D4.1

Syllabus

skillbill

SKILL TO BOOST INNOVATION & PROFESSIONAL FULFILLMENT IN A SUSTAINABLE ECONOMY

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ABBREVIATIONS

BS	Bachelor's Degree
MS	Master's Degree
EQF	European Qualification Framework
SNG	synthetic natural gas

Executive Summary

The purpose of this deliverable is to present the programme of the European Specialisation School in Sustainable Energy set up as part of the Horizon Europe SKILLBILL Project activities.

The aim of the European Specialisation School in Sustainable Energy, described in the grant agreement as “EUROPEAN MASTER”, is to create the necessary infrastructures and network to educate the professionals and practitioners who will lead the energy transition towards carbon-neutrality, thanks to a unique combination of in-depth knowledge of the renewable energy sources technologies, their application for heat and power generation, sustainable mobility and efficiency, as well as sound understanding of the social, environmental and economic implications of the energy transition (e.g. circular economy, natural capital valuation, environmental life cycle assessment, security of supply, grid reliability and flexibility, economics of energy transition, social costs of unsustainable energy).

This deliverable aims to provide the overall visions of the European Specialisation School in Sustainable Energy, in details:

- Overall organisation, including the admissions standards, the attendance and effort requirements (**chapter 1**)
- The detailed description of all the courses (**chapter 2**)

1. General Description

1.1 Overview of the School

1.1.1 *Our Mission*

Sustainable energy will be the building block of our future. Sustainable is not only clean but also available all over the world, secure, and affordable. The achievement of the ambitious COP-27 goals urgently demands for more post-graduate trained staff specialised in all aspects of sustainable energy. In this framework, four leading European Universities (University of Tuscia, Utrecht University, Metropolia University of Applied Sciences, and University of Seville) organise European Specialization School in Sustainable Energy.

Our goal is to create proactive professionals able and willing to lead the energy transition, thanks to a unique combination of in-depth knowledge of the technology underlying renewable energy, sustainable fuels and mobility, and of social-economic aspects related to energy transition, such as circular economy, economic potential of energy transition, social costs of unsustainable energy.

1.1.2 *Our Approach*

The European Specialisation School in Sustainable Energy has a unique approach to teaching that gives the students the opportunity to experience an international environment that hinges on the efforts of the four organising universities and to learn through the most advanced teaching concepts. Supervised work will extensively leverage on practical cases, laboratories, and design activities, while augmented and virtual reality will be used to improve the student's self-study experience and to allow an immersive remote access to laboratories. The School will provide the augmented reality contents for self-study, and virtual reality software and hardware for immersive remote laboratory access.

The School is strongly oriented to practitioners who already have at least a BSc (Bachelor's Degree) degree and work in the energy transition field. However, fresh BSc and MSc (Master's Degree) graduate students will also benefit from its innovative teaching approach. To this end, all activities will be provided on-site as well as remotely (live streaming, remote interaction with the class, recorded material). All students will have the opportunity to finalise their path through stages organised in collaborations with leading industries and research institutions. To accomplish its mission the European Specialisation School in Sustainable Energy lays on the 6 pillars represented in Table 1.

Sustainability, circularity, and social-economic aspects of energy transition			
Sustainable and renewable fuels	Renewable and sustainable heat	Renewable and sustainable electricity	Sustainable mobility
System integration, energy management, storage and efficiency			

Table 1: The 6 pillars on which the European Specialisation School in Sustainable Energy is based.

Four of such pillars are vertically specialised on each technology related to energy transition, while the two horizontally integrated pillars guarantee a global vision of energy transition and the ability to re-think energy design and research.

In addition to the main teaching courses, some monograph talks will be offered, such as on European financial instruments, EU regulatory frame, active participation and involvement of citizens or selected soft skills coming out as a result of the stakeholder involvement foreseen in other activities of SKILLBILL project.

1.1.1 *Admission*

Available positions:	50
Applications deadline:	September 30, 2023
Admission requirements:	BSc in Engineering, Physics, Mathematics, Chemistry or Economics.
Required documents:	CV, motivational letter, valid ID, BSc diploma certificate
How to apply:	by email to didatticasid@unitus.it

To guarantee high teaching standards, 50 selected students will be admitted to the School each year. Candidates are required to hold a Bachelor (or equivalent) degree in Engineering, Physics, Mathematics, Chemistry or Economics and will be selected based on their CV and motivational letter.

Curricula evaluation will consider:

- the Candidates' academic profile in terms of coherence to our school objectives, final BSc score, eventual other higher education degrees (e.g. masters, specialisation or vocational schools) and experiences (e.g. participation in international mobility programs, research projects, internships).
- the Candidates' professional profile in terms of coherence to our School objectives and current and previous positions within the organisation they worked for.

