization. **Influencing and Negotiation** Convincing decision-makers and stakeholders to invest in energy-efficient technologies or implement energy-saving policies often requires negotiation and persuasion skills. Energy managers must be adept at presenting compelling arguments and demonstrating the financial and environmental benefits of their proposals.		
26	**Problem-Solving** Problem solving involves analyzing complex situations, identifying solutions, and making decisions based on critical thinking. • **Critical Thinking** Analyzing energy data, identifying inefficiencies, and devising effective solutions require strong critical		

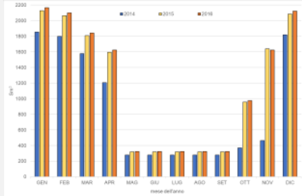
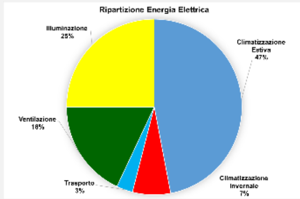
	thinking skills. Energy managers should be able to evaluate complex situations and make data-driven decisions. **Problem-Solving** Identifying and resolving energy-related challenges, such as equipment malfunctions or energy wastage, is a crucial part of the job. Energy managers must be adept at troubleshooting and finding practical solutions.		
27	**Adaptability** To be adaptable means to be open to change, able to learn from experiences, and therefore able to adjust behaviors and ideas to new circumstances, challenges, or technologies. • **Adaptability** The energy landscape is constantly evolving with new technologies and regulations. Energy managers must stay current with industry trends and adapt to changes, whether it's integrating renewable energy sources or complying with new energy efficiency standards. **Innovation** Finding innovative ways to reduce energy consumption and increase sustainability is essential. Energy managers should be creative and open to exploring new ideas and technologies.		
28	**Teamwork** Being able to work collaboratively with others, respecting diverse perspectives, and contributing to a group's success requires a mix of soft skills already described, that range from communication to leadership, from openness to innovation to interpersonal skills.		
29	This video summarizes the activity of Energy Manager and starting from minute 1:50 describes the skills required to perform this activity.		Video YouTube – Duration 3:55 https://youtu.be/sJf0Gjha1fU?feature=shared

6.3 How to perform an Energy Audit

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	An energy audit • determines where, when, why and how energy is being used • gives you information you can use to improve efficiency, and reduce your energy costs and greenhouse gas emissions can verify the effectiveness of the energy-efficiency projects you implement		Image diagnosi_energetica.png 
2	The characteristics of an energy audit: • Completeness: The ability to comprehensively describe the system, encompassing all significant aspects. • Reliability: The acquisition of data that is both quantitatively and qualitatively satisfactory. • Traceability: Ensuring easy identification of data sources, results processing methods, and working hypotheses assumed. • Utility: Evaluating energy efficiency interventions in terms of cost-effectiveness. Verifiability: Identifying elements that enable the customer to verify the efficiency improvements resulting from the proposed interventions' application.		
3	The five 5 main steps that must be performed to implement an energy audit are: 1. Planning and Preparation 2. Data Analysis and benchmarking 3. Site Inspection and Survey		

	4. Identifying and Analyzing Energy Conservation Measures (ECMs) 5. Reporting and implementation Planning These activities can be performed at the auditor's office – at least part of them - and others at the organization's facilities.		
4	**Planning and Preparation** A careful planning is crucial for the energy audit success. You should: **Set the Objectives** Define the goals and scope of the energy audit. This might include identifying specific areas for energy savings, compliance with regulations, or overall energy efficiency improvements. **Create a Team** Assemble a team with the necessary skills and expertise. This team might include internal staff (like facility managers and engineers) and external experts (like energy auditors or consultants). **Collect Data** Gather necessary data such as past energy bills, equipment lists, facility layouts, and operational schedules. This step is crucial for understanding the current state of energy usage.		Subtopic of screen/title n.3
5	Here there are some examples of which kind of data could be useful to perform the audit: • Building floor plans, technological elements, and systems • Set-point values of internal environmental parameters (temperature, air flow, lighting, noise) • Occupation profiles • Technical reports or Energy Performance Certificates • Documentation related to maintenance and/or energy retrofit interventions carried out		

	• Surface area of the buildings and envelope characteristics • Energy bills to understand the historical energy consumption patterns Energies sources used by the company, such as electricity, natural gas, diesel, and so on		
6	**Data Analysis and Benchmarking** During this phase it is very important to engage with facility staff to understand operational practices and constraints, as their input is vital for a realistic and effective energy audit. The use of advanced analytical tools and technologies, like energy management software, can greatly enhance the accuracy and depth of the analysis. There are different steps involved in this phase • Energy Consumption Analysis • Benchmarking • Energy Flow Analysis • Performance Indicators Identification • Demand Analysis • Load Profile Analysis • Energy Efficiency Opportunities Identification • Cost Analysis Measurement and Verification Plan Development		Subtopic of screen/title n.3
7	***Energy Consumption Analysis*** Analyze historical energy consumption data to understand patterns and identify anomalies. All the operations of the organization must be analyzed, as well as the equipment consuming higher energy.		Subtopic of screen/title n.6 Image data_analysis.png

	The processes which have higher energy consumption must be identified in order to determine the potential for reducing it and to define the energy saving measures to improve global energy performance. All information collected is used to evaluate the different uses of energy within the process and to establish a breakdown of the energy consumed.		
8	***Benchmarking*** Compare the facility's energy performance against similar facilities or industry standards to identify areas for improvement. During this phase you should also establish an energy baseline against which future improvements can be measured. This involves understanding the normal energy consumption patterns and identifying any anomalies.		Subtopic of screen/title n.6
9	***Energy Flow Analysis*** Analyze the flow of energy throughout the facility. This includes identifying major energy-consuming equipment and processes, and understanding how energy is distributed and used in each part of the facility.		Subtopic of screen/title n.6 Image energy_flow_IT.png (to be translated) 
10	***Performance Indicators Identification*** Identify Key Performance Indicators (KPIs) for energy use. These metrics help in measuring and tracking energy efficiency over time.		Subtopic of screen/title n.6
11	***Demand Analysis***		Subtopic of screen/title n.6

	Analyze the demand patterns for different energy sources. Understanding peak demand times and how they correlate with operational activities is crucial for effective energy management.		
12	***Load Profile Analysis*** Create load profiles for major energy-consuming systems. This helps in identifying inefficiencies and potential areas for load management or load shifting.		Subtopic of screen/title n.6
13	***Energy Efficiency Opportunities Identification*** Identify opportunities for improving energy efficiency. This can involve both quick wins (like fixing leaks or improving insulation) and longer-term investments (like upgrading to more energy-efficient equipment).		Subtopic of screen/title n.6
14	***Cost Analysis*** Analyze the cost associated with energy consumption. This involves not just the direct cost of energy but also the operational and maintenance costs related to energy use.		Subtopic of screen/title n.6
15	***Measurement and Verification Plan Development*** Develop a plan for measuring and verifying the effectiveness of any implemented energy-saving measures. This is crucial for quantifying the benefits of the energy audit and for future planning.		Subtopic of screen/title n.6
16	**Site Inspection and Survey** To assess the actual building conditions that are relevant to energy consumption it is mandatory to perform a walk-through audit, that includes a detailed inspection of the facility.		Subtopic of screen/title n.3

	It is required to conduct a physical inspection of the facility to observe energy-related operations and identify visible issues like leaks, insulation problems, or outdated equipment. This preliminary audit is designed to be quick (often completed in a day or less) and to identify obvious areas of energy waste or inefficiency. It provides a foundation for deciding whether a more detailed audit is warranted and, if so, how it should be conducted. If any problem is identified problem in specific areas or systems, you must conduct a more detailed inspection using tools like thermal imaging cameras, flow meters, or data loggers. It also serves to establish communication between the auditor and the facility's personnel, which is crucial for successful energy management		
17	The site inspection and survey activity requires and implies the following: • Visual Inspection • Interviews with Employees and Review of Facility Operation • Spot Measurements and Observations • Preliminary Energy Conservation Measures Report Preparation		Subtopic of screen/title n.16
18	**Visual Inspection** The auditor performs a simple visual inspection of the building's envelope and key energy-using systems. This includes the heating, ventilation, and air-conditioning (HVAC) systems, lighting, water heating, and any process equipment.		Subtopic of screen/title n.17
19	**Interviews with Employees and Review of Facility Operation**		Subtopic of screen/title n.17

	The auditor discusses operational practices with the building occupants and maintenance staff to understand schedules, issues, and maintenance practices that could affect energy consumption. Also relevant are the building's operational characteristics, including hours of operation, occupancy patterns, and equipment usage.		
20	**Spot Measurements and Observations** It is not uncommon that the auditor takes some spot measurements of temperatures, light levels, and power consumption using portable instruments to gather some data to be used in the inspection report.		Subtopic of screen/title n.17
21	**Preliminary Energy Conservation Measures** During the walk-through, the auditor could possibly identify low-cost/no-cost energy conservation measures (ECMs). He/she looks for opportunities to save energy that are readily apparent, such as signs of excessive energy consumption, equipment running unnecessarily when the building is unoccupied, and areas that are over-lit or under-lit. Also, potential areas of energy conservation could emerge that require further investigation or a more detailed audit.		Subtopic of screen/title n.17
22	**Report Preparation** Do not forget to prepare a brief report that summarizes findings and recommendations for immediate improvements and outlines the next steps for a more detailed audit if necessary.		Subtopic of screen/title n.17
23	**Identifying, Analyzing and Implementing of Energy Saving Measures**		Subtopic of screen/title n.3

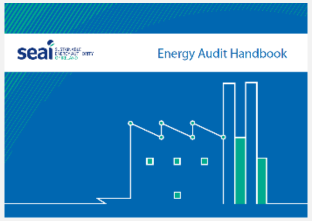
	Once all the data collected has been analyzed, energy saving measures can be identified. The information collected and analyzed enables the auditor to detect potential energy conservation measures such as equipment upgrades, process changes, or behavioral adjustments. A feasibility analysis is required to assess the technical and financial feasibility of each identified measure, including cost estimates, potential energy savings, and return on investment calculations.		
24	**Interfering and non-interfering measures** Energy saving measures can be classified as Interfering and non-interfering. Interfering measures generally have a more significant impact on a building's systems and operations and often involve a higher initial cost and longer payback period. In contrast, non-interfering measures are typically easier to implement, less costly, and involve less disruption to the building's operations, often providing a quicker return on investment.		
25	**Interfering Energy Saving Measures** These measures involve changes that can affect the building's operations, comfort levels, or system interactions. Implementation of these measures usually requires a significant alteration of existing systems or processes and therefore the interference not only relates to the physical aspect but also to the operational changes that may affect the occupants' routine. Examples include replacing an HVAC system with a more efficient one, changing the building envelope (like adding insulation), or redesigning the lighting system.		Subtopic of screen/title n.24

	The implementation of these measures often requires downtime or disruption to normal operations during installation and may require a significant substantial capital investment or a major retrofit.		
26	**Non-Interfering Energy Saving Measures** Non-interfering measures are those that have little to no impact on the existing operations or comfort levels. They often involve behavioral changes, maintenance activities, or minor modifications that do not require large capital investments. Examples include implementing a switch-off campaign to encourage occupants to turn off lights and equipment when not in use, regular maintenance to ensure systems are running optimally, or adding timers or sensors to control energy use more effectively. These measures can usually be implemented without significant disruption to the daily activities within the building and for this reason they are often the first step in an energy conservation plan because they can be done quickly and typically at a lower cost.		Subtopic of screen/title n.24
27	**Return on Investment (ROI) computation** The analysis or simulation of the Return on Investment (ROI) for energy-saving interventions is a crucial financial assessment that should be performed before implementing the measures. This analysis helps determine the economic viability and prioritization of the proposed energy efficiency improvements. A thorough ROI analysis not only ensures financial prudence but also helps in securing funding or approval from stakeholders by demonstrating the cost-effectiveness of the proposed energy-saving interventions.		Image ROI_analysis.png (also as PPTX) 

28	**Total costs, Savings and Payback** After identifying all possible energy-saving measures (ESMs) that could be implemented you should estimate the total costs involved. This includes initial investment costs such as purchasing and installing new equipment, as well as any ongoing operational or maintenance costs. The next step is to estimate the energy savings that each measure is expected to provide. This usually involves calculating the amount of energy conserved and multiplying it by the cost of energy, potentially considering future energy price escalations. You can now calculate the simple payback period, which is the time it takes for the savings from the energy efficiency measure to cover the initial investment cost. This is a straightforward calculation: divide the initial cost by the annual savings.		
29	**NPV, IRR and LCCA** A more complex computation is Net Present Value (NPV). The NPV calculation takes into account the time value of money by discounting future savings back to present-day values. It is more complex than the simple payback period but that provides a better picture of the measure's value over time. You can then calculate the IRR (Internal Rate of Return), which is the interest rate at which the net present value of costs and benefits breaks even. This is often used to compare the profitability of different investments. Another computation useful to evaluate the investment is the Life-Cycle Cost Analysis. Perform an LCCA to consider all the costs associated with the measure over its entire lifetime, not just the initial costs. This includes		

	maintenance, operation, and disposal costs, as well as savings and revenues over the life of the measure.		
30	**Sensitivity Snalysis and Risk Analysis** Because energy savings and costs can be uncertain, particularly if you are planning to change the energy mix, it's important to perform a **sensitivity analysis** to understand how changes in key assumptions (like energy price escalation rates or maintenance costs) affect the ROI. Other evaluation to be performed are a **Risk Analysis**, to assess the potential risks associated with the energy-saving measures, such as technology performance risks, operational risks, and financial risks and Scenario Analysis to evaluate the potential outcomes of the investment under various conditions (e.g., best case, worst case, most likely case).		
31	**Final ROI Report** Eventually you should compile the findings into a report that clearly presents the potential ROI of each measure. Decision-makers can then use this report to prioritize measures, make informed decisions, and proceed with the interventions that offer the best financial return and align with organizational goals.		
32	**Energy audit report** Following the energy audit, an energy audit report must be issued, which should include at least the following information: • Technical scope: this point includes facilities, services and included areas and level of depth in the analysis and detail required. • Methodology: this point includes the analysis of the state of art of the facilities (energy inputs, technologies and services), measurement results and energy balance.		

	Suggested energy saving measures: this point includes a description of each energy saving measure, including potential energy savings, economic savings, investment needed and payback.		
33	The Energy Audit Report table of contents could look like this one EXECUTIVE SUMMARY INTRODUCTION GENERAL PRESENTATION OF THE SITE DESCRIPTION OF THE BUILDING SYSTEM PLANTS • Envelope • Systems • Electrical system • Lighting ANALYSIS OF ENERGY CONSUMPTION • Methane • Electric energy • Energy performance indicators • Costs SIMULATION OF THE BUILDING SYSTEM PLANT • Simulation results of the building system plant • Model validation ENERGY REQUALIFICATION INTERVENTIONS • Identification of potential areas of intervention • Interventions on the envelope • Interventions on mechanical systems • Interventions on electrical systems • Monitoring of consumption • Use of renewable sources • User training and awareness measures		

	• Intervention scenarios and cost-benefit analysis CONCLUSIONS		
34	A word of advice Too often, audit reports gather dust on the shelf. The goals of the audit report should be to provide a clear account of the facts upon which your recommendations are made and to interest readers in acting on those recommendations. A “sales job” may need to be done on the audit’s findings, and the audit report is your vehicle for making the sale. You should apply some principles of good technical writing: • Know Your Reader • Use Simple, Direct Language • Present Information Graphically • Make Your Recommendations Clear • Explain Your Assumptions • Be Accurate and Consistent Present Your Calculations Clearly		
35	Further reading The following document could be helpful to gather more information on how to perform an Energy audit An interesting 65-pages booklet by Sustainable Energy Authority of Ireland which describes the Energy Audit process. https://www.seai.ie/publications/SEAI-Energy-Audit-Handbook.pdf		Image sea_energy_audit_handbook.png 

6.4 Project Management

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	In the past, only people qualified as “project managers” managed projects. Today, the changes taking place in the work environment have led to a more project-oriented to any kind of activity approach and as a result the number of people who need to acquire project management skills is increasing. There are three main factors for this increase in attention to projects in a corporate environment: the greater importance of team work, continuous change and greater autonomy.		
2	Project management is a dynamic process that requires constant attention and adaptability. The project manager must navigate complex interdependencies and adjust to the ever-changing project environment to ensure successful project completion.		
3	Projects come in all shapes and sizes, and this can make it difficult for people to understand that they are working on a project and are therefore a project manager. Here are some examples of projects. • Preparing a birthday cake with a new recipe. • A group of artists and marketers come together to create a new TV ad for their company. • The design and documentation of a production process in order to satisfy market demand • The selection and hiring of a human resources manager.		

	Requesting a purchasing manager to select, purchase, and install new office furniture.		
4	The definition of a project is "A set of unique, non-repetitive activities that create a tangible, observable product or service" The key features are therefore • unique and non-repetitive activities tangible results		
5	The first characteristic of a project is that it is a set of unique and non-repetitive activities. ''Unique'' means that each project is different from the others, with a different set of objectives and results, and involves doing something that has never been done before. Since each project is a non-repetitive activity, it has a well-defined time frame within which it must start, carry out and end, Unlike regular office tasks, which represent a set of repetitive tasks performed on a regular basis, projects are not permanent tasks.		
6	The second characteristic of a project is that it creates a tangible and observable product or service as an end result. Tangible and observable results simplify the task of defining when the project has been successful and help evaluate whether or not the project has achieved the objectives for which it was started. The results of a project are often called, in English, deliverables.		
7	Large projects are often broken down into distinct parts or phases to allow for better management control.		

	When a project is made up of different phases, these describe the life cycle of the project and define its evolution, from start to finish. The number of phases that make up the life cycle and their names vary greatly in different companies and in different industrial sectors. Think for example of a project for the installation of a photovoltaic system. This type of project could be divided into five phases: • Phase 1: Feasibility study • Phase 2: Planning the installation • Phase 3: Stipulation of contracts and purchase of materials • Step 4: Installation Phase 5: Testing and approval		
8	Taking a broader perspective, the project management process is segmented into five distinct phases: • Initiation • Planning • Execution • Monitoring and Controlling Closing		
9	**Initiation** This phase involves defining the project at a broad level. Key activities include identifying the project goals, feasibility study, and stakeholders analysis. The primary outcome is the project charter, which formally authorizes the start of the project.		
10	**Planning**		

	Planning is the most complex phase, where the project plan is developed. It encompasses setting clear and achievable objectives, defining the outcomes, and planning the various steps to achieve those outcomes. It includes creating work breakdown structures, schedules, budgets, risk management plans, and communication plans.		
11	**Execution** During the execution phase, the project plan is put into motion and the work required is performed. This is often the longest phase in the project management cycle, where physical project deliverables are developed and presented to stakeholders. It includes resource allocation, team development, and task assignments		
12	**Monitoring and Controlling** This phase occurs concurrently with the execution phase. It involves tracking, reviewing, and regulating the progress and performance of the project. Key activities include quality management, performance reporting, and progress measurement against the project plan. Adjustments are made as necessary to ensure the project stays on track.		
13	**Closing** The final phase involves formally closing the project, completing any remaining deliverables, and settling all contracts and financials. The project's success is evaluated, and a final project report is developed. Lessons learned are documented to inform future projects.		

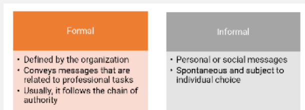
14	As an energy manager embarking on a project to implement energy-saving measures, there are some guidelines that will increase the likelihood of success and sustainability of your projects. • Involve Stakeholders Early • Perform a sound Energy Audits and Set Clear Objectives • Define Priorities and Implement in Phases • Communicate and Train Document and Share Success		
15	**Stakeholders Involvement** Involve all stakeholders, including management, employees, and maintenance staff, from the outset. Their buy-in is crucial for the smooth implementation of energy-saving measures. Create a detailed plan that outlines the steps needed to achieve the energy-saving goals, including timelines, responsibilities, budgeting, and resources.		
16	**Energy Audits and Clear Objectives** This is obvious, but assessing before implementing any measures the current energy consumption patterns and identify areas with the greatest potential for savings is vital for the success of your projects. Define **S**pecific, **M**easurable, **A**chievable, **R**elevant, and **T**ime-bound (SMART) goals for your energy-saving project. This will guide the project's direction and help in tracking its progress.		
17	**Prioritize Measures and Implement in Phases** Not all energy-saving initiatives are equal.		

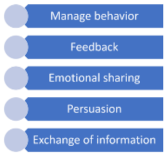
	Prioritize measures based on factors like energy savings potential, cost, return on investment, and ease of implementation. Roll out energy-saving measures in manageable phases. Start with low-hanging fruits that offer quick wins and use the momentum to tackle more complex projects.		
18	**Communicate and Train** Keep all parties informed about the project's progress and the benefits of energy-saving measures. Effective communication can foster a culture of energy efficiency within the organization. Communication involves also training and education. Provide training for the staff to ensure proper use and maintenance of new systems or processes. Educating employees about energy efficiency can also encourage energy-saving behaviors.		
19	**Document and Share Success** Documenting successes and lessons learned from the project is valuable for future initiatives. Sharing these successes can also help in building support for subsequent energy management efforts.		
20	Project Management is in art that requires time and dedication to be learned thoroughly. Many specific courses are available in order to acquire these skills. You can also consider to be certified by the ProJect Management Institute. Here you can find more information https://www.pmi.org/certifications		Image PMI_logo.png

6.5 Communication

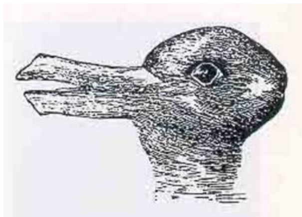
ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	Communication skills are vital for an energy manager for several reasons as they facilitate stakeholder collaboration, enable knowledge sharing and foster support for initiatives. Here there are some situations where good communication skills could prove very useful: • Stakeholder Engagement • Persuasion and Advocacy • Education and Training • Reporting and Presentation • Change Management • Problem-Solving and Negotiation • Crisis Management Networking		
2	**Stakeholder Engagement** Energy managers must regularly interact with a variety of stakeholders, including senior management, facility managers, technical staff, and external contractors. Effective communication is crucial to align all stakeholders with the energy management goals and strategies.		
3	**Persuasion and Advocacy** Convincing decision-makers to invest in energy-saving measures often requires persuasive communication.		

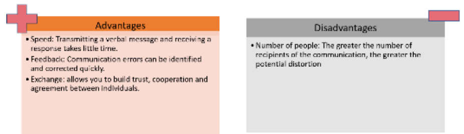
	Energy managers must articulate the benefits of such investments in terms of cost savings, sustainability, and corporate responsibility.		
4	**Education and Training** An energy manager is often responsible for educating the workforce about energy efficiency. Clear communication helps in imparting knowledge about best practices and motivates staff to adopt energy-saving behaviors.		
5	**Reporting and Presentation** Energy managers need to report on energy consumption, savings, and efficiency projects. Good communication skills help in creating reports and presentations that are clear, concise, and impactful.		
6	**Change Management** Implementing new energy policies or technologies often involves change within the organization. Effective communication is key to managing this change and minimizing resistance from employees.		
7	**Problem-Solving and Negotiation** Energy managers often negotiate with suppliers and contractors. They also need to communicate effectively to solve problems that arise from managing complex energy systems.		
8	**Crisis Management**		

	In the event of an energy-related crisis, such as a sudden energy shortage or system failure, an energy manager must communicate quickly and clearly to manage the situation effectively.		
9	**Networking** Building professional networks is important for staying updated on best practices, new technologies, and potential vendors. Effective communication skills are a must for successful networking.		
10	What is communication? The transfer and understanding of a message. This the basis of any organization, because no group or organization can exist without sharing messages among its members. Before communication takes place, it needs a purpose, a message to convey between a sender and a recipient. Then, the sender encodes the message, that is the sender converts it into a symbolic form, and passes the message through a medium, a channel (e.g. face-to-face conversation, email, video call, ...) to the recipient. The receiver decodes it and the final result is a transfer of meaning from one person to another.		Image Comunicazione_01.png Also communication.pptx – slide 1 
11	Communication can be done using two different channels: • Formal • Informal Formal communication format is defined by the organization, conveys messages that are related to professional tasks and it usually follows the chain of authority.		Image communication_02.png Also communication.pptx – slide 2 

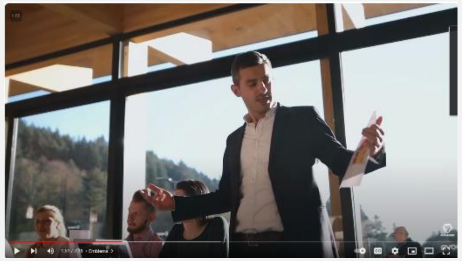
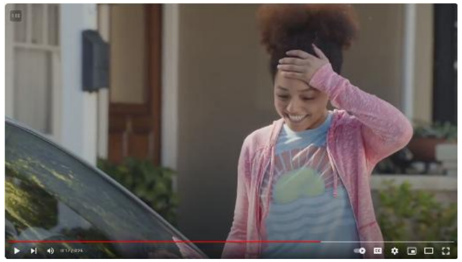
	Informal communication is used for personal or social messages and it is spontaneous and subject to individual choices		
12	Why is communication so important? Let's see what functions communication performs: • Manages behavior • Supplies Feedback • Let's people share emotions • Can be used to persuade others Let's exchange information		Image communication_03.png Also communication.pptx – slide 3 
13	**Manage behavior** Organizations have hierarchies of authority and formal employee guidelines that guide the flow of communication. When employees follow their Job Descriptions or comply with company policies, communication performs a management function. Informal communication also controls behavior. For example, when work groups tease or harass a member who produces too much.		
14	**Feedback** Communication is necessary to set goals, give feedback on progress and reward desired behaviors, it stimulates motivation. Communication creates feedback by clarifying to employees: • what they have to do, • how well they are doing it, how they can improve their performance.		

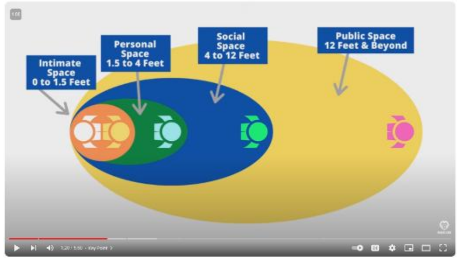
15	**Emotional sharing** The workgroup is a primary source of social interaction for many employees. The concept of extreme formality in organizations, without human interaction or emotional sharing, is outdated. Intragroup communication is a critical mechanism through which members display satisfaction and frustration. It involves the emotional sharing of feelings and the satisfaction of social needs. Nowadays, it can be difficult for companies to remain neutral, they may need to show that they take a certain position on political or social issues, and this can be used to the company's advantage.		
16	**Persuasion** It's important to remember that persuasion can benefit or harm an organization. It can be good or bad, depending on what a leader is trying to persuade a work group to do: • Good deeds (for example, engaging in the organization's corporate social responsibility (CSR) initiatives) Illegal activities or unfair tasks (for example, breaking the law to achieve an organizational goal)		
17	**Exchange of information** It is one of the most obvious and easily understood functions. The exchange of information facilitates the organization's decision-making processes and is essential to ensure fair and equitable decisions such as provide		

	the information that individuals and groups need to make decisions, transmitting the data necessary to identify and evaluate choices.		
18	**The context in communication** Communication can also be ambiguous because perceptions are also influenced by context. What we see often depends on how we look at things. This image for example can be interpreted as a rabbit or a duck. The information we receive influences our ability to understand, and it is therefore important to ensure the quality of the information we transmit.		Image duck_rabbit.jpg 
19	**Perception biases** Perception biases are cognitive shortcuts or distortions that influence how individuals interpret and respond to information. These biases often arise from an individual's personal experiences, preferences, emotions, and social influences, leading to skewed perception and judgment. Perception biases can affect decisions and interactions, often unconsciously, potentially leading to misunderstandings, misjudgments, and inefficiencies in both personal and professional contexts. They are a significant area of study in psychology and behavioral economics because of their impact on consumer behavior, business decisions, and interpersonal relationships.		
20	This short video (1' 41'') demonstrates just how bad humans are at spotting unexpected events in their environment when they are focusing other things. https://www.youtube.com/watch?v=IGQmdoK_ZfY		Image monkey_illusion.png

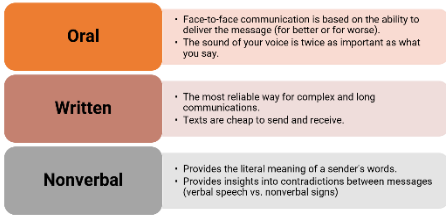
	The video is an experiment performed by Daniel Simons and Christopher Chabris and It's called The Monkey Business Illusion. It is also known as The Invisible Gorilla for reasons that will become clear after you have seen the video. If you are interested, you can read the full paper from this link https://doi.org/10.1068/i0386		 Link https://www.youtube.com/watch?v=IGQmdoK_ZfY
21	Communication can be classified in 3 different ways: • Based on **Mode** Communication can be oral, written and non-verbal • Based on **Direction** Communication can flow vertically or laterally, through formal networks of small groups or through informal routes. • Based on **Style** Communication can be assertive, passive or aggressive. We will focus on communication styles.		
22	Based on **Mode - Oral communication** It is the main means of transmitting messages and has important social, cultural and emotional implications. Forms: Speeches, formal one-on-one and group discussions, any other method that conveys written words or symbols.		Image communication_04.png Also communication.pptx – slide 4 
23	Based on **Mode - Written communication** Written business communication today is usually conducted through letters, presentations, emails, chats, text messages, social media, apps and blogs.		Image communication_05.png Also communication.pptx – slide 5

	Some of these allow you to create digital or physical archives that can be consulted over time, while the advantage of others is a rapid and fleeting exchange of information. The advantages depend on which written method is used; for example, through e-mail it is possible to communicate via e-mail at any time, even when the recipient is busy with other activities. Chat, on the other hand, requires an almost immediate response. Forms: letters, emails, instant messaging, periodic business communications, and any other method that conveys written words.		
24	Based on **Mode – Nonverbal communication** Forms: the movements of the body, the intonations or emphasis we give to words, facial expressions and the physical distance between the sender and the recipient. • Every movement of the body has a meaning. • Intonations can change the meaning of a message. • Facial expressions, along with intonations, can show arrogance, aggression, fear, shyness, and other characteristics. The right physical distance between people depends largely on cultural norms. • Too close: may indicate aggression or sexual interest. Further: disinterest or displeasure.		
25	Based on **Mode – Nonverbal communication** Every **movement** has meaning, and no movement is accidental (although some are unconscious). We express our mood with non-verbal body language. For example, we smile to project confidence, we cross our arms to appear approachable, and we stand to signal authority.		Image gestures.png YouTube video https://www.youtube.com/watch?v=DsL1bey_ki4

	The video (7' 18'') describes the classic 5 Types of hand Gestures in nonverbal communication. Researchers Ekman and Friesen developed this research on gestures in 1968 and these have been foundational parts of how we understand gestures to this day.		
26	Based on **Mode – Nonverbal communication** **Intonation** supplies a lot of information and sets the communication context. If you read the minutes of a meeting, you would not be able to grasp the impact of what was said in the same way as if you had been present or could have seen the meeting on video. Why not? There is no trace of non-verbal communication, and the emphasis given to words or sentences (intonation) is missing. Both make the meaning clear. Intonations can change the meaning of a message. The video (25'') shows a couple of examples of how the same sentence can be said using different intonations.		Image intonation.png YouTube video https://www.youtube.com/watch?v=vxG0JIWppGc&t=15s 
27	Based on **Mode – Nonverbal communication** **Facial expressions** also convey meaning. Facial expressions, along with intonations, can show arrogance, aggression, fear, shyness and other characteristics. In this video (12' 28'') Former FBI agent and body language expert Joe Navarro explains the non-verbal ways we communicate using facial expressions.		Image Facial_expressions.png YouTube video https://www.youtube.com/watch?v=VAB9cUlGrRo 

28	Based on **Mode – Nonverbal communication** **Physical distance** also has meaning. What is considered the right distance between people depends largely on cultural norms. A professional distance in some European countries, seems intimate in many parts of North America. If someone stands closer to you than is considered appropriate, it may indicate aggression or sexual interest; if further away, it can signal disinterest or disappointment in what is being said. The video (5' 58) explains the basic concept of proxemics, that is the nonverbal communication study of how much personal space people prefer to leave between themselves and others. It is a key feature of human interaction because it gives us cues about the nature of our relationships with others.		Image proxemics.png YouTube video https://www.youtube.com/watch?v=z1Ak18pM3u0 
29	Based on **Mode – Nonverbal communication** It may seem strange but even by remaining silent you can communicate. Silence can have different meanings: • May indicate disapproval; • It may indicate that you are not available to communicate; • It can be used to surface clarifying and revealing information. Silence is a dimension of nonverbal communication that can help you communicate assertively. Why? Because if you respond quickly to another person's non-communication, i.e. by reducing the gap of silence, you will appear more assertive than someone who pauses frequently or seems to be searching for the right words, People generally feel embarrassed during long silences and rush to fill the void.		
30	Based on **Mode – Nonverbal communication**		

	Paralanguage is the word that defines all vocal aspects of messages beyond actual words: tone of voice, rate of conversation, inflection, volume, energy level, fluency, and so on. It is very difficult to control because it is largely an involuntary behavior and therefore is closely linked to emotions. Paralanguages includes vocalizations such as laughing and crying, participatory sounds such as "uh-huh", and fillers ("er"), that are different in different languages but exists in any of them. Paralanguage is culture specific, but it is also specific to the individual.		
31	Based on **Mode – Nonverbal communication** Paralanguage reveals our attitudes towards ourselves and others and the situation at hand. It also reveals the part of the world or the country we come from. Paralanguage also reveals emotions: It changes according to our mood and let the other know if we are angry, happy, impatient, surprised or perplexed, or any other emotion. It is culture specific. In Europe, for example, we often characterize people who speak “too loud” as rude or aggressive. People who speak too softly are often characterized as insecure or shy, that is, not very assertive. On the other hand, persons who speaks “loudly” in an Arab nation are seen as demonstrating strength and sincerity.		
32	Why do people choose one communication channel over another?		Image communication_06.png Also communication.pptx – slide 6

<table>
<tr>
<td></td>
<td></td>
<td></td>
<td>
</td>
</tr>
<tr>
<td>33</td>
<td>Based on Direction - Vertical

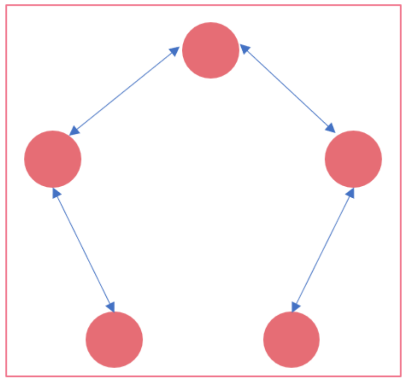
Vertical communication can have two different directions: downward or upward.

