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SOLAR:
Integrated Food and Energy System for Climate Smart Agriculture

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R1: SOLAR Competences and Curriculum

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1. Introduction

1.1. Project description

The SOLAR project aims to lead towards climate-smart agriculture via supporting awareness-raising about environmental and climate-change challenges. Focusing on multifunctional agriculture and integrated food and energy systems (IFES), project partnership offers strengthening new key competences for climate-smart agriculture. It will be possible thanks to developed methodology for introducing SOLAR competences in curricula, as well as learning materials developed according to this curriculum.

The project is implemented by a partner network from six European countries, i.e. France, Spain, Bulgaria, Italy, Czech Republic, and Poland. Partner organizations were carefully selected based on their profile, and previous experience in coordination, management and implementation of EU-funded projects in the respective field.

An IFES is a diversified farming system, which is a system of agricultural production that incorporates agro-biodiversity and builds on the principles of sustainable production intensification. IFES can functions at various scales and configurations, from small-scale operations managed at the village or household level primarily to meet domestic needs and sustain local livelihoods to large-scale operations designed for commercial activities. Depending on the circumstances, the generation of solar, thermal, geothermal, photovoltaic, wind and water energy can be an integral part of the system.

The specific project objectives seek to develop and/or integrate existing vocational curricula by providing multidisciplinary knowledge and know-how on the food and energy systems through the development of personalized learning materials in farms or organizations from rural sector. Through its activities and project's results, project contributes to disseminating learning outcomes improvements of non-formal learning activities as well as spreading the utilisation of open and innovative education. The main aims of the developed Personalized Training System are to provide latest knowledge and know-how on the Integrated Food and Energy Systems (IFES) with strong orientation on personal needs of individuals from focused groups. It means that thanks to principles of personalized learning (learner profiles, customized learning paths, proficiency-based progress etc.) a learner will be able to find exactly that kind of information which she/he is looking for. In addition, the activities and outcomes of the project will allow:

- filling in the knowledge gap of how rural communities are managing climate change threats on food security and energy access by implementing integrated food and energy systems;
- supporting decision-making process by direct involvement in developing policies and strategies for IFES;
- sharing research and educational outcomes, innovations, methodologies, products, publications;
- regular monitoring of agricultural policies and rural development as they affect sustainable rural development.

Personalized Training System and Open Educational Resources (OERs) for multifunctional agriculture and Integrated Food and Energy Systems will be elaborated through web technologies tailored to the needs of specific target group - learners from rural areas. The aim is to enlarge the skill and knowledge and improve implementation of innovation in agricultural sector and sustainability of rural development.

The SOLAR project plans to develop following project results and learning outputs/materials:

- R1: Result 1 *"SOLAR competences and curriculum"* - Methodology for introducing SOLAR competences in curricula; SOLAR competences framework; SOLAR curriculum;
- R2 - Result 2 *"Case Studies and Open Education Resources on IFES"* – Case studies of successful ways of implementation on IFES – Integrated learning modules & Open educational resources;
- R3 - Result 3: "Personalized Learning Platform" – aimed at developing, testing and implementing a Personalized Training System - web portal and application for smart devices that will provide comprehensive and up-to-date approach to web page of the project, developed learning materials, case studies, best practices, etc.

The main target groups (TG) of the SOLAR project are as follows: TG 1: Adults, especially small and young farmers, which have interest about sustainable agricultural land use, climate changes, environment protection and safeguarding high quality living in the rural in the future; TG2: VET institutions in the field of formal, non-formal and informal education and training, which can act for improving the current situation for small and family farms. Most EU farm managers have acquired agricultural experience through practical work and only around 20% of them had attended some agricultural training.

1.2. Presentation of Result 1

The 1st result of the SOLAR project is aimed at the following: 1. To develop a methodology and identify competences for curriculum; 2. To develop comprehensive and relevant SOLAR competence framework and identify the set of competences necessary for climate-smart agriculture based on implementation of IFES principle; 3. To develop SOLAR curriculum which together comprise the course content, but which can also be used independently. The methodology will refer to desk and field research and will guide the subsequent evidence collection activities by defining appropriate research methods and techniques for each target group. The methodology will also provide guidelines on how to formulate learning outcomes in terms of what a learner knows, understands and is able to do upon the completion of learning process and how to link learning outcomes with learning material and assessment methods.

2. Preliminary Analysis

In order to establish the Competence Framework, project partners had to perform a preliminary analysis on the current situation in the respective partner countries. For this reason, a Desk Research (A1), including an overview of agricultural sector, best practices and current state in the field of Integrated Food-Energy Systems in the rural areas of each partner country was carried out by partners at national level. In addition, a Field Research in which the main target groups (young farmers/adults from rural areas, VET providers) were asked about their opinion on the main aspects of the project in order to better identify and define their exact training needs on implementing the IFES approach.

2.1. Desk Research

The main conclusions reached out from the extended desk research performed in each partner country pointed out the need to develop customized training materials related to multifunctional agriculture and implementation of IFES principles, aimed at providing new key competences for climate-smart agriculture in the partner countries.