The motivational letter should prove the Candidate's willingness to up-skill and/or re-skill with the aim to significantly contribute to the sustainable energy transition. To this end, Candidates should show how they plan to use knowledge and skills from our School to impact the real world (e.g improve their organisation, spread new ideas, create a new job).

Applications should be submitted by email to UNITUS administrative office (didatticasid@unitus.it) before September 30, 2023. Selection results will be released by October 31, 2023.

1.1.2 *Contacts*

For further information on the School or to schedule an appointment you can reach us by email:

- *Administrative office*: Mrs. Anna Filippetti, Mr. Marco Passarelli *didatticasid@unitus.it*
- *School coordinator*: Prof Andrea Luigi Facci *andrea.facci@unitus.it*
- *Tutor*: Dott. Gabriele Loreti *gabriele.loreti@unitus.it*

1.1.3 *The School*

Legal course duration: 1 academic year

Number of ECTS[1]: 60 ECTS

Number of exams: 8 + Final dissertation

Evaluation framework: From A (Excellent) to E (seriously insufficient) - threshold C

EQF[2] Level: Level 7

Fees: Waived until 2025 as part of the SkillBill project

1.1.4 *Legal Organisation*

The European Specialisation School in Sustainable Energy is co-organized by University of Tuscia (IT), Utrecht University (NL), University of Seville (ES), Metropolia University of Applied Sciences (FI), and is legally based at the University of Tuscia. To complete the European Specialisation School in Sustainable Energy, the Candidates have to fulfil 60 ECTS distributed over 1 year. The University of Tuscia will award the title of "First Level Master" to the students that successfully complete the whole programme. It is a legally valid Higher Education Title equivalent to an EQF Level 7 degree. Certificates of attendance can be awarded by each venue to the students that successfully take single modules.

1.1.5 *Lessons and Courses Organization*

The School is organised into 4 periods (see Table 2)

	Classes	*Exams*
Period 1	December, 1- January, 31	February 1 - February, 15
Period 2	February, 15 - April, 15	April, 15 - April, 30
Period 3	May, 1 - July, 1	July, 1 - July, 15
Period 4	August, 16 - October, 15	October 15, October, 31
Graduation Project/ Final Dissertation/	November	
Vacation	December 20-January 8 July 15 - August, 15	

Table 2 Schedule of the teaching periods

[1] European Credit Transfer and Accumulation System (link)

[2] European Qualification Framework (link).

The School is structured in 8 modules (see Table 5), 6 of which are compulsory and 2 electives, to be selected among a panel of 12. The students' commitment is 6 ECTS for each module (48 ECTS total). Elective modules must be selected within the same pillar. The final graduation project, including the project, the thesis and the final dissertation covers the remaining 12 ECTS. The internship in an organisation relevant for the energy sector (e.g. industry or research institution) is compulsory.

All modules verify the achievement of the objectives through one or more individual assignments and a final written exam to be performed at the end of the courses. Assignments are mandatory to be admitted to the written exam and will be reviewed only once. Failed exams (i.e. score below C) can be repeated only once during the following examination period.

In Table 3 modules highlighted in green are compulsory and modules with virtual reality contents have a "*" after the name (additional modules can be available during the years):

	Renewable and Sustain-able fuels	**Renewable and sustain-able heat**	**Renewable and sustain-able electricity**	**Sustainable mobility**	**Sustainability, circularity and social-economic aspects of energy transition**	**System integration, energy management, storage and efficiency**
Period 1	Biofuels		Introduction to the power grid and market of electricity			Energy management
			Dispatchable Renewable Energy Technologies*			
Period 2	Waste to fuels	Renewable heat technologies*	Variable Renewable Energy Technologies*	Road transport	Water energy nexus	
Period 3		Sustainable heat in built environment*		Air Transport	Sustainability in the context of transitions	Energy storage*
Period 4	Power to X	Industrial renewable heat		Maritime transport	Circular economy	Multi-energy systems
Stage - Thesis - Final dissertation						

Table 3: Organization of courses and lessons

1.1.6 *Attendance- and effort requirements*

Presence during the lectures is not mandatory but strongly advised. If the student decides to be present during the lectures, he should respect others' ideas and have an active participation. If the student cannot attend a mandatory exam due to severe illness or other reasons beyond his control, the mandatory attendance will not apply. The student must be able to prove that the reason for absence was beyond his own control. Ultimately, the course coordinator will have the final decision on the matter.

1.1.7 *Prerequisites*

For each course some initial knowledge can be required as described in the following paragraphs. However, the most important prerequisites are:

i) to have a respectful attitude towards those with a knowledge level that differs from yours who do not have the same knowledge as you,

ii) to enrich the lectures through appropriate, proactive participation humbly enrich the lectures with the knowledge you already have and

iii) maintain an attitude of openness to challenges, even when they extend beyond your comfort zone to get out of your comfort zone and actively participate in the different activities.