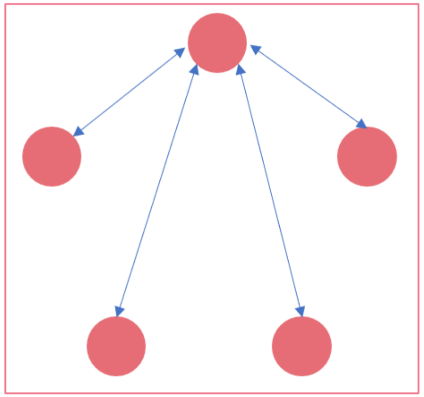
Downward communication:
flows from one level of a group or organization to a lower level.
The mode of delivery and context of the information are of great importance!
Used by team leaders and managers to:
assign goals,
provide work instructions,
explain policies and procedures,
report problems that need attention,
offer feedback.
This communication is influenced by the way the information is delivered (e.g. without saying please or implying "if you don't mind") and the context in which it is delivered (e.g. the manager asks the employee to do something on the weekend or during the holiday).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Based on Direction - Vertical

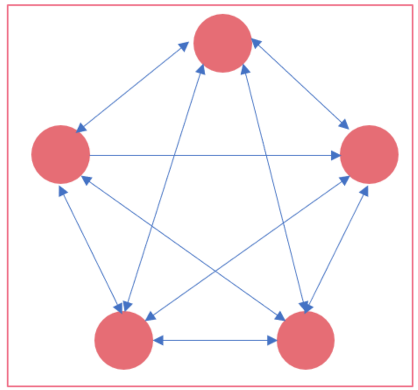
Vertical communication can have two different directions: downward or upward.

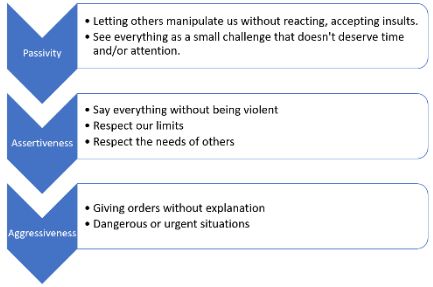
Upward communication
Flows to a higher level in the group or organization.</td>
<td></td>
<td></td>
</tr>
</table>

	• It keeps managers aware of how employees feel about their work, about their colleagues, and about the organization in general. • Used by employees to Provide feedback to superiors or inform them of progress towards goals and report current problems. • Used by managers to have ideas on how to improve working conditions. Upward communication is increasingly difficult because managers can become overwhelmed and distracted. To engage in effective upward communication, try to communicate in short summaries rather than long explanations, support your summaries with actionable items, and prepare an agenda to ensure you use your boss's attention well.		
35	Based on **Direction - Lateral** It occurs between members of the same work group, members at the same level in separate work groups, or any other horizontally equivalent worker. They are often created informally to avoid vertical hierarchy and speed up actions. Lateral communication that occurs with management's knowledge and support can be beneficial. However, if the employees avoid vertical communication, problems car arise for managers. Problems can arise when employees bypass formal vertical channels, bypass or match their superiors, or when managers discover that actions or decisions have been taken without their knowledge.		
36	**Formal small group networks**		

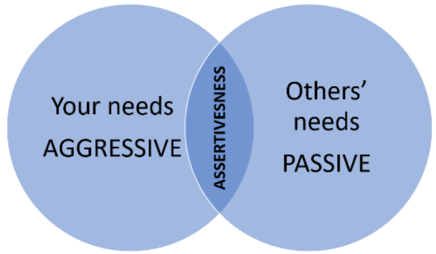
	Formal organizational networks can be complicated, including hundreds of people and a half-dozen or more hierarchical levels. There are several options for organizing networks and letting the communication flow: • Chain organization • Wheel organization All channel organization		
37	**Chain organization** The chain strictly follows the formal chain of command; this network approximates the communication channels that would be found in a rigid three-tier organization.		Image communication_07A.png Also communication.pptx – slide 7 
38	**Wheel organization**		Image communication_07B.png

	The wheel is based on a central figure who acts as a conduit for all group communications; simulates the communication network that might be found in a team with a strong leader.		Also communication.pptx – slide 7  **Wheel** Makes it easier to identify a leader
39	**All channel organization** The all-channel network allows group members to actively communicate with each other; is most often characterized by self-managing teams, where group members are free to contribute and no one person takes on a leadership role. Many organizations today like to think of themselves as all channel, meaning anyone can communicate with anyone!		Image communication_07C.png Also communication.pptx – slide 7

			 **All-channel** Greater member satisfaction
40	**Informal communication network** Word-of-mouth information about a company from peers has important effects on recruitment. For example, informal ratings on websites like Glassdoor. Within the company, informal communication is used: • By employee: small talk creates a sense of closeness and friendship among those who share information. By managers: gives them insight into their organization's morale, the issues employees consider important, and employee anxieties.		
41	Based on **Style** Communication styles can be considered along a continuum. Passivity and Aggressiveness are two extremes and assertiveness is a balanced state in the middle.		Image communication_08.png Also communication.pptx – slide 8

			
42	Based on **Style** Main features of the three communication styles.		Image communication_09.png Also communication.pptx – slide 9 
43	Based on **Style** The characteristics of the three behavioural models.		Image communication_10.png Also communication.pptx – slide 10 
44	Based on **Style - Assertiveness** Assertiveness is a personal behavior and communication style aimed to defend one's needs and interests in an open and direct way.		

	The assertive person defends the things that matter to them while, at the same time, respecting the things that matter to others. Examples • The boss who is open to your ideas, but who reserves the right to make the final decisions. The colleague who is not afraid to speak up in meetings and defend his points of view.		
45	**Communicate vertically with assertiveness** Recognize autonomy, status and experience • The decision is yours... • I'm coming to talk to you because you're in charge of... • Can you share with me your knowledge of similar situations you have experienced... Provide data on behavior and impact Frame positive consequences around the interests of the organization and the supervisor • I think fewer mistakes would be made if... And I'm sure you'll worry less about...		
46	**Why is it so difficult to be assertive?** You can't think and act assertively until you understand what matters to you in your personal and professional life. What we mean with the sentence "what matters" are your needs, desires, interests, values and goals. Together, they provide the sense of purpose that will lead you to a destination you must endure, even when the going gets tough.		Image communication_11.png Also communication.pptx – slide 11

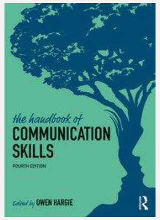
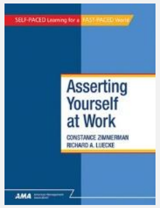
			
47	**Barriers to communication** Barriers to communication are all those factors that prevent effective communication, which can slow it down or distort it. We need to know them in order to reduce their impact. Here there are some examples of barriers: • Information overload • Emotions • Filtering • Language • Fear of communication • Selective perception Cultural barriers		
48	**Information overload** The information received exceeds our processing capacity. As a result people tend to select it, ignore it, or forget it, or they could postpone further processing until the overload situation ends.		
49	**Emotions** You can interpret the same message in different way, depending on your mood: • Positive moods:		

	You have more confidence in opinions after reading a persuasive message, so well-thought-out arguments have a stronger impact on your opinions. • Negative moods: Your are more likely to scrutinize messages in greater detail, while if you were in positive moods you would have accepted communications at face value. Extreme emotions such as elation or depression most likely hinder effective communication. In these cases, we are more inclined to neglect our rational evaluation and replace it with emotional judgment.		
50	**Filtering** The sender intentionally manipulates information so that the receiver views it more favorably. The more vertical levels in the organization's hierarchy, the more opportunities for filtering. Beware that some filtering will occur wherever there are differences in status. Factors such as fear of delivering bad news and the desire to please the boss often lead employees to tell their superiors what they think they want to hear, thus skewing communications upward.		
51	**Language** Words mean different things to different people. For example, "You can take it whenever you need it" could refer to almost anything. However, if it is said by a doctor to a patient, then the context is clear, and the listener can guess that it refers to medicines. Age and context are two of the biggest factors influencing these differences.		
52	**Fear of communication**		

	This barrier appears when there is excessive tension and anxiety in oral communication, written communication, or both. Since almost all jobs require some oral communication, this fear can impact job performance. Be aware that some people severely limit their oral communication and rationalize their actions by telling themselves that communicating is not necessary to do their job effectively.		
53	**Selective perception** Receivers selectively process, see, and hear based on their needs, motivations, experiences, background, and other personal characteristics. For example, an interviewer who expects a candidate to put her family ahead of her career is likely to see this characteristic in all candidates, regardless of whether any of the women feel this way.		
54	**Cultural barriers** Language difficulties in intercultural communications can be caused by: • Semantics. Some words don't translate between cultures. • Connotations of words. Words imply different things in different languages. • Differences in tone. In some cultures, the language is formal, in others it is informal. In some cultures, the tone changes depending on the context. • Conflict tolerance and methods for resolving them. • Degree to which context influences the meaning individuals take from communication: ○ High-context cultures: rely heavily on nonverbal cues and understandings of the situation; Far-east countries fall in this category.		

	low-context cultures: rely on spoken and written words to convey meaning. Europe and Western countries belong to this category		
55	Here there are some examples of cultural barriers: **Semantics**. Some words are impossible to translate between cultures. For example, the Finnish word "sisu" means something like "courage" or "stubbornness," but is essentially untranslatable into English. **Connotations**. Words imply different things in different languages. Negotiations between U.S. and Japanese executives can be difficult because the Japanese word “hai” translates as “yes,” but its connotation is “Yes, I am listening” rather than “Yes, I agree.” **Tone**. Depending on the context: People speak differently at home, in social situations and at work. Using a personal, informal style when a more formal style is expected may be inappropriate for many people, especially for people of different national cultures. **Differences in conflict tolerance and conflict resolution methods**. People from individualistic cultures tend to be more comfortable with direct conflict and will make the source of their disagreement obvious. Collectivists are more likely to recognize conflict only implicitly and avoid emotionally charged disputes.		
56	**Communication traps** • Criticize Criticize the other instead of expressing a criticism or a request • Contempt Insults and/or sarcasm Rolling eyes Eyes half closed • Counterattack Escalation of violence and destruction of the relationship Partial victory that makes the other suffer and increases the emotional		

	distance Complete retreat After days or weeks of criticism, attacks and counterattacks, one of the people abandons the field, at least emotionally May lead to more violence for the other side		
57	**How to avoid communication traps** Instead of John has demonstrated incompetence, this report sucks Use a different expression There are some ideas in this report that seem to be missing to communicate our message.		
58	**How to avoid communication traps** Instead of You just make irrelevant comments! So, you'd better not say anything! Use a different expression John, it's good for you to tell me this so I can review how I participate. I would like you to tell me exactly what is not useful in my interventions. When you say it's more useful to do nothing, I get angry and frustrated. I need to feel/know that I'm important to the team even when things aren't going so well."		
59	**How to avoid communication traps** Instead of Don't raise your voice at me!		

	Use a different expression When you talk loudly, I can't concentrate		
60	**How to avoid communication traps** Instead of This proposal is rubbish! Use a different expression When proposals are presented to the client containing errors, I feel embarrassed as it reflects on our professional image, which is crucial. The aspect of maintaining our reputation holds significant importance to me, particularly in light of the extensive efforts we have undertaken to achieve recognition.		
61	**Further reading** If you want to study and drill down your communication skills, we can suggest some books • The Handbook of Communication Skills Edited ByOwen Hargie https://doi.org/10.4324/9781315436135 Asserting Yourself At Work by Constance Zimmerman, Richard A Luecke https://www.oreilly.com/library/view/asserting-yourself-at/9780761214366/		Image book_communication_skills_9781138219137.jpg  Image book_zimmermann.jpg 
62	**How to speak so that people want to listen**		Image treasure.png

	Have you ever felt like you're talking, but nobody is listening? In this video (9' 58'') Julian Treasure demonstrates some useful vocal exercises and shares tips on how to speak with empathy, he offers his vision for a sonorous world of listening and understanding.		YouTube video – TED talk https://www.youtube.com/watch?v=eIho2S0ZahI 
63	The Power of Communication and Body Language Video 15' 26'' Rodney is a body language expert with more than 18 years of law enforcement experience. He holds a BA in Criminal Justice and an MS in Criminal Justice Administration and has extensive training in body language, interview and interrogation, statement analysis, and micro expressions. His extensive training, education, and practice of nonverbal communication has made him an expert and consultant to his fellow law enforcement colleagues as well as entrepreneurs and others interested in learning about micro expressions and body language.		Image rodney_smith.png YouTube video – TEDx Talk https://www.youtube.com/watch?v=Ku3rksZFeaM 
64	Voice Training Exercise | Easy steps to improve the sound of your voice In this video (9' 10'') Peter Baker offers some suggestions to improve your voice and way you speak.		Image peter_baker.png YouTube video https://www.youtube.com/watch?v=aeyn3kLd1Y0

			
65	**Think Fast, Talk Smart: Communication Techniques** A longer (58' 19'') but comprehensive video on communication techniques. In this talk you will learn techniques that will help you speak with greater confidence and clarity. This video was recorded on October 25, 2014, in collaboration with the Stanford Alumni Association as part of Stanford Reunion Homecoming and the Graduate School of Business Fall Reunion/Alumni Weekend.		Image matt_abrahams.png YouTube video https://www.youtube.com/watch?v=HAnw168huqA 

3.3.2.7 Final Assessment

This section provides a detailed description of the Final Assessment module.

The following table provides a list of the planned content for this section, while the specifics of the single units are provided in the following pages.

Segment	Title	Expected Duration
7.1	Introduction	1 m. 45 secs
7.2	Knowledge check (10 questions)	15 questions
7.3	Overview of RES technologies	30 questions
7.4	How companies are organised and the Energy Manager role	20 questions
7.5	Energy Audit and International regulations and standards	31 questions
7.6	Soft and hard skills	19 questions
7.7	Assessment Results	1m. 30 secs
7.8	Course Completion	30 secs

7.1 INTRODUCTION

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	Welcome to the final assessment of the Energy Manager course. This assessment is designed to evaluate your understanding and grasp of the key concepts, methodologies, and practical applications that we have explored throughout the course. The assessment consists of 10 multiple-choice questions, encompassing all the topics covered in the course. These questions are structured to test your knowledge in various areas of energy management, including energy auditing, efficiency strategies, renewable energy technologies, regulatory frameworks, and best practices in energy conservation. As you answer these questions, remember to reflect on the comprehensive lessons, case studies, and discussions we've engaged in during our sessions. This is an opportunity to demonstrate your learning and the insights you've gained.		
2	Please note the following guidelines for the assessment: • There are questions with only one correct answer and other with multiple correct answers. You can detect which one from the buttons' shape: round for the firsts and square for the latter. • Read each question carefully before selecting your response. • There is no negative marking for single choice question. • Questions with multiple correct answer have a penalty for each wrong answer, but the overall minimum score for the question is zero. • The assessment is timed, and you will have a total of 30 minutes to complete it. We wish you the best of luck and look forward to your successful completion of this course.		

7.2 KNOWLEDGE CHECK – JOB PROFILE

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	Question What is the difference between an Energy Manager and an Energy Management Expert? - A) They are the same role - B) Energy Manager has a more operational role - C) Energy Management Expert focuses only on lighting - D) Energy Manager does not work on energy efficiency		Correct Answer B
2	Question What is a primary concern for buildings like airports in terms of energy? - A) Only air conditioning - B) Only heating - C) Air conditioning and heating - D) Only lighting		Correct Answer C
3	Question What is one of the key tasks of an Energy Manager? - A) Designing building structures - B) Identifying energy-saving opportunities - C) Cooking in the cafeteria		Correct Answer B

	- D) Driving the airport shuttle		
4	Question: What is a primary responsibility of Energy Managers within an organization? - A) Event planning - B) Managing energy consumption and initiatives - C) Staff recruitment - D) Legal counseling		Correct Answer B
5	In complex organizations, what position is an energy manager likely to hold? a) Technical specialist b) Middle management c) Managerial position d) External consultant		Correct Answer C
6	In small companies, who typically fulfills the role of Energy Manager? a) Internal technician b) CEO c) External consultant possessing technical skills d) All employees collectively		Correct Answer C
7	What is an important collaboration for an energy manager in a company?		Correct Answer A

	a) With the purchasing department for energy contracts b) Only with the technical staff c) Exclusively with external vendors d) Solely with top management		
8	What kind of people does an energy manager need to communicate effectively with a) Only technical people b) Only external stakeholders c) Non-technical people d) Solely with energy suppliers		Correct Answer C
9	What is a key skill for dealing with other corporate functions as an energy manager? a) Mathematical skills b) Legal expertise c) Technical expertise d) The ability to explain technical concepts in simple terms		Correct Answer D
10	In the context of a manufacturing company, what is one of the roles of an Energy Manager? a) Identifying energy-intensive processes ✔ b) Direct product manufacturing c) Marketing products d) Hiring staff		Correct Answer A
11	What does Directive 2012/27/EU define an energy audit as?		Correct Answer: B

	- a) A cost-saving procedure - b) A systematic procedure to identify energy savings opportunities - c) A financial assessment of energy use - d) A technical evaluation of equipment		
12	Which of the following is an example of an Energy Performance Indicator (EnPI)? - a) kWh consumed per site - b) Total annual energy cost - c) Number of energy-efficient equipment installed - d) Energy policies implemented		Correct Answer: A
13	What is the focus of consumption management and interventions by an Energy Manager? - a) Implementing technological upgrades - b) Organizational changes related to equipment utilization - c) Financial restructuring - d) External consultancy		Correct Answer: B
14	What is crucial in the implementation of good practices by an Energy Manager? - a) Conducting energy measurement campaigns - b) User training and information - c) Financial analysis - d) Reporting to management		Correct Answer: B

15	What is a key component of the Energy Manager's role in optimizing supplies? - a) Analyzing contractual and accounting documents - b) Implementing new technologies - c) Training employees on energy efficiency - d) Designing new energy systems		Correct Answer: A

7.3 KNOWLEDGE CHECK – OVERVIEW OF RES TECHNOLOGIES

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	Question What does the term "energy" in physics signify? - A) The capacity for doing work or causing a change. - B) A type of fuel. - C) A measurement of power. - D) A unit of force.		Correct Answer: A
2	Question What is the unit of measurement for energy in the International System of Units (SI)? - A) Newton. - B) Watt. - C) Joule. - D) Erg.		Correct Answer C
3	Question What is the difference between power and energy? - A) They are the same. - B) Power is a type of energy. - C) Power expresses the rate at which energy is transferred. - D) Energy is a measure of power.		Correct Answer C

4	Question What principle states that energy cannot be created or destroyed? - A) Law of Motion. - B) Law of Conservation of Energy. - C) Law of Thermodynamics. - D) Law of Gravitational Force.		Correct Answer B
5	Question What is the distance between the Earth and the Sun? - A) 150 million kilometers - B) 100 million kilometers - C) 200 million kilometers - D) 50 million kilometers		Correct Answer A
6	Question What is the efficiency range of commercial solar panels currently? - A) 5% to 10%. - B) 10% to 15%. - C) 15% to 20%. - D) 20% to 25%.		Correct Answer B
7	Question What is the primary driver of Earth's climate and weather patterns?		Correct Answer B

	- A) The Moon's gravitational pull. - B) Solar energy. - C) Earth's magnetic field. - D) Ocean currents.		
8	Question What does the "solar constant" measure? - A) The constant temperature of the Sun. - B) The amount of solar energy at the Earth's outer atmosphere. - C) The amount of solar energy at the Earth's surface. - D) The constant solar energy produced by the Sun.		Correct Answer B
9	Question Which technology is primarily used for capturing solar energy? - A) Wind turbines. - B) Hydropower. - C) Photovoltaic. - D) Biomass.		Correct Answer C
10	Question What principle do wind turbines operate on? - A) Solar energy conversion. - B) Hydroelectric power. - C) Capturing kinetic energy of wind. - D) Thermal energy conversion.		Correct Answer C

11	Question What is the approximate lifespan of wind turbines? - A) 5-10 years. - B) 10-15 years. - C) 20-25 years. - D) 30-35 years.		Correct Answer C
12	Question What is a challenge in integrating wind energy into power grids? - A) The color of turbines. - B) Noise pollution only. - C) Careful management to balance supply and demand. - D) Only the initial cost.		Correct Answer C
13	Question What is the energy payback period of wind turbines? - A) Less than a year or two. - B) About 5 years. - C) 10 years. - D) More than 15 years.		Correct Answer A
14	Question What is a drawback of wind energy? - A) High greenhouse gas emissions. - B) Dependence on wind speed and consistency.		Correct Answer B

	- C) High water usage. - D) Radioactive waste.		
15	Question What is the most productive setting for wind farms? - A) Urban rooftops. - B) Inland, along mountain ridges. - C) Offshore. - D) Desert areas.		Correct Answer C
16	Question What is the primary function of a hydropower plant? - A) To purify water for drinking and other purposes - B) To use the kinetic energy of flowing water. - C) To irrigate agricultural fields and supply the water table - D) To provide water for industrial use and depuration.		Correct Answer: B
17	Question What is a characteristic of small hydropower plants? - A) They require large dams. - B) They are built on smaller water bodies. - C) They have a higher capacity than large plants. - D) They primarily use pumped storage technology		Correct Answer: B
18	Question		Correct Answer: C

	Which type of hydropower facility can function like a giant battery? - A) Diversion. - B) Impoundment. - C) Pumped storage hydropower. - D) Micro hydropower.		
19	Question What is an advantage of large hydropower plants? - A) They require minimal infrastructure. - B) They have high energy output and can function as energy storage systems. - C) They are always environmentally friendly. - D) They are inexpensive to build.		Correct Answer: B
20	Question What is a drawback of wind energy? - A) High dependency on fossil fuels. - B) Produces large amounts of greenhouse gases. - C) Can lead to fluctuations in energy production due to varying wind patterns. - D) Requires a lot of water for operation.		Correct Answer: C
21	Question What is the concept behind biomass power plants? - A) Conversion of organic matter into energy. - B) Splitting of atoms to release energy.		Correct Answer: A

	- C) Capturing solar energy through panels. - D) Generating electricity from wind.		
22	Question What is the primary advantage of biomass power plants for grid stability? - A) They can operate continuously. - B) They require minimal maintenance. - C) They are inexpensive to build. - D) They don't require water for cooling		Correct Answer: A
23	Question What is considered a negative environmental impact of biomass plantations? - A) They increase biodiversity. - B) They lead to deforestation. - C) They reduce carbon dioxide in the atmosphere. - D) They improve soil quality.		Correct Answer: B
24	Question What is a byproduct of biomass combustion that requires proper management? - A) Oxygen and Hydrogen. - B) Steam and liquid water. - C) Ash and residues. - D) Nitrogen.		Correct Answer: C

25	How is the energy balance of a biomass power plant calculated? - A) By comparing total energy output to total energy input. - B) By measuring the efficiency of the turbines. - C) By the amount of feedstock produced. - D) By the electricity prices in the market.		Correct Answer: A
26	Question What is the main function of geothermal power plants? - A) To produce natural gas. - B) To harness the Earth's natural heat to generate electricity. - C) To extract oil from underground. - D) To filter and purify groundwater.		Correct Answer: B
27	Question What type of geothermal power plant uses high-temperature steam directly from the Earth? - A) Flash Steam Plants. - B) Binary Cycle Plants. - C) Dry Steam Plants. - D) Pumped Storage Plants.		Correct Answer: C
28	Question Which country was the first to develop geothermal power commercially? - A) New Zealand.		Correct Answer: C

	- B) The United States. - C) Italy. - D) Iceland.		
29	Question What is a key advantage of geothermal energy compared to solar and wind energy? - A) It is only available during daytime. - B) It requires less land. - C) It is available around the clock. - D) It uses fossil fuels.		Correct Answer: C
30	Question What environmental impact can geothermal power plants have? - A) They release large amounts of carbon dioxide. - B) They have no environmental impact. - C) They can release trace gases and potentially harmful elements. - D) They always lead to deforestation.		Correct Answer: C

7.4 KNOWLEDGE CHECK – HOW COMPANIES ARE ORGANISED AND THE ENERGY MANAGER ROLE

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	Question What is essential for companies in terms of people and assets? - A) Close coordination between them. - B) Keeping them separate. - C) Focusing only on assets. - D) Focusing only on people.		Correct Answer: A
2	According to economist Gino Zappa, what is a key characteristic of a company? - A) Temporary organization. - B) Designed to last over time. - C) Focused solely on profit. - D) Independent of economic context.		Correct Answer: B
3	Question What is a company primarily formed for? - A) Conducting business activities. - B) Providing free services to the public. - C) Promoting cultural activities. - D) Conducting scientific research.		Correct Answer: A
4	Question		Correct Answer: D

	Which of the following is NOT a category of companies? - A) Public companies. - B) Private companies. - C) Non-profit companies. - D) Temporary companies.		
5	Question Why is reliable energy supply important for companies? - A) It's important for aesthetic reasons. - B) It prevents disruptions in business operations. - C) It's only relevant for manufacturing companies. - D) It affects only the IT industry.		Correct Answer: B
6	Question How can efficient energy use impact a company's cost structure? - A) Has no impact. - B) Increases operational costs. - C) Reduces operational costs. - D) Only affects employee salaries		Correct Answer: C
7	Question What does a company's environmental policy primarily deal with? - A) Financial investments - B) Employee welfare and human resources management - C) Environmental activities and interactions - D) Marketing strategies		Correct Answer: C

8	Question What is the first step in implementing an Environmental Management System? - A) Conducting an internal environmental audit - B) Developing a marketing strategy - C) Initial environmental analysis - D) Finalizing the product design		Correct Answer: C
9	Question What is the purpose of ISO 50001:2011 in relation to energy management? - A) To support companies in using energy efficiently - B) To regulate companies' global financial transactions - C) To manage employee performance and welfare - D) To oversee international shipping standards and support logistics		Correct Answer: A
10	Question What does the PDCA approach in the ISO standards stand for? - A) Plan-Do-Check-Act - B) Product-Design-Cost-Audit - C) Plan-Direct-Control-Assess - D) Product-Development-Customer-Approval		Correct Answer: A
11	Question What is a critical component in the 'Plan' phase of the PDCA cycle for energy management?		Correct Answer: A

	- A) Appointing an energy officer and formulating the energy policy - B) Increasing the company's stock value and financial assets - C) Hiring new employees and promoting welfare policies - D) Launching a new product line		
12	Question What is the primary objective of implementing an Environmental Management System (EMS)? - A) To increase company sales - B) To reduce consumption and produce less waste - C) To expand the company workforce - D) To invest in stock markets		Correct Answer: B
13	Question What is a criticism of ISO 9000 and 9001 according to Dalgleish? - A) Lack of international recognition. - B) Excessive and inefficient paperwork burden. - C) Overemphasis on employee training. - D) Inadequate customer service guidelines.		Correct Answer: B
14	Question In ISO 9001:2015, what is risk-based thinking intended to do? - A) Limit the scope of quality management. - B) Infuse risk assessment into the entire quality management system. - C) Focus only on financial risks. - D) Eliminate the need for leadership directives.		Correct Answer: B

15	Question What is the purpose of the ISO 9000 family of standards? - A) To regulate international financial transactions. - B) To ensure organizations meet customer and other stakeholder needs related to a product or service. - C) To provide guidelines for employee health and safety. - D) To set environmental conservation standards.		Correct Answer: B
16	Question What does ISO 9001 focus on? - A) Environmental management. - B) Quality management system requirements. - C) Information security management. - D) Occupational health and safety.		Correct Answer: B
17	Question What major change occurred in ISO 9001:2015 compared to its predecessors? - A) Increased focus on risk-based thinking. - B) Emphasis on financial management. - C) Reduction in quality management principles. - D) Focus on product innovation only.		Correct Answer: A
18	Question Which of these is not a direct benefit of risk-based thinking as per ISO 9001:2015?		Correct Answer: B