The main conclusions from the desk research implemented in all participating countries are as follows:

- In France: In response to the ecological transition, the public has been encouraged to eat organic food and to have their homes equipped with solar

equipment. French consumption has also changed due to the Covid 19 pandemic and more and more people are turning to local and organic products. Waste generation has also slowed down significantly. The agricultural sector is only at the beginning of its slow transformation. The number of farms wanting to become greener is increasing at a steady rate. However, despite these advances, it is regrettable that a French farmer has to go through numerous administrative steps just to obtain a certification indicating the implementation of practices favoring the use of more environmentally, animal and human friendly production methods. At the same time there are 13 ISO standards that a farmer could obtain. Farmers are not equal in terms of the subsidies they can receive to transform their farms as some rural areas do not have access to government and European support. Despite the creation of some individual IFES good practices at national level, there is still room for improvement in rural areas, such as: better adaptation to climate change; reduce waste; increase of biodiversity; mitigation of CO_2 emissions; soil conservation, etc.

- In Spain: there are examples of good practices of IFES both at international and national level, and these kinds of facilities bring a good number of advantages that are needed in the rural areas, such as: better adaptation to climate change; soil conservation; shading; increase of biodiversity; financial resilience; mitigation of CO_2 emissions; mitigation of the indirect land use change (ILUC) by integration of different crops; carbon sequestration; less use of resources, etc. In addition, at national level there is a need of better regulation and implementation of promotional policies, as most of the projects are innovative and do not fit usual kind of facilities taken into account in national policies. Even more, it would be important to develop innovative sandboxes to promote piloting of IFES facilities and learn better on how to foster them in a better way.

- In Bulgaria: as agri-food value chains constantly evolve and modernize, alternatives to fossil fuel energy sources are required to ensure that food systems are built on secure, environmentally sustainable and resilient foundations. Markedly, renewable energy can play a critical role in meeting the demands for electricity, heating, cooling and transport needs of food systems in the country. Thus, it can advance efforts to lower greenhouse gas emissions, increase the adaptive capacity of farmers and agricultural enterprises, raise incomes, especially of people from the rural areas, and lessen the environmental impact of the agricultural sector. Renewable energy

solutions and integrated food-energy systems can directly advance energy and food security, while also contributing to job creation, gender equality and climate resilience and adaptation. Scaling-up the use of renewable energy in agri-food systems in the country requires the combined efforts of government, farmers, financing agencies, and training institutions. The provision of an innovative, tailor-made set of training methodology and materials the field of integrated food and energy systems for climate-smart agriculture, planned by the SOLAR partnership, will provide the project target groups with powerful training tools, aimed at developing their knowledge, skills, and competences in the field, supporting their continuing personal and professional development, active citizenship, social inclusion and employability.

- In Poland: there is a constant progress towards ecology. Consumers are increasingly aware of what they eat and where the food comes from. That is why such initiatives as bio bazaars, socially supported agriculture, food cooperatives are so popular. More and more people are also aware of how important our consumption choices are. Therefore, all activities promoting ecology and positive effect on the planet are warmly welcomed and practical ideas are eagerly implemented. It is worth focusing on the development of agriculture in terms of friendly food production and climate friendliness. All possibilities to introduce ecology to small, medium and large farms have their pluses and minuses. The focus should be on promoting all methods of taking care of the planet while at the same time indicating and directing people what is good for them and what is not. Only knowledge, careful analysis and sound choices can provide a positive ending with benefits in many aspects.

- In Italy: the debate on IFES practices is not an easy one. Many areas of southern Italy, including the Daunian Mountains, have been affected by a continuous increase of installations of renewable energy facilities, specifically wind turbines, which in the absence of an ad hoc regulation, which does not provide for the obligation to identify specific areas where to create wind farms, has caused a scattering of wind turbines throughout the territory in an uncontrolled way, causing a real disfigurement of the landscape. It should be added that these aerogenerators are installed by companies, very often foreign companies that benefit from renewable energy as opposed to local communities who are left with a defaced landscape. IFES systems are certainly central to achieving climate neutrality by 2050 and pursuing the goals of the Green New Deal. However, there is a need for greater

involvement of local communities and their stakeholders to ensure that these systems are first of all understood and accepted not only for their environmental sustainability but also as tools to supplement farmers' income. Practices such as energy communities can be very interesting in this respect, precisely to create those participatory and generative dynamics capable of involving the whole community in the management of energy systems.

- In the Czech Republic: there are many examples of best practices if IFES implementation in the country. However, most of them focused on using biomass/biogas in agriculture production. In addition, using solar energy is limited by the legislation fact that on the soil where solar panels are located is not possible to use for agriculture production.

2.2. Field Research

The aim of this quantitative survey was to support the SOLAR project partnership to identify the current training needs and key competences (knowledge-skills-attitudes) in the field of Integrated Food and Energy Systems for climate-smart agriculture in project partner countries. The answers, provided by the respondents, will be used for development and implementation of an innovative and effective pilot training, intended mostly for small and middle-scale farmers from rural areas in the participating countries.

The questionnaire was distributed by partners at national level, in their national languages, to ensure the optimal reach of the target group. In total, 95 respondents (potential trainees) participated in the field research. A summary of the information, gathered from the Field Research results, collected by the participating organizations in the partner countries, is presented below.