2. Detailed Description of Pillars, Modules, and Courses

2.1 Sustainability, circularity and social-economic aspects of energy transition

This pillar embraces all the relevant technologies for energy transition. Its objective is to provide a solid comprehension of concepts such as sustainability and circularity as bases for an effective and efficient application of the technology. It specifically focuses on the economic perspectives related to energy transition (e.g. job and investment opportunities), financial aspects and public support schemes for energy transition.

In Table 4 the overview of the pillar.

Compulsory courses		Elective courses	
Module	***Period***	***Module***	***Period***
Sustainability in the context of transitions	Period 3	Water energy nexus	Period 2
		Circular economy	Period 4

Table 4: Summary of the pillar module "Sustainability, circularity and social-economic aspects of energy transition"

2.1.1 *Sustainability in the context of transitions*

Sustainable development includes many challenges. Companies are facing an increasing number of challenges in their daily business. This course will introduce the many dimensions of sustainable development. A system perspective is central to understanding the potential contribution and impact of technologies. In this course, the students will get an overview of the tools and techniques to evaluate and assess the sustainability of company processes. Hence, the course provides a basis for students to understand the contributions and limitations of the energy transition towards a sustainable society.

Period:	Period 3
Course coordinator:	Dr. ir. Jesús Rosales Carreón - Utrecht University- email: j.rosalescarreon@uu.nl
Lecturer:	Dr. ir. Jesús Rosales Carreón - email: j.rosalescarreon@uu.nl Dr. Javanshir Fouladvand - email: j.fouladvand@uu.nl

Educational management portal:	moodle.unitus.it
Objectives:	The specific contribution of this course to the endpoints and qualifications of the specialisation programme is: • Develop a system thinking mind-set • Develop a set of communicating and visioning skills associated with issues of global change • Foster awareness and literacy to debate the concept of sustainability in order to promote global environ- mental and social change • Assist in learning efficient and consistent methods in order to effectively explore and give advice to businesses regarding sustainability assessment. • Allow critical reflection upon the role of science and technology in society and understanding this as an ongoing, adaptive process
Programme:	The course will start with an introductory lecture which provides an overview of the course. This will be followed by three main themes: i) the fundamentals of Systems Thinking, ii) sustainability challenges iii) assessment. On the basis of this knowledge, tools and insights are offered to assess the potentials and hurdles of technologies and processes needed for a sustainable world. The course integrates the three pillars attributed to the study of sustainability, namely: social, environmental and economic aspects
Pre-requisites:	The course requires basic knowledge in: i) mass balances, ii) economic analysis, and iii) social systems.
Study material:	● Lecture slides; ● Reading material; ● Additional resources handed out during the course / made available via Blackboard

2.1.2 *Circular Economy*

The Circular Economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products for as long as possible thereby extending the life-cycle of products. In practice, it implies reducing waste to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever

possible thanks to recycling. These can be productively used again and again, creating further value. This is a departure from the traditional, linear economic model, which is based on a take-make-consume-throw away pattern. This model relies on large quantities of cheap, easily accessible materials and energy. Planned obsolescence, when a product has been designed to have a limited lifespan to encourage consumers to buy it again, is also part of this model[1].

Period:	Period 4
Course coordinator:	Dr. ir. Jesús Rosales Carreón - Utrecht University- email: j.rosalescarreon@uu.nl
Lecturer:	Dr. ir. Jesús Rosales Carreón - email: j.rosalescarreon@uu.nl Dr. Javanshir Fouladvand - email: j.fouladvand@uu.nl
Educational management portal:	moodle.unitus.it
Objectives:	The specific contribution of this course to the endpoints and qualifications of the specialisation programme is: - Understand the basic concept of a circular economy, its opportunities and limitations - Describe a set of tools to measure the impacts of a circular economy - Apply the tools and critically reflect upon the results
Programme:	The course is an elective course for the students within the specialisation programme. The course will provide students with the knowledge and tools to critically evaluate Circular Economy and its relation with the energy transition.
Pre-requisites:	The course requires basic knowledge in: i) mass balances, ii) economic analysis, iii) social systems.
Study material:	● Lecture slides;

[1] https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

- Reading material;

Additional literature handed out during the course / made available via Moodle.

2.1.3 *Water Energy Nexus*

The water-energy nexus is the relationship between the water used for energy production, including both electricity and sources of fuel such as oil and natural gas, and the energy consumed to extract, purify, deliver, heat/cool, treat and dispose of water (and wastewater) sometimes referred to as the energy intensity (EI)

Period:	Period 2
Course coordinator:	Prof. David Sanchez - University of Seville - email: ds@us.es
Lecturer:	Prof. David Sanchez - University of Seville email: *ds@us.es*
Educational management portal:	moodle.unitus.it
Objectives:	To analyse and to provide the students the instruments to understand the intimate connection between energy production/efficiency and water usage
Programme:	● Connection between climate change, water, and energy. ● Energy industry water requirements. ● Energy sources and the urban water cycle. ● Water footprint from of energy related activities.
Pre-requisites:	The course requires basic knowledge in: i) Thermodynamics fundamentals. ii) Energy conversion systems fundamentals; iii) Renewable energy fundamentals.
Study material:	● Lecture slides; ● Reading material; ● Additional literature handed out during the course / made available via Moodle.