	- A) Improved governance. - B) Increased product innovation. - C) Improved compliance practices. - D) Improved customer satisfaction.		
19	Question What are the four components examined in SWOT analysis? - A) Sales, Weaknesses, Opportunities, Threats. - B) Strengths, Weaknesses, Opportunities, Threats. - C) Strategy, Workforce, Operations, Technology. - D) Security, Weaknesses, Objectives, Techniques.		Correct Answer: B
20	Question What is the first step in managing risk according to ISO 9001:2015? - A) Implementing corrective actions. - B) Identifying the risks and opportunities. - C) Integrating the response into the Quality Management System (QMS). - D) Evaluating the effectiveness of risk management.		Correct Answer: B

7.5 KNOWLEDGE CHECK – ENERGY AUDIT AND INTERNATIONAL REGULATIONS AND STANDARDS

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	Question What does the application of technical standards become when referred to in legislative provisions? A) Always optional B) Binding within the reference context C) Irrelevant to legislation D) Only advisory		Correct answer: B
2	Question According to Directive 98/34/EC, what is a 'standard'? A) A mandatory legal document B) A voluntary technical specification approved by a recognized standardization body C) A government-issued regulation D) A universally accepted business practice		Correct answer: B
3	Question What is the focus of the ISO 9001:2015 standard? - A) Environmental management - B) Quality management system requirements - C) Energy management - D) Information security management		Correct answer: B

4	Question What is the acronym ISO in standards identification? - A) Identifies standards developed by national standardization bodies - B) Represents the International Organization for Standardization - C) Indicates a European standard - D) Signifies a standard specific to the technology sector		Correct answer: B
5	Question What does EN 16247-2:2022 specifically focus on? - A) Energy audits for buildings - B) Energy audits for industrial processes - C) Energy audits for transport - D) General energy audit requirements		Correct answer: A
6	Question What is a primary objective of the integrated management system? - A) To only focus on profit maximization. - B) To guarantee the satisfaction of interested parties like customers and workers. - C) To limit company's expansion to domestic markets. - D) To focus on individual department goals without overall organizational integration.		Correct Answer: B
7	Question		Correct Answer: B

	What is a key advantage of implementing an integrated management system? - A) Restricting company's focus to a single business area. - B) Standardization of improvement objectives and creation of a single document repository. - C) Eliminating the need for external audits. - D) Focusing solely on environmental aspects.		
8	Question What is SA 8000 primarily concerned with? - A) Guaranteeing high product quality. - B) Ensuring socially responsible organizational behaviour. - C) Focusing on international sales and marketing. - D) Setting guidelines for IT security.		Correct Answer: B
9	What does ISO 45001 specify? - A) Requirements for a financial risk management system. - B) Requirements for an occupational health and safety (OSH) management system. - C) Guidelines for corporate social responsibility. - D) Standards for quality control in manufacturing.		Correct Answer: B
10	What is the purpose of ISO 14001? - A) To establish financial reporting standards.		Correct Answer: B

	- B) To focus on an organization's performance towards the environment. - C) To manage customer data privacy. - D) To standardize employee recruitment processes.		
11	Question What is the primary purpose of ISO 14001? - A) To set international financial reporting standards. - B) To outline requirements for an environmental management system. - C) To establish guidelines for employee health and safety. - D) To define digital security protocols.		Correct Answer: B
12	Question Which standards use the same High-Level Structure as ISO 14001, making them easily integrable? - A) ISO 27001 and ISO 31000. - B) ISO 9001 and ISO 45001. - C) ISO 22000 and ISO 26000. - D) ISO 50001 and ISO 55001.		Correct Answer: B
13	Question Who is ISO 14001 suitable for? - A) Only large multinational corporations. - B) Only governmental organizations. - C) All types and sizes of organizations.		Correct Answer: C

	- D) Solely environmental agencies.		
14	Question What does ISO 14001 require organizations to consider? - A) Their financial bottom line and one or two specific environmental issues - B) Internal operational efficiency and energy savings - C) A range of environmental issues relevant to their operations. - D) Solely their product quality.		Correct Answer: C
15	Question What is the first tip for getting started with ISO 14001? - A) Immediately purchase new equipment. - B) Define the organization's environmental objectives. - C) Disregard senior management involvement. - D) Focus solely on product development		Correct Answer: B
16	Here are 8 multiple-choice questions based on the provided text about Life Cycle Assessment (LCA): Question What does Life Cycle Assessment (LCA) primarily evaluate? - A) The financial cost of a product or service. - B) The environmental footprint of a product or service along its entire life cycle. - C) The market competitiveness of a product.		Correct Answer: B

	- D) The employee satisfaction in producing a product.		
17	Question In LCA, what is achieved during the Life Cycle Impact Assessment (LCIA) phase? - A) Evaluating the financial impact of the product. - B) Associating inventory results with environmental impact categories and indicators. - C) Determining the transportation methods for product distribution. - D) Assessing the customer satisfaction with the product.		Correct Answer: B
18	Question What does the 'goal and scope' phase of LCA involve? - A) Determining the final cost of the product. - B) Defining the aims of the study and making key methodological choices. - C) Focusing only on the marketing strategy of the product. - D) Selecting the geographical locations for product sale.		Correct Answer: B
19	Question What is the main objective of conducting an LCA study? - A) To maximize product profitability. - B) To reduce and manage the environmental impact of production processes. - C) To solely focus on the distribution phase of products. - D) To enhance employee efficiency.		Correct Answer: B

20	Question Which standards regulate the LCA methodology at an international level? - A) ISO 9000 series. - B) ISO 14040 series. - C) ISO 26000 series. - D) ISO 22000 series.		Correct Answer: B
21	Question What is the primary purpose of ISO 50001? - A) To increase the financial profitability of organizations. - B) To improve energy management and efficiency in organizations. - C) To enhance employee productivity. - D) To focus solely on reducing electricity consumption.		Correct Answer: B
22	Question ISO 50001 is based on which continual improvement framework? - A) Plan - Do - Check - Act. - B) Research - Develop - Analyze - Implement. - C) Design - Build - Test - Launch. - D) Conceptualize - Execute - Evaluate - Modify.		Correct Answer: A
23	Question What is the purpose of conducting an internal audit of the EnMS as per ISO 50001?		Correct Answer: A

	- A) To assess conformity and functionality of the EnMS and determine improvement areas. - B) To prepare for external financial audits. - C) To evaluate employee performance. - D) To inspect the physical condition of the company's assets.		
24	Question What are Energy Performance Indicators (EnPIs) in the context of ISO 50001? - A) Financial benchmarks for energy-related expenses. - B) Indicators that summarize energy use and monitor its evolution over time. - C) Targets for sales teams to achieve. - D) Guidelines for marketing strategies.		Correct Answer: B
25	Question What is the significance of the Energy Policy in ISO 50001? - A) It is a detailed technical manual for machinery operation. - B) It is a legal document for regulatory compliance. - C) It is a commitment by top management to improve energy performance. - D) It serves as an employee handbook.		Correct Answer: C
26	Question What is the primary goal of Lean Management? - A) To improve employee work-life balance.		Correct Answer: C

	- B) To increase shareholder wealth. - C) To optimize processes by reducing non-value-added tasks. - D) To expand the company’s market share.		
27	Question What is one of the key reasons to integrate Lean, energy efficiency, and greenhouse gas reduction efforts? - A) To increase employee productivity. - B) To reduce energy costs and its impact on business performance. - C) To simplify management processes. - D) To focus solely on environmental conservation.		Correct Answer: B
28	Question Which principle is NOT one of the five key principles of Lean thinking? - A) Value. - B) Value streams. - C) Employees' fitness. - D) Perfection.		Correct Answer: C
29	Question in Lean Management, what is the purpose of mapping the value chain? - A) To evaluate employee performance.		Correct Answer: B

	- B) To identify and eliminate steps in the process that do not add value. - C) To calculate the financial value of the company. - D) To plan marketing strategies.		
30	Question What does the Just In Time (JIT) philosophy emphasize? - A) Producing in large batches for efficiency. - B) Producing only what is needed when it is needed. - C) Stockpiling resources for future use. - D) Focusing on individual task completion.		Correct Answer: B
31	Question What is a recognized advantage of Lean Production? - A) Increased material stock. - B) Longer production times. - C) Reduction of customer problems. - D) Less focus on quality.		Correct Answer: C

7.6 KNOWLEDGE CHECK – SOFT SKILLS AND HARD SKILLS

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
1	Question What soft skill is crucial for an energy manager to inspire others to follow energy-efficient practices? - A) Leadership - B) Deep technical knowledge - C) Empathy - D) Humor		Correct Answer: A
2	Question What is essential for conducting energy audits as an energy manager? - A) Negotiation Skills - B) Data Analysis Skills - C) Marketing Strategies - D) Legal Expertise		Correct Answer: B
3	Question What soft skill is important for an energy manager when resolving energy-related challenges? - A) Problem-Solving - B) Singing Ability		Correct Answer: A

	- C) Gardening Skills - D) Acting Skills		
4	Question What is the most relevant use of communication skills for an energy manager? - A) Communicating energy-saving recommendations to stakeholders - B) Write academic texts on energy-saving - C) Performing arts and drama at company parties - D) Video game development about energy saving		Correct Answer: A
5	Question What is the primary objective of an energy audit? - A) To design new energy systems - B) To improve aesthetic building design - C) To identify energy usage and efficiency improvement opportunities - D) To train facility staff		Correct Answer: C
6	Question In the context of energy audits, what are 'Interfering Energy Saving Measures'? - A) Measures that do not affect the building's operations - B) Measures that require significant alterations to existing systems - C) Simple changes in employee behavior		Correct Answer: B

	- D) Changes in office layout		
7	Question What is included in the 'Return on Investment (ROI) computation' for energy-saving interventions? - A) Estimating decor costs - B) Assessing the financial viability of the measures - C) Planning corporate events - D) Evaluating employee satisfaction		Correct Answer: B
8	Question What is the purpose of conducting interviews with employees during an energy audit? - A) To evaluate employee performances - B) To understand operational practices affecting energy consumption - C) To gather feedback on company policies - D) To discuss vacation plans		Correct Answer: B
9	Question What is a key component of the Site Inspection and Survey phase in an energy audit? - A) Assessing visually the facility - B) Planning the next corporate meeting - C) Redesigning the company location - D) Conducting employee performance reviews		Correct Answer: A
10	Question		Correct Answer: B

	What is a key characteristic of a project? - A) Routine and repetitive activities - B) Unique and non-repetitive activities - C) Daily administrative tasks - D) Permanent tasks		
11	Question In project management, why is stakeholder involvement crucial? - A) For arranging company events - B) For the smooth implementation of project measures - C) For deciding the lunch menu - D) To select office locations		Correct Answer: B
12	Question Which phase in project management involves setting clear and achievable objectives? - A) Execution - B) Planning - C) Closing - D) Monitoring and Controlling		Correct Answer: B
13	Question During which phase of project management are physical project deliverables developed? - A) Initiation - B) Planning		Correct Answer: C

	- C) Execution - D) Closing		
14	Question What is a key activity in the Monitoring and Controlling phase of project management? - A) Defining project goals and deliverables - B) Creating work breakdown structures - C) Tracking and reviewing project progress - D) Formally closing the project		Correct Answer: C
15	Question Why are communication skills crucial for stakeholder engagement in energy management? - A) To align stakeholders with energy management goals - B) To increase social media presence - C) For planning company picnics - D) To choose office furniture		Correct Answer: A
16	Question What is the main advantage of 'assertive' communication? - A) It allows for expressing needs while respecting others - B) It is used to issue commands - C) It is ideal for casual conversations - D) It is best for discussing personal matters		Correct Answer: A
17	Question		Correct Answer: A

	What is the main objective of upward communication in an organization? - A) To keep managers informed about employee feelings and progress - B) To delegate tasks to employees - C) To organize social events - D) To implement new technologies		
18	Question How can 'information overload' act as a barrier to effective communication? - A) By causing people to select, ignore, or forget information - B) By enhancing the clarity of the message - C) By making communication more entertaining - D) By reducing the need for follow-up communication		Correct Answer: A
19	Question In the context of energy management, why is the skill of persuasion and advocacy important? - A) To persuade decision-makers to invest in energy-saving measures - B) To discuss leisure activities - C) To plan vacation schedules - D) To choose company uniforms		Correct Answer: A

7.7 ASSESSMENT RESULTS

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
	Congratulations on successfully completing your final assessment in Energy Management! Your performance reflected your deep understanding and commitment to the subject. Your ability to think critically and strategically about energy management solutions shows a level of proficiency that is essential for a successful career in this field. As you move forward, continue to build on this strong foundation. Stay curious, keep learning, and stay updated with the latest trends and technologies in energy management. Your potential is immense, and I am confident that you will make significant contributions to the field. Well done once again on this achievement!		In case of assessment completed successfully
	I wanted to reach out following the results of your final assessment in the Energy Management course. Firstly, I want to acknowledge the effort and commitment you have shown throughout the course. However, I understand that the outcome of the final assessment wasn't what you hoped for. It's important to remember that setbacks like this are a natural part of the learning process. They do not define your abilities or your potential in the field of energy management. Remember, persistence is key.		In case of assessment failed

7.8 COURSE COMPLETION

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions/Developer Notes
	Congratulations to all the students on the successful completion of the Energy Manager course! Your hard work, dedication, and passion for learning have equipped you with the knowledge and skills necessary to make a significant impact in the field of energy management. As you move forward, may you use this achievement as a stepping stone to drive innovation, improve energy efficiency, and contribute to a sustainable future. Well done and best of luck in your future endeavors!		

3.3.3 *Photovoltaic Panels*

The Photovoltaic Panels Course has been developed to address the growing demand for skilled professionals capable of understanding, evaluating, and working with solar energy systems. It provides a structured, modular training path that combines theoretical grounding with applied knowledge on PV system components, power electronics, and safe installation practices. Delivered fully online, the course is designed to be accessible and flexible, supporting self-paced learning and promoting participation from diverse target groups, including underrepresented audiences in technical fields. Special attention is given to the integration of interactive and immersive learning tools, such as Augmented Reality (AR), to enhance the training experience and ensure alignment with innovative digital education practices. The course is a key output of the SKILLBILL project and contributes to building a future-proof, green-skilled workforce in the renewable energy sector.

To ensure instructional quality and coherence, the course was designed using detailed storyboards. Storyboards are planning tools used in digital learning development to visualize the sequence, structure, and content of each learning module. They include screen-by-screen descriptions of text, media elements, learner interactions, and pedagogical objectives. The following section presents the actual storyboards created for each module of the Photovoltaic Panels Course, forming the blueprint for the course production and implementation.

Module 1 – Photovoltaic Panels Introduction

The following table offers a concise outline of the general characteristics of the Introduction section:

Duration	7’ 15’’
Characters	Narrator
Notes	Outlines module goals, audience definition, recommended prerequisites, broader energy topics for exploration, and an overview of the course

The following table contains a synthesis of the segments in which the Introduction section is organised.

Segment	Title	Word count	Expected Duration
1.1	Learning objectives	560	3m. 40 sec.
1.2	Target Audience	56	30 sec.
1.3	Requisites	40	20 sec.
1.4	Context of training	61	5 sec.
1.5	Course Map	220	1m. 20 sec.

A detailed description of the content of the individual segments is available in the tables of the following pages.

1.1 Learning Objectives – 560 words – 3' 40''

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
1.	**Module 1 – Introduction** • Present the course map and its structure **Module 2 - Fundamentals** • The meaning of energy, power and efficiency. • The meaning of some terms currently used when speaking of photovoltaic panels and their meaning. • The historical development of how scientists have tried to generate electricity using light. • What LCOE means and how can be used to compare different energy sources. • How the implementation of solar plants has changed the production costs. • The challenges that a large scale adoption of solar plant poses. **Module 3 – Theory** • Understand the basics of how solar energy is produced and its impact on Earth and assess the potential of solar energy to meet global energy demands. • Explore how Earth's atmosphere affects the solar spectrum, absorbs and reflects solar energy and the implications of such factors for solar cells. • Understand the concept of Air Mass Index (AM) and learn about the factors that influence the efficiency and performance of photovoltaic panels, including weather conditions and geographic location. • Learn some basic concepts on semiconductors, how	

	p-n junctions are formed and their significance in the operation of solar panels, including the separation of electron-hole pairs to generate electric current. • Learn how to identify the Maximum Power Point (MPP) on the I-V curve and its importance in extracting the maximum power from a photovoltaic device. • Understand the impact of factors such as irradiance, temperature, and module design on the efficiency of PV panels and learn how to compute the efficiency of a photovoltaic panel under actual operating conditions.	
2.	**Module 4 – Power Electronics** • Understand the application of Kirchoff's laws to photovoltaic (PV) cells. • Comprehend the impact of interconnection methods and bypass diodes on PV system efficiency. • Learn how the resistance of the load determines the operating point on the PV panel's current-voltage curve and explore the impact of varying loads and environmental conditions, such as changes in sunlight and temperature, on the performance and power output of PV panels. • Comprehend the principles and methods of Maximum Power Point Tracking (MPPT) for optimizing PV panel efficiency and learn about different MPPT methods. • Understand the role and types of DC-DC converters in photovoltaic (PV) systems and the role of MPPT solar charge controllers in maximizing power output and efficiency in off-grid PV applications. • Learn about conversion from DC to AC and get acquainted with the various kinds of inverters available, as well as their features and applications. • Understand the factors affecting the conversion efficiency of power converters. • Learn about the differences between static and	

	dynamic MPP tracking efficiency. **Module 5 – Balance of System** • Understand the concept and components of the Balance of System (BOS) for a photovoltaic (PV) plant. • Analyze the cost implications of BOS components in PV plant installations. • Understand the electrical components and safety measures of a PV plant: • Assess the environmental and operational challenges for PV plant components and the importance of proper insulation and mounting to ensure long-term reliability. • Understand the mechanical Balance of System (BOS) requirements for PV panels • Analyze the environmental and operational challenges for PV plant components, and understanding the importance of using appropriate materials and design considerations to mitigate these challenges	
3.	**Module 6 – PV Installation** • Safety precautions for installation • Unpacking and storage of panels • General information on how to install modules • How to make electrical connections and ground modules • Some mounting instructions • How to keep panels efficient by properly maintenance and cleaning	

1.2 Target Audience– 56 words – 30''

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes

1.	This course is aimed to people that wish to better understand how solar panel works, their potential and the technical problems involved in their use. It is NOT intended as a professional course for installators, but could complement such a course giving a broader understanding of issues and opportunities offered by electricity production by solar energy.	

1.3 Requisites– 40 Words – 20’’

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
1.	In order to get the most out of the course, it is advisable to have some basic knowledge of electrical quantities and electrical systems. The course, however, recalls the basic principles of electrical engineering necessary for understanding the proposed contents.	

1.4 Context of Training - 61 words – 5’

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
1.	You could expand your knowledge beyond the limits of this course exploring some topics related to energy production by solar panels.	

2.	Here some links to website that you could explore to find more information about these threads: Storage systems https://energy.ec.europa.eu/topics/research-and-technology/energy-storage_en https://www.epa.gov/energy/electricity-storage https://www.irena.org/Energy-Transition/Technology/Energy-Storage Energy communities https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumers-and-prosumers/energy-communities_en Energy efficient buildings https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings_en Small-Scale Wind Farms https://energypedia.info/wiki/Small-Scale_Wind https://www.energy.gov/energysaver/small-wind-electric-systems Economic analysis of Solar PV systems https://www.iea.org/energy-system/renewables/solar-pv#tracking	

1.5 Course Map- 220 words – 1’ 20"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
1.	Course Map	
2.	*In this module you will review some basic concepts about energy, power and efficiency, learn the terminology used when speaking of photovoltaic panels, see a short history of PV. You will learn how the implementation of solar plants has changed the production costs and look at the challenges that a large scale adoption of solar plant poses.*	
3.	*This module introduces solar energy, analyzing the solar spectrum and the effects of Earth’s atmosphere on it. It discusses the impact on solar cell performance, evaluates energy reaching Earth's surface, and explores solar panel efficiency. It also covers the behavior of semiconductors and p-n junctions, emphasizing the importance of the I-V curve and Maximum Power Point for predicting panel efficiency.*	
4.	*This module reviews some electrical circuit concepts and their application to PV cells. It discusses the effects of shading and soiling, the importance of matching load to panel characteristics, and the role of power converters and MPPT in maximizing efficiency. It also covers DC-DC converters, DC-AC converters (inverters), and the significance of MPP tracking for optimal performance.*	

5.	*This module outlines safety precautions during installation, proper unpacking and storage of panels, physical and electrical installation of PV modules, and mechanical mounting on the supporting structure.* *It also covers maintenance and cleaning procedures to ensure the proper operation of PV panels over time.*	

Module 2 – Photovoltaic Panels - Fundamentals

The following table offers a concise outline of the general characteristics of the Introduction section:

Duration	20’32
Characters	Narrator
Notes	Covers basic energy concepts, PV terminology, historical development of photovoltaics, the cost and learning curve of PV systems, and economic and scaling challenges for widespread adoption.

The following table contains a synthesis of the segments in which the Introduction section is organised.

Segment	Title	Word count	Expected Duration
2.1	Learning objectives	69	45 sec.
2.2	Basic concepts of Energy, Power and Efficiency	992	6 m. 37 sec.
2.3	Terminology	725	4 m. 50 sec.
2.4	A short history of PV	491	3 m. 15 sec.
2.5	PV learning curve	765	5m. 05 sec.

A detailed description of the content of the individual segments is available in the tables of the following pages.

2.1 Learning Objectives – 69 words – 45''

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
4.	In this module you will learn or review: • The meaning of energy, power and efficiency. • The meaning of some terms currently used when speaking of photovoltaic panels. • The historical development of how scientists have tried to generate electricity using light. • What LCOE means and how can be used to compare different energy sources. • How the implementation of solar plants has changed the production costs. • The challenges that a large-scale adoption of solar plant poses.	

2.2 Basic concepts of Energy, Power and Efficiency– 992 words – 6' 37''

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
5.	In physics, energy is the quantitative property that designates the capacity for doing work or causing a change such as causing objects to move, generating heat, or initiating chemical reactions. Energy exists in different forms, each characterized by its distinct properties and the role it plays in interactions between matter and forces.	

6.	The word “energy” comes from Ancient Greek ἐνέργεια (enérgeia) 'activity'.	
7.	From a mechanical point of view, energy is defined as the product of force applied by the displacement generated.	
8.	To give you an example of what energy means in practice, let’s consider Lisa, who weighs 65 kilograms. If she climbs a staircase for 2 meters, she acquires some energy (at the. expenses of her own muscular energy). This energy is due to her positions: she had to exert a force against the gravity to rise on the staircase and this was done for 2 meters.	
9.	The unit of measurement for energy in the International System of Units (SI) is the joule (J). Lisa has displaced her weight exerting a force of 65 kg x 9,8 m/s2 = 637 Newton for 2 meters. Her energy is now 1.274 J	
10.	The Joule is the measurement unit in the International System (SI), but there are many other units used to express energy such as • Ergs • Calories • British thermal units • kilowatt-hours • kilocalories It is easy to convert one unit into another if you know the correct conversion factor.	
11.	Energy can have many different forms, and they can be converted from one form to another with proper technology.	

	Potential energy is stored energy that an object possesses due to its position or configuration in a system. The cyclist on the left has potential energy because it is up on the hill. Going down, he loses potential energy, but he is no longer still, he is moving at some speed, potential energy is converted into kinetic energy	
12.	The Sun radiates **electromagnetic energy** that travels from the Sun to the Earth. This energy can be converted to **electrical energy** using proper device, such as solar panels.	
13.	Power expresses the rate at which energy is transferred or transformed. It represents the measure of how quickly work is done or how rapidly energy is converted from one form to another. The concept of power is essential for understanding the dynamic aspect of energy interactions and the efficiency of various processes. Power (P) is defined as the amount of energy (E) transferred or transformed per unit of time (t): Power = Energy / Time If you measure energy in Joule and time in seconds, the unit of measure of power is Watt.	
14.	The unit of measurement of power, watt, is a small unit not suited for power plants. To express the power of equipment that ranges from a dishwasher to a nuclear plant normally are used units of measurement that multiple of watts.	

	Kilowatts are used to measure the power consumption of appliances, electrical devices, and the output of power plants. 1 kilowatt equals 1000 watts. Megawatts are often used to measure the output of large power plants, industrial machinery, and energy consumption on a larger scale. 1 megawatt equals 1000 kilowatts, which is one million watts. Gigawatt is used to describe the power output of very large power plants, complex industrial processes, and large-scale energy generation. 1 gigawatt equals 1000 megawatts that is one billion watts	
15.	When dealing with electrical units, such as voltage and current, power is defined as the product of voltage and current. So, a device that absorbs 3 A at 12 V dc has a power consumption of 36 W. A solar panel with a voltage of 18 V that is able to produce a current of 8 A has a power rating of 144 W	
16.	Energy produced by a solar panel can be computer as the product of power generated multiplied by the time that power is generated. If a panel has a nominal power of 144 W but is lighted in optimal conditions only for 8 hours a day, it can generate an energy of 144 x 8 = 1152 Wh, that is a little more than 1 kWh. For sake of comparison, with this amount of energy a TV set with a power consumption of 60 W can run continuously for more than 19 hours, and a modern washing machine with ECO program for 3 hours.	
17.	From a general point of view, efficiency refers to the effectiveness with which a physical system or process converts input resources	

	into useful output, achieving its intended goal while minimizing waste, losses, or undesirable effects. It quantifies how well a system utilizes its inputs to produce the desired results. Efficiency is a crucial concept across various domains of science, engineering, economics, and even everyday life.	
18.	Efficiency is always a ratio that can be expressed as a percentage and its values range from 0 (null efficiency) to 1 (maximum efficiency), or from 0% to 100%. You will never get from a closed physical system more output than the input – this will violate the principle of conservation of energy. Moreover, no physical system can attain an efficiency of 1 exactly – the efficiency can approach such value, but even the more efficient system devised have an efficiency that is below that limit.	
19.	Here there are some typical efficiency ranges for various types of machines: Gasoline-powered automobile engine: 20% - 30% efficiency Diesel engine (automobiles and trucks): 30% - 40% efficiency Large marine diesel engines: 40% - 50% efficiency Aircraft jet engines: 30% - 40% efficiency Conventional steam power plants: 30% - 40% efficiency (can be higher with advanced technology) Large hydroelectric power plants: 80% - 90% efficiency (conversion of mechanical energy to electrical energy) Modern onshore wind turbines: 30% - 50% efficiency (conversion of wind energy to electrical energy)	

	Commercial photovoltaic solar panels: 15% - 20% efficiency (conversion of sunlight to electrical energy) Electric motors (varies widely depending on type and load): 70% - 95% efficiency	

2.3 Terminology– 725 words – 4' 50"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
2.	Let's start by introducing some words that we will use thoroughly in this course. Later in the course we will describe the working principles of technologies and their roles in a photovoltaic power plant.	
3.	The course deals with "photovoltaic" or PV, panels. The term photovoltaic is a combination of the Greek word phōtós (light) and the adjective "voltaic" that derives from last name of the Italian physicist Alessandro Volta who invented the electric battery, called "voltaic pile"	
4.	A solar cell is a device that converts light into electricity. Solar cells can be made of different materials, but commercial cells are often made of silicon, the most common and economic photovoltaic material. Silicon solar cells deliver voltages of approximately 0.5 V and this value is strictly related to the physical characteristics of silicon.	

	A solar cell can deliver a current that depends on the cell area and intensity of light, and it varies between 0 and 10 amps.	
5.	Solar cells are connected in series to achieve more usable voltages in the range of 20 to 50 volts. This is done in a solar module, where the cells are protected against mechanical damage and the environment, such as moisture.	
6.	As an example of a simple solar system, let us consider a residential building with domestic loads such as a washing machine and some lighting. The house has some photovoltaic modules onto the rooftop that produce electrical energy from the impinging light from the Sun. To build up the voltage, several modules must be connected in series into a string. In this case we have multiple strings connected in parallel and this forms a solar array.	
7.	Solar panels deliver direct current (DC), but all the domestic appliances require an alternating current (AC). We need to convert the DC into AC, and this is done by the inverter. After converting DC into AC, we can also feed power into the public grid. To account for the power generated and used by the house owner, the power distribution company needs to know how much electricity we feed into and out of the public grid and at what time. This is done by the meter. Modern meters are bidirectional, that is they are able to measure not only amount of current flowing, but also its direction.	

	In a real plant there are of course many more components that we haven't described here for sake of simplicity, but we will go through real plant and the required equipment later in the course.	
8.	Photovoltaics are used in a wide range of devices and applications, from very small to large installations, from house rooftops to the International Space Station. Any classification is arbitrary, but for the purposes of this course we may divide photovoltaics into grid-connected and stand-alone systems.	
9.	Stand-alone systems can be used to power grids that are not connected to the public grid (microgrids). A microgrid produces and distributes electricity independently in a smaller area. Stand-alone PV can power specific devices, such as in product-integrated PV. This includes outdoor lighting products, vehicles, solar-driven rescue ladders and harbors, and even pocket calculators.	
10.	The grid-connected systems can be divided into three categories: residential, commercial, and utility-scale system. The residential and commercial systems are most often simply installed on rooftops, whereas utility scale covers the PV power plants and solar parks. Rooftop installations have historically been realized by applying photovoltaic modules onto existing roof constructions.	
11.	However, PV modules may be integrated into the building and thus serve two purposes, producing energy and contributing as a building material for instance, as a cladding material.	

	This type of system is known as building integrated photovoltaics, or simply BIPV. Developers of BIPV systems have successfully created architecturally and aesthetically pleasing systems in a variety of colors, which enables the conservation of the building's architectural appearance.	
12.	On the utility scale, there's a large variety of PV power plants, and this includes tracking systems and bifacial modules, where the light is absorbed from both sides of the module, floating PV, where the modules are located on water, agrivoltaics, where the agricultural use of land is combined with the use of land for photovoltaics and the list goes on.	
13.	The applications marked with the green dot are examples of optimizing area resources, such as the rooftop system, where the photovoltaic system produces energy and doesn't take up any additional land area.	

2.4 A short History of PV– 491 Words – 3' 15''

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
2.	The photovoltaic effect was experimentally demonstrated first by French physicist Edmond Becquerel. In 1839, at age 19, he built the world's first photovoltaic cell in his father's laboratory. He had placed two platinum electrodes in a conductive electrolyte and was measuring the current between them.	

	He then discovered that when illuminating the electrodes, the electric current would increase in strength. This conversion of light into electricity would later be known as the photovoltaic effect.	
3.	Becquerel's cell was electrochemical and used a liquid electrolyte – not very practical. In 1877 William Adams and Richard Day were able to build the first ever solar cell made from solid materials. They applied two platinum electrodes to a solid rod of selenium and illuminated the selenium: electric current flew through the electrodes. In 1883, Charles Fritts built the first solar module by depositing 30 square centimeters of selenium onto a thin gold electrode and he reached an efficiency of almost one percent.	
4.	The understanding of the underlying physics, as well as a very relevant fabrication technique, matured in the first half of the 20th century. The development of quantum mechanics and solid-state physics made possible the development of the modern junction semiconductor solar cell, which was patented by American inventor Russell Ohl. Other advances in techniques were instrumental in developing viable commercial solutions, such as the method devised in 1916 by the Polish chemist Jan Czochralski to grow large monocrystalline ingots of semiconductors. His method was originally intended to grow crystals of germanium but was easily adapted to grow silicon crystals as well.	