The number of respondents by participating country and the respective percentage is presented in Figure 1.

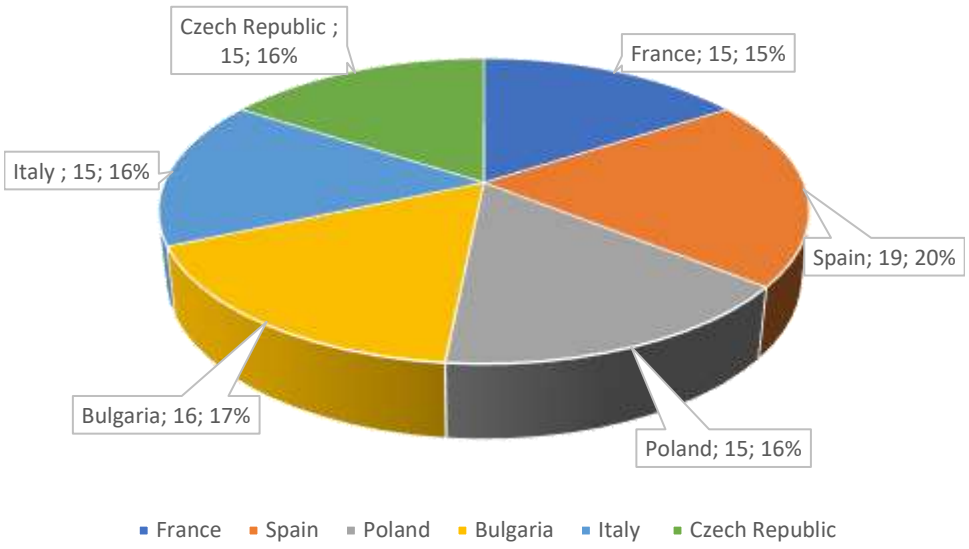

Figure 1. Number of respondents by country

The age distribution of the respondents who participated in the survey is shown in Figure 2.

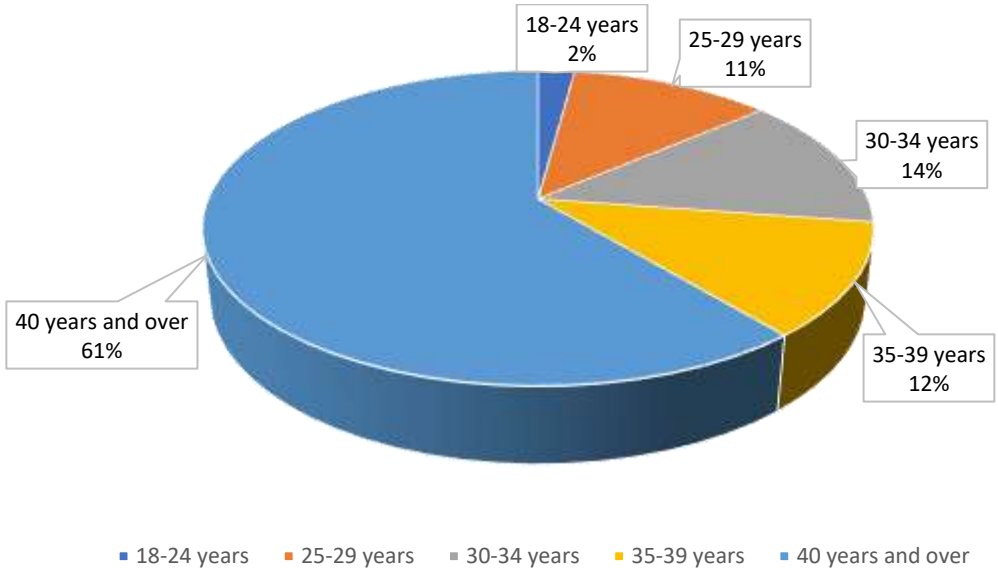

Figure 2. Age of survey respondents

As seen from the survey results, approximately 2/3 of survey respondents were from over 40-year-old (58 respondents), followed by the age categories 30-34 years (13 respondents). Only 2 survey participants (2%) were from the age group 18-24 year olds.

A graphical representation of respondents' educational background in presented in Figure 3.