2.2 Renewable and Sustainable Fuels

This pillar focuses on the production, deployment and distribution of non-fossil fuels, in particular biomass (e.g. biogas, bio-methane, bio-diesel, bio-ethanol), waste (pyrolysis syngas) and electrolytic fuels (SNG, H_2, Ammonia). It focuses on the real sustainability of such fuels (e.g food competition, local pollution emissions etc).

In Table 5 the overview of the pillar.

Compulsory courses		Elective courses	
Period	Module	Period	Module
Biofuels	Period 1	Waste to Fuels	Period 2
		Power to X	Period 4

Table 5: Summary of the pillar module "Renewable and Sustainable Fuels"

2.2.1 *Biofuels*

Biofuels are liquid or gaseous transport fuels, such as biodiesel and bioethanol, made from biomass. They serve as a renewable alternative to fossil fuels in the EU's transport sector, helping to reduce greenhouse gas emissions and secure supply availability in the EU. By 2030, the EU aims to increase the share of renewable energy in transport to at least 14%, including a minimum share of 3.5% of advanced biofuels. EU countries are required to set out an obligation for fuel suppliers that ensures the achievement of this target.[1]

Period:	Period 1
Course coordinator:	Esa Toukoniitty, Metropolia University of Applied Sciences. Email: Esa.Toukoniitty@metropolia.fi
Lecturer:	Esa Toukoniitty, Metropolia University of Applied Sciences. Email: Esa.Toukoniitty@metropolia.fi
Educational management portal:	moodle.unitus.it
Objectives:	An introduction to biomass properties and potential. Overview of main conversion processes, raw materials and biofuel product properties.
Programme:	Setting the scene - fuels today (liquid, solid gaseous, applications, sustainability, fuel properties/standards, LCA, emissions). Introduction to biofuels, biomass chemistry - lignocellulose, fats and lipids, sugars composition, key reactions, chemistry of biomass

[1] https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biofuels_en

	conversion, catalysis. Biofuel processes (general overview, gasification, syngas, FT, bio-oils/upgrading, biomass monomer production and pre-treatment, sugar conversion, non-sugar monomers, triglyceride upgrading.
Pre-requisites:	Fundamentals of Chemistry and Process Technology
Study material:	● Lecture slides; ● Reading materials ● Additional literature handed out during the course / made available via Blackboard/Moodle.

2.2.2 *Waste to Fuels*

Waste to Fuel technology is part of "Waste to Energy" technologies, focussing on reusing waste raw materials (biomass) to produce fuel. Waste to Energy, is a term that is used to describe various technologies that convert non-recyclable waste into usable forms of energy including heat, fuels and electricity. Waste to Energy can occur through a number of processes such as incineration, gasification, pyrolysis, anaerobic digestion, and landfill gas recovery

Period:	Period 2
Course coordinator:	Esa Toukoniitty, Metropolia University of Applied Sciences. Email: Esa.Toukoniitty@metropolia.fi
Lecturer:	Esa Toukoniitty, Metropolia University of Applied Sciences. Email: Esa.Toukoniitty@metropolia.fi
Educational management portal:	moodle.unitus.it
Objectives:	Overview of waste to fuels concept, available waste streams and processes. Second and third generation biofuels from waste feedstocks.
Programme:	● Introduction ● Processes: waste oils; HVO; pyrolysis of biomass, pyrolysis/gasification of plastic waste, biowaste to biogas
Pre-requisites:	i) Fundamentals of Chemistry and Process technology ii) Completed Biofuels module
Study material:	● Lecture slides ● Reading material ● Additional literature handed out during the course / made available via Blackboard/Moodle.

2.2.3 *Power To X*

Power-to-X means using renewable electricity, for example wind power, to create something else ('X'). The 'X' created is an energy carrier – usually renewable hydrogen – which can power medium- to heavy-duty transport or be used in industry.

Period:	Period 4
Course coordinator:	Esa Toukoniitty, Metropolia University of Applied Sciences. Email: Esa.Toukoniitty@metropolia.fi
Lecturer:	Esa Toukoniitty, Metropolia University of Applied Sciences. Email: Esa.Toukoniitty@metropolia.fi
Educational management portal:	moodle.unitus.it
Objectives:	Introduction to emerging P2X technologies, processes, products and their future potential.
Programme:	Renewable energy to chemicals and fuels. Power to hydrogen, methane, ammonia, syngas processes (fundamentals, technology, applications, future potential).
Pre-requisites:	i) Fundamentals of Chemistry and Process Technology; ii) Completed Biofuels module
Study material:	● Lecture slides; ● Reading material ● Additional literature handed out during the course / made available via Blackboard/Moodle.

