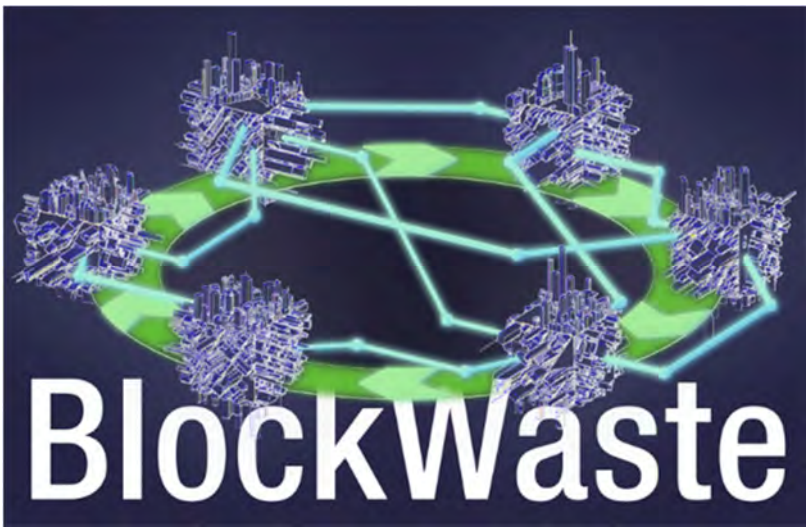
Municipal waste management curriculum using blockchain technology



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Course /content name	**Module 01** **Circular Economy** – general		
Study programme Cycle	*Subject on a Master`s degree*		
ECTS:	6	**Number of hours**	**60**
Productive Sector	Generic, focus on waste industry		
Entry Profile	-Civil Engineering -Building engineer -Mining engineers -Geologist -Architects -Environmental sciences -Sustainability Studies -Sustainable Business and Management Studies -Environmental IT Studies		
Job positions:	-Environmental Consultant -Environmental Technician -Manager or Construction site Director -Mining Manager -Manufacturing Manager -Waste manager -Consultants for Circular Economy and Waste Economics -Data Scientists		
Course aims / Learning outcomes	Increase students' awareness of the Circular Economy concept and upgrade their skills including technological ones in the circular management of specific substance cycles.		

	Students have deepened their understanding of Circular Economy concepts and their skills in managing waste flows in a Circular Economy. They are specifically capable of • analyzing circular flows of substances • analyzing and designing smart equipment infrastructure required for waste cycles • understanding and analyzing data generation and data flows mirroring substance streams • determining the landscpae of stakeholders in waste and substance cycles and addressing interested parties' interest adequately with the help of innovative digital tools such as blockchain and data analytics • understanding waste value chains and deriving financial benefits from them
General competences and specific competences:	GC 1. Having a broadly based understanding of the concept and functioning of a Circular Economy with specific regard to waste streams SC 1.1. Understanding possible health and environmental hazards of waste substances SC 1.2. Being aware of the impact and the requirements the emerging transition from a linear to a circular economy brings SC 1.3. Understanding the technological options available for supporting a Circular Economy SC 1.4. Integrating the flow of both substances and data into any modelling of substance cycles SC 1.5. Having a sound understanding of legal frameworks of waste management and the Circular Economy at national and EU levels

	GC 2. Being capable to analyse, remodel and combine waste substance and data cycles in a Circular Economy Being able… SC 2.1. … to model equipment parks for use in a Circular Economy with special regard to sensoring, IoT and robotics SC 2.2. … to design data collection and data management cycles used in waste management SC 2.3. … to manage waste and substance cycles in accordance with circularity principles SC 2.4. … to design argumentative strategies for decision making processes in the transition to a Circular Economy
	GC 3. Prove to have the skill to analyse, manage and integrate stakeholder interests in waste management Being able SC 3.1. … to map stakeholders and their interests SC 3.2. … to determine mutual benefits of stakeholders in waste chains and communicating them with an integrative attitude SC 3.3. … to model waste data flows in a way that benefits all stakeholders SC 3.4. … to understand and exploit the opportunities of data sharing over Distributed Ledger networks (Blockchain)
	GC 4. Understanding and managing the value propositions to be derived from Circular Economy waste cycles. Being able SC 4.1. … to valuate waste streams and substances SC 4.2. … to show a sound understanding of sustainability accounting practices SC 4.3. … to make viable investment decisions on the basis of value created

	GC 5. Understanding and applying the legal frameworks that govern the Circular Economy and waste management. SC 5.1. Understanding waste classifications and waste hierarchy principles SC 5.2. Being aware of all relevant standards and norms applying to the Circular Economy and waste management SC 5.3. Being familiar with all relevant certicates and certification procedures
Syllabus: Teaching units and skills	**Teaching Unit 1 – The Circular Economy model** • Natural capital • Linear vs circular business models and value chains
	Teaching Unit 2 - Analysis of waste and emissions footprint • Mapping substance flows • Impacts of substances
	Teaching Unit 3 – Life Cycle Assessment • Sustainable procurement • Supply chain management
	Teaching Unit 4 - Circularity hierarchies • 4 R (reduce, recycle, reuse, renew) / 7R (+ re-think, re-design etc)/ 10R models • Taxonomy of value creation from waste
	Teaching Unit 5 - Measuring CE performance • Key Performance Indicators of CE cycles, • Valuation of substances • Cost-benefit analysis of CE transition • Sustainability accounting,