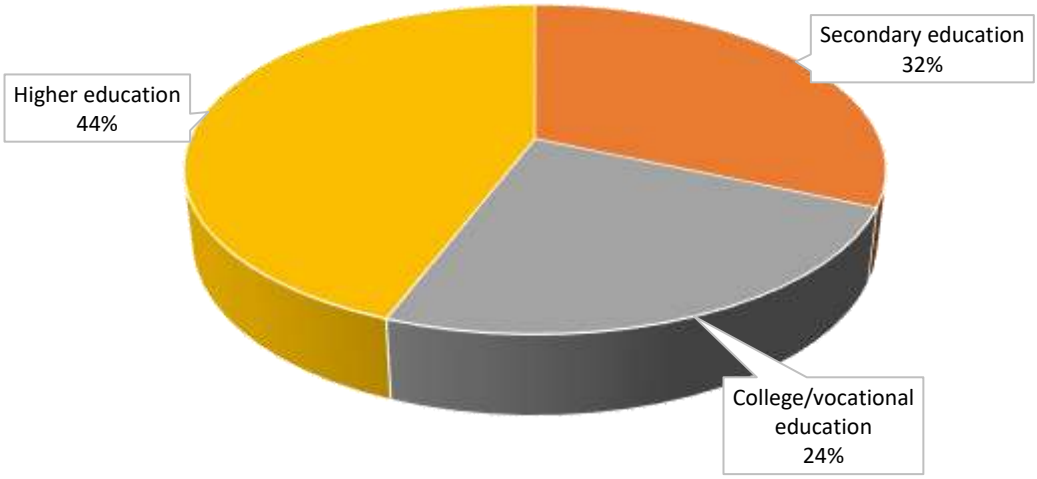

Figure 3. Educational background of survey respondents

As seen from the above figure, the vast majority of respondents (42 persons, 44%) have graduated from higher educational institutions/universities, followed by persons, who have completed secondary education (18 persons, 32%). Although most of survey participants have acquired a higher education diploma, they still might be considered as low-skilled adults regarding their knowledge and skills related to implementation of IFES principles.

A graphical representation of survey respondents' position on the labour market is given in Figure 4.

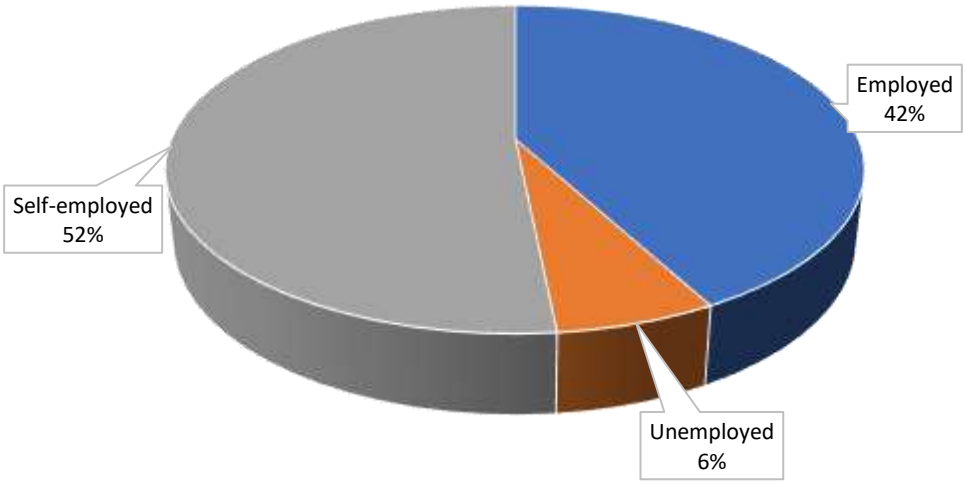

Figure 4. Position of survey respondents on the labour market

The vast majority of the survey respondents (89 persons, 94%) stated they participate in the labour market of the partner countries, either as self-employed or employed persons. However, the opportunities, provided by the SOLAR project

regarding the development and dissemination of innovative training methodology and materials on climate-smart agriculture, represent an excellent opportunity to enhance learners' knowledge, skills and professional competences.

A graphical representation of respondents' self-assessment on their current level of theoretical knowledge and practical skills related to the implementation of the IFES concept, based on a 5 point Likert scale, is shown in Figure 5.

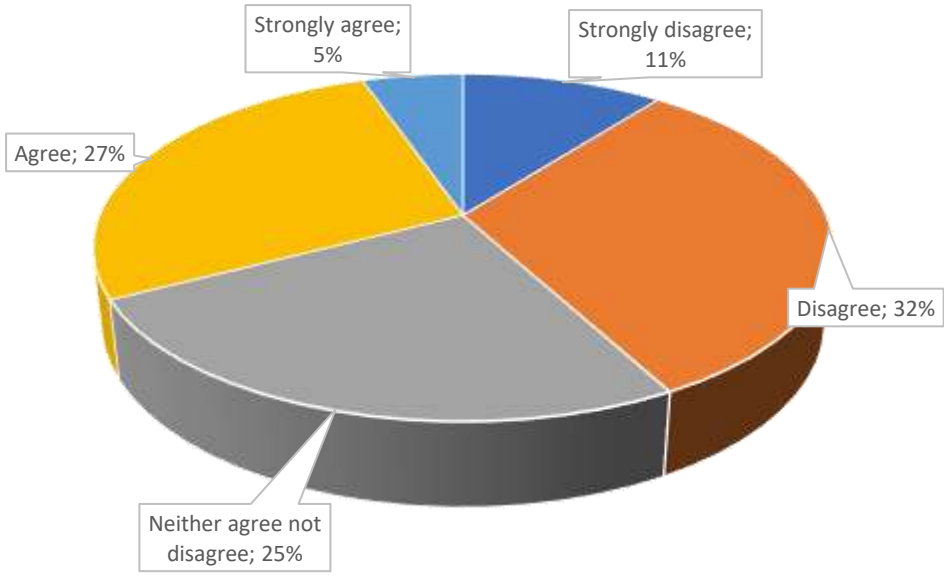

Figure 5. Respondents' self-assessment on IFES concept

As seen from Figure 5, about 1/3 of survey respondents (31 persons) stated they have acquired some level of knowledge, skills and competences in the implementation of IFES principles. The majority of survey participants did not assess their current knowledge in sustainable, climate-smart agriculture and IFES as sufficient.