2.3 Renewable and Sustainable Heat

This pillar focuses on the technology, environmental impact, and sustainability of renewable heat vectors.

In Table 6 the overview of the pillar.

Compulsory courses		Elective courses	
Module	Period	Module	Period
Renewable heat technologies	Period 2	Sustainable heat in the built environment	Period 3
		Industrial renewable heat	Period 4

Table 6: Summary of the pillar module "Renewable and Sustainable Heat"

2.3.1 *Renewable heat technologies*

Renewable heat technologies include renewable biofuels, solar heating, geothermal heating, heat pumps and heat exchangers.

Period:	Period 2
Course coordinator:	Dr. Javanshir Fouladvand – Utrecht University - email: j.fouladvand@uu.nl
Lecturer:	Dr. Javanshir Fouladvand - email: j.fouladvand@uu.nl – Dr. Jesus Rosales Carreon - email: j.rosalescarreon@uu.nl
Educational management portal:	moodle.unitus.it
Objectives:	Introduction to design and analysis of renewable heat technologies.
Programme:	Geothermal plant, bioenergy (including CHP), waste heat, electrical heating and district heating.
Pre-requisites:	i) Thermodynamics fundamentals. ii) Energy conversion systems fundamentals; iii) Renewable energy fundamentals.
Study material:	● Lecture slides; ● Reading material; ● Virtual Reality material; ● Additional literature handed out during the course / made available via Moodle.

2.3.2 *Sustainable heat in built environment*

The complexities of socio-technical sustainable thermal energy system design in built environment: the improvement of the energy efficiency and the achievement of the sustainability in buildings it's necessary to limit energy use, improve buildings' energy performance, and reduce energy consumption; the green building rating systems, regulations and policies, technology utilisation, economic assessment and burdens, social factors should be taken into consideration as well.

Period:	Period 3
Course coordinator:	Dr. Javanshir Fouladvand - Utrecht University - email: j.fouladvand@uu.nl
Lecturer:	Dr. Javanshir Fouladvand - email: j.fouladvand@uu.nl – Dr. Jesus Rosales Carreon – email: j.rosalescarreon@uu.nl
Educational management portal:	moodle.unitus.it
Objectives:	Complexities of socio-technical sustainable thermal energy system design in built environment.
Programme:	Insulation, heat pumps, solar energy, wood-pellet, district heating and heat storage, needed regulations, policies and techno-economic assessments.
Pre-requisites:	i) Thermodynamics fundamentals. ii) Energy conversion systems fundamentals; iii) Renewable energy fundamentals.
Study material:	● Lecture slides; ● Reading material; ● Virtual Reality material; ● Additional literature handed out during the course / made available via Blackboard/Moodle

2.3.3 *Industrial renewable heat*

The industrial sector uses heat for many applications, including washing, cooking, sterilising, drying, preheating boiler feed water, viscosity control, and many other processes.

Industrial heat makes up two-thirds of industrial energy demand and almost one-fifth of global energy consumption. It also constitutes most of the direct industrial CO_2 emitted each year, as the vast majority of industrial heat originates from fossil-fuel combustion.[1]

Period:	Period 4
Course coordinator:	Dr. Miriam Benedetti - University of Tuscia - email: miriam.benedetti@enea.it.
Lecturer:	Dr. Miriam Benedetti - University of Tuscia - email: miriam.benedetti@enea.it.
Educational management portal:	moodle.unitus.it
Objectives:	The general objective of this module is to provide the students with theoretical and practical skills on the efficient production and usage of thermal energy in the industrial environment.
Programme:	Heat recovery in industrial environment; efficient heat production in industry, pinch analysis.
Pre-requisites:	Basic thermodynamics and heat transfer.
Study material:	● Lecture slides; ● Reading material; ● Additional literature handed out during the course / made available via Blackboard/Moodle

[1] https://www.iea.org/commentaries/clean-and-efficient-heat-for-industry

2.4 Sustainable and Renewable Electricity

This pillar focuses on technology, environmental impact, and sustainability of renewable electricity technologies such as wind, hydro-power, photovoltaic, solar thermodynamic power, geothermal power, tide power etc.

In Table 7 the overview of the pillar.