5.	In 1954, Daryl Chapin, Gerald Pearson, and Calvin Fuller fabricated the first ever silicon solar cell in the Bell Labs. The silicon solar cell has an area of two square centimeters and an efficiency of six percent, making it six times more efficient than the selenium cell. The cell had a p-n junction. They fabricated a silicon pn-junction able to absorb light and generate an electric current; further improvements in the following years increased the efficiency to an astonishing 10 percent.	
6.	The first solar cells were very costly, and therefore they were only used for special applications. In 1958 the satellite Vanguard1 was launched into space equipped with six silicon solar cells on its surface that successfully powered the satellite for six years. Throughout the 1960s the further development of solar cells was driven by space applications. The terrestrial use of photovoltaics for energy production was rather limited until the oil crisis in 1973 that sparked an interest for alternative sources of energy.	
7.	In 1977, Sandia National Laboratories began developing modules with the aim of producing a standard product for economical mass production. Concerns about oil shortage and, more recently, the climate change evidence have fostered the research to look for alternative energy sources and this led to improvement in performances of PV and reduction of costs. The result is a wider adoption of solar panel to produce energy, on different scales.	

2.5 PV Learning Curve - 765 words – 5’ 05"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
3.	Technologies that follow Wright’s Law get cheaper at a consistent rate, as the cumulative production of that technology increases. Solar technology is an example of a technology that follows Wright’s Law	
4.	The graph shows that the globally installed PV capacity has skyrocketed with an annual growth rate of about 20 percent worldwide for several decades	
5.	The cumulative installed solar capacity, measured in gigawatts (GW). of the 27 states of European Union shows an analogous steep increase, with more than 200 installed GW in 2022.	
6.	The price of solar modules declined by 99.6% since 1976. As the cumulative installed capacity increased, the price of solar declined exponentially. For more than four decades, the price of solar panels declined by 20% with each doubling of global cumulative capacity. Both axes in this chart are logarithmic and on a logarithmic axis, a measure that declines exponentially follows a straight line. Such a dramatic drop in prices is due to four factors. R&D efforts: the more we develop and optimize fabrication processes and the design of our photovoltaic devices, the more efficient and cheaper the technology becomes.	

	Learning by doing is a by-product of the actual deployment. Where companies develop and improve industrial operations, installation procedures, as well as their sales and financing processes. Economies of scale are the result of companies getting larger, where fixed costs are spread over a larger volume of product sales. Economies of scale propagates through the whole value chain. Finally, we have synergies, where improved supply chains, processes and knowledge in general pave the way for similar industries. A great example is the rapid development of the silicon-based electronics industry, where synergies laid the foundation for the silicon-based PV industry.	
7.	The graphs show the record performance of various types of solar cells since the 1970s. “Performance” or efficiency is a percentage that indicates how much of the impinging solar energy is converted to electricity. Crystalline silicon cells are market dominant and have efficiencies measured in laboratories above 20 percent. But we must distinguish between record devices and what is actually mass produced. The materials for mass production must be very cheap to manufacture and the production must be easy to scale up	
8.	The materials used for making world record solar cells are of course only the very best quality and therefore extremely expensive. This brings us to the most important economic parameter we need to minimize in a PV system, the levelized cost of energy, or simply LCOE. LCOE is a measure of the average cost of electricity generated over the lifetime of the generator. It is used for investment planning	

	and to compare different methods of electricity generation on a consistent basis.	
9.	The graphs show the trends of LCOE for different energy sources from 2009 to 2020. Solar panels show the most dramatic decrease.	
10.	Solar cells using high quality materials in fact produce more electricity than commercial solar cells, but the production cost is much higher, and this is not viable for the market. We should think also in terms of module efficiency and not just “cell” efficiency. In an actual solar panel, the solar cells must be protected from the environment, and the casing affects the performance. The record performance of silicon solar cell is close to 27 percent efficient, whereas the record silicon module performance is just above 24 percent. The ratio between the solar cell and module performance is known as the “cell to module ratio”. The average efficiency of the solar modules that were mass produced in 2020 was close to 18-20 percent.	
11.	There are many things to take into consideration when constructing a PV power plant, which is not simply reflected by the efficiency of a solar module. We have to consider the solar resource at the site we want to install our modules, as well as other environmental factors such as potential sandstorms or shading from the horizon and closer objects like trees.	
12.	Furthermore, have we even modelled the daily power production and how well does it match the power demand of the public grid? And how reliable is this power production? Also, are our plants still reliable after several years of operation?	

	Are we able to provide a commercial warranty of at least 25 years? What happens after the end of the power plants lifetime? Are we able to recycle the materials we've used and are the constituent elements environmentally friendly during the operation and decommissioning of the plant? Could it be that we are going to run out of some materials on earth, such as silver, which is used for busbars and fingers?	

Module 3 – Photovoltaic Panels - Theory

The following table offers a concise outline of the general characteristics of the Introduction section:

Duration	42’20’’
Characters	Narrator
Notes	Explains solar energy basics, solar spectrum and atmospheric effects, introduces Air Mass Index, semiconductors and p-n junctions, the IV curve, Maximum Power Point, and factors affecting PV efficiency.

The following table contains a synthesis of the segments in which the Introduction section is organised.

Segment	Title	Word count	Expected Duration
3.1	Learning objectives	165	1 m. 10 sec.
3.2	Solar Energy	682	5 m.
3.3	The solar spectrum	308	2 m.
3.4	The sun and the atmosphere	1137	8 m.
3.5	How to estimate the energy produced by solar cells	1137	8 m.
3.6	Physics of Solar Cells	1232	8 m. 10 sec.
3.7	The Panel IV curve	752	5 m.
3.8	The maximum Power Point	755	5 m.

A detailed description of the content of the individual segments is available in the tables of the following pages.

3.1 Learning Objectives – 165 words – 1’ 10"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
20.	In this module you will: • Understand the basics of how solar energy is produced and its impact on Earth and assess the potential of solar energy to meet global energy demands. • Explore how Earth’s atmosphere affects the solar spectrum, absorbs and reflects solar energy and the implications of such factors for solar cells. • Understand the concept of Air Mass Index (AM) and learn about the factors that influence the efficiency and performance of photovoltaic panels, including weather conditions and geographic location. • Learn some basic concepts on semiconductors, how p-n junctions are formed and their significance in the operation of solar panels, including the separation of electron-hole pairs to generate electric current. • Learn how to identify the Maximum Power Point (MPP) on the I-V curve and its importance in extracting the maximum power from a photovoltaic device. • Understand the impact of factors such as irradiance, temperature, and module design on the efficiency of PV panels and learn how to compute the efficiency of a photovoltaic panel under actual operating conditions.	

3.2 Solar Energy– 682 words – 5'

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
14.	Solar energy A brief introduction to solar energy and its effects on planet Earth.	
15.	The Sun is the star in the center of our solar system, and it is composed mainly by hydrogen and helium, plus other elements such as oxygen, carbon, neon and iron and this hydrogen fuses into helium releasing enormous amounts of energy. This energy is radiated from the surface of the Sun in all directions. After about eight minutes, a small fraction of this energy reaches Earth. Let us look at whether we get enough power from the Sun to cover our energy demand on earth.	
16.	The ultimate source of energy in the Sun comes from nuclear processes: the hydrogen nuclei fuse to form helium nuclei. During the fusion process there is the transformation of a small mass into energy and this conversion produces a huge amount of energy according to Einstein's formula. The fusion process takes place only into the inner core of the Sun and the energy is transferred outward through many successive layers. Eventually it reaches the outer layer, the solar photosphere, from where it is radiated into outer space. The Sun is an incredibly powerful source of energy that is emitted in any direction. A small portion of this energy output is collected by the Earth located 150 million kilometers away from the Sun.	

17.	The world energy consumption in yea 2021 was 19.6 Terawatts, and we expect that to stay below 30 Terawatts by the year 2050.	
18.	The Sun energy that reaches the Earth is 23 000 TW if only considering the area over land and is 89 000 TW if we also consider the oceans! Therefore, the solar energy potential on earth has been calculated to be more than 1000 times that of our current energy demand and this is only considering area over land.	
19.	Not all the solar energy that reaches Earth's outer atmosphere makes it to the surface. Earth's atmosphere absorbs and scatters a portion of the incoming sunlight. Some wavelengths, such as ultraviolet (UV) and most X-rays and gamma rays, could be harmful to life and are absorbed by the atmosphere. A significant portion of solar energy is reflected back into space by Earth's surface, clouds, and the atmosphere. The amount of reflected energy depends on surface type (land, water, ice), cloud cover, and atmospheric conditions. Part of the energy received is also emitted into outer space as thermal radiation. Greenhouse gases limit the amount of thermal radiation dispersed and help keep the planet warm. Earth's energy budget involves a balance between incoming solar radiation and outgoing thermal radiation. Any imbalance in this budget can lead to changes in global temperature and climate patterns, which has important implications for the planet's ecosystems and the well-being of its inhabitants.	

20.	The energy input from the Sun seems to be largely enough to power human needs, but we also have to consider how efficiently are we converting this energy. Photosynthesis is by far the ancient light conversion process on Earth. It started about 2.7 billion years ago. Solar energy is crucial for the process of photosynthesis in plants, which converts sunlight into chemical energy stored as glucose. This process forms the basis of the food chain, as plants are consumed by herbivores and then by carnivores. Additionally, solar energy is stored in the biomass of living organisms through the food they consume. Photosynthetic efficiency depends on the frequency of the light being converted, on light intensity, temperature, and concentration of carbon dioxide in the atmosphere. It ranges from 0.1% to 8%. Efficiency of solar panels is about 20% for mass-produced panels, and above 40% in laboratory devices.	
21.	Solar energy is the primary driver of weather. The solar energy that is not reflected is absorbed by Earth's surface, oceans, and atmosphere. This absorbed energy is a primary driver of Earth's climate and weather patterns. Differential heating of the Earth's surface causes variations in temperature and pressure, which in turn create wind patterns. Similarly, solar energy heats the ocean's surface, leading to the formation of ocean currents that redistribute heat around the planet.	

3.3 The solar spectrum– 308 Words – 2’

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
8.	The solar spectrum. In this section we analyze the solar spectrum into its components and introduce the concept of solar constant	
9.	The electromagnetic spectrum is the full range of electromagnetic radiation. The spectrum is divided into separate bands, which have different names. Radio waves, microwaves, infrared have a wavelength that is larger than visible light, while ultraviolet, X-rays, and gamma rays have a wavelength shorter. Visible light occupies only a small portion of the spectrum. The electromagnetic waves in each of these bands have different characteristics, such as how they are produced, how they interact with matter, and their practical applications.	
10.	The electromagnetic waves with shorter wavelengths carry more energy and interact strongly with matter, while waves with longer wavelengths carry less energy. Wavelength and frequency are linked by the speed of light that is the product of wavelength times frequency. The energy and the waves wavelengths or the frequency are related by this equation. When frequency increases, the energy carried increases proportionally.	

11.	The Sun emits electromagnetic radiation all over the spectrum, but not all frequencies are emitted with the same intensity. The sun emission spectrum is very close to the ideal blackbody spectrum at 5,777 °K, with the peak in the visible range at 502 nm, corresponding radiation we perceive as green light.	
12.	The solar constant measures the amount of energy per second received at the atmosphere entry point, about 8000 km above Earth surface, on a surface of one square meter. The solar constant includes radiation over the entire electromagnetic spectrum. At most about 75% of the solar energy actually reaches the earth's surface, as even with a cloudless sky it is partially reflected and absorbed by the atmosphere. The solar energy arriving at the surface with the sun directly overhead can vary from 550 W/m2 with cirrus clouds to 1025 W/m2 with a clear sky.	

3.4 The Sun and the atmosphere - 1137 words – 8’

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
13.	In this section we will analyze how the atmosphere affects the solar spectrum which doesn't only change throughout the year, but it changes throughout the day as well. The sky is blue at noon but becomes more reddish during a sunrise or a sunset and this is due to changes in spectrum composition due to atmosphere selective absorption of some wavelengths.	

	These changes are critical in the context of solar cells, because the performance of these devices depends on the solar spectrum.	
14.	The red bands show the components of solar spectrum that reach Earth's surface, due to the atmosphere absorption. These are the parts of the spectrum that we can exploit with terrestrial solar panels to produce electricity. Earth's atmosphere affects the Solar spectrum in various ways: - Absorption of light by molecules such as water, oxygen or carbon dioxide as show by deep dips in the red bands - Reflection of light - Scattering, either by molecules (Rayleigh scattering) or by aerosols and dust particles	
15.	The Air Mass Index describes how long is the path to reach Earth that light from the Sun has to travel through the atmosphere. Before entering in more detail about Air Mass Index let's introduce a few basic angles describing the position of the sun in the sky.	
16.	The first angle is called the solar azimuth angle. It's often denoted gamma subscript s. North of the equator, the angle is defined as the deviation from directly south facing. Now that we know the Sun's deviation from south, we need to know how far above the horizon the Sun is positioned.	

	This is called the solar altitude angle, often denoted alpha subscript s. The horizon is, however, not always that easy to define. Therefore, one could have to use the zenith angle, describing the angle between the sun and the vertical and this is the angle being used more frequently.	
17.	Sunlight can be is scattered by ozone, air molecules and trace gases. The size of the scattering particles is less than the light wavelength. This is called Rayleigh scattering and it depends on light wavelength: the shorter the wavelength, the more efficient the scattering is. This explains why the sky is blue: the blue wavelengths get scattered all over the hemisphere more efficiently than the red wavelengths. When the optical path through the atmosphere gets very long, the blue is completely scattered. At sunsets the sky looks red because the Sun is low over the horizon and light has to travel a longer path – blue component of the spectrum is removed and only the red component reaches your eyes.	
18.	Aerosols are another source of light scattering. They are made of particles less than one micron in diameter. These dimensions are by far larger than light wavelength and in this case the scattering doesn't depend on wavelength – it is called Mie scattering. All wavelengths of visible light are scattered with the same intensity.	

	Clouds are an example of airborne aerosols: the water droplets in the cloud scatter all the wavelengths in the same way and the cloud looks white. Other particles than water droplets can absorb selectively some wavelength and therefore the aerosol looks colored: clouds carrying desert sand dust look reddish because the iron oxide in the dust absorbs blue wavelengths. The atmospheric concentration of aerosols is described by a parameter called the aerosol optical depth, that ranges from 0 to 1. Values close to 0 means extremely clear aerosol while values close to 1 means that all sunlight is absorbed or scattered by aerosols. In Denmark, the aerosol optical depth is between 0.1 and 0.2, but in by Beijing is between 0.4 and 0.5 as a result of heavy air pollution.	
19.	The length of path light travels in atmosphere is important therefore to computer efficiency of terrestrial solar panel. Air Mass Index commonly referred as AM followed by a number, is a parameter that allows to compare panels that operate in different conditions and latitudes. The spectrum outside the atmosphere is referred to as "AM0", meaning "zero atmospheres". Solar cells used for space power applications, like those on communications satellites, are generally characterized using AM0. AM1 refers to the vertical distance through the atmosphere.	

	The spectrum after travelling through the atmosphere to sea level with the sun directly overhead is referred to, by definition, as "AM1". This means "one atmosphere". AM1 is a useful range for estimating performance of solar cells in equatorial and tropical regions. Solar panels do not generally operate under exactly one atmosphere's thickness: if the sun is at an angle to the Earth's surface the effective thickness will be greater. Many of the world's major population centers, and hence solar installations and industry, across Europe, China, Japan, the United States of America and elsewhere (including northern India, southern Africa and Australia) lie in temperate latitudes. An AM number representing the spectrum at mid-latitudes is therefore much more common. AM1.5 refers to light travelling 1.5 times the optical path compared to the vertical distance. The AM value is calculated from the Zenith angle	
20.	AM1.5 is useful to represent the overall yearly average for mid-latitudes. The specific value of 1.5 has been selected in the 1970s for standardization purposes, based on an analysis of solar irradiance data in the conterminous United States. Since then, the solar industry has been using AM1.5 for all standardized testing or rating of terrestrial solar cells or modules, including those used in concentrating systems. The latest AM1.5 standards pertaining to photovoltaic applications are the ASTM G-173 and IEC 60904	

21.	The Air Mass index is related to the zenith angle from this relation. This shows that the zenith angle for AM1.5 is about 48 degrees, which means a solar angle of 42° Do not forget that AM1.5 is an average over the year's spectrum.	
22.	A solar array is simply a collection of solar modules in the same plane. Usually, the solar array is tilted at an angle to maximize the global irradiance and thus maximize power production.	
23.	The array is able to produce a certain amount of electricity, even though the Sun is not shining directly onto the panel. There are actually other contributions than direct light to irradiance and they can be rather significant even when the Sun is shining onto the panel. The overall irradiance seen by the module is referred to as the global irradiance in the plane of array, or simply G_POA and it derives from three contributions: The beam component or the direct component, which is perceived in a direct path from the Sun. The diffuse component, which is perceived from allover the hemisphere. The ground component, which refers to light being reflected off from the ground and on to the panel. These components are rather difficult to model and predict and measuring all of them is therefore complex and expensive.	

3.5 How to estimate the energy produced by solar cells- 1137 words – 8'

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
6.	In this section we evaluate, with the help of some cartographic databases, the quantity of energy that reaches the surface of the Earth in different areas, with particular reference to Europe, and we evaluate, starting from this data, how much energy it is possible to obtain from solar panels.	
7.	Photovoltaic panels generate electricity directly from sunlight. This means that their output is highly dependent on weather conditions, time of day, and geographic location. Cloudy days, nighttime, and seasonal changes in day length and sun position will result in reduced energy generation. The amount of electricity of a solar panel suffers of two major problems: • Intermittence = alternance day/night (on/off; fully predictable) • Variability = fluctuations of production intra-day and day-to-day (forecast accuracy < 100%) For these reasons the Capacity Factor (CF) is an important parameter to be evaluated as the ratio between the amount of energy actually produced and the product of the PV panels nameplate power by the time you want to span.	
8.	Solar radiation maps represent graphically the energy received annually on a horizontal surface.	

	These maps supply the information of how much total radiated energy a square meter of exposed panel will receive annually and are therefore very useful to predict how much energy can be produced by a solar array.	
9.	The Photovoltaic Geographical Information System (PVGIS) provides information on solar radiation and photovoltaic system performance for any location in the world, except the North and South Poles. On the website three online tools are available • Photovoltaic performance. Provides data about the amount of electricity produced per year by a PV system performance for any location. • Solar radiation. Supplies time series of hourly, daily or monthly values of solar radiation and PV performance. • Typical meteorological year. Let you access hourly data set of nine climatic variables over a "typical" year, formatted for building energy calculation tools.	
10.	NREL is a national laboratory of the U.S. Department of Energy that supplies solar data, tools and maps for the whole World.	
11.	The graph shows the average global irradiance for a solar panel lying flat on the ground in June in Copenhagen. The two components or irradiance, direct and diffuse, sum up to get a global value that varies during the time of the day. As you can see, the diffuse irradiance is quite a significant contribution to the global irradiance.	

12.	By computing the total area below the curve, you can get the total amount of solar energy received at the point of the Earth during a typical day. This Is called insolation, and it is measured in watt-hours per square meter. In the example of Copenhagen, we get 5.7 kilowatt hours per square meter	
13.	Another important concept is Sun-hour that can be used to normalize computation among different places. One Sun-hour or one full-load hour defined as one kilowatt-hour per square meter. Using this unit of measure we can convert the energy of 5.7 kilowatt-hours per square meter received in June by the solar panel at Copenhagen into 5.7 Sun-hours. Although in June in Copenhagen the Sun rises at 4.00 in the morning and the sunset is at 20:00, the energy intensity varies during the day. The figure of 5.7 Sun-hours means that all the energy received by solar panel during the course of the day is equivalent to what it would have received had the Sun been shining at full-load for 5.7 hours and been completely shut off the rest of the day.	
14.	Every solar panel comes with a datasheet whether rated power, also called the peak power, is specified. For instance, let’s rake the 305 watt peak panel The word peak simply means that the panel produces 305 watts when the Sun shines at full-load.	

	In this case, the full-load irradiance has also been explicitly specified to be 1,000 watts per square meter.	
15.	With these three pieces of information: • The number of Sun-hours or full-load hours in the plane of our solar panel in a given location. In Denmark we can estimate an average of 1000 kilowatt-hours per square meter, as show in the map. • The rated power off the panel, 305 watts • The irradiance at the given location, around 1000 watt per square meter We can estimate how much electric energy the plant could expect to produce in a year, which is 305 kWh This is a rough estimate that does not include many effects such as temperature, AOI, mismatch losses, and others. Reference for the map: Long-term Global Radiation Measurements in Denmark and Sweden - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Average-yearly-solar-irradiation-on-horizontal-in-Denmark-obtained-by-DMI-for-period_fig1_331307939 [accessed 8 Sept 2024]	
16.	Solar energy is a distributed energy source and therefore PV panels require significant space to collect it. To generate 1 MW of energy a surface of one hectare (100 meters x 100 meters) is required.	
17.	The upfront cost of purchasing and installing PV panels can be relatively high, including expenses for solar panels, inverters, mounting systems, and installation labor.	

	While the cost of solar technology has decreased over the years, the initial investment can still be a barrier for some individuals, businesses, or governments. Photovoltaic panels due to their flexibility and scalability however can be easily installed in surfaces that are used for other purposes, such as rooftops of existing building, parking, industrial plants.	
18.	The appearance of PV panels installed on top of buildings – especially if historical or ancient - can be seen as unattractive or may not fit the architectural style of certain structures. Panel extensions can also affect the landscape by their intrusiveness.	
19.	While PV panels require generally low maintenance, but anyway they still require periodic cleaning and inspection. Dust, debris, shading, and extreme weather conditions can affect their performance over time. Panel lifetime is estimated in 25 to 30 years, and this should be considered for cost analysis and long-term planning.	
20.	The energy balance of solar panels refers to the comparison between the total energy used in the production and manufacturing of the panels and the total energy produced by those panels during their operational lifetime. This balance is often expressed as the Energy Pay Back Time" (EPBT) or "energy return on investment" and is an important metric to understand the environmental impact and sustainability of solar panel technologies. The energy balance calculation takes into account various factors, including the energy required for raw material	

	extraction, manufacturing processes, transportation, installation, and maintenance of the solar panels. It is then compared to the energy output of the panels over their operational lifespan, considering factors like solar insolation (amount of sunlight), system efficiency, and degradation of panel performance over time. It's important to note that the energy balance can vary based on factors such as the type of solar panel technology (e.g., monocrystalline, polycrystalline, thin-film), the location of installation (solar insolation levels), the energy mix used for manufacturing, and the recycling or end-of-life considerations for the panels.	

3.6 Physics of Solar Cells- 1232 words – 8’ 10"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
1.	To better understand the characteristics of solar panels and their limits it is very important to have some knowledge, even if superficial, of the behavior of the materials that compose them. This section describes in broad terms the behavior of semiconductors and p-n junctions	
2.	Electricity is the movement of charged particles – usually electrons - through a material. Conductors, semiconductors, and insulators are three types of materials that behave differently when it comes to the flow of electricity. Conductors	

	Conductors are materials that allow electric current to flow through them very easily. All metals, at different degree, such as copper, silver, and aluminum, are conductors. This is because they have free electrons that are not tightly bound to their atoms and therefore they can move around easily, carrying electric current. Conductors are essential for building things like electrical wires and circuits because they efficiently transmit electricity. Insulators Insulators are materials that do not allow electric current to flow easily. Many materialis, such as rubber, glass, wood, and plastic are insulators. In these materials, the electrons are very tightly bound to their atoms and can't move freely and therefore electricity can’t pass through them. Insulators can be used to cover conductors that carry electricity, like the plastic coating around electrical wires. Semiconductors Semiconductors are materials with a behavior that falls between conductors and insulators. They conduct electricity worse than metals, but their ability to conduct electricity can be controlled. By adding tiny amounts of other elements (a process called "doping"). Silicon and germanium are well-known examples of semiconductors..	
3.	In a solid, electrons can occupy the valence band, where they keep the atoms together by chemical bonds, or could be in the conduction band, where they can freely move to carry electricity. In insulators, all electrons are in the valence band and there no electrons in the conduction band – there are no electrons available to carry electricity.	

	In conductors, there electrons both in the valence band and in the conduction band – therefore there are electrons available to carry electricity. In semiconductors, electrons are normally in the valence band, but some can be promoted to the conduction band, either by heating the material or by adding some other elemens that could change the electron equilibrium within the semiconductor, with a process called «doping».	
4.	The promotion of an electron from valence band to conduction band in a semiconductor could happen thanks to the energy from Sun: light wave, or photons, can supply enough energy to make an electron available for conduction, leaving in the valence banc an «hole» that carries a positive charge. For an electron in the valence band of a semiconductor to be excited by a photon into the conduction band, the energy of the photon must be, at least, that of the energy that separates the two bands, called bandgap.	
5.	The photons carry an energy that is proportional to their wavelength. Each semiconductor has a bandgap that is specific to its composition and atom structure. When light impinges on a semicondutor, there are two possible phenomena: The lightwave energy is lower that the bandgap: nothing happens, because no electron is promoted to the conduction band The lightwave energy is equal or highe that the bandgap: the electron is promoted to the conduction band, leaving behind a hole in the valence band, and an electric current could be generated. If, due to the excess of photon energy, the electron is excited higher into the conduction band relative to the conduction band edge this excess energy is lost as heat in a process known as thermalization.	
6.	The overall concept of the ideal solar cell is illustrated in the figure where the electron-hole pairs are generated in the absorber material and the electrons are extracted via an electron selective layer and similar for the holes.	

	Holes and electrons, having opposite charge, tend to recombine. In order to extract useful electricity from the solar panel we should capture these charge carriers before they recombine. This is done using a P-N junction by doping the semiconductor that creates an electric field to separate holes and electrons.	
7.	Doping is a crucial process in semiconductor technology that alters the electrical properties of pure semiconductors, typically silicon, to create either P-type or N-type materials. Doping significantly alters the energy band structure of semiconductors by introducing impurity atoms into the crystal lattice, which modifies the distribution of energy levels. In intrinsic (pure) semiconductors, the valence band is filled with electrons, while the conduction band is empty, with a band gap separating the two. https://www.jingsun-power.com/news/latest-solar-n-type-silicon-wafers-plummeted-77319632.html	
8.	In N-type doping, some silicon atoms are replaced by atmos from other elements called donor atoms, which have more valence electrons than the semiconductor material. Silicon has four valence electrons and it is commonly doped with elements from Group V of the periodic table, such as phosphorus (P), arsenic (As), or antimony (Sb). These dopants have five valence electrons. When these atoms are introduced into the silicon lattice, four of the dopant's electrons bond with the silicon atoms, while the fifth electron becomes a free charge carrier. This extra electron contributes to electrical conductivity, making N-type semiconductors negatively charged. The concentration of free electrons can be controlled by the amount of dopant introduced, thus allowing for tailoring the semiconductor's conductivity.	

	https://upload.wikimedia.org/wikipedia/commons/c/c0/Periodic_Table_Of_Elements.svg Dmarcus100, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons	
9.	Conversely, P-type doping involves introducing acceptor atoms that have fewer valence electrons than silicon. This is typically done using elements from Group III, such as boron (B), aluminum (Al), or gallium (Ga), which have three valence electrons. When these acceptor atoms replace silicon atoms in the lattice, they create "holes" where an electron is absent. These holes can accept electrons from neighboring atoms, creating a positive charge carrier. As a result, P-type semiconductors have an abundance of holes, making them positively charged. Similar to N-type semiconductors, the conductivity of P-type materials can be adjusted by varying the dopant concentration.	
10.	When two types of semiconductor materials, p-type and n-type, are generated in a single crystal a p-n junction is formed. The "n" (negative) side contains freely-moving electrons, while the "p" (positive) side contains freely-moving electron holes. Connecting the two materials causes creation of a depletion region near the boundary, as the free electrons fill the available holes, which in turn allows electric current to pass through the junction only in one direction. The depletion region is so called because it contains practically no mobile charge carriers	

	https://commons.wikimedia.org/wiki/File:Pn-junction-equilibrium-graphs.png TheNoise, CC BY-SA 3.0 <http://creativecommons.org/licenses/by-sa/3.0/>, via Wikimedia Commons	
11.	Across the depletion region an electrical field is established and this electric field and the corresponding built-in voltage are exploited in solar panels to separate holes and electrons produced by impinging light and avoid their recombination. https://commons.wikimedia.org/wiki/File:Pn-junction-equilibrium-graphs.png TheNoise, CC BY-SA 3.0 <http://creativecommons.org/licenses/by-sa/3.0/>, via Wikimedia Commons	
12.	If the juction is lighted, electron-hole pairs are generated by photons in the depletion region and are separated by the electric field, with the electron attracted to the positive n-type side and holes to the negative p-type side, reducing the charge (and the electric field) built up by the diffusion just described. If the device is unconnected (or the external load is very high) then diffusion current would eventually restore the equilibrium charge by bringing the electron and hole back across the junction, I the load connected is small enough, the electrons prefer to go around the external circuit in their attempt to restore equilibrium, doing useful work on the way.	

3.7 The Panel IV curve - 752 words – 5’

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes

1.	Knowing the I-V curve for a photovoltaic panel is essential to predict the behavior of the panel under different ambient conditions, including light and temperature.	
2.	The I-V curve describes the characteristics of any electronic component such as photovoltaic devices but can be applied to other devices such as resistors, transistors or motors. I stands for current, and V stands for voltage. The curve shows the relationship between these two parameters in a device. Namely, it links the current flowing through a device and the voltage across its terminals.	
3.	A resistor that follows the Ohm's law as a I-V curve that is a straight line. Ohms law says that voltage value is obtained multiplying the current by a constant, that is the resistance. In an ideal resistor the resistance doesn't change with voltage and / or current and therefore the curve is a line. An ideal voltage source is an electrical component that provides a constant voltage output regardless of the current drawn from it. In other words, it maintains a fixed voltage across its terminals, no matter how much current it supplies. Its curve is a vertical line at the set voltage: the voltage doesn't change at any current value. An ideal current source is an electrical device that delivers a constant current regardless of the voltage across its terminals or the load connected to it. Its curve is a horizontal line at the set current: the current doesn't change at any voltage value. In the real world neither ideal resistor nor ideal current / voltage sources exist. In a real resistor, for instance, the current flowing can heat the resistor itself and its resistance varies according to device temperature change – in that case the resistor curve deviates from the straight line.	

4.	The I-V curve of a PV device largely corresponds to that of a photodiode. The photodiode shown on the left here is therefore interchangeable with the symbol for a PV device shown on the right here. In schematics of PV systems, it is more common to see the symbol on the right. The part of the I-V curves of interest for PV panels lies in the first quadrant, which is highlighted in blue. When the characteristic curve is in this quadrant, it means that both current and voltage are positive, and the PV cell is acting as a generator. Quadrant 1 indicates that light is shining on the PV device and that the power produced is being consumed by an external circuit.	
5.	There are three key measured points on the I V curve of most interest and they are: The open circuit (Voc). This is the point on the I-V curve where voltage is highest, and current is zero. It is measured when the PV device is connected to a load with very high resistance. The short circuit current (Isc). This is the point on the I-V curve where current is highest, and voltage is zero. It is measured when the PV device is connected to a load with zero resistance. The third point, the maximum power point (MPP or Pmax), will be described in detail in the next section.	
6.	The shape of the I-V curve changes depending on the solar spectrum, the plane of array irradiance, and the cell temperature If any one of these conditions change, the curve changes accordingly.	