Based on the summary of respondents' answers of the question *"Which of the following topics and competences you think are the most important for incorporating the Integrated Food and Energy Systems approach in small-scale agricultural farms?"* (question no. 7 of the questionnaire), the following main topics and competences can be outlined:

1. Production of feedstock for food and energy on the same land, through multiple-cropping patterns

2. Production of feedstock for food and energy on the same land, through agroforestry systems

3. Production of renewable energy from other locally available (non-biological) renewables such as solar thermal, photovoltaic, geothermal, wind and water power

4. Sustainable crop and livestock integration

5. Optimal use of the available biomass resources, recycling and efficient utilization of by-products and residues

6. Adoption of agro-industrial technologies (such as gasification or anaerobic digestion)

The vast majority of the respondents clearly expressed their interest in participating in seminars and courses related to the topics of the project, which is quite positive with regards to the future activities to be carried out with the target group.

3. SOLAR Competence Framework

3.1. Competence Framework description

The main aim of the Competence Framework is to provide a structure of the most important training content requirements to promote the acquisition of relevant knowledge in climate-smart agriculture and integration of IFES principles. In this line, the partnership has developed a Competence Framework structure that encourages the association of a series of hard and soft skills with aspects relevant for farmers/people from rural areas. In order to create the Competence Framework, the partnership has taken into account the information obtained from the Desk Research at national level, as well as the responses obtained in the Field Research, which have been previously presented and analyzed.

The result of this work is the finalized Competence Framework that will not only provide a view on specific skills useful for the target groups but will also be essential to implement the following project phases.

The proposed Competence Framework model is divided into the following three levels (Figure 6):

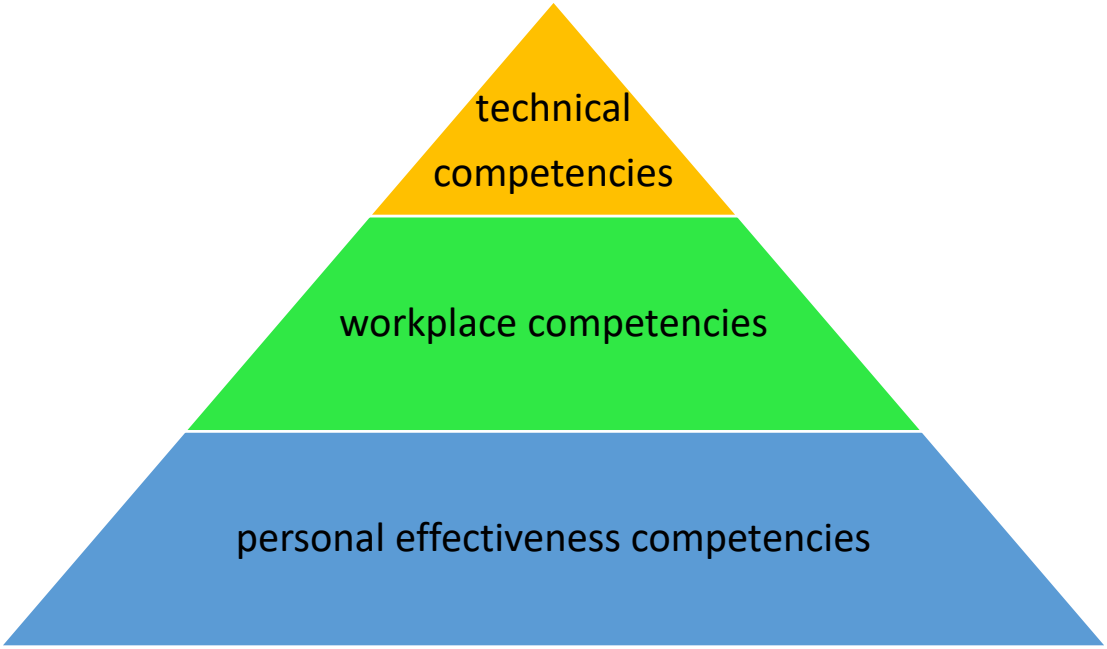

Figure 6. Competence Framework structure

The arrangement of the levels in a pyramidal shape is not meant to be hierarchical, or to imply that competencies at the top are at a higher level of skill. The model's shape represents the increasing specialization and specificity in the application of skills as learners move up the levels. The proposed levels represent competency areas, i.e. the applied skills, knowledge, and abilities essential to successful performance.

3.2. Personal effectiveness competencies

Personal Effectiveness Competencies are at the base of the proposed competence pyramid because these competencies are essential for all life roles. Often referred to as "soft skills," personal effectiveness competencies represent personal attributes that may present some challenges to teach or assess.

Interpersonal Skills: Displaying skills to work with people.
Learning Outcomes: Work effectively with people who have diverse personalities and backgrounds. Show understanding of others' behavior by demonstrating appropriate responses. Demonstrate respect for the opinions, perspectives, and individual differences of others by including others in problem solving and decision-making.