Compulsory courses		Elective courses	
Module	Period	Module	Period
Introduction to the power grid and market of electricity	Period 1	Dispatchable Renewable Energy Technologies	Period 1
		Variable Renewable Energy Technologies	Period 2

Table 7: Summary of the pillar module "Sustainable and Renewable Electricity"

2.4.1 *Introduction to the power grid and market of electricity*

Electricity is central to many parts of life in modern societies, and will become even more so as its role in transport and heating expands through technologies such as electric vehicles and heat pumps. The current global energy crisis has placed electricity security and affordability high on the political agenda in many countries; its relevance goes beyond energy and climate issues, since electricity supply impacts economies, regional development, the budgets of businesses and households, and many other areas.[1]

Period:	Period 1
Course coordinator:	Prof. David Sanchez - University of Seville - email: ds@us.es
Lecturer:	To be decided
Educational management portal:	moodle.unitus.it
Objectives:	Familiarise the students with the characteristics of the power grid in different regions worldwide as well as with the mix of power generation technologies. Familiarise the students with the characteristics of the electricity market. Familiarise the students with different incentive schemes to accelerate the adoption of renewable energy technologies for power generation.

[1] https://www.iea.org/reports/electricity-market-report-2023

Programme:	● Characteristics of the power grid: topology, requirements, operation of the system ● Variability of the energy mix in different regions worldwide ● Operation of the electricity market: wholesale market of electricity, ancillary services ● Using incentives to promote the installation of renewable energy technologies for power generation
Pre-requisites:	i) Fundamentals of Thermodynamics, in particular energy conversion systems for power generation. ii) Fundamentals of fluid dynamics (turbomachinery would be useful, though not mandatory)
Study material:	● Lecture slides; ● Reading material; ● Additional literature handed out during the course / made available via Blackboard/Moodle.

2.4.2 *Variable Renewable Energy Technologies*

Variable renewable energy or intermittent renewable energy sources are renewable energy sources that are not dispatchable due to their fluctuating nature, such as wind power and solar power, as opposed to controllable renewable energy sources, such as dammed hydroelectricity or biomass, or relatively constant sources, such as geothermal power.

Period:	Period 2
Course coordinator:	Prof. David Sanchez - University of Seville - email: ds.us@es
Lecturer:	To be decided
Educational management portal:	moodle.unitus.it
Objectives:	Provide the students with the principles of design and operation of variable renewable energy technologies for power generation: photovoltaics and wind
Programme:	● Fundamentals of photovoltaic systems ● Design of photovoltaic systems: small and large scale ● Fundamentals of wind turbines ● Design of wind turbines ● Operation of VRE systems: interaction with the grid"
Pre-requisites:	i) Fundamentals of Thermodynamics, in particular energy conversion systems for power generation.

	ii) Fundamentals of fluid dynamics (turbomachinery would be useful, though not mandatory).
Study material:	● Lecture slides; ● Reading material; ● Virtual reality material ● Additional literature handed out during the course / made available via Blackboard/Moodle.

2.4.3 *Dispatchable Renewable Energy Technologies*

Dispatchable generation refers to sources of electricity that can be programmed on demand at the request of power grid operators, according to market needs. Dispatchable generators may adjust their power output according to an order. Main types of renewable energy that are dispatchable without separate energy storage are hydroelectric, biomass, geothermal and ocean thermal energy conversion.

Period:	Period 1
Course coordinator:	Prof. David Sanchez - University of Seville - email: ds.us@es
Lecturer:	To be decided
Educational management portal:	moodle.unitus.it
Objectives:	Provide the students with the principles of design and operation of dispatchable renewable energy technologies for power generation: hydroelectric, concentrated solar power, geothermal, waste heat recovery
Programme:	● Fundamentals of hydraulic turbines ● Design of hydroelectric power stations ● Fundamentals of Concentrated Solar Power ● Design of CSP plants: linear collectors, central receiver ● Fundamentals of geothermal and waste heat recovery systems ● Fundamentals of Organic Rankine Systems and application to CSP, WHR and geothermal energy sources
Pre-requisites:	i) Fundamentals of Thermodynamics, in particular energy conversion systems for power generation. ii) Fundamentals of fluid dynamics (turbomachinery would be useful, though not mandatory).
Study material:	● Lecture slides; ● Reading material; ● Virtual reality material ● Additional literature handed out during the course / made available via Blackboard/Moodle

2.5 Sustainable Mobility

This pillar focuses on the development of sustainable power-trains (hybrid, electric, hydrogen), mobility paradigms (i.e. collective transport, sharing, multi-modal mobility), infrastructures (i.e. recharging stations, H_2 distribution) and IT services to support sustainable mobility.

In Table 8 the overview of the pillar.