	In field conditions therefore there is not a single I-V curves, but a family of curves related to different conditions. To make possible a comparison of different PV panels, the I-V curves are plotted in standard test conditions or STC. They are defined as the global air mass 1.5 solar spectrum, a total in-plane irradiance of 1000 watts per meter squared, and a cell temperature of 25 degrees C. PV module manufacturers will always report I-V characteristics at STC on their data sheets	
7.	The shape of the I-V curve changes depending on the solar spectrum, the plane of array irradiance, and the cell temperature If any one of these conditions change, the curve changes accordingly. In field conditions therefore there is not a single I-V curves, but a family of curves related to different conditions. To make possible a comparison of different PV panels, the I-V curves are plotted in standard test conditions or STC. They are defined as the global air mass 1.5 solar spectrum, a total in-plane irradiance of 1000 watts per meter squared, and a cell temperature of 25 degrees C. PV module manufacturers will always report I-V characteristics at STC on their data sheets	

3.8 The Maximum Power Point - 755 words – 5'

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes

1.	On the I-V curve the Maximum Power Point is a point very relevant to define the panel efficiency. This section describes how to compute the panel efficiency in actual operating conditions and how to compare it with STC	
2.	We have seen the short circuit current (Isc) and the open circuit voltage (Voc) as two points that qualify the I-V curve. There is also another important point, Maximum Power Point, or MPP. Power is computed as the product of current by voltage. And the MPP is simply the maximum value on the power voltage curve.	
3.	The blue curve shows the product of current by voltage and its maximum is the MPP, that is the operating point where the most power can be extracted from a PV device. The PV panel must be loaded in such a way to get the maximum power from it. This means that the load must be adjusted to get the current at the voltage that, multiplied one by the other, let the panel generate the maximum power.	
4.	Efficiency – represented by the Greek letter “eta” - of a give system can be defined as the ratio between power in output divided by power in input. In the case of PV panels, the numerator is the electrical power generated by the system. The denominator is the optical power available to the PV system which is the global irradiance multiplied by the PV device area. Efficiency is a number without dimensions from 0 to 1. It is often multiplied by 100 to express it as a percentage, from 0 % to 100%	
5.	The graph shows the efficiency of a contemporary silicon PV module as a function of in-plane irradiance. The data depicted refers to a 295 Wp module with 5 bus bars.	

	The peak efficiency in the graph at any given temperature is about 600 watts per squared meter. For example, at 25 degrees – the curve in turquoise - the peak efficiency is a little over 18%. At 600 W/m2 This peak efficiency strongly depends on module design; there are for instance PV panels that Have their peak efficiency at 1000 watts per meter squared.	
6.	To compute PV efficiency, you use the panel area, but we should agree on which area to use in computation. The active area of a cell would exclude the front metallization such as the busbars for PV modules, which are composed by multiple PV cells that have some “non-active” gaps among them. It is customary to use the entire module area for efficiency calculations and this is sometimes called the frame-to-frame area, which includes inactive parts of the PV module, which is parts that do not transform light into energy. Using the frame-to-frame area for efficiency calculations is fair when you consider that PV system designers often work with roof or land area that have limited space. Therefore, the expected efficiency of the system must account for the true area of the PV module.	
7.	PV systems rarely operate at standard test conditions and the efficiency varies widely with fluctuations in irradiance and temperature. Therefore, it can be useful to have a way to visualize PV efficiency across all such conditions. One common metric used is the relative efficiency that is calculated as the ratio between MPP at any given irradiance and temperature condition and the MPP at	

	STC, multiplied by 1000 watts per square meter and normalized by the in plain radiance. The result is a contour plot that shows the cell temperature is plotted against irradiance, with the different colors representing the efficiency relative to STC, marked by the red X at 1000 W/m2 irradiance and 25 °C. All points on the contour plot are relative to this point.	
8.	The Fill Factor, or FF, is computed as the ratio between MPP and the product of Isc and Voc. The fill factor cannot equal one and the highest fill factor the PV panel can attain will depend on the PV technology. For mono crystal and silicon PV the highest fill factor we can expect will be between 0.8 and 0.85. For multi crystal PV the highest fill factor is slightly lower, between 0.75 and 0.8. The lowest fill factor of any PV technology is 0.25 and such a value would only happen if severe degradation and shunting occurred.	
9.	FF is a measure of the I-V curve's “squareness and it is a good diagnostic tool for assessing the health of a PV system. With the fill factor we can identify when a PV devices series or shunt resistance has changed.	

Module 4 – Power Electronics

The following table offers a concise outline of the general characteristics of the Introduction section:

Duration	35’
Characters	Narrator
Notes	Describes interconnection of PV cells, effects of shading and mismatch losses, bypass diodes, and introduces DC-DC and DC-AC converters, Maximum Power Point Tracking (MPPT), and inverter types and efficiency.

The following table contains a synthesis of the segments in which the Introduction section is organised.

Segment	Title	Word count	Expected Duration
4.1	Learning objectives	175	1 m. 10 sec.
4.2	Cell Interconnection	1382	9 m. 12 sec.
4.3	Power converters for PV panels	1037	7 m.
4.4	DC-DC converters	477	3 m. 10 sec.
4.5	DC-AC converters	1461	10 m.
4.6	The efficiency of Power Converters	646	4 m. 20 sec.

A detailed description of the content of the individual segments is available in the tables of the following pages.

4.1 Learning Objectives – 175 words – 1' 10"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
21.	In this section you will: • Understand the application of Kirchoff's laws to photovoltaic (PV) cells. • Comprehend the impact of interconnection methods and bypass diodes on PV system efficiency. • Learn how the resistance of the load determines the operating point on the PV panel's current-voltage curve and explore the impact of varying loads and environmental conditions, such as changes in sunlight and temperature, on the performance and power output of PV panels. • Comprehend the principles and methods of Maximum Power Point Tracking (MPPT) for optimizing PV panel efficiency and learn about different MPPT methods. • Understand the role and types of DC-DC converters in photovoltaic (PV) systems and the role of MPPT solar charge controllers in maximizing power output and efficiency in off-grid PV applications. • Learn about conversion from DC to AC and get acquainted with the various kinds of inverters available, as well as their features and applications.	

	• Understand the factors affecting the conversion efficiency of power converters. • Learn about the differences between static and dynamic MPP tracking efficiency.	

4.2 Cell Interconnection– 1382 words – 9’ 12"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
22.	In this section we will review some fundamental electrical circuit concepts, focusing on Kirchoff’s laws and their application to photovoltaic (PV) cells. PV cells can be interconnected in parallel or series, forming strings that influence overall voltage and current and we will present the features offered by the different kind of connection. Effects of shading and soiling that affect PV system efficiency will be described, as well as advances in module design aim to increase power output.	
23.	Let us start with a reminder of some of the fundamental concepts of electrical circuits: the two Kirchoff’s laws. Kirchoff's current law states; that for every point in an electrical circuit, the sum of all currents entering the junction is equal to the sum of all currents leaving the junction.	https://it.wikipedia.org/wiki/Leggi_di_Kirchhoff#/media/File:Kirchhoff's_Current_Law.svg inductiveload - Pubblico dominio https://commons.wikimedia.org/w/index.php?curid=1414332
24.	Kirchoff's Voltage Law states; the sum of all voltages in a closed loop is zero.	

	This means that the voltage generated in a loop must equal the voltage drop of the loads in the circuit.	
25.	The photovoltaic cells operate similar to diodes, as you can see in this four-quadrant graph. Active operating region of the solar cells is in the first quadrant, highlighted in blue. When reverse biased, cells can also operate in the second quadrant. If the reverse voltage is too high however, PV cells will break down (not shown). If on the other hand, the forward voltage is too high, meaning beyond the open-circuit voltage, the cell operates in the fourth quadrant. Here, the current becomes negative, and power is dissipated. The irradiance variations shown as a family of curves at different irradiance levels, affect linearly the current but affect logarithmically voltage and can be considered constant in practice.	
26.	PV cells can be interconnected in two different ways: parallel and serial. Cells interconnected are called a “string”. In the case of parallel connections, the string voltage is limited by the voltage of the individual cells and the string current is the sum of all individual currents. The actual operating point of the string depends on the load.	

27.	Serial connection leads to a string voltage that is the sum of all individual cell voltages. The current on the other hand is constant throughout the string. Depending on the load, the operating current and voltage will vary. Serial interconnections lead to higher voltages and lower currents compared to parallel interconnections.	
28.	Silicon cells are usually connected in series because this leads to: • Lower current, which means lower ohmic (resistive) losses. • Higher voltage, which means less transformation required for feed-in. This configuration can lead to some problems due to cell mismatches. Most common PV modules feature 60 cells per module in six rows while other common sizes include 48,54 or 72 cells. The main consideration of having these numbers of cells is that an even number of rows simplifies the layout and reduces the length of DC lines within the module. In the last years, modules using half-cut cells have also become increasingly popular usually featuring 120 cells where two times 20 half-cell strings are connected in parallel and three of these clusters in series.	
29.	The advantages of the half-cell modules are low ohmic losses and six pixels instead of three for shade management.	

	Most of today's modules reach rated output powers of more than 300 watts at STC. Currently, leading manufacturers in industry are aiming for models achieving output power of more than 500 watts. These modules are usually based on larger wafer sizes and feature 144 half-cut cells.	
30.	So far, we have presented interconnection of identical cells, What happens however if the cells are not identical? For example, one of the cells may be shaded or damaged, which leads to the current being reduced while the voltage stays approximately the same. In parallel connections, the power losses are relatively minor as a reduced current only affects a single cell on the string. Therefore, the string output power is only reduced by the power lost in the single cell. In serial connections, things become a little bit more complicated. The string current is limited by the current of the weakest cell, meaning that the current of the entire string will be reduced. This in turn leads to significantly larger reductions in string power output than in the case of parallel interconnections. These power losses are referred to as mismatch losses.	
31.	In most PV modules, cells are connected in series to achieve low current and high voltage which minimizes ohmic losses.	

	However, serial connection is highly susceptible to mismatch losses. For example, when one cell is shaded the current of the entire string is limited by the cell with the lowest current. A single shaded cell can lead to unacceptably high-power losses in the module. The primary cause for mismatch losses is related to differences in radiance, for example, due to shading. Proper planning and installation of PV systems can minimize shading by external structures, but radiance reduction due to soiling is unavoidable, Soiling includes dirt, dust, leaves, bird droppings and other materials that may cover PV modules. Another possible cause for mismatch losses is related to use of cells with different electrical properties. Even if it can be reduced or removed by design, it may occur by degradation in time of cells due to cell cracking, encapsulant browning or corrosion of electrical interconnections.	
32.	In serial connections, when the power of a string is reduced due to shading, the current generated in the unshaded cells nevertheless has to pass through the shaded cells. This can lead to reverse bias, which in turn means that power gets dissipated by the modules. The energy is converted into heat and can lead to hotspots which may permanently damage the PV cell.	

	The picture shows the thermal image of a PV panel with hot spots.	
33.	In order to reduce the power losses caused by cell mismatches, bypass diodes are used. They are connected in parallel to the strings, providing an alternative current path in case one or more cells become shaded. During normal operation, when no cells are shaded, current passes through all strings in the model. In case a cell becomes shaded, the maximum current in this shaded string is reduced. Without the bypass diode, this would reduce the current off the entire module and lead to high power dissipation in the shaded cell. With the bypass diode in place, however, the majority of the current generated by the unshaded strings can bypass the shaded string and so the unshaded strings will operate at a higher current and therefore reduce power losses in the PV module. The cell heating is limited, and the formation of dangerous hotspots is prevented. Bypass diodes provide vital protection for cells, but they have a minor drawback. In normal operations, a small leakage current is always present through the diode, leading to a small power loss. This is why the number of bypass diodes is usually kept as low as possible.	

	The bypass diodes are typically located in a junction box at the back of the module.	
34.	Solar PV panels can be connected in series within a PV string, to increase the PV power. The output power and voltage of the string will increase proportionally with the number of panels connected in series (M). The output current of the string will remain the same. In practice, a limited number of PV panels can be connected in series, depending on the maximum voltage rating allowed, depending on country regulations and system size: 600 Vdc – US residential systems 1000 Vdc – IEC residential and utility systems 1500 Vdc – new utility scale PV systems	
35.	The PV power output can be further increased by connecting PV strings in parallel, into PV arrays. The output power and current of the array will increase proportionally with the number of strings connected in parallel. The output voltage of the array will remain the same as the PV string. The maximum power of the array is limited only by the power and current rating of the other system components	

4.3 Power converters for PV panels– 1037 Words – 7’

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
13.	This section explains the importance of matching the load to the panel’s characteristics to maximize the actual output power of a photovoltaic (PV) panel. It discusses the challenges of maintaining optimal power output due to varying loads and environmental conditions, such as changes in sunlight and temperature. The section highlights the need for power converters to match the input voltage and current to the load’s requirements, ensuring efficient power conversion. It introduces the concept of Maximum Power Point Tracking (MPPT) as a technique to maximize power output and various MPPT methods are described. The section emphasizes the significance of MPPT in improving the efficiency of solar energy systems and ensuring optimal performance under varying conditions.	
14.	The actual output power of a PV panel is determined by the load connected at the terminals. A DC bulb, LED, or heater are examples of resistive loads that can be powered directly by the PV, although such a configuration is rarely used. The resistance of the load determines the operating point on the panel’s current-voltage curve and in order to get the most power from the panel It needs to match the panel its characteristics – this is not always the case.	

	In a real application the load might not always be constant. For example, multiple devices can be turned on or off, or a DC heater can have different heat settings. Even if the panel matches the load, changes in sunlight or temperature can affect performance. The load won't get the maximum power, and the panel's current or voltage might not fit the load's needs. Also, a single PV panel might not provide enough power for the load.	
15.	IF the irradiance or temperature changes • The load will not extract the maximum available power from the PV panel anymore. • The current or voltage of the PV panel may no longer be compatible with the DC load. If a single PV panel cannot provide sufficient power to the load, you can connect panels in parallel to increase the current and therefore the output power, keeping constant the PV voltage. However, bigger currents increase resistive losses and require bigger and more expensive cables.	
16.	The schema shows a PV panel directly connected to a battery. The circuit will work only if the battery charging voltage is lower than the open-circuit voltage of the PV panel. Otherwise, the battery might discharge instead of charging, and the battery voltage will determine the operating point on the panel's current-voltage curve. The battery voltage will determine the operation point on the I-V characteristic.	

	The battery voltage must be well matched with the MPP voltage of the panel to charge the battery with near the maximum available power from the PV	
17.	Let's consider a case when the battery and panel are not well-matched. Here a standard 230 W, 28 V panel will charge a 12 volt battery. In this situation, the battery would force the panel to operate at a low voltage (green area). The gray area shows the lost power, that is the difference between the maximum power available at MPP, 230 W, and the actual power extracted from the panel, about 106 W. Half of the available power, 125 W, therefore, will be lost and dissipated as heat in the panel due to the mismatch in the battery and the MPP panel voltage.	
18.	We need an active device, called Power Converter, between the PV panels and the load that is capable of converting the input voltage and current to match the electrical requirements of the load, at any given time under variable environmental and load operating conditions. The active device should be capable of finding and tracking the maximum power operating point of the generator independent of the irradiance and temperature conditions and at the same time to be able to react and adapt changes in the load. Moreover, the conversion should occur with high efficiency and minimal losses.	

19.	To maximize the power output from a solar panel using active loading a technique called Maximum Power Point Tracking (MPPT) is used. This is achieved by continuously adjusting the electrical operating point of the modules or array. The goal is to ensure that the PV panels operate at their maximum power point (MPP), which is the point where the product of current and voltage is at its highest. Solar panels have a non-linear current-voltage (I-V) characteristic, meaning that their output power varies with changes in sunlight intensity and temperature. The MPP changes with these conditions, so a fixed operating point would not be efficient. MPPT systems dynamically adjust the operating point to track the MPP as conditions change, ensuring optimal performance.	
20.	There are several methods for implementing MPPT, including: • Perturb and Observe (P&O): This method involves perturbing the operating voltage and observing the change in power. If the power increases, the perturbation continues in the same direction; if it decreases, the direction is reversed. • Incremental Conductance (IncCond): This method calculates the derivative of the power with respect to voltage and compares it to instantaneous conductance. It adjusts the operating point based on the comparison to find the MPP. • Constant Voltage (CV): This simpler method maintains the operating voltage at a fixed percentage of the open-circuit voltage, which is assumed to be close to the MPP.	

	MPPT is crucial for solar energy systems because it significantly improves the efficiency of power conversion. Without MPPT, the system would operate at a suboptimal point, leading to lower energy harvest and reduced overall efficiency.	
21.	The MPPT can be implemented by an active load using a power converter, The MPP of a generator can be tracked for a wide range of irradiance and temperature conditions. Assuming that the load can handle the maximum power output of the panel the converter will monitor the input voltage, current, and power of the PV generator, and is able to control either the PV voltage or current, effectively controlling the operating point on the IV characteristic of the PV generator. Given these conditions, the converter is able to actively search for the maximum power continuously using one of the MPPT algorithms. Moreover, the converter adapts voltage and current to the load ratings such that it can be operated safely, and for a wide range of environmental conditions.	

4.4 DC-DC converters- 477 words – 3' 10"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
24.	This section explains the role of electronic converters in photovoltaic (PV) systems and describes three main types of	

	DC-DC converters, namely boost converters, buck converters and buck-boost converters. Additionally, it covers the functions of DC converters in battery charging, safety, and protection in off-grid PV applications.	
25.	We have already introduced power converters speaking about active loads. In general terms, an electronic converter is a device connected to a power source which could be anything from a battery. PV panel or array, diesel generator, another converter or even the electrical grid. The purpose of this device is to convert the input voltage and current of the power source to an output current and voltage compatible with the load connected at the output. This load could be an electric appliance, a battery, another converter or the electrical grid. Power electronic converters will perform the conversions with high efficiency, usually above 90%.	
26.	If both the input and output current and voltage are DC electricity, then the converters are called DC to DC converter. The output power of the converter will always be slightly less than input power, since some energy is always lost to heat during the conversion process. However, the relation between the input and output voltages or currents can be controlled dynamically and depends on the converter type.	

27.	The main subtypes of DC / DC converters are three. In all of them output power is reduced compared to input power by the conversion efficiency, which is always less than 100%. The converters that step up or increase the input voltage while reducing the current output are called boost converters. The converters that are used to reduce the input voltage with a consequent increase in current value are called buck converters. The two graphs show the power, current and voltage relationship for this kind of converter. The last kind of converters, called buck-boost converters, can either step up or step down the input voltage depending on how the converter is being set.	
28.	DC-DC converters are often used in MPPT solar charge controllers in off-grid PV applications, such as solar home systems, stand-alone PV systems, or solar-powered water pumps, to charge the battery for energy storage, and to power any DC loads. For such systems, an additional stand-alone inverter is required for powering AC loads and appliances.	
29.	MPPT solar charge controllers are often based on buck converters as the voltage of the PV generator is usually higher than the battery voltage. The main functions performed by the DC converter in such an application are: • maximum power point tracking and extraction, • efficient DC-DC conversion, • battery charging with different levels of complexity according to the battery type and chemistry.	

	Moreover, such systems implement operator battery and load safety and protection functions, such as battery over and undercharged protection, load switch off in case of power surge, power conditioning, and other safety functions.	

4.5 DC-AC converters- 1461 words – 10’

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
21.	This section introduces general concepts about inverters that convert DC to AC and describes the various kinds of inverters available and their features and applications.	
22.	DC to AC converters - also known as inverters - will convert a DC current and voltage to an AC current. Voltage and frequency are determined by the requirements of the load. This AC load is the electrical grid itself for grid connected PV systems or our everyday household appliances.	
23.	Power Electronics converters are built using power semiconductor transistors such as MOSFET (Metal Oxide Semiconductor Field Effect Transistors) and IGBT (Insulated Gate Bipolar Transistors) that operate as switches. The converter switching and operation are controlled by a Pulse Width Modulated (PWM) signal generated by the controller of the converter	Di User:ArséniureDeGallium (2005) - Opera propria, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=264625

24.	A single-phase inverter is an electronic device that converts direct current (DC) into alternating current (AC). It is commonly used in applications such as solar power systems, uninterruptible power supplies (UPS), and various household appliances. The inverter receives DC power from sources like batteries, solar panels, or rectifiers. A driver circuit controls the switching of the power electronic switches, and it ensures that they operate with the correct timing to produce the desired AC waveform. Power electronic Switches are typically IGBTs or MOSFETs and they are responsible for switching the DC input to create an AC output. The output of the inverter is often passed through a filter circuit, usually consisting of inductors and capacitors, to smooth out the waveform and reduce harmonic distortion.	
25.	A three-phase inverter is an electronic device that converts direct current (DC) into three-phase alternating current (AC). It is widely used in industrial applications, renewable energy systems, and electric vehicles. The inverter receives DC power from sources such as batteries, solar panels, or rectifiers. A driver circuit controls the switching of the power electronic switches, and it ensures that they operate with the correct timing to produce the desired three-phase AC waveform. Power electronic Switches are typically IGBTs or MOSFETs and they are responsible for switching the DC input to create an AC output.	

	In a three-phase inverter, there are usually six switches arranged in a three-leg configuration, with each leg corresponding to one phase. The output of the inverter is often passed through a filter circuit, usually consisting of inductors and capacitors, to smooth out the waveform and reduce harmonic distortion. Such inverters are used for PV systems above five kilowatts, whereas single-phase inverters are prevailing for systems below that threshold.	
26.	DC converters are used as PV power optimizers to maximize the energy output of shaded or mismatched PV strings. Power optimizers perform maximum power point tracking (MPPT) at the panel level and convert the energy to deliver it efficiently to a string PV inverter. They can be based on buck-boost or hybrid converter topologies, with several types available on the market. Besides panel-level MPPT and efficient energy conversion, they offer advanced functions like panel-level shutdown for safe voltage handling during daylight, and performance monitoring to quickly detect panel failures, degradation, or underperformance.	
27.	The main advantage and purpose of power optimizers is to reduce power mismatch, especially in shaded PV strings. A PV module with a power mismatch can reduce power output for the entire string. There are several reasons that could produce a PV module power mismatch.	

	It could be due to shading or swelling of the panels, to different panel orientations in the same string, to inconsistency in panels quality during the manufacturing process, to the weather and irradiance variability especially in long PV strings or to PV panel failure or uneven degradation of the panels in the same string. For example, if a PV panel and a string is shaded by a nearby tree, the resulting power and current mismatch would limit the power of the whole string, since the panels are all series-connected. In this situation, installing a power optimizer on the shaded panel would allow each module to produce the maximum energy available. This way, the mismatched module does not affect the performance of the rest of the system. Using power optimizer has some drawback. There are additional initial costs of the optimizers. They also introduce some conversion losses that could be greater, if the modules are not mismatched, of the energy losses that they are intended to avoid in case of mismatch. As a last pint you should consider that the more devices you add to your system the more possible failure point exists.	
28.	DC/DC boost converters are often integrated in 3-phases PV inverters for boosting the string voltage to 600 V. DC/DC buck-boost converters are often integrated in both monophase and 3-phases PV inverters for extending their input voltage range such that they are compatible with a large variety of PV string configurations.	

	Both are used for allowing multiple inverter inputs with individual MPPTs	
29.	Type of inverters • Microinverters offer the same advantages as power optimizers with cost savings on the string cabling and plug & play flexibility. • String and multi string inverters are versatile and used in a wide range of PV systems from residential to commercial and utility scale. • Multi string inverters offer some of the system design flexibility of micro inverters but with a lower cost. • Central inverters have a high efficiency and are designed to operate optimally in utility scale PV plants, where shading and string mismatch is minimal. • Standalone inverters are used off grid applications and can form a control the local AC grid. • Grid tie inverters are designed to operated linked to the electrical grid and must meet a series of safety and power quality requirements before they are allowed to connect to the grid.	
30.	Microinverters • Power rating 200-600 VA – single phase • Each PV module has own single phase inverter and MPPT • Same advantages as for power optimizers ○ No string mismatch losses	

	o High modularity – plug & play o Easy module level shutdown o Use of standard AC installation materials this implies reduced costs o No need for string diodes • Disadvantages: o Lower efficiency compared to power optimizers o More difficult to maintain o Higher cost/kWp • PV modules with integrated micro-inverter -> AC modules	
31.	String inverters • Small PV systems with PV strings from 500W to 3 kW are generally built with single string inverters • Only PV modules with same orientation, tilt and freedom from shade should be connected in the same PV string • If the string voltage is high enough then no voltage boosting is required and there is higher efficiency • The string inverters are paralleled and connected to the grid • String inverters facilitate easier installation and reduce installation costs	
32.	Multi-String inverters • Each string has its own converter enabling better MPPT • The strings can have different orientations, tilt, shading or type of module • From a few kW up to 60 kVA • Used in:	

	• Utility PV • Commercial PV • Residential PV • Wide MPP voltage window • Efficiency 94 99% • No string diodes and combiner boxes are required	
33.	Central inverters Used in utility scale PV systems Power rating ~50 kVA 2.5 MVA Input voltages up to 1.5 kV Few MPP trackers Several PV strings connected in parallel High conversion efficiency 98 99 % Active grid support functions --> operate like power plants Disadvantages: • power losses due to common MPPT • power loss due to module mismatches • losses in the string diodes • lower reliability of the whole system single point of failure	
34.	Standalone PV inverters Used in off-grid PV applications to power AC loads Used in conjunction with battery energy storage and external or integrated charge controllers	
35.	Standalone PV inverters	

	To form and control the local grid voltage (230 V/ 50 Hz) Can be used in conjunction with normal grid tie inverters Features: • High efficiency in partial load range • The capacity to deliver high starting currents for short duration (motor startup) • Economical standby with automatic load detection • Short-circuit and voltage surge protection • Low harmonic distortion and EMI • Bidirectional operation DC/AC and AC/DC	
36.	Grid -tied PV inverters The PV inverter is linked to the mains electricity grid directly or via the buildings grid. Inverters up to 5 kWp are usually single phase, above 5 kWp a three-phase grid connection is required. Functions and requirements: • Synchronize with the grid voltage amplitude, phase and frequency • Automatic startup and synchronization in the presence of sufficient insolation • Automatic shutdown in the absence of sufficient insolation • Startup and operation only if the grid is operational • Immediate shutdown in the event of a power failure to avoid stand-alone operation • Power surge protection on AC and DC side • Prevent DC current injection into the grid • Low harmonic distortion compliant with national grid	

	regulations • Low EMI on AC and DC side should not interfere with household electronics • Low open circuit loss and low minimum startup and shut down power • Minimum power consumption during nighttime • High level of reliability (15 20 years)	

4.6 The efficiency of Power converters - 646 words – 4' 20"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
1.	The section explains how the conversion efficiency of a power converter is computed and is influenced by various losses. Maximum Power Point (MPP) tracking efficiency is crucial for photovoltaic (PV) systems, and both static MPP tracking and dynamic MPP tracking are described. The section ends explaining how weighted efficiencies can provide a more realistic performance measure over different conditions and locations.	
2.	The conversion efficiency of a power converter is defined as the ratio between the output power and input power and is limited by the different losses occurring in the converter. The conversion efficiency is load dependent and varies between inverter models/types/manufacturers. Converter efficiency curves are usually reported relative to the nominal power	

3.	Losses in a converter • Inductor, capacitor and wire losses • Switch conduction losses • Switch turn on turn off losses • Body diode losses • Transformer losses • Control circuit power consumption	
4.	The graph shows the efficiency curve of various solar inverters, plotted against the percentage of maximum output power. For example, the conversion efficiency of different commercial PV inverters can vary significantly between manufacturers, inverter types, as well as the inverter load. Moreover, some PV inverters also have a significant input voltage dependency of the power conversion efficiency. Some loss mechanisms are temperature dependent as well, lowering the conversion efficiency at higher operating temperatures. In general, PV converters are designed and dimensioned to operate with the highest efficiency at the nominal input power and voltage. Whereas they will have a lower conversion efficiency they're operated under lower loads or input voltages.	
5.	Maximum Power Point (MPP) tracking efficiency is crucial for optimizing the performance of photovoltaic (PV) systems. Static MPP tracking efficiency refers to the efficiency of the MPP tracker under steady-state conditions, where the environmental conditions (such as irradiance and temperature) remain constant.	

	Under static conditions, the MPP tracker can achieve high efficiency because it has ample time to adjust and find the optimal operating point. Typically, the efficiency deviation under static conditions is minimal, as low as 0.02%. When irradiance varies smoothly over time, static MPP tracking system can achieve high efficiency	
6.	Dynamic MPP tracking efficiency refers to the efficiency of the MPP tracker under changing environmental conditions, such as fluctuating irradiance and temperature. Under dynamic conditions, the MPP tracker must quickly adapt to changes, which can lead to lower efficiency compared to static conditions. The efficiency deviation under dynamic conditions is generally higher than static MPP tracking efficiency due to the rapid changes and can be around 0.13% Static MPP tracking is more stable and efficient due to constant conditions, while dynamic MPP tracking requires rapid adjustments, leading to potential efficiency losses. On the other side, dynamic MPP tracking is more complex and challenging to implement effectively due to the need for quick response to changing conditions. When irradiance changes rapidly, for instance due to fast moving clouds, MPP tracker must adapt rapidly, and this leads to lower efficiency than static MPP tracking	
7.	The total converter efficiency is calculated as product of the MPPT and the conversion efficiency.	

	The peak efficiency is usually located in the partial load range of 50% 80% of nominal power	
8.	• Solar irradiation changes over the day • Inverter may only operate in its peak efficiency range for a very small part of the day or not at all • Weighted efficiencies offer an indication of how an inverter might perform throughout the day and year at different locations The weighted efficiency gives a more realistic picture of the inverter performance for a specific location or climate	
9.	• The "European Efficiency" is an averaged operating efficiency over a yearly power distribution corresponding to middle Europe climate. • This was proposed by the Joint Research Center (JRC/ Ispra), based on the Ispra climate (Italy), and is now referenced on almost any inverter datasheet. • The value of this weighted efficiency is obtained by assigning a percentage of time the inverter resides in a given operating range	

Module 5 – Balance of System

The following table offers a concise outline of the general characteristics of the Introduction section:

Duration	12’ 50’’
Characters	Narrator
Notes	Introduces the Balance of System (BOS) components, explains electrical and mechanical elements like wiring, switches, inverters, mounting systems, and discusses safety, insulation, and environmental issues.

The following table contains a synthesis of the segments in which the Introduction section is organised.

Segment	Title	Word count	Expected Duration
5.1	Learning objectives	101	40 sec.
5.2	Introduction to Balance of System	309	2 m.
5.3	Electrical Balance of System	557	3 m. 40 sec.
5.4	Mechanical Balance of System	964	6 m. 25 sec.

A detailed description of the content of the individual segments is available in the tables of the following pages.

5.1 Learning Objectives – 101 words – 40''

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
22.	In this section you will • Understand the concept and components of the Balance of System (BOS) for a photovoltaic (PV) plant. • Analyze the cost implications of BOS components in PV plant installations. • Understand the electrical components and safety measures of a PV plant: • Assess the environmental and operational challenges for PV plant components and the importance of proper insulation and mounting to ensure long-term reliability. • Understand the mechanical Balance of System (BOS) requirements for PV panels • Analyze the environmental and operational challenges for PV plant components, and understanding the importance of using appropriate materials and design considerations to mitigate these challenges	

5.2 Introduction to Balance of System– 309 words – 2'

ScreenTitle	Audio Narration	Media Files / Visual Instructions

/Number		/Developer Notes
36.	This section introduces the concept of Balance of System (BOS) for a photovoltaic (PV) plant.	
37.	The Balance of System (BOS) for a photovoltaic (PV) plant includes all the components of the PV system except for the photovoltaic panels themselves. These components are essential for the operation and integration of the PV panels into either a grid-tied or off-grid system. The PV modules generate energy, and the remaining components support energy production and transport of the energy to the consumer. Therefore, everything that is not the PV modules is called the balance of systems, abbreviated BOS. The BOS can be divided into hard BOS - the hardware that concur to energy distribution - and soft BOS that contains the cost of all the labor involved in creating a plant.	
38.	The hard BOS typically includes: • Wiring Electrical cables that connect the PV panels to other components. • Switches Devices to control the flow of electricity. • Mounting System Structures to support and secure the PV panels. • Solar Inverters Devices that convert the direct current (DC) generated by the PV panels into alternating current (AC) used by most electrical devices. • Battery Bank and Battery Charger	

	For storing and managing energy in off-grid systems. • Protection Devices Such as fuses and circuit breakers to ensure safety.	
39.	• Monitoring and Control Systems To optimize the performance and efficiency of the PV system • The cost of all the labor involved in creating a plant	
40.	The graph, taken from the International Technology Roadmap for Photovoltaics (ITRPV) 2020 report, shows a clear trend: the BOS component constituents will amount to 25-30 percent of the total plant cost for utility scale installations. For residential and commercial systems, the share might actually even be higher. The BOS hardware costs are almost the same as the cost of PV modules themself and therefore, acting on the BOS offers a great saving potential.	