Maintain open communication with others. Recognize and accurately interpret the verbal and nonverbal behaviors of others. Demonstrate flexibility and open mindedness when dealing with a wide range of people. Listen to and consider others' viewpoints and alter own opinion when it is appropriate.
Initiative: Demonstrating a commitment to effective job performance.
Learning Outcomes: Ensure that job is done safely, accurately, and completely. Identify new and better processes or procedures. Follow instructions and direction from supervisor and co-workers. Take responsibility for completing one's own work assignments.
Dependability and Reliability: Displaying responsible behaviors at work.
Learning Outcomes: Come to work when scheduled and on time. Comply with company policies. Manage stressful situations effectively. Fulfill obligations of the job.
Lifelong Learning: Demonstrating a commitment to self development and improvement.
Learning Outcomes: Identify goals and career interests. Demonstrate an interest in learning. Seek opportunities to learn new skills and tasks. Participate in training to learn new skills and to refine current skills. Adapt quickly to changes in process or technology. Accept help from supervisors and co-workers.
Critical and Analytical Thinking: Using logical thought processes to analyze information and draw conclusions.
Learning Outcomes: Identify inconsistent or missing information.

Critically review, analyze, synthesize, compare, and interpret information. Draw conclusions from relevant and/or missing information. Test possible hypotheses to ensure the problem is correctly diagnosed and the best solution is found.
Information Literacy: Functional and critical thinking skills related to information, media, and technology.
Learning Outcomes: Locate information efficiently (time) and effectively (sources). Evaluate information critically and competently. Review information obtained for relevance and completeness. Recognize important gaps in existing information. Use information accurately and creatively for the issue or problem at hand. Manage the flow of information from a wide variety of sources. Organize/reorganize information as appropriate to get a better understanding of a problem.

3.3. Workplace competencies

Workplace competencies represent motives and traits, as well as interpersonal and self-management attitude.

Teamwork: Developed capacities used to work with others.
Learning Outcomes: Accept membership in the team. Identify with the goals, norms, values, and customers of the team. Use a group approach to identify problems and develop solutions based on group consensus. Effectively communicate with all members of the team to achieve goals. Develop constructive and cooperative working relationships with others. Show sensitivity to the thoughts and opinions of others. Respond appropriately to positive and negative feedback. Learn from other team members. Apply interpersonal skills to help team achieve goals.

Keep all parties informed of progress and all relevant changes to project timelines. Demonstrate loyalty to the team.
Adaptability and Flexibility: Adjusting to changing work requirements.
Learning Outcomes: Adjust to changing priorities. Refocus attention to new assignment quickly. Quickly learn new assignments. Abilities to work on multiple projects. Anticipate and accept changes in work.
Marketing and Customer Focus: Actively looking for ways to identify market demands and meet the customer, client, or stakeholder need.
Learning Outcomes: Understand and anticipate customer needs and future needs. Actively look for ways to help customers by identifying and proposing appropriate solutions and/or services. Be pleasant, courteous, and professional when dealing with internal or external customers. Follow up with customers during projects and following project completion.
Planning, Organizing, and Scheduling: Demonstrating the ability to work within a schedule using prescribed procedures.
Learning Outcomes: Prioritize various competing tasks and perform them quickly and efficiently according to their urgency. Find new ways of organizing work area or planning work to accomplish work more efficiently. Estimate resources needed for task completion and allocate time and resources effectively. Anticipate obstacles to task completion and develop contingency plans to address them. Plan and schedule tasks so that work is completed on time. Make arrangements that fulfill all requirements as efficiently and economically as possible. Keep track of details to ensure work is performed accurately and completely. Take steps to verify all arrangements; recognize problems, generate effective

alternatives, and take corrective action.

Problem Solving and Decision-Making: Applying problem-solving and critical-thinking skills to help grow the business and/or to resolve workplace conflict.

Learning Outcomes:

Anticipate or recognize the existence of a problem.

Identify the nature of the problem by analyzing its component parts.

Effectively use both internal and external resources to locate and gather information; examine information obtained for relevance and completeness; recognize important gaps in existing information and take steps to eliminate those gaps; recall previously learned information that is relevant to the problem; organize information as appropriate to gain a better understanding of the problem.

Integrate previously learned and externally obtained information to generate a variety of high quality alternative approaches to the problem.

Use logic and analysis to identify the strengths and weaknesses, the costs and benefits, and the short and long-term consequences of different approaches.

Choose the best solution after contemplating available approaches to the problem; make decisions even in highly ambiguous or ill-defined situations;

Commit to a solution in a timely manner and develop a realistic approach for implementing the chosen solution; observe and evaluate the outcomes of implementing the solution to assess the need for alternative approaches and to identify lessons learned.

Working with Tools and Technology: Having capability to operate and troubleshoot technical equipment and products, as appropriate.

Learning Outcomes:

Select and apply appropriate tools or technological solutions to frequently encountered problems.

Carefully consider which tools or technological solutions are appropriate for a given job and consistently choose the best tool or technological solution for the problem at hand.

Use tools and equipment in compliance with user manuals and training.

Demonstrate an interest in learning about new and emerging tools and technologies.