Compulsory courses		Elective courses	
Module	Period	Module	Period
Road transport	Period 2	Air transport	Period 3
		Maritime Transport	Period 4

Table 8: Summary of the pillar module "Sustainable Mobility"

2.5.1 *Road Transport*

Transport on roads can be roughly grouped into goods and persons transports. As Europe moves towards reducing detrimental impact on the environment, transport encompasses multiple opportunities to contribute significantly to these efforts. The transport sector should reduce its carbon emissions and pollution while ensuring inclusive mobility. To achieve a sustainable transport sector is a significant challenge, but also a huge opportunity for the EU: to reduce impact on the environment, provide healthier and cleaner alternatives to mobility of goods and people and increase the uptake of sustainable alternative transport fuels for land, waterborne and air both in the EU and globally.[1]

Period:	Period 2
Course coordinator:	Prof. David Sanchez - University of Seville - email: ds.us@es
Lecturer:	Prof. David Sanchez - University of Seville - email: ds.us@es
Educational management portal:	moodle.unitus.it
Objectives:	Familiarise the students with the main characteristics of the vehicles used to transport people and freight by road, in particular the powertrains used Provide an insight into road transport technologies that are more sustainable Provide a holistic view of how current infrastructures would have to change to enable more sustainable means of transport by road
Programme:	• Vehicles used for road transport: light vs. heavy transport

[1] https://commission.europa.eu/system/files/2020-10/move_sp_2020-2024_en.pdf

	● Fuels and emissions of road vehicles. Legislation More sustainable energy sources/carriers: electric vehicle, hydrogen car, biofuels ● Generation, distribution and storage of biofuels ● Fast chargers for electric vehicles"
Pre-requisites:	Fundamentals of Thermodynamics, in particular energy conversion systems for power generation.
Study material:	● Lecture slides; ● Reading material; ● Additional literature handed out during the course / made available via Blackboard.

2.5.2 *Air Transport*

Emissions from aviation are a significant contributor to climate change. Aeroplanes burn fossil fuel which not only releases CO2 emissions but also has strong warming non-CO2 effects due to nitrogen oxides (NOx), vapour trails and cloud formation triggered by the altitude at which aircraft operate. These non-CO2 effects contribute twice as much to global warming as aircraft CO2 and were responsible for two-thirds of aviation's climate impact in 2018. Emissions from aviation are growing faster than any other mode of transport.[1]

Period:	Period 3
Course coordinator:	Prof. David Sanchez - University of Seville - email: ds@ us es
Lecturer:	To be decided
Educational management portal:	moodle.unitus.it
Objectives:	Familiarise the students with the main characteristics of the contemporary aircraft: capacity, engine technology, fuels Provide an insight into more sustainable aircraft: SAFs, hydrogen and electric aircraft Provide a holistic view of how current land infrastructures and aircraft concepts would have to change to enable more sustainable aviation
Programme:	● Introduction: carbon footprint of aviation todayight vs. heavy transport ● Contemporary aircraft technology: short-haul vs. long-haul. Legislation

[1] https://www.transportenvironment.org/challenges/planes/airplane-pollution

	● Sustainable Aviation Fuels: role, production and impact on carbon footprint: electric vehicle, hydrogen car, biofuels ● Hydrogen aircraft: concepts, impact on aircraft specifications of biofuels ● More electric aircraft: concepts, impact on aircraft specifications
Pre-requisites:	Fundamentals of Thermodynamics, in particular energy conversion systems for power generation.
Study material:	● Lecture slides; ● Reading material; ● Additional literature handed out during the course / made available via Blackboard.

2.5.3 *Maritime Transport*

Maritime transport plays and will continue to play an essential role in global and European trade and economy Shipping emissions are currently increasing and will most likely continue to do so in the future due to the increase of global-scale trade. Ship emissions have the potential to contribute to air quality degradation in coastal areas, in addition to contributing to global air pollution. Mitigation strategies to achieve sustainability are possible. [1] [2]

Period:	Period 4
Course coordinator:	Prof. David Sanchez - University of Seville - email: ds@ us es
Lecturer:	Prof. David Sanchez - University of Seville - email: ds@ us es
Educational management portal:	moodle.unitus.it
Objectives:	Familiarise the students with the main characteristics of cargo ships used today. Provide an insight into more sustainable propulsion systems for cargo ships Provide a holistic view of the impact of using more sustainable fuels and propulsion systems on ship concept and infrastructures
Programme:	● Introduction: carbon footprint of maritime transport today ● Contemporary cargo ship technology

[1] https://www.sciencedirect.com/science/article/pii/S1352231014002313

[2] https://www.eea.europa.eu/highlights/eu-maritime-transport-first-environmental

	● Sustainable Maritime Fuels: role, production and impact on carbon footprint
Pre-requisites:	Fundamentals of Thermodynamics, in particular energy conversion systems for power generation.
Study material:	● Lecture slides; ● Reading material; ● Additional literature handed out during the course / made available via Blackboard.

2.6 System integration, energy management, storage and efficiency

This pillar provides an as-a-whole integrated vision of the green technologies through: (i) Energy efficiency concepts, instruments, and technology application in industry, buildings, and services (e.g. tri- or co-generation); (ii) Effective integration between different green technologies and with existing conversion and distribution infrastructures; (iii) Energy storage technologies.

In Table 9 the overview of the pillar.