	Teaching Unit 6 - Economics of waste cycles in CE • Product/Service systems (PSS) • Waste economics • Value algorithms in the Circular Economy • Value propositions in the Circular Economy • Externalization/ internalization of cost
	Teaching Unit 7 - **Administrative cycles in CE** • Data generation • Data collection • Data management
	Teaching Unit 8 - **Analysis and design of architectures of CE cycles** • Analysis of (sub)cycles • Sector and/or substance-specific case studies (plastics, automotive, textiles …)
	Teaching Unit 9 - **Overview of Digitalization trends in CE** • IoT • Big Data analysis • Blockchain / DLT
	Teaching Unit 10 - **CE logistics** • Supply chain analysis • Commodities exchanges • Supply chain finance
	Teaching Unit 11 - **Standards and compliance** • CE-relevant waste legislation at EU level • ISO and other standards • Compliance • Certification
	Teaching Unit 12 - **Stakeholder mapping** • Stakeholder analysis • Stakeholder management • Stakeholder communication
	Teaching Unit 13 – Consumer / waste producer integration

	• Consumer behaviour • Incentivization and nudging for change • Monetization
	Teaching Unit 14 - **Simulation game** • Inputs vs output analysis • Extending lifecycles
Teaching methods	Three teaching / learning modes will dominate: • Short lectures delivering concepts and content • Inverted classrooms where students restructure and apply knowledge they have acquired in self-study • Practice workshops and simulations where students work on models and scenarios

Module /content name	**Module 02** **Circular Economy and MSW management -** specific		
Study programme ***Cycle***	*Subject in a Master`s degree or Degree*		
ECTS / hours	3	**Number of hours**	**20**
Productive Sector	Stone Manufacturing		
Formal qualifications, entry profile	-Civil Engineering -Building engineer -Mining engineers -Geologist -Architects -Environmental sciences		
Job positions	-Environmental Consultant -Environmental Technician -Manager or Construction site Director -Manufacturing Manager -Waste manager -etc.		
Module learning objectives	Increasing the skills and qualifications of active workers (bachelor level) to improve their adaptation to the labour market towards the transition to a green economy in order toachieve smart, sustainable and integrated growth in the waste management sector. This Circular Economy Course and MSW management module is multidisciplinary and applied, aimed at anyone seeking to kick-start circular economy and waste management.		
General competences and specific competences	GC 1. Detailed and well-founded understanding of the theoretical and practical aspects and working methodology in the field of the Circular Economy. SC 1.1. Know the principles of sustainable development applied to municipal waste management.		

	SC 1.2. Carry out operations at all times prioritizing the Circular Economy and sustainable processes. SC 1.3. Adopt the environmental measures established for the prevention to damage the environment.
	GC 2. Be able to predict and control the evolution of complex situations through the development of new and innovative work methodologies adapted to the field of Circular Economy. SC 2.1. To know the advantages and disadvantages ofthe waste treatment approaches and to be able to evaluate which treatment approach is economically and environmentally profitable. SC 2.2. To be able to apply circular models to MSW management. SC 2.3. To understand and apply new technologies in order to improve the circular processes associated with MSW management. SC 2.4. Ability to apply ethical criteria and sustainability in decision making.
	GC 3. Be able to take responsibility for their own professional development and their specialization in Environmental Engineering, Circular Economy and Sustainable MSW management processes. SC 3.1. Knowledge of the impact of MSW management on the achievement of sustainable development and, especially, deepening the knowledge of the regulations and policies from the point of view of circular economy. SC 3.2. In-depth knowledge of the techniques for assessing the environmental impact of MSW treatment approaches. SC 3.3. Ability to reconcile environmental requirements with the conditions of sustainable development.

	GC 4. Be able to foster, in professional contexts, the technological, social or cultural advancement within a society based on knowledge. SC 4.1. Know the different tools of environmental management, as well as its correct application to reduce environmental problems of MSW management. SC 4.2. Ability to manage computer tools that allow data management, problem solving and help decision making.
	GC 5. Be able to take responsibility for their own professional development and their specialisation in one or more fields of study. SC 5.1. Plan the implementation of an environmental management system, as well as coordinating and maintaining through advances of new technologies.
Syllabus: Teaching units and skills	**Teaching Unit 1. Introduction to Municipal Solid Waste** S.K.1.1. Definition S.K.1.2. Classification of MSW. Categories of municipal waste, according to Eurostat (2017). S.K.1.3. MSW stream characteristics 1. Methods of Characterizing MSW 2. Materials in MSW by Weight 3. Discards of MSW by Volume 4. Variability of MSW Generation S.K.1.3. MSW and the environment 1. Quantities of MSW 2. Emission of Pollutants from MSW 3. MSW Management and Climate Change

	4. MSW management and Public Health
	Teaching Unit 2. Introduction to MSW management S.K.2.1. Introduction to MSW management. 1. Waste generation and management issues. 2. Integrated waste management. 3. Typical costs for main waste management options S.K.2.2. Waste management hierarchy. Prevention, Preparing For Re-Use, Disposal, Recovery, Recycling. S.K.2.3. Common principles in MSW management. Affordability, polluter pays and sustainability.
	Teaching Unit 3 MSW treatment S.K.3.1. Landfill. S.K.3.2. Incineration and energy recovery. S.K.3.3. Composting and biomethanisation. S.K.3.4. Recycling.
	Teaching Unit 4 MSW management in a CE (4.0 hours). S.K.4.1. Conceptual outline of the circular economy in the MSW management sector. 1. Definition of circular economy and its importance in the MSW management sector.

	2. Evolution of the MSW management sector towards the circular economy. S.K.7.2. Development of the circular economy in the MSW management sector. 1. Roles of MSW management sector agents in the circular economy. 2. Challenges and barriers in the development of the circular economy in the MSW management sector. S.K.7.3. Circular management of MSW waste. 1. Circular MSW Management Studies. 2. Circular MSW Management