Seek out opportunities to improve knowledge of tools and technologies that may assist in improving productivity.

Sustainable Practices: Understanding the concept of meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Learning Outcomes:

Understand how the concepts of sustainability provide the basis for the consideration of renewable energy systems.

Use environmentally-friendly processes utilizing fewer natural resources.

Use equipment as designed to minimize environmental impact.

Seek to upgrade processes beyond pollution control to pollution prevention.

Utilize advances in science and technology to upgrade levels of efficiency and environmental protection.

Abide by applicable European, national, and local regulations and policies.

3.4. Technical competences

These competences represent the knowledge and skills that are common across the energy industry sector. These technical competencies build on, but are more specific than, competencies represented on the previous two competence levels.

Fundamentals of Energy and Power: Knowledge of the basic and emerging principles and concepts that impact the generation, transport, installation, operation, and maintenance of technologies and related equipment used to produce energy.

Learning Outcomes:

Understand the basic principles of power generation, including use of different fuel types.

Understand the flow of energy from generation through distribution to the customer.

Understand the basics of energy consumption.

Understand the fundamentals of electric power operations, including generation, transmission, distribution, and typical electrical service supplies to buildings and facilities.

Understand the components and workings of the electric transmission and distribution network.

Understand the basics of electricity and heat, and how conventional energy generation (natural gas, oil, nuclear energy) and renewable energy contribute to energy supplies.

Understand and use basic terminology in the energy field.

Understand the concepts of traditional and renewable energy production.

Energy Efficiency: Knowledge of the basic and emerging principles and concepts that

promote energy conservation and efficiency while reducing the dependency on fossil fuels.
Learning Outcomes: Understand how energy efficiency is connected to the production of energy (supply), and how to reduce demand for energy vs. employing renewable energy. Describe return on investment – (the concept of "payback" from using energy efficiency and renewable technologies). Understand the impact of environmental and geographic factors on the effective implementation of renewable energy technologies. Demonstrate an understanding of the advantages and disadvantages of energy sources.
Renewable Energy Basics: Producing sustainable, clean energy from sources such as the Sun, earth's heat, wind, plants, and water.
Learning Outcomes: **Biomass:** Generation of power for heat or electricity from organic, nonfood, and renewable resources. **Solar:** Systems that utilize solar energy or convert it into other usable forms, such as electricity and heat. **Wind:** Conversion of wind's kinetic energy to mechanical or electrical energy. **Geothermal:** Using thermal energy contained in the earth to supply heat directly or converting it to mechanical or electrical energy. **Water:** Utilization of power derived from the energy of moving water.
Quality Assurance and Continuous Improvement: Ensure product and process meets quality system requirements as defined by customer and product specifications.
Learning Outcomes: Understand how changes in conditions, operations, or the environment will affect quality. Monitor/assess performance of self, other individuals, or organizations to make improvements or take corrective action. Determine how a system should work and how changes in conditions, operations, and the environment will affect outcomes. Identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.

Legislative Regulations: Compliance with applicable European, national, regional, and local laws and regulations in the energy sector.
Learning Outcomes: Demonstrate awareness of the policies, standards, equipment, and work practices that mitigate the environmental impacts of human activity, including energy use. Demonstrate professional responsibility for maintaining all policies and standards for health, safety, and the environment. Comply with all relevant environmental regulations issued by the respective European and/or national authorities. Maintain current knowledge of regulatory procedures governing operations.
Safety and Health: Compliance with the procedures necessary to ensure a safe and healthy work environment, as appropriate.
Learning Outcomes: Take actions to ensure the safety of self and others, in accordance with established personal and jobsite safety practices. Anticipate and prevent work-related injuries and illnesses. Comply with the European, national, regional, and local regulations and health and safety policies (including European Agency for Safety and Health at Work). Recognize common hazards and unsafe conditions that occur at work, their risks, and appropriate controls to address them. Evaluate changes in the environment with respect to their impact on safety of self and others. Promote effective security operations for the protection of people, data, property, and institutions. Follow procedures and protocols for workplace emergencies and emergency response. Properly handle and dispose of hazardous materials. Use equipment and tools in compliance with user manuals and training. Understand potential threats created by deviation from safety procedures and improper use of tools and equipment. Use appropriate personal protective equipment (e.g., safety glasses, work boots, and hard hats) and keep equipment in good working order. Recognize how workplace risks can affect one's life. Understand the legal rights of people regarding workplace safety and protection from hazards. Contribute to discussion of safety concerns in the workplace, making suggestions as

appropriate.

The proposed Competence Framework is aimed at developing the necessary skills, competences and mind-set to promote the acquisition of relevant knowledge in climate-smart agriculture and integration of IFES principles. As the Framework is based on a transnational data collection, it also enables a comparison between the requirements in different project partner countries, which in turn enables mutual learning and learning from peers, regarded as powerful tools for improving the quality of VET education in all participating countries.

4. SOLAR curriculum design

The proposed topics and subtopics of the training modules to be developed by the project partners in the latter stages of SOLAR project development are aimed at addressing the competences, described in details in the SOLAR Competence Framework (section 3 of this document), needed by the targeted groups for effective implementation of climate-smart agriculture and IFES principles in the project partner countries. The combination of technical, i.e. “hard” skills, and the necessary “soft” skills, will ensure the acquisition of advanced theoretical knowledge, practical skills, and attitudes by the foreseen learners.