Compulsory courses		Elective courses	
Module	Period	Module	Period
Energy Management	Period 1	Energy storage	Period 3
		Multi energy systems	Period 4

Table 9: Summary of the pillar module "System integration, energy management, storage and efficiency"

2.6.1 *Energy Management*

Energy management includes planning and operating energy production and energy consumption units as well as energy distribution and storage. Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need. It is closely connected to environmental management, production management, logistics and other established business functions.

Period:	Period 1
Course coordinator:	Prof. Gabriele Loreti - University of Tuscia - email: gabriele.loreti@unitus.it
Lecturer:	Prof. Gabriele Loreti - University of Tuscia - email: gabriele.loreti@unitus.it
Educational management portal:	moodle.unitus.it
Objectives:	This module aims at providing the students with the instruments and methodologies for effective energy management in final uses
Programme:	Industrial energy vectors; Metering energy consumption and efficiency; Statistical energy management; Energy benchmarking (KPIs); Energy prices and contracts; Efficiency incentivization. Fundamentals of local energy storage: Financing Renewable energy
Pre-requisites:	i) Thermodynamics fundamentals.

	ii) Energy conversion systems fundamentals; iii) Renewable energy fundamentals
Study material:	● Lecture slides; ● Reading material; ● Additional literature handed out during the course / made available via Blackboard.

2.6.2 *Energy Storage*

Energy storage is the collection of energy produced at one time for use at a later time to reduce imbalances between energy demand and energy production. A device that stores energy is generally called an accumulator or battery. Energy comes in multiple forms including radiation, chemical, gravitational potential, electrical potential, electricity, elevated temperature, latent heat and kinetic energy. Energy storage involves converting energy from forms that are difficult to store to more conveniently or economically storable forms.

Period:	Period 3
Course coordinator:	Prof. Gabriele Loreti - University of Tuscia - email: gabriele.loreti@unitus.it
Lecturer:	Prof. Gabriele Loreti - University of Tuscia - email: gabriele.loreti@unitus.it
Educational management portal:	moodle.unitus.it
Objectives:	Analysis of the technologies and rationale for energy storage, instruments and methodologies for effective energy management in final uses
Programme:	EES: Pumped Hydro; Electrochemical storage; CAES; Hydrogen storage; Supercapacitors; flywheels. TES: sensible heat storage, latent heat storage, chemical heat storage. Power to gas systems. Standardisation
Pre-requisites:	i) Thermodynamics fundamentals. ii) Energy conversion systems fundamentals; iii) Renewable energy fundamentals
Study material:	● Lecture slides; ● Reading material; ● Virtual reality material ● Additional literature handed out during the course / made available via Blackboard/Moodle

2.6.3 *Multi energy systems*

Multi-energy systems (MES) whereby electricity, heat, cooling, fuels, transport, and so on, optimally interact with each other at various levels (for instance, within a district, city or region) represent an important opportunity to increase energy efficiency, along with technical, economic and environmental performance.[1] In addition, the rapid development of technologies has resulted in amplifying the joint operation of the multi-generation systems. This highlights the importance of focusing on multiple alternatives such as integration of renewable energy sources, effective energy conservation, energy storage, etc.

Period:	Period 4
Course coordinator:	Prof. Gabriele Loreti - University of Tuscia - email: gabriele.loreti@unitus.it
Lecturer:	Prof. Gabriele Loreti - University of Tuscia - email: gabriele.loreti@unitus.it
Educational management portal:	moodle.unitus.it
Objectives:	The objective of this module is to give to the students the design techniques to integrate different energy systems.
Programme:	EES: Pumped Hydro; Electrochemical storage; CAES; Hydrogen storage; Supercapacitors; flywheels. TES: sensible heat storage, latent heat storage, chemical heat storage. Power to gas systems. Standardisation
Pre-requisites:	i) Thermodynamics fundamentals. ii) Energy conversion systems fundamentals; iii) Renewable energy fundamentals.
Study material:	● Lecture slides; ● Reading material; ● Additional literature handed out during the course / made available via Blackboard/Moodle.

1

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
AzzeroCO2 climate in our hands	AZZERO CO2 SRL	AzzeroCO2
Q-PLAN INTERNATIONAL	Q-PLAN INTERNATIONAL ADVISORS PC	Q-PLAN
WHITE	WHITE RESEARCH SPRL	WR
Università degli Studi della Tuscia	UNIVERSITA DEGLI STUDI DELLA TUSCIA	UNITUS
Universidad de Sevilla	UNIVERSIDAD DE SEVILLA	USE
Metropolia University of Applied Sciences	METROPOLIA AMMATTIKORKEAKOULU OY	METROPOLIA
Utrecht University	UNIVERSITEIT UTRECHT	UU
EREF European Renewable Energies Federation	EUROPEAN RENEWABLE ENERGIES FEDERATION	EREF
SINERGIE	SINERGIE SOC CONS ARL	SINERGIE
PEDAL CONSULTING	PEDAL CONSULTING SRO	PC

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