5.3 Electrical Balance of System – 557 Words – 3' 40''

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
22.	This section discusses the electrical components of a PV plant set aside the panels themselves. It highlights the need of using appropriate cables and connectors, and outlines key safety measures such as overvoltage protection, grounding, and DC breakers for maintenance and fault management, as well as to prevent electrical hazards.	

23.	Safe operation of PV panels requires that the current carrying conductors are properly insulated, preventing electrical shocks, leakage currents and electrical arcs. Further, the system needs to have protective means for overvoltages and currents. Similarly, the panel needs to stay in the mounting position despite wind loads, snow loads, and other weather phenomena. These requirements apply for the full lifespan of the plant, which is 25-30 years in the outdoor conditions while UV light from the sun degrades all the polymers and the chemical environment can cause corrosion of the mounting structures. and temperature and humidity cycles pose other environmental stress factors.	
24.	The drawing shows a plant that covers an area of about 500 m x 100 m. The plant has a peak capacity of 1.7 megawatts corresponding to somewhere between 5.5 and 6000 PV panels. All the blue rectangles are single axis trackers, with PV strings on them. Each rectangle has a length of around 40-50 meters, and they are arranged in two rows. The transformer is in the middle, which is the point of grid connection, where the outputs of all the inverters need to be collected to feed power to the grid. A lot of power needs to be connected over a large area, requiring kilometers of cables with a high cross-section which can either be AC or DC depending on the choice of inverters. PV cables need to conduct high currents in an outside environment over fairly long distances and other electrical	

	components of the plant must resist sunlight, rain and humidity, as well as heat.	
25.	The PV cables are made with double insulated cable jacket and can sustain test voltages up to more than 10 kilovolts. They are UV protected, heat resistant up to 100 °C and they are flame retardant but free of halogens to avoid release of toxic fumes in case of fire. For a given installation, it is important to use the right cable cross-section. Guidance can be found in VDE 0100-712 which states that the total cable DC loss should be less than one percent at rated load.	
26.	Industry standardized connectors are readily available that comply with various standards and are cleverly designed to prevent hidden conductors from touching and to prevent wrong connections as well. For DC the MC-4 is (almost) de-facto standard, while for AC there are multiple connectors available.	By Multi-Contact AG - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=23953040
27.	Strings and / or arrays connections are assembled in combiner boxes, which could range from very simple, for residential applications, to sturdy elements full weather-proof. Advanced combiner boxes can also include some electronics for remote monitoring of plant sections.	
28.	There are three important safety measures.	

	The first is overvoltage protection often done by varistors, which resistance decreases with higher voltages, and therefore they conduct the current to the ground. Grounding the structures and frames is a second but very relevant safety measure often done to avoid electrical shock hazards. Finally, DC breakers are required and used in the case of ground faults and for maintenance. For string inverters, DC disconnects are integrated into the inverter.	

5.4 Mechanical Balance of System - 964 words – 6' 25"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
30.	This section outlines the mechanical Balance of System (BOS) requirements for photovoltaic (PV) panels, emphasizing the need for secure mounting to ensure safe and reliable operation over the plant's lifespan. It discusses the impact of static and dynamic forces, such as wind and snow loads, on the stability of PV structures.	
31.	The requirement for the mechanical BOS is to ensure that the panels stay in place for their intended lifetime, thus enabling the plant to operate safely, reliably and continuously. On the panels and structures act static and dynamic forces that must be counterbalanced in order to achieve stability. The panel mounting must not damage the panels and also environmental degradation, such as the corrosion of the metal	

	structures, UV degradation of the polymeric materials must be addressed. BOS is a third or even more of the plant costs and any savings on the structures and work procedures are greatly appreciated.	
32.	The forces acting on the panels and the structures can be divided into static and dynamic forces. The static forces are the weight of the panels and the mounting structures. The dynamic forces acting on the installations are wind loads and snow loads. Both of these loads are strongly dependent on wind speeds and shape factors. Snow loads are only of relevance in areas with snowfall. The weight of the PV panels is mostly determined by the weight of the glass and therefore it's easy to estimate this load. For glass back sheet panels, the load is approximately 10-12 kilos per square meter, or 17-20 kilos per 60 cells module. For glass-glass modules like bifacial modules and thin-film modules, this weight is increased up to 20 kilos per square meter. In addition to the weight of the panels themselves comes the weight of the mounting structures. The module clamps, the rails and the rail hooks are generally not contributing with any significant weight. If substructures for the module rails are needed, these can play a role.	http://svpowersolution.com/structures.html

	For a flat roof ballast systems are often used, and the weight of the ballast is significant.	
33.	For most buildings, the weight of solar panels and mounting structures is not a challenging addition for the load capabilities of the construction. However, industrial buildings like agricultural barns and stables, warehouses, and similar can be so cost optimized that the additional weight should be carefully evaluated with the help of static structure's engineers.	
34.	Wind loads are another significant challenge to PV structures. It's important to be aware that PV panels with flat-plate structures are big sails with a significant area and behave like air foils. When the wind is passing by a freestanding panel, the flow pattern could generate a pressure difference which results in an upward force. If the mounting structures and fixing methods are not strong enough, the panels can simply fly away. In general, the forces are proportional to the square of the wind velocity, the area, and are dependent on the wind direction relative to the panels and therefore also the tilt of the panels.	
35.	Snow and associated loads are also important to consider in areas where snow falls occur. Snow will fall on the panels and the tilt angle, combined with partial melting creates uneven distributions of loads. Lastly, snowdrift with a combination of just moderate winds enable the snow to pile up behind the wind obstacles, such as	https://blog.s-5.com/blog/how-to-protect-your-solar-panels-and-your-roof-in-snowy-weather

	freestanding racks that are great obstacles enabling snow pilling. PV modules are at least made for snow loads of 2400 pascals corresponding to 240 kilos per square meter and it is recommended to use modules with snow nodes rating of 5400 Pascals per square meter in snow prone regions.	
36.	The snow load is very location-dependent and for Europe, the snow load dimensioning is described in the Eurocode 1. For Italy for instance the reference norm is UNI EN 1991-1-3/AN that divides the country into three zones, with different snow loads. You can find more information on the website on Eurocodes tools.	https://eurocodes-tools.com/en/zone-snow-wind-seism-explanations/
37.	The polymeric materials used for boxes and wires are exposed to outdoor conditions and must be UV resistant. The metals are exposed to corrosion, which could be of two kinds: ordinary corrosion and galvanic corrosion. Materials such as aluminum or even better anodized aluminum and stainless steel are corrosion resistant and could last for the whole plant life, 20 to 25 years. Corrosion of galvanized steel and standard aluminum is faster in salty and marine environments. Galvanic corrosion is an electrochemical corrosion that happens when two dissimilar metals are joined. The two metals will have the same surface potential and the least noble will corrode. The so-called galvanic series lets you define which metals are prone to galvanic corrosion. One particular	

	bad combination is the contact between aluminum and stainless steel that will result in the corrosion of aluminum. Therefore, all contacts between stainless steel and aluminum should be electrically insulated. Thermal expansion and namely differences in expansion for different materials, can cause mechanical stresses on structure. Therefore, relief for thermal expansion needs to be adopted in design and construction of structures.	
38.	The modules can be attached to rails with the help of so-called module clamps. The rail contains a rail where a nut allows a screw via the module clamps to press the module down to the rail. For freestanding structures, rails are mounted directly on a construction supporting the rail, and this construction defines modules' tilt and orientation.	
39.	On sloped roofs, the rails are mounted on hooks attached to the rafters and each roof type has a roof hook matching the roof type. The amount of roof hooks per meter is determined by the load calculations. On slope roofs, the slope makes the water run away, but on flat roofs water penetration could become a challenge and require specific precautions.	

Module 6 – Photovoltaic Panels installation

The following table offers a concise outline of the general characteristics of the Introduction section:

Duration	14’ 25’’
Characters	Narrator
Notes	Details safety precautions, unpacking and storage procedures, module installation, wiring and grounding methods, mounting requirements, and maintenance practices to ensure safe and efficient PV system operation.

The following table contains a synthesis of the segments in which the Introduction section is organised.

Segment	Title	Word count	Expected Duration
6.1	Learning objectives	45	20 sec.
6.2	Safety Precautions	310	2 m.
6.3	Unpacking and storage	267	1 m. 45 sec.
6.4	Module installation	545	3 m. 40 sec.
6.5	Wiring and grounding	569	3 m. 45 sec.
6.6	Module mounting	279	1 m. 50 sec.
6.7	Maintenance and cleaning	169	1 m. 05 sec.

A detailed description of the content of the individual segments is available in the tables of the following pages.

6.1 Learning Objectives – 45 words – 20''

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
23.	In this section you will get acquainted with: • Safety precautions for installation • Unpacking and storage of panels • General information on how to install modules • How to make electrical connections and ground modules • Some mounting instructions • How to keep panels efficient by properly maintenance and cleaning	

6.2 Safety Precautions – 310 words – 2'

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
41.	This section describes safety precautions during installation.	
42.	Only licensed personnel can install PV modules. All modules must be installed by licensed electricians in accordance with the applicable electrical either national or international. Do not allow children or unauthorized persons near the installation site or module storage area.	

43.	Before attempting to install, wire, operate and/or service the module and other electrical equipment, all instructions should be read and understood. PV module connectors pass direct current (DC) when exposed to sunlight or other light sources. Contact with electrically active parts of the module, such as terminals, can result in injury or death, irrespective of whether or not the module and the other electrical equipment have been connected. Electrical Shock Risk even if the module is disconnected.	
44.	If the disconnects and over current protection devices (OCPDs) cannot be opened or the inverter cannot be powered down, cover the fronts of the modules in the PV array with an opaque material to stop the production of electricity when installing or working on a module or wiring.	
45.	Protective clothing (non-slip gloves, clothes, etc.) must be worn during installation to prevent direct contact with 30 V DC or greater, and to protect hands from sharp edges. Use electrically insulated tools to reduce the risk of electric shock.	
46.	Prior to installation, remove all metallic jewelry to prevent accidental exposure to live circuits.	
47.	When installing modules in light rain, morning dew, take appropriate measures to prevent water ingress into the connector. Also, do not install modules in strong wind. Keep the junction box cover closed at all times.	

48.	Do not use or install damaged modules. Contact with module surfaces or frames may cause electric shock if the front glass is broken or the backsheet is torn. The PV module does not contain any serviceable parts. Do not attempt to disassemble, repair or remove any part of the module.	

6.3 Unpacking and Storage– 267 Words – 1’ 45’’

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
29.	This section describes how to unpack panels and how to properly store them.	
30.	Modules should be stored in a dry and ventilated environment to avoid direct sunlight and moisture. If modules are stored in an uncontrolled environment, the storage time should be less than 3 months and extra precautions should be taken to prevent connectors from being exposed to moisture or sunlight, like using connector endcaps.	
31.	Unpack module pallets carefully, following the steps shown on the pallet. Unpack, transport and store the modules with care. Modules must always be unpacked and installed by two or three people. Always use both hands when handling modules.	

	During unpacking, the unpacked modules should be properly fixed. Do not lift modules by their wires or junction box, lift them by the frame.	
32.	When unpacking, the unpacked modules must be positioned so that they do not get damaged. After unpacking, it is recommended to place the remaining modules in the pallet shall be placed horizontally.	
33.	Do not allow the panels to sag or bow under their own weight when being carried. Stack modules with frames aligned, Stacks of modules should contain no more than 12 modules, and the frames should be aligned. Do not place excessive loads on the module or twist the module frame.	
34.	Localized heavy loads may cause severe microcracks at cell level, which in turn may compromise module reliability. Be careful not to stand, step or walk on modules and do not drop or place heavy objects, such as tools, on the modules. Avoid module backsheets being damaged by sharp objects, as scratches may directly affect product safety.	

6.4 Module installation- 545 words – 3’ 40''

ScreenTitle	Audio Narration	Media Files / Visual Instructions

/Number		/Developer Notes
40.	This section deals with physical installation of PV modules.	
41.	Prior to installing modules, please obtain information about any requirements and necessary approvals for the site, installation and inspection from the relevant authorities. Check applicable building codes to ensure that the construction or structure can bear the module system load.	
42.	Modules can be wired in series to increase voltage or in parallel to increase current.	
43.	To connect modules in series, connect the cables from the positive terminal of one module to the negative terminal of the next module.	
44.	To connect in parallel, connect the cables from the positive terminal of one module to the positive terminal on the next module.	
45.	The quantity of bypass diodes in the module's junction box provided may vary depending on the model series. Only connect the quantity of modules that corresponds to the voltage specifications of the inverters used in the system. Modules must not be connected together to create a voltage higher than the maximum permitted system voltage stated on the module nameplate, even under the worst local temperature conditions (check panel documentation for the correction coefficients that apply to open-circuit voltage).	

46.	Three or more strings can be connected in parallel if an appropriate and certified over-current protection device (fuses, etc.) is installed in series within each string. The PV system design must ensure that the reverse current of any particular string is lower than the module maximum fuse rating at any circumstances. Only modules with similar electrical parameters should be connected in the same string to avoid or minimize mismatch effects in arrays.	
47.	Modules should be safely fixed to bear all expected loads, including wind and snow loads. A minimum clearance of 7 mm between modules is required to allow for thermal expansion of the frames. The drainage holes on the underside of the module must not be blocked.	
48.	To maximize the annual yield, please calculate the optimum orientation and tilt for PV modules in that specific installation site. The highest yields are achieved when sunlight shines perpendicularly onto the PV modules.	
49.	Modules shall not be permanently shaded under any circumstance. Permanent shading includes shading of the same cell, cell row, or module portion for extended and repeated periods of time.	

	Power dissipated in fully or partially shaded cells will result in power loss, reduced yield and can cause localized overheating, which in turn may negatively impact the module service lifetime.	
50.	Do not install modules directly behind any object (e.g., tree, antenna, etc) to prevent occurrence of permanent shading. Permanent shading may cause accelerated ageing of the encapsulation material and place thermal stress on the bypass diodes. It can be mitigated through the use of Module Level Power Electronic (MLPE) devices. Even temporary partial shading will reduce the energy yield. A module can be considered to be unshaded if its entire surface is free from shading all year round, including on the shortest day of the year.	
51.	Regular maintenance is required to keep modules clean. Particular measures should be taken to avoid permanent shading from dirt or debris (e.g., plants, bird droppings, etc).	
52.	Sufficient clearance (at least 100 mm) between the module frame and the mounting surface is required to allow cooling air to circulate around the back of the module. This also allows condensation or moisture to dissipate.	

6.5 Wiring and grounding- 569 words – 3’ 45''

ScreenTitle	Audio Narration	Media Files / Visual Instructions

/Number		/Developer Notes
1.	The section describes electrical installation of PV panels.	
2.	Wiring is strongly device specific. The information in this module is intended as an example – please refer to your panels' documentation for details.	
3.	Ensure that the wiring is correct before starting up the system. If the measured open circuit voltage (Voc) and short-circuit current (Isc) differ from the specifications, this indicates that there is a wiring fault.	
4.	When modules have been installed but the system has not been connected to the grid yet, each module string should be kept under open-circuit conditions and proper actions should be taken to avoid dust and moisture penetration inside the connectors.	
5.	The picture shows some examples of cable connection between modules: • Portrait two rows installation Adjacent two modules (up and down) need to be rotated 180 degrees • Portrait one row installation • Landscape installation Adjacent two modules (left to right) need to be rotated 180 degrees	
6.	Connectors are not waterproof when unmated. When installing modules, connectors should be connected to each other as soon as possible or connector endcaps should be used to	

	prevent damage from moisture and dust entering the connector. Do not connect different connectors (manufacturer and type) together. No lubricant or other chemical is required on connectors. End caps, if present on un-mated connectors, can be removed by hand. Do not use sharp tools that could damage the connector.	
7.	Use dedicated solar cable that is sunlight-resistant and suitable connectors. Be sure that all wiring is in perfect electrical and mechanical condition. Select a suitable conductor gauge to minimize voltage drop and ensure that the conductor current carrying capacity complies with local regulations.	
8.	Secure the cables to the mounting system using UV-resistant cable ties and protect exposed cables from damage by placing them inside plastic or metallic conduits. Protect exposed connectors from weathering damage by using appropriate protections and avoid exposure to direct sunlight. Do not place connectors in locations where water could easily accumulate.	
9.	Solar panels typically use an anodized aluminum frame to resist corrosion and therefore it is necessary to connect the	

	frame to the grounding conductor to prevent discharges and electrical shocks. The grounding device should be in full contact with the metal frame and should penetrate the oxidized surface layer of the frame.	
10.	The grounding device should be in full contact with the metal frame and should penetrate the oxidized surface layer of the frame. Modules often have pre-drilled holes and marked with the grounding symbol. These holes should be used for grounding only and not for mounting modules. Do not drill additional grounding holes into the module frame; manufacturers often claim that doing so will void the warranty.	
11.	To avoid galvanic corrosion, the grounding contact must not involve the use of metals capable of generating electrochemical potentials. IEC 60950-1 recommends that metal combinations do not generate an electrochemical potential difference greater than 0.6 Volts. All bolts, nuts, flat washers, lock washers and other relevant hardware should be made of stainless steel, which develops a potential of only 0.4 V with aluminum.	
12.	Place the wire between the flat washer and the cup washer. Ensure that the cup washer is positioned between the frame and the wire with the concave side up to prevent galvanic corrosion. Tighten the bolt securely using the SS toothed nut. A wrench may be used to do this.	

13.	The grounding lugs are designed to fit alum rails and are common components for bonding and earthing system.	

6.6 Module mounting- 279 words – 1' 50"

ScreenTitle /Number	Audio Narration	Media Files / Visual Instructions /Developer Notes
1.	This section describes mechanical mounting of PV panels on the supporting structure.	
2.	Standard PV modules can be mounted onto a support structure using one of several approved methods as described by the manufacturer. For detailed information about installation methods, please refer to PV modules documentation. The information here supplied is for general reference only. Use appropriate corrosion-proof fastening materials. All mounting hardware (bolts, spring washers, flat washers, nuts) should be hot dip galvanized or stainless steel. To fasten nuts and bolts use a torque wrench and do not drill additional holes or modify the module frame.	
3.	In areas with heavy snowfall further countermeasures such as the use of additional support bars should be considered to avoid snow loads damaging the lowest row of modules.	
4.	Use the mounting holes in the rear frame flanges only to bolt modules to supporting structures.	

	Each module must be securely fastened at a minimum of 4 points on two opposite sides. Use additional mounting points in areas with heavy wind load. The picture shows as an example the bolting holes position on the module frame.	
5.	Clamping methods will vary and are dependent on the mounting structures. Each module must be securely fastened at a minimum of four points on two opposite sides and the clamps should be positioned symmetrically.	
6.	Pay attention not to bend the module frame or touch or cast shadows on the front glass. Do not damage the surface of the frame and ensure adequate overlapping of clamps on the module frame both in depth and length. The picture shows as an example the position of four clamps on long side of frame and rails perpendicularly to the long side frame	

6.7 Maintenance and cleaning- 169 words – 1’ 05''

ScreenTitle /Number	Audio Narration	On screen text	Media Files / Visual Instructions /Developer Notes
1.	This section describes the maintenance and cleaning procedures to be performed after installation to ensure proper operation of PV panels over time.		

2.	Regular maintenance is required to keep modules in the best operating conditions. Periodically inspect the system to check the integrity of all wiring and supports. To protect against electric shock or injury, electrical or mechanical inspections and maintenance should be performed by qualified personnel only.		
3.	Regular cleaning is required to keep modules clear of snow, bird droppings, seeds, pollen, leaves, branches, dirt spots, and dust. Modules with at least 15° tilt generally may not require cleaning (rain will have a self-cleaning effect).		
4.	Noticeable dirt must be rubbed away using soft cloth, sponge or brush with soft bristles. If the module has become soiled, wash with water and a non-abrasive cleaning implement (sponge) during the cool part of the day. Do not scrape or rub dry dirt away, as this may cause micro scratches.		
5.	Do not scrape or rub dry dirt away, as this may cause micro scratches.		

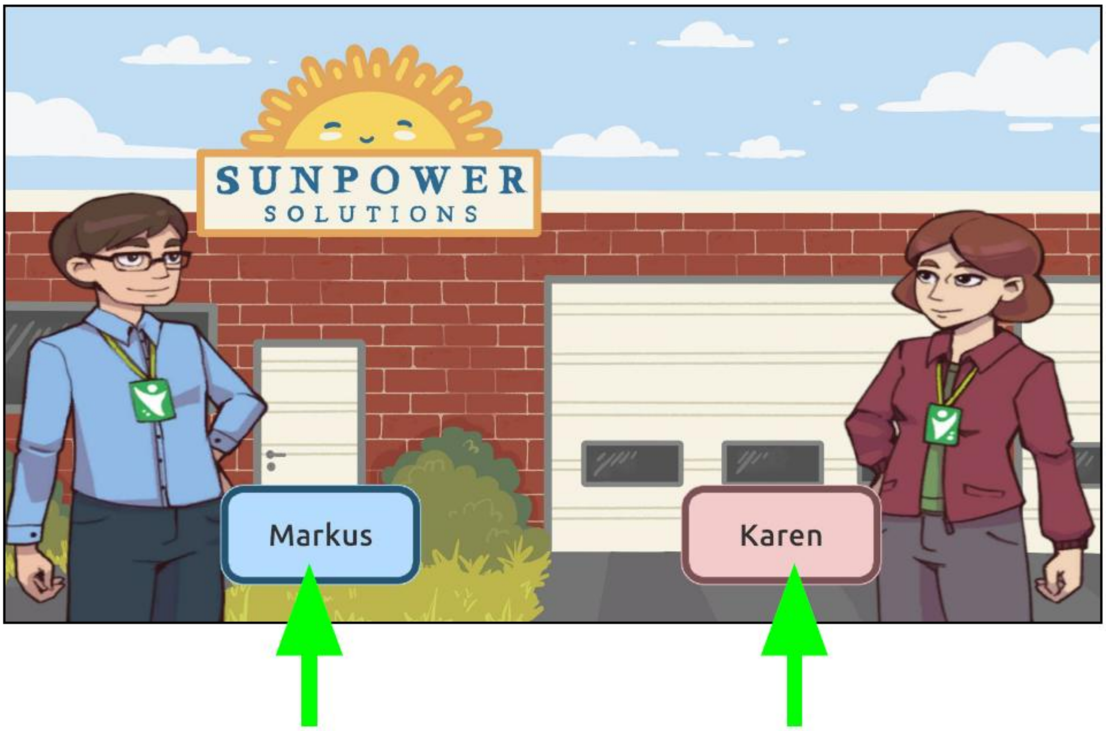
Solar Panel Installation RPG

Solar Panel Installation RPG is an interactive, browser-based serious game designed to train learners in the essential steps of photovoltaic (PV) panel installation. Through a gamified role-playing experience, users take on the role of a technician completing a real-world solar installation task—from selecting tools and components to ensuring worker safety, navigating to the site, and performing the step-by-step installation. Guided by a mentor character and enriched with embedded knowledge cards, the game blends simulation, decision-making, and technical accuracy to reinforce learning outcomes in an engaging and accessible format.

Scene	Title	Learning Objective / Purpose	User Interaction / Gameplay	Media / Visuals	Notes for Developers
0	Start & Character Selection	Introduce the scenario, let user choose avatar.	Player chooses between two characters. One becomes mentor throughout the game.	Intro screen, clickable character portraits	Choice is cosmetic; mentor gives feedback during gameplay.
1	The Daily Worksheet	Present the mission: install PV panels at a building site.	Player clicks to review and accept the task.	Office desk, task sheet popup	First instructional touchpoint – defines game goals.
2	Storehouse – Tools	Identify and collect the correct tools for PV panel installation.	Drag-and-drop correct tools into toolbox.	Shelves of tools, checklist notebook	Feedback on correct/incorrect selections.
2.5	Storehouse – Components	Identify and collect correct PV components.	Drag-and-drop items like PV panels, inverter, wiring into component list.	Visuals of components, notebook UI	Tooltips available on hover/click.
3	Ready? Go!	Ensure team readiness and safety compliance.	Player clicks on improperly dressed workers to correct safety violations.	Worker avatars with missing gear	Correct selections unlock next stage.
4	On the Road	Introduce route selection and decision-making.	Choose one of three travel routes to job site (city route, scenic route, fast route).	Simple top-down city map	May affect time or minor outcomes, purely illustrative.
5	Installation Site Settings	Familiarize with the job site and select setup locations.	Click through roof inspection points (antenna, structure, access) to prepare installation.	Rooftop environment, checklist UI	Must find all 4 correct points to continue.
6	On the Roof	Verify safety and readiness	Interactive roof inspection with	3D environment	Reinforces safe workspace setup.

		before starting installation.	clickable elements.	or photo overlay	
7	Installation (Steps 1–6)	Simulate PV module installation in correct sequence.	Drag-and-drop or guided click-through of installation steps: mount, wire, ground, check.	Module, rails, tools, wiring diagram	Visual guidance needed at each step; match real installation best practices.
8	Final Steps	Review work, ensure client satisfaction, and wrap up installation.	Clean area, check system status, confirm with client.	Clean tools, checklist animation, smiling client	Ends the session and may link to feedback or quiz.
–	Information Cards	Provide extra knowledge on safety, tools, components, and procedures throughout the game.	Cards unlocked automatically at each relevant stage, accessible via notebook icon.	Illustrated flashcards or popups	Non-blocking; enriches learner understanding.

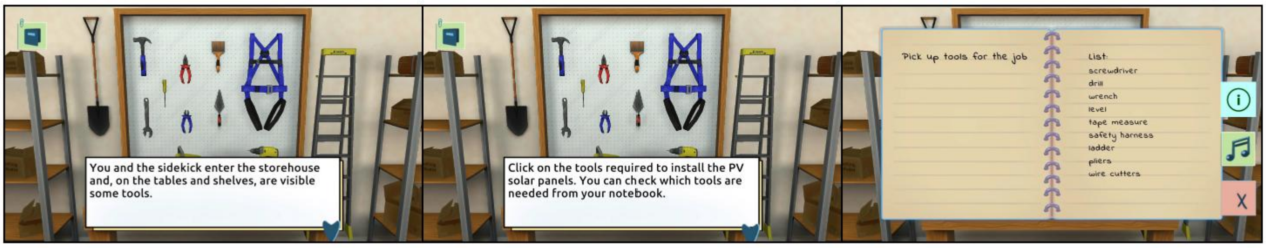
Screenshots from the mobile game



Choose your player Markus/Karen.
(The choice is purely cosmetic and does not affect gameplay content.)

Scene 1: The Daily Worksheet

Player is given the task for the day.



Open notebook

Info cards

Volume slider

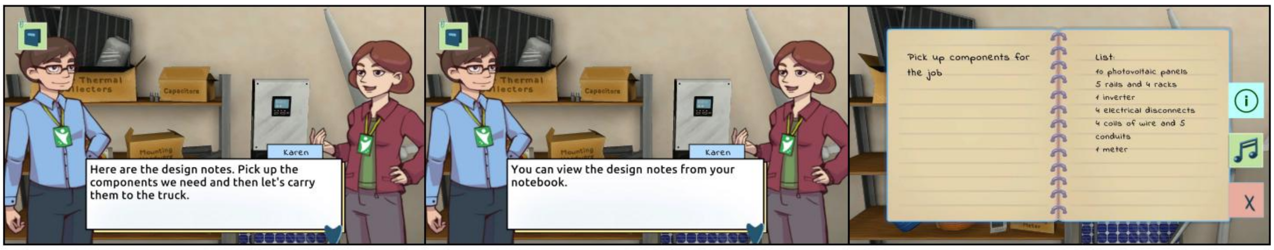
Close notebook

Scene 2: Storehouse - Tools

Collect tools needed for installing PV solar panels.

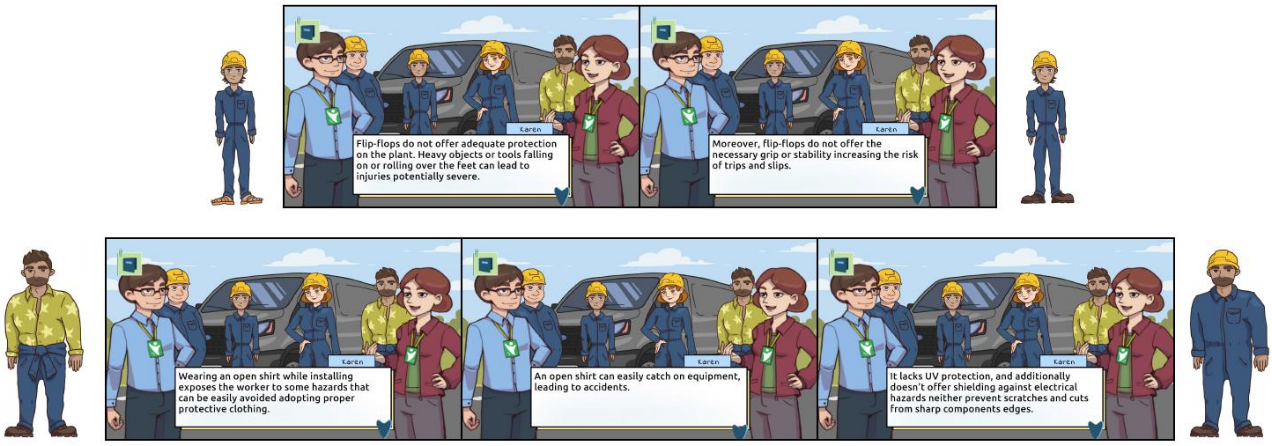
Scene 2: Storehouse - Tools

Tool information



Scene 2.5: Storehouse - Components

Collect components needed for installing PV solar panels.



Scene 3: Ready? Go!

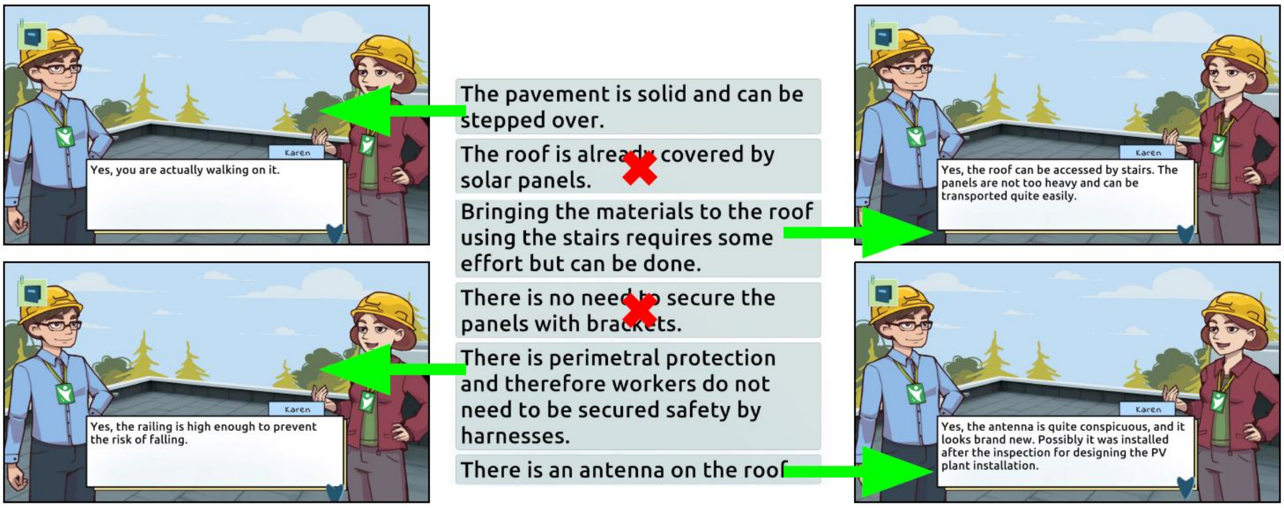
Explanations

Scene 4: On the road!

Choose which path to take to the ACME office

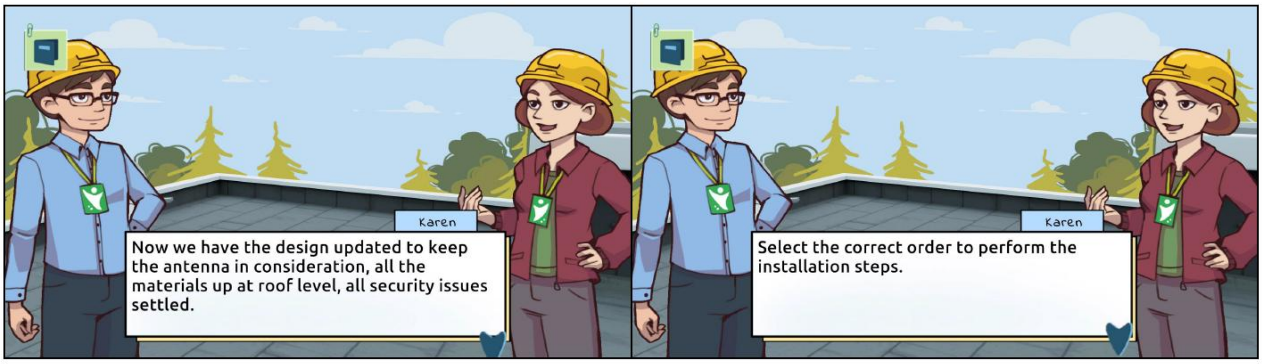
Scene 5: Installation site settings

You have arrived at the ACME office



Scene 6: On the roof

Choose all 4 correct options to continue

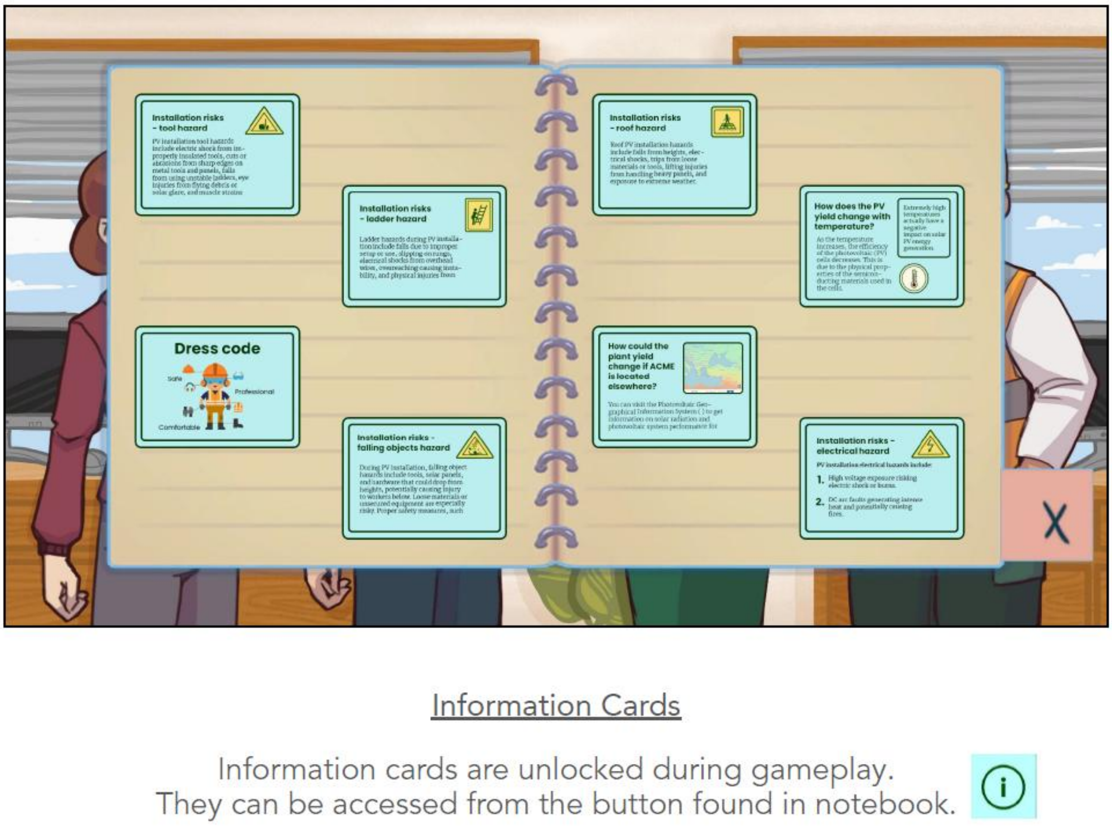


Scene 7: Installation

Choosing the right installation order

Scene 8: Final steps

Clean the installation site, secure the wiring and ensure client satisfaction.



Module 7 – Final Assessment

The following table offers a concise outline of the general characteristics of the Introduction section:

Duration	Max 80 min
Characters	Narrator
Notes	Introduces and explains the structure of the final assessment, which covers all course modules through multiple-choice questions and knowledge checks, and provides feedback and completion criteria.

The following table contains a synthesis of the segments in which the Introduction section is organised.

Segment	Title	Word count	Expected Duration
7.1	Introduction	233	1 m. 45 sec.
7.2	Knowledge Check PV Fundamentals	/	8 questions
7.3	Knowledge Check Theory	/	10 questions
7.4	Knowledge Check Power Electronics	/	8 questions.

7.5	Knowledge Check Balance of System	/	5 questions
7.6	Knowledge Check Installation	/	5 questions
7.7	Assessment Results	242	1 m. 30 sec.
7.8	Course Completion	77	30 sec.

A detailed description of the content of the individual segments is available in the tables of the following pages.

7.1 Introduction – 233 words – 1’ 45’’

#	Audio Narration	
1.	Welcome to the final assessment of the Photovoltaic Panel course. This assessment is designed to evaluate your understanding and grasp of the key concepts, methodologies, and practical applications that we have explored throughout the course. The assessment consists of 10 multiple-choice questions, encompassing all the topics covered in the course. These questions are structured to test your knowledge in various areas covered by the course. As you answer these questions, remember to reflect on the comprehensive lessons, case studies, and discussions we've engaged in during our sessions. This is an opportunity to demonstrate your learning and the insights you've gained.	
2.	Please note the following guidelines for the assessment: • There are questions with only one correct answer and others with multiple correct answers. You can detect which one from the buttons' shape: round for the firsts and square for the latter. • Read each question carefully before selecting your response. • There is no negative marking for single choice question. • Questions with multiple correct answers have a penalty for each wrong answer, but the overall minimum score for the question is zero. • The assessment is timed, and you will have a total of 30 minutes to complete it. We wish you the best of luck and look forward to your successful completion of this course.	

7.2 Knowledge Check – PV Fundamentals - 8 questions

#	Questions	Answers
1.	What is the unit of measurement for energy in the International System of Units (SI)? A) Erg B) Calorie C) Joule D) Watt	Correct Answer C
2.	Which of the following units is used to measure the power output of very large power plants? A) Kilowatt B) Megawatt C) Gigawatt D) Watt	Correct Answer C
3.	What is the typical efficiency range for commercial photovoltaic solar panels? A) 10% - 15% B) 15% - 20% C) 20% - 25% D) 25% - 30%	Correct Answer B
4.	What is the purpose of an inverter in a photovoltaic system? A) To store energy B) To convert AC to DC C) To convert DC to AC D) To measure energy output	Correct Answer C
5.	What event in 1973 sparked an interest in alternative sources of energy, including photovoltaics? A) The launch of Vanguard 1 B) The development of quantum mechanics C) The oil crisis D) The invention of the silicon solar cell	Correct Answer C
6.	What was the efficiency of the first solar module built by Charles Fritts?	Correct Answer A

	A) 1% B) 6% C) 10% D) 20%	
7.	By what percentage has the price of solar modules declined since 1976? A) 50% B) 75% C) 90% D) 99.6%	Correct Answer D
8.	What law describes the consistent rate at which technology gets cheaper as cumulative production increases? A) Moore's Law B) Wright's Law C) Newton's Law D) Ohm's Law	Correct Answer B

7.3 Knowledge Check – Theory – 10 questions

#	Question	Correct Answer
1.	What is the estimated solar energy potential on Earth compared to our current energy demand? A) 100 times B) 500 times C) 1000 times D) 2000 times	Correct Answer: C
2.	What percentage of solar energy actually reaches the Earth's surface with a clear sky? A) 50% B) 60% C) 75% D) 90%	Correct Answer: C
3.	What is the peak wavelength of the Sun's emission spectrum, corresponding to the radiation we perceive as green light?	Correct Answer B

	A) 400 nm B) 502 nm C) 600 nm D) 700 nm	
4.	What is the primary driver of Earth's climate and weather patterns? - A) The Moon's gravitational pull. - B) Solar energy. - C) Earth's magnetic field. - D) Ocean currents.	Correct Answer B
5.	What does the "solar constant" measure? - A) The constant temperature of the Sun. - B) The amount of solar energy at the Earth's outer atmosphere. - C) The amount of solar energy at the Earth's surface. - D) The constant solar energy produced by the Sun.	Correct Answer B
6.	What does AM1.5 represent in the context of solar irradiance? A) Light traveling through one atmosphere's thickness B) Light traveling 1.5 times the optical path compared to the vertical distance C) Light traveling through zero atmospheres D) Light traveling through two atmospheres' thickness	Correct Answer: B
7.	What is the Capacity Factor (CF) in the context of photovoltaic panels? A) The ratio between the amount of energy actually produced and the product of the PV panels nameplate power by the time span B) The total area of solar panels installed C) The cost of installing solar panels D) The efficiency of solar panels in converting sunlight to electricity	Correct Answer: A
8.	What are the standard test conditions (STC) for plotting I-V curves of PV panels? A) Global air mass 1.0 solar spectrum, 500 watts per meter squared, and 15 degrees C	Correct Answer: B

	B) Global air mass 1.5 solar spectrum, 1000 watts per meter squared, and 25 degrees C C) Global air mass 2.0 solar spectrum, 1500 watts per meter squared, and 35 degrees C D) Global air mass 0.5 solar spectrum, 2000 watts per meter squared, and 5 degrees C	
9.	What does the I-V curve of a photovoltaic panel describe? A) The relationship between current and resistance B) The relationship between voltage and power C) The relationship between current and voltage D) The relationship between temperature and irradiance	Correct Answer: C
10.	What is the Maximum Power Point (MPP) on the I-V curve? A) The point where voltage is highest and current is zero B) The point where current is highest and voltage is zero C) The point where the product of current and voltage is maximum D) The point where the efficiency is minimum	Correct Answer: C

7.4 Knowledge Check – Power electronics – 8 questions

#	Question	Correct answer
1.	What is the primary cause of mismatch losses in PV modules? A) Differences in voltage due to eddy currents B) Differences in irradiance due to shading C) Differences in temperature D) Differences in module size	Correct Answer: B
2.	What is the purpose of bypass diodes in PV modules? A) To increase the voltage output and the current absorption B) To provide an alternative current path in case of shading C) To reduce the overall current and the output power	Correct Answer: B

	D) To increase the temperature of the cells by Joule's effect	
3.	Which MPPT method involves perturbing the operating voltage and observing the change in power? A) Incremental Conductance (IncCond) B) Perturb and Observe (P&O) C) Constant Voltage (CV) D) Fixed Operating Point (FOP)	Correct Answer: B
4.	What is the purpose of Maximum Power Point Tracking (MPPT) in a solar energy system? A) To increase the size of the solar panels to maximize the power output B) To maintain a fixed operating point, namely at the Maximum Power Point Top C) To maximize power output by adjusting the electrical operating point D) To decrease the efficiency of power conversion to reduce heat production	Correct Answer: C
5.	Which type of inverter is typically used in utility-scale PV systems? A) Microinverters B) String inverters C) Central inverters D) Standalone inverters	Correct Answer: C
6.	What is the primary function of a DC to AC converter (inverter) in a PV system? A) To increase the voltage of the DC current B) To convert DC current and voltage to AC current C) To store energy for later use D) To decrease the current of the AC voltage	Correct Answer: B
7.	What is the main advantage of using power optimizers in PV systems? A) To increase the initial cost of the system B) To reduce power mismatch, especially in shaded PV strings C) To decrease the efficiency of energy conversion	Correct Answer: B

	D) To increase the number of failure points in the system	
8.	Select the answer that corresponds to the correct definition of conversion efficiency for a power converter. A) The ratio between input power and output power B) The ratio between output power and input power C) The ratio between voltage and current D) The ratio between current and resistance	Correct Answer: B

7.5 Knowledge Check – Balance of Systems – 5 questions

#	Question	Correct Answer
1.	What does the Balance of System (BOS) for a photovoltaic (PV) plant include? A) Only the PV panels B) All components of the PV system except for the PV panels C) Only the wiring and switches, excluding bolts and clamps D) Only the mounting system and solar inverters	Correct answer: B
2.	Which of the following is NOT typically included in the hard BOS? A) Wiring B) Solar Inverters C) Battery Bank and Battery Charger D) Labor costs	Correct answer: D
3.	What percentage of the total plant cost do BOS components typically amount to for utility scale installations? A) 10-15% B) 15-20% C) 25-30% D) 35-40%	Correct answer: C
4.	What is the recommended total cable DC loss at rated load according to VDE 0100-712? A) Less than 0.5% B) Less than 1%	Correct answer: B

	C) Less than 2% D) Less than 5%	
5.	What is the function of varistors in PV systems? A) To increase the current flow toward the power converter B) To decrease the voltage output and increase current C) To provide overvoltage protection by conducting current to the ground D) To enhance the efficiency of the PV panels by increasing irradiance	Correct answer: C

7.6 Knowledge Check – Installation – 5 questions

#	Question	Correct Answer
1.	What should be done if the disconnects and over current protection devices (OCPDs) cannot be opened or the inverter cannot be powered down? A) Continue working on the module using wool gloves B) Cover the fronts of the modules with an opaque material C) Disconnect the module from the wiring D) Remove all protective clothing and use only head protection	Correct Answer: B
2.	What type of tools should be used during the installation of PV modules to reduce the risk of electric shock? A) Regular household tools B) Electrically insulated tools C) Metal tools D) Plastic tools	Correct Answer: B
3.	How should modules be lifted during unpacking? A) By their wires or junction box B) By the frame C) By one person D) By the glass surface	Correct Answer: B

4.	To prevent galvanic corrosion when grounding the frame of a solar panel, which precaution should be adopted? A) Use metals capable of generating electrochemical potentials B) Use stainless steel hardware C) Drill additional grounding holes into the module frame D) Use sharp tools to remove end caps	Correct Answer: B
5.	How many points should each module be securely fastened at a minimum? A) 2 points on one side B) 3 points on three sides C) 4 points on two opposite sides D) 6 points on all sides	Correct Answer: C

7.7 Assessment Results – 242 Words – 1’ 30’’

#	Audio Narration	
	Congratulations on successfully completing your final assessment of this course. Your performance reflected your deep understanding and commitment to the subject. Your ability to think critically and strategically shows a level of proficiency that is essential for a successful career in this field. As you move forward, continue to build on this strong foundation. Stay curious, keep learning, and stay updated with the latest trends and technologies in this field. Your potential is immense, and I am confident that you will make significant contributions to the field. Well done once again on this achievement!	In case of assessment completed successfully
	I wanted to reach out following the results of your final assessment of this course. Firstly, I want to acknowledge the effort and commitment you have shown throughout the course. However, I understand that the outcome of the final assessment wasn't what you hoped for. It's important to remember that setbacks like this are a natural part of the learning process. They do not define your abilities or your potential in this field. Remember, persistence is key.	In case of assessment failed

7.8 Course Completion - 77 words – 30''

#	Audio Narration
	Congratulations to all the students on the successful completion of the Photovoltaic panels course! Your hard work, dedication, and passion for learning have equipped you with the knowledge and skills necessary to make a significant impact in the field of energy management. As you move forward, may you use this achievement as a stepping stone to drive innovation, improve energy efficiency, and contribute to a sustainable future. Well done and best of luck in your future endeavours!

3.4 Task 5.2.3 Content Design

Based on the design scripts developed for the training materials, Metropolia designed the main content for the training software. The contents' users would utilize their own mobile devices for the training, and the training should be available both on-site and remotely. This means that the trainee must be able to use any mobile device they happen to have. These requirements directed the design of the content and lead to the following decisions:

1. To support any device, content will be displayed in the browser, no additional installs are required.
2. Extended reality content must be used sparingly, to avoid unnecessary battery drainage.
3. Graphical interface should be simplified to be easy-to-use on a small screen.

Current capabilities of mobile browser for displaying extended reality content are still a bit limited, especially on older devices. Because of this, Metropolia selected Zappar[3] as the most stable and most capable system for utilizing augmented reality content. The selection was based on the principle "best value or money", after confronting Zappar's capabilities and price with the few comparable services of 8th Wall and Blippar. The main training would happen in a mobile game world, with small AR tasks added throughout. It was decided that the game world would be seen from an isometric view, allowing for a clear view of the environment, with simple graphics and characters. As the script was based on discussions, a dialogue system was designed as the main interaction method. These two main concepts, isometric view and dialogue system were the leading factors in the design of the content.

3.4.1 Energy Manager

The work for Energy Manager content started with Developing moodboards for environment and characters. This work started with finding a suitable mood and detail level for them. Three different

[3] https://www.zappar.com/

environment detail styles were considered. All of them had low polygon environment, which is more mobile-friendlier. First type had simple colours and lighting, to allow for maximum processing power. Second type had simple colours, but atmospheric lighting. This would bring more life and atmosphere to the environment. And third one had simple lighting but more detailed textures, which would require less processing for lights, but more resources for texturing. In the end, the simple version was selected, with little additional lighting atmosphere when possible.

Figure 1 - Environment type 1, simple colours and lighting

Figure 2 - Environment type 2, simple colours, atmospheric lighting

Figure 3 - Environment type 3, simple lighting, detailed textures

For the characters used in the training, four different styles were considered: anime, cartoon, clipart and realistic. The final design selected was close to clipart. This was because the design is clear, the change from 2D to 3D was simple, and the design direction allows the change of artist easily, as it is less about the personal style of the artist.

Figure 4 - Examples of different character styles: anime, cartoon, clipart and realistic

Figure 5 - First drafts of Markus in different colour schemes

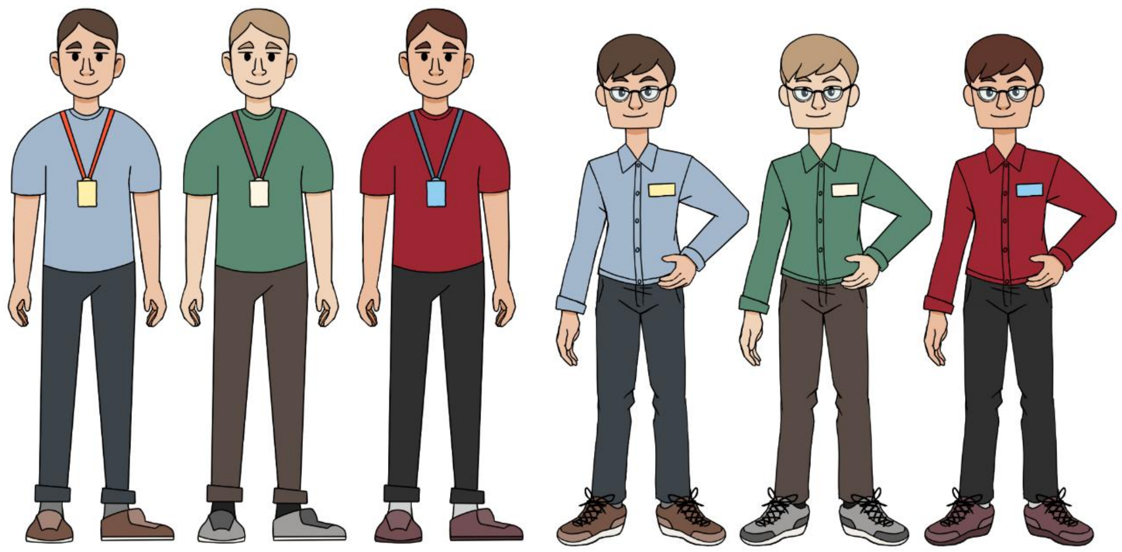
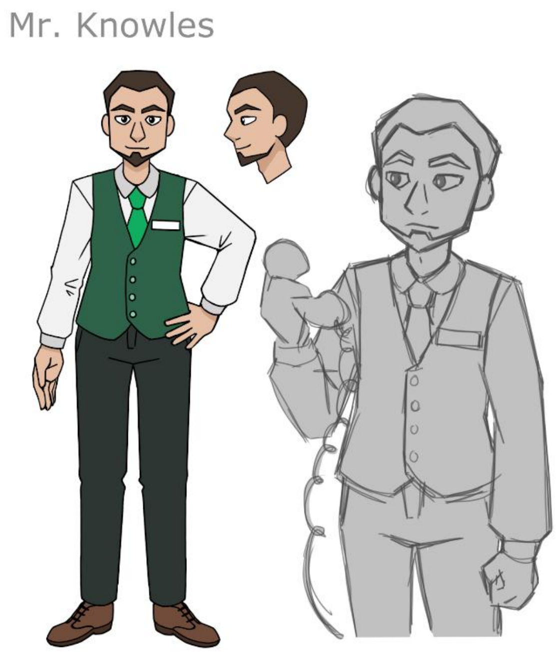


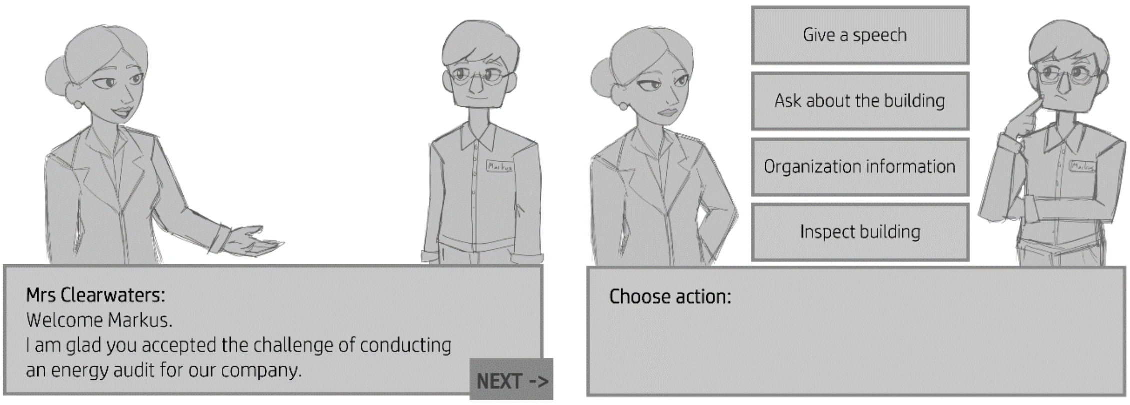
Figure 6 - Final concept of Mr. Knowles



After the design direction was selected, the implementation started. Game mechanics, such as AR minigames, dialogue system, movement and selection and player feedback were implemented in Unity game engine, and 3D models and UI graphics were done with Maya and Blender. To make sure, each of the mechanics worked in the designed environment, it was important to create general models of them first to evaluate their effectiveness, before committing to full scene development. The goal of the character was to conducted audit visit for a company, and inspect the company building. This meant that they would have to discover potential issues in energy consumption by inspecting the building, discussing with people and going through data.

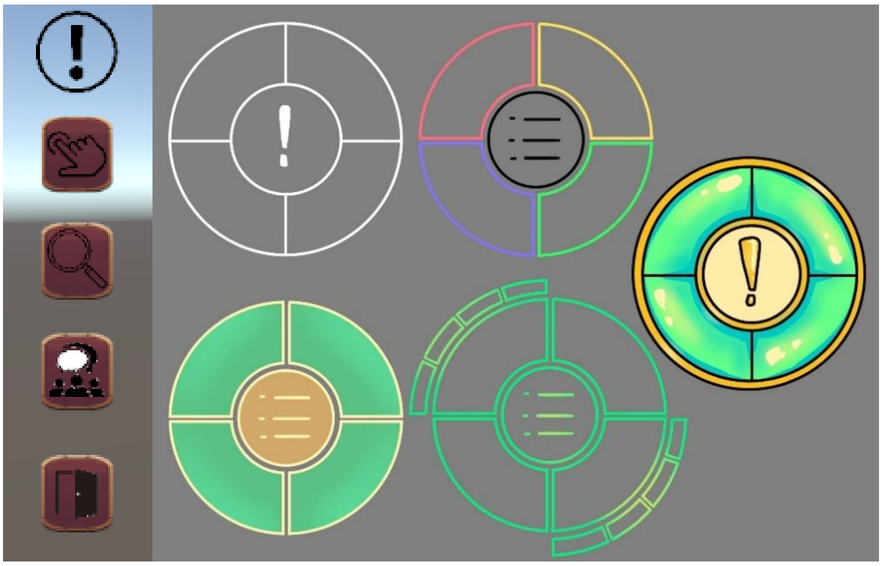
Firstly, we started with the dialogue system. It was designed as a multiple-choice tree, where the player character could discuss different matters with non-player characters (NPCs). These choices could lead to further dialogue, other scenes in the application or to discoveries made by the character.

Figure 7 - Example dialogue drafts



Secondly, we designed different UI styles and button positioning. It was important to consider usability on mobile devices, but at the same time consider potential transfer to other platforms in the future. Different colour schemes were also evaluated, and finally a suitable design was selected.

Figure 8 - Column and radial menu options.



Thirdly, we designed the environment in a way, that it could be assembled from small elements, to allow maximum reuse of elements in different scenes. These elements needed to attachable to each other in any order, and of suitable scale and colour, so they fit well together.

Figure 9 - Wall parts, modelled and textured

Based on the script for the Energy Manager, the game was divided into different scenes. These scenes were completed one by one. First the environment was built from separate pieces, then NPCs were added and finally different interactive points and dialogue were added to the level. Energy Managers consisted of 10 scenes, first and last of these were separate, as they represented starting and ending the game. The others were part of the actual learning content.

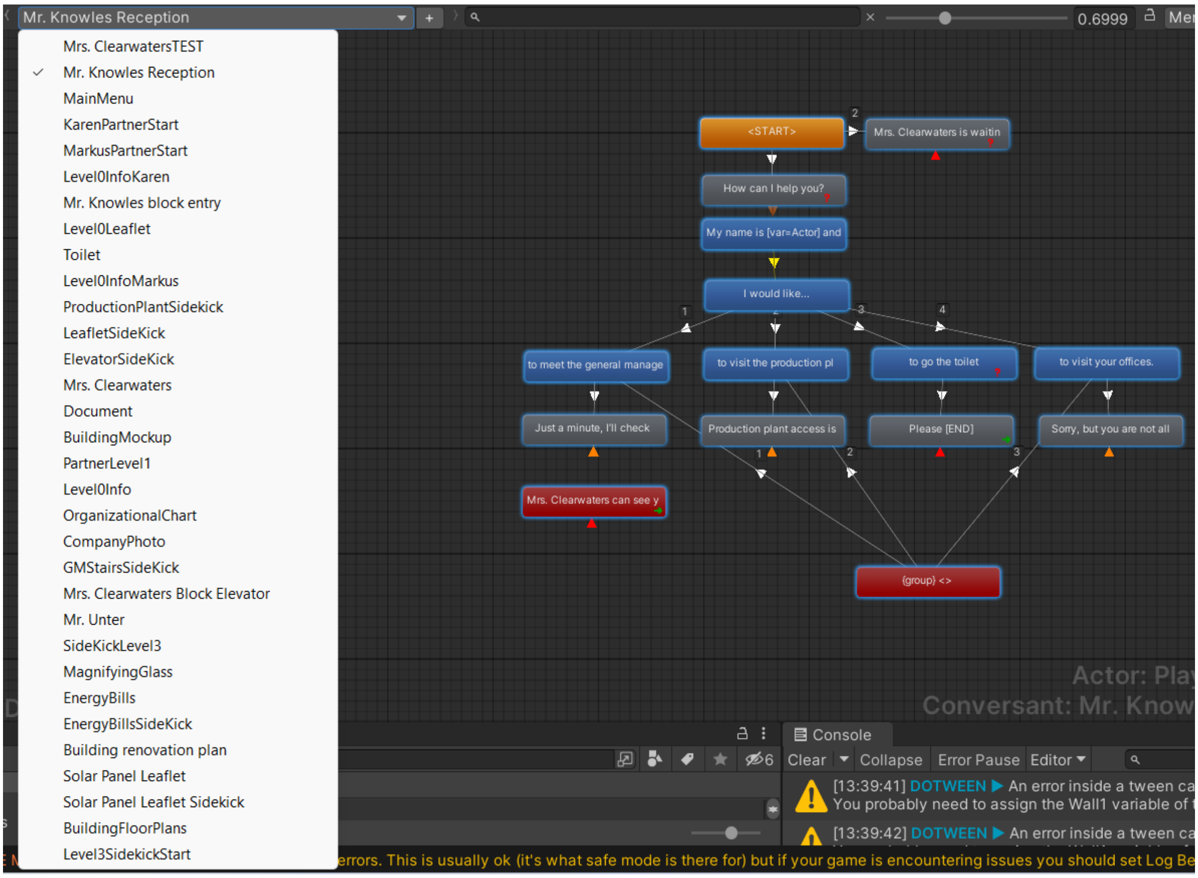
Figure 11 - Floorplan of level 1

The building being audited was divided to different floors, and these floors each contained one scene. To create a single floor, a floorplan was created first.

Figure 10 - Environment type 2, simple colours, atmospheric lighting

Then, an environment was built based on the floorplan. Characters and other interactive points were added and finally the UI was enabled. After this, the dialogue options and other selections for the scene were programmed. And finally, the scene was ready for testing. This similar process was repeated for each scene of the script.

Figure 12 - Level 1 Dialogue option tree



3.4.2 Photovoltaic Panels

Content Design

Based on the design script for the training materials, Metropolia developed new main content for the Solar Panel Installation training software, a spin-off of the Energy Manager project. Like Energy Manager, the training utilizes the trainees' own mobile devices and is entirely web-based. Due to a shorter schedule compared to the Energy Audit solution, it was decided to exclude augmented reality and minimize the use of complex 3D-scenes. In terms of resources, a similar team worked on both this and Energy Audit, but this one was created twice as fast. The tools used for the development were the same in both cases.

The entire training is delivered through a straightforward 2D storytelling approach, incorporating simple missions that effectively provide the necessary skills and knowledge for solar panel installation. Given that the new training script was simpler and more linear, the flow was designed to progress sequentially from scene 1 through scene 8, guided by straightforward task completion logic.

The design also adopted the familiar notepad functionality from Energy Manager, enabling trainees to gather and reference important task-related information, thus supporting them in completing tasks accurately and efficiently.

Solar Panel Installation

Development of the Solar Panel Installation RPG began with structuring scenes based on the provided script. Utilizing the existing moodboard from Energy Manager allowed rapid planning and production of both 2D and 3D assets, enabling immediate progression into development. The existing Dialogue System from Energy Manager was reused, significantly streamlining programming efforts. Additionally, focusing primarily on 2D imagery for scene creation helped achieve the tight deadline efficiently. The limited number of 3D scenes in the project reduced the typically extensive workload related to lighting and optimization tasks required for WebGL web game development.

Despite the minimal use of 3D scenes, the graphical quality needed to be clear and showcase certain elements. Because of this, attention was given to ensure consistency across all visual elements. This ensured that trainees could experience the training environment, despite the simplified graphical approach. Each scene was carefully designed to clearly communicate the key tasks and objectives required for solar panel installation. Moreover, regular testing throughout the development phase ensured compatibility and smooth performance across various mobile devices and browsers, further enhancing the overall user experience. The simplified graphical approach also contributed positively to accessibility, allowing trainees with older or less powerful devices to engage effectively with the training material.

Figure 1 - Scene structure based on the script.

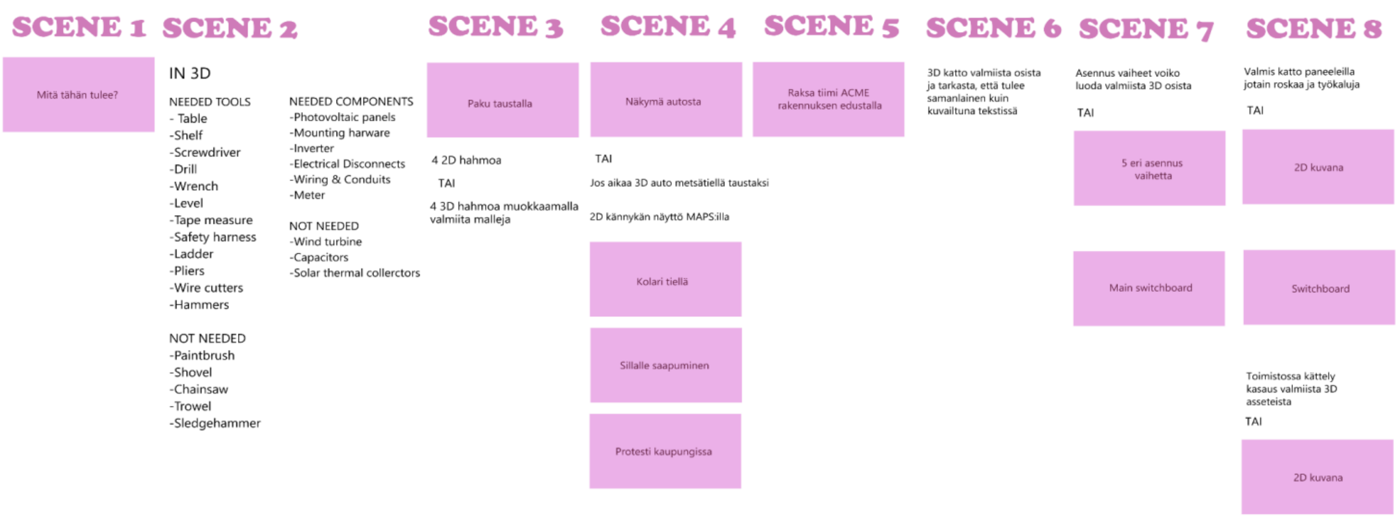
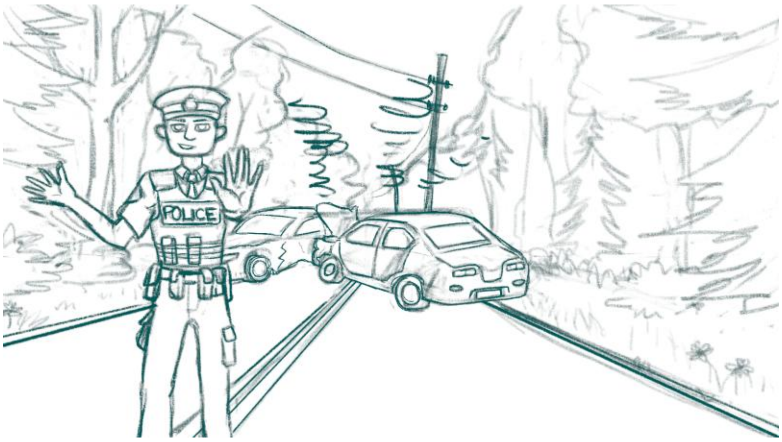


Figure 2 & 3 - First sketches about new 2D scenes, using Energy Manager's style



For the training about needed equipment for the solar panel installation it was decided to use 3D to help understand better the use of the equipment and make some gamification to help achieve the learning of the procedures needed in said training application. Dialogues for all the scenes were done pretty quickly so making a couple gamified levels was in the scope of development.

Figure 4 - First blockout of equipment provided in the script.

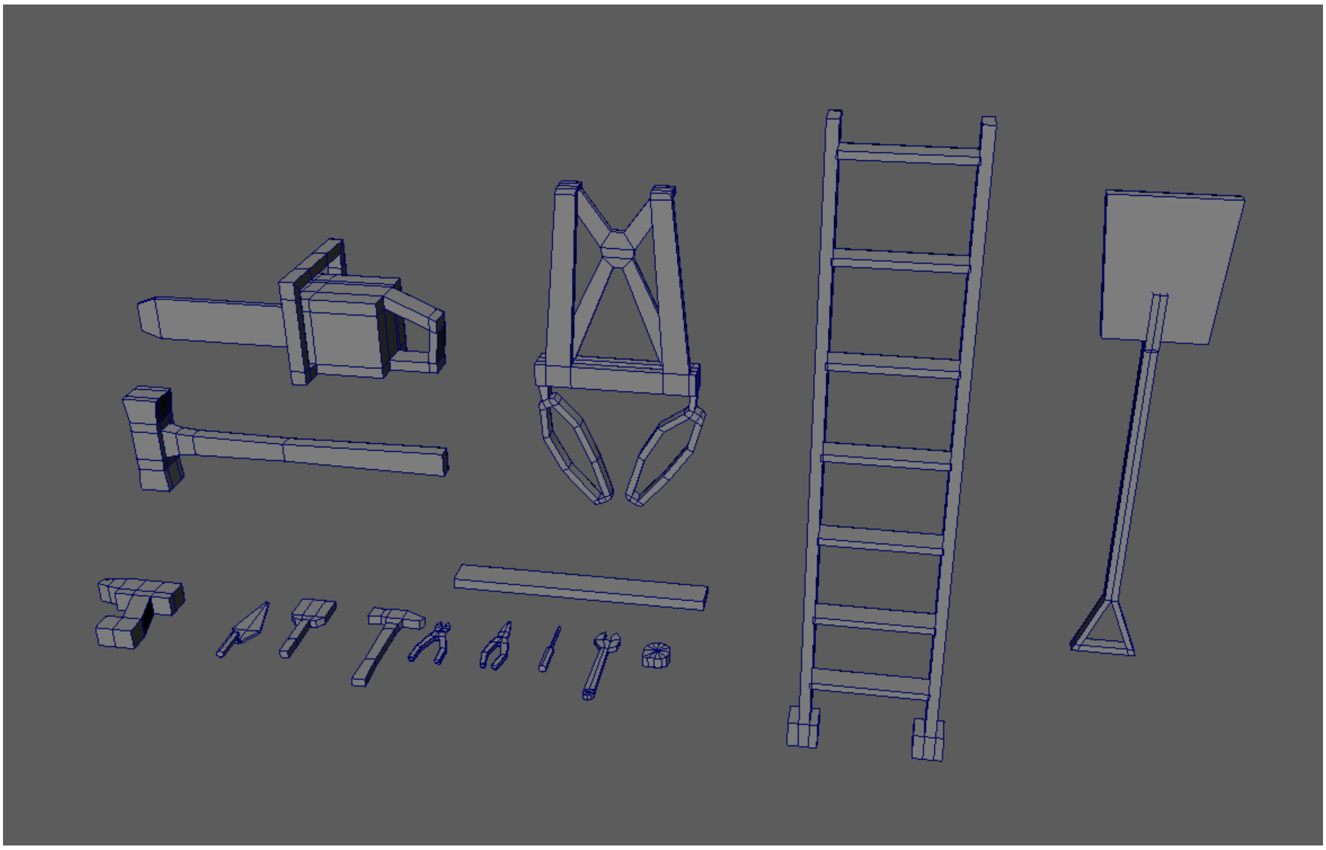


Figure 5 - Finished 2D scene with the finalized style

Figure 6 - Early development version of the scene where user would gather correct equipment

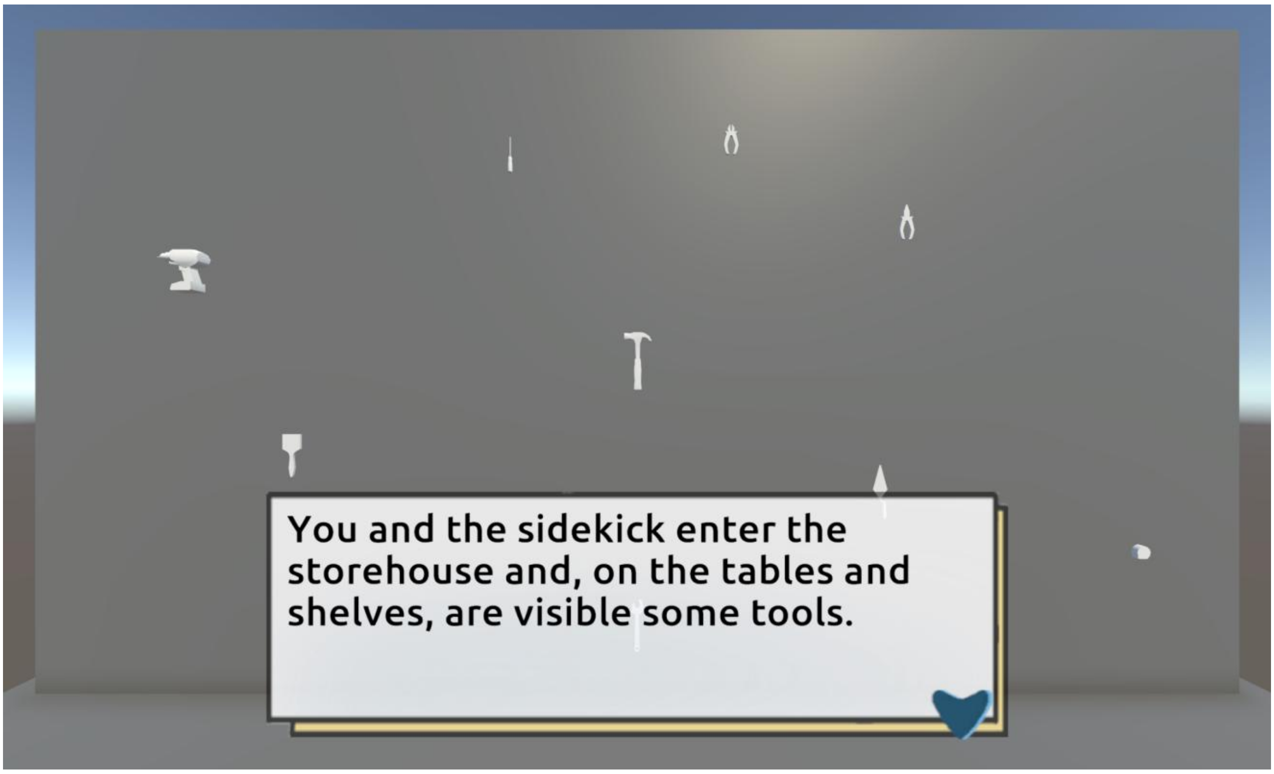
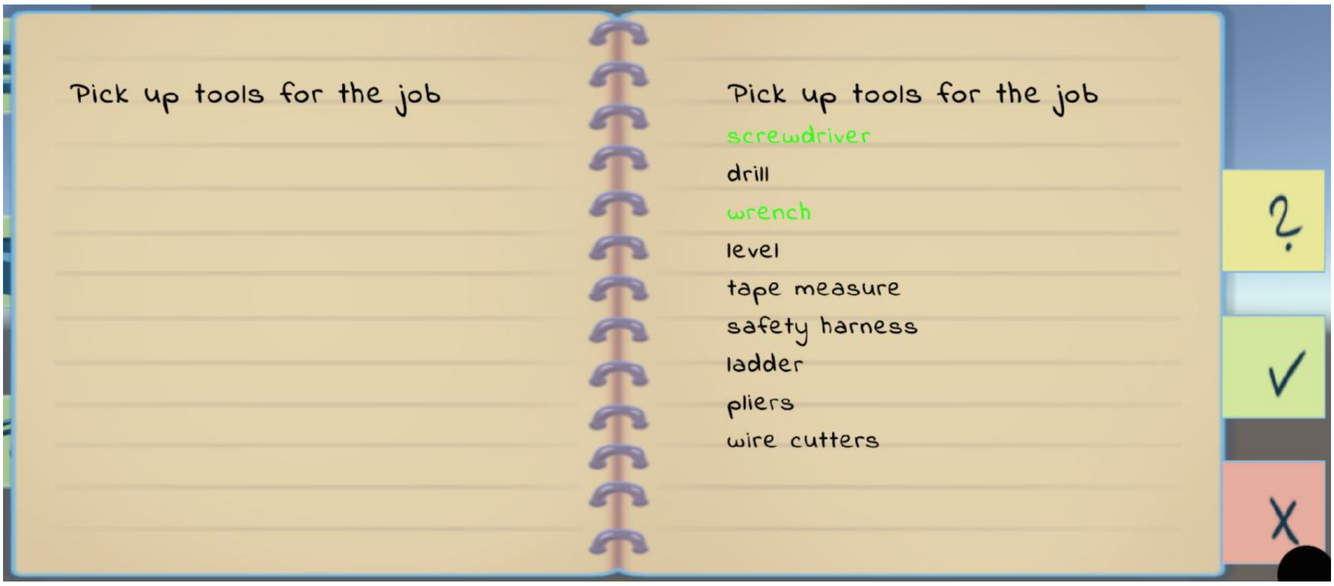


Figure 7 - Notebook that helps user to follow the completion of tasks



The previous development done in Energy Manager greatly simplified the new project's workflow, as the Dialogue System and UI were already fully functional and required no further development. Based on the script, all the scenes could be developed simultaneously since the gameplay mechanics remained largely consistent across the different scenarios and tasks. However, the few 3D scenes required additional effort, particularly in programming and texturing.

Figure 8 - First version of the textured 3D equipment scene.

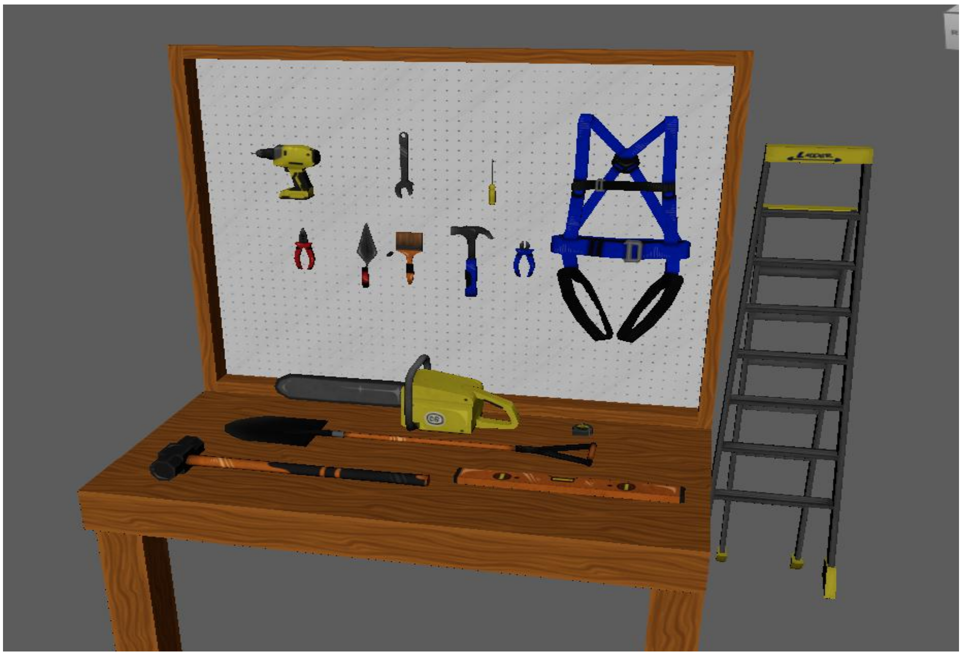


Figure 9 - First iteration of the second 3D scene and textured models

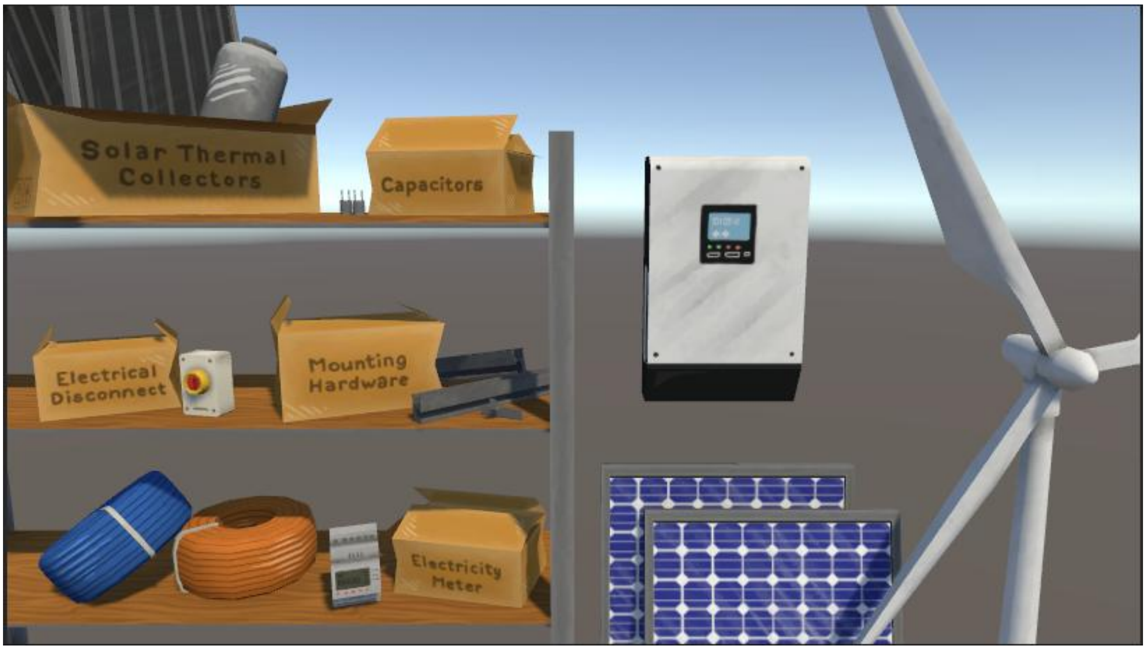
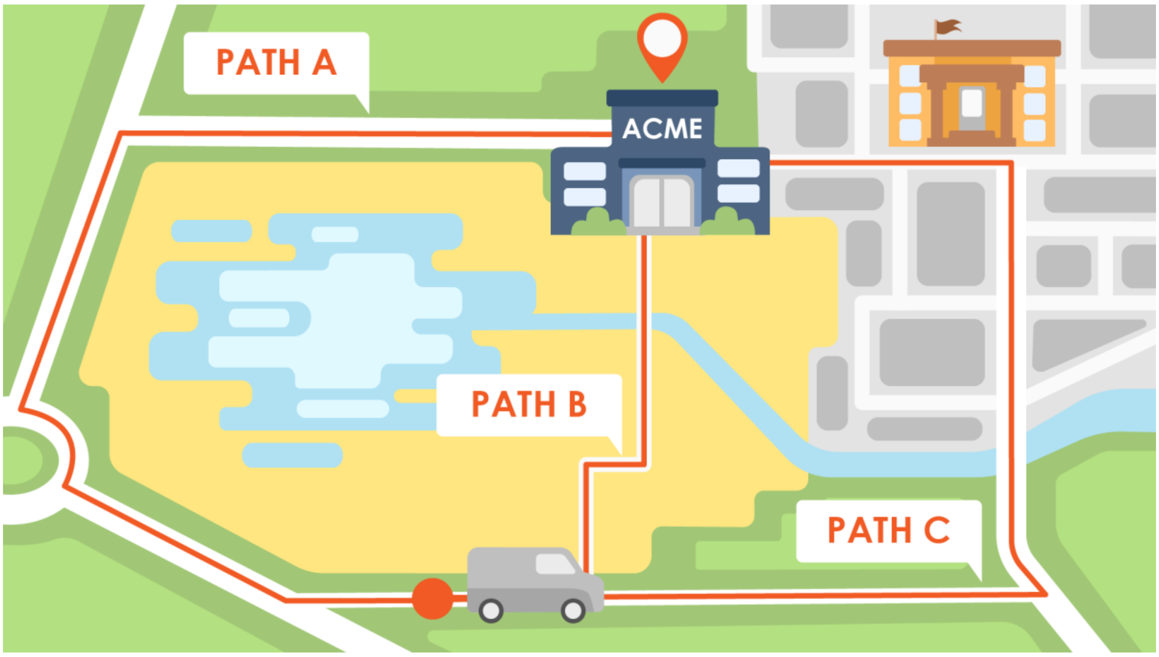


Figure 10 - Completed map of the route selection task



The training script included information cards, which were an important part of the training content. Development of these cards began after the primary scenes were finished. Due to the large amount of information each card needed to contain and the limited space on typical mobile phone screens, the initial design used scrolling to navigate through the content. However, user testing showed that trainees found scrolling difficult and unclear. Based on this feedback, it was decided to redesign the information cards using a multiple page approach, making them easier to navigate and improving the overall user experience.

Figure 11 - All the information cards with all the pages.

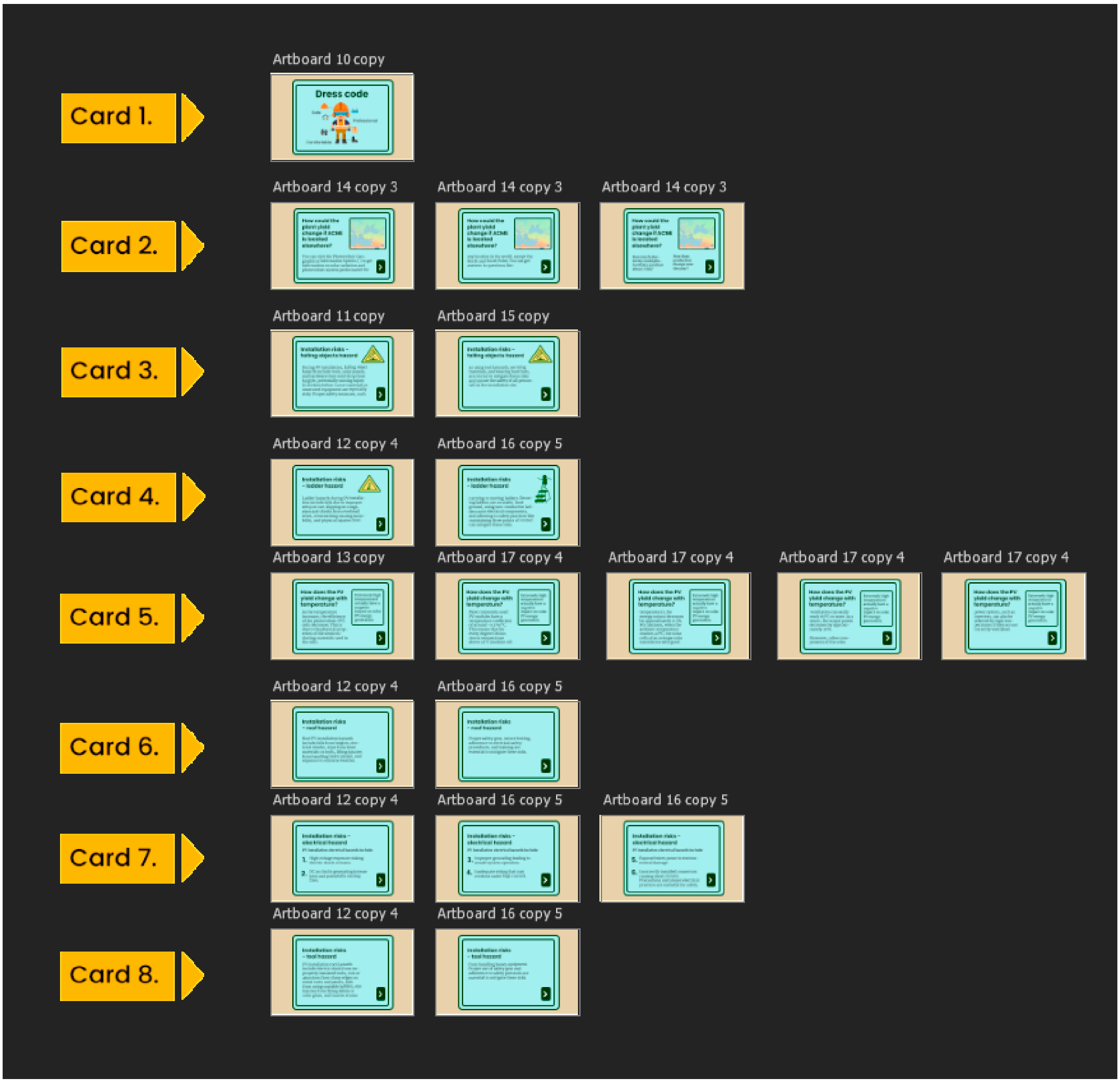


Figure 12 - Closer look at the information on the cards.

The Solar panel installation on the rooftop was done using the correct sequence and if the user made correct choices the scene would progress based on them. These scenes were achieved with the use of 3D and 2D art mixed together.

Figure 13 - Rooftop with the first action done.

Figure 14 - Rooftop with finished installation

Figure 15 - Installation ends with closure meeting with the customer. Here some of the character models from Energy Audit solution were reused to reduce the development time.

Conclusion (WIP)

This report outlines the key activities and decisions taken during the development of content design for the Solar Panel Installation training software, a spin-off from the previous Energy Manager project. By leveraging prior work from Energy Manager, especially in UI and Dialogue System development, Metropolia efficiently produced a web-based training solution optimized for mobile devices.

Due to project time constraints, it was decided to focus primarily on a simplified 2D storytelling approach complemented by selective 3D visualizations. This strategy enabled timely delivery while ensuring clarity and usability across diverse mobile devices. The introduction of gamified elements significantly enhanced learning engagement and retention.

User testing provided valuable insights, particularly regarding the usability challenges associated with the initially scroll-based information cards. Adjustments were subsequently made to implement a paged card system, improving overall accessibility and user satisfaction.

This Solar Panel Installation training software is now complete and ready for deployment, effectively meeting its educational objectives and offering an accessible, engaging learning experience for users.

4. CONCLUSIONS

At the time of writing, the SKILLBILL project has made substantial progress under Work Package 5 (WP5), particularly within Task 5.2, which focuses on curriculum and content development. Two distinct training paths have been conceptualised and partially implemented: the Energy Manager course and the Photovoltaic Panels course. Each is accompanied by a dedicated “Training of the Trainers” component, ensuring scalability and replication across partner countries.

The Energy Manager course was the first to be designed and deployed, featuring a strong focus on energy governance, audit procedures, RES technologies, and soft skills. The course is enhanced by a mobile-based Augmented Reality (AR) simulation, which immerses learners in a realistic energy audit scenario. Instructional materials and storyboards were created to support both synchronous and asynchronous modalities, with positive feedback already collected from early-stage piloting.

Building on this experience, the Photovoltaic Panels course was developed to support technicians in gaining the theoretical and practical skills needed to work with solar energy systems. Like its counterpart, it includes an AR-based simulation—a serious game that guides learners through the process of PV panel installation. This training path places significant emphasis on safety, installation procedures, wiring, and maintenance, responding to concrete technical skill gaps identified during the needs analysis.

While both training courses have reached an advanced stage of instructional design and digital content creation, they remain subject to iteration and refinement based on feedback from piloting and replication activities. Continuous collaboration among content experts, instructional designers, and AR developers ensures that the material remains up-to-date, pedagogically sound, and aligned with EU and national training needs.

The outputs from Task 5.2 provide a strong foundation for the final phases of WP5, including broader dissemination, validation, and integration of user feedback. They demonstrate SKILLBILL’s capacity to deliver modular, innovative, and inclusive training solutions aimed at upskilling the workforce in the Renewable Energy Sector—supporting both the green transition and lifelong learning objectives set out by the European Union.

The project

SKILLBILL's overall objective is to develop a large and strong foundation for the growth and acceleration of renewable energy's deployment, thanks to engaging with stakeholders of the whole chain, diffusing scientific culture and skilling multi-level workers. The basic idea underling the project is that the knowledge should be diffused at several different levels and qualitatively appropriate both to train the adequate number of workers and to increase RES awareness and to reach a more social and inclusive Europe. The project aims at creating several pathways to induce target groups to get interested or involved in RES besides their initial level of education and their working position. It's important, beside the creation of instruments for the upskilling and reskilling of workers, technician and designers, to have awareness modules for unspecific public in order to fight against lack of information, bad quality material, gender gap and the phenomenon of functional illiteracy: it is widely documented that lifelong suitable learning process is the fundamental driver to support the development, maintenance and update of skills. Thus, SKILLBILL proposes concrete actions to accelerate the deployment of renewable energy at different levels to analyse and involve all the interested parts in open discussion using adequate language; create several different pathways to increase skills after having mapped knowledge gap and without gender prejudice; develop and implement innovative learning method; and evaluate the work performed.

Coordinator: **AZZERO CO2 SRL (AzzeroCO2)**

PARTNER		SHORT NAME
	AZZERO CO2 SRL	AzzeroCO2
	Q-PLAN INTERNATIONAL ADVISORS PC	Q-PLAN
	WHITE RESEARCH SPRL	WR
	UNIVERSITA DEGLI STUDI DELLA TUSCIA	UNITUS
	UNIVERSIDAD DE SEVILLA	USE
	METROPOLIA AMMATTIKORKEAKOULU OY	METROPOLIA
	UNIVERSITEIT UTRECHT	UU
	EUROPEAN RENEWABLE ENERGIES FEDERATION	EREF
	SINERGIE SOC CONS ARL	SINERGIE
	PEDAL CONSULTING SRO	PC

CONTACT US **info@skillbill-project.eu** **VISIT** **www.skillbill-project.eu**

@ SKILLBILL Project @ SKILLBILL Project @ SKILLBILL Project @ SKILLBILL Project