1. Introduction to Integrated Food-Energy Systems (IFES) concept for climate-smart agriculture

- Energy in the context of food security and climate change;
- Sustainable energy options in the rural sector: integrated food–energy systems (growing fuelwood on-farm; viable bioenergy alternatives to fuelwood use; other renewable energies in rural farming systems, etc.);
- Agro-ecological farming practices contributing to climate-smart agriculture and food security;
- Challenges for the implementation of small-scale IFES;
- Renewable energy value chain.

2. Production of feedstock for food and energy on the same land, through multiple-cropping patterns and agroforestry systems

2.1. Multiple cropping systems – definition and description of the concept as a way for intensifying agricultural production and diversifying the crop mix for economic and environmental benefits; different types of cropping systems; basic types of multiple cropping; selection of crops; benefits and

challenges of adopting multiple cropping systems to maximize ecosystem services;

2.2. Agroforestry practices – definition and description of the agroforestry concept; common agroforestry practices (alley cropping; forest farming; riparian forest buffers; silvopastures; windbreaks, etc.; benefits and ecosystem services provided by agroforestry (soil erosion control, microclimate modification for yield enhancement, economic diversification, livestock production and well-being, water quality protection, etc.).

3. Production of renewable energy from other locally available (non-biological) renewables such as solar thermal, photovoltaic, geothermal, wind and water power

3.1. Solar energy: systems that utilize solar energy or convert it into other usable forms, such as electricity and heat

- Solar Photovoltaic Systems - conversion of solar energy into electricity using photovoltaic technologies; systems and components; applications
- Solar Heating and Cooling Systems - conversion of solar energy into thermal energy for use in heating and cooling applications
- Concentrating Solar Power (CSP) - use of concentrated solar energy to produce steam and electricity

3.2. Geothermal energy: using thermal energy contained in the earth to supply heat directly or convert it to mechanical or electrical energy

- Geothermal Power Plants - use hot fluids produced from wells drilled into geothermal reservoirs to generate electricity; main generation technologies used to generate electricity (steam, flashed steam, and binary cycle).
- Geothermal Direct Uses – utilization of a natural resource, flow of geothermal fluid at elevated temperatures, which is capable of providing heat and cooling to buildings, greenhouses, aquaculture ponds, and industrial processes.
- Geothermal Heat Pump Systems - transfer heat stored in the earth or in ground water into a building during the winter, and transfer it out of the building and back into the ground during the summer.

3.3. Water energy: utilization of power derived from the energy of moving water.

- Hydropower - water is captured using man-made dams and diversions and utilizes “head” (potential energy created by elevation difference) to generate electricity; pumped storage: a configuration of hydropower that allows for the storage of energy by pumping water from a lower reservoir to an upper

reservoir, and then using the water to generate electricity when it is needed, utilizing conventional hydropower technology.

3.4. Wind energy: conversion of wind's kinetic energy to mechanical or electrical energy

- Costs and benefits and the economic and environmental impact wind energy; major phases of a wind power project: manufacturing, project development, installation, and operation and maintenance; transmission infrastructure and wind integration.
- Small wind turbines - electric generators that utilize wind energy to produce clean, emissions-free power for individual homes, farms, and small businesses; they can be used in connection with an electricity transmission and distribution system, or in stand-alone applications that are not connected to the utility grid; wind water pumping systems.

4. Sustainable crop and livestock integration (integrated crop–livestock systems)

- definition and description of the concept;
- principle aspects and major components of integrated crop-livestock systems (ICLS) as sustainable and climate-resilient agricultural systems;
- potential of ICLS as an option to achieve food security;
- benefits of ICLS for the farm and the ecosystem, e.g. higher on-farm diversity and resilience, increased yield and profit, improved soil health, improved sequestration of carbon into the soil, etc.

5. Optimal use of the available biomass resources, recycling and efficient utilization of by-products and residues

- Bioenergy – energy derived from any organic matter that is available on a renewable basis, including forest and mill residues, agricultural crops and associated field as well as processing residues, wood and wood waste, animal excreta, aquatic plants, fast-growing trees and herbaceous crops, municipal and industrial waste, etc.;
- Types of biomass feedstocks – agricultural waste and by-products; animal manure; forestry waste and residues; industry waste; municipal and sewage waste; energy crops;
- Bioenergy technologies/biomass conversion paths;
- Biomass applications – biofuels; biobased products; space heating; combined heat and power (cogeneration, CHP), etc.;
- Bioenergy value chain.

6. Adoption of agro-industrial technologies (such as gasification or anaerobic digestion)

- main types of agro-industrial technologies;
- biogas production through anaerobic digestion (AD) – feedstocks (agricultural residues, agro-industrial by-products, animal manure, organic urban wastes, livestock residues, wastewater, etc.); basics of energy production through anaerobic digestion;
- biomass gasification (BG) as a biomass energy-based system; Biomass Integrated Gasification Combined Cycle (BIGCC);
- potential benefits of gasification and anaerobic digestion for rural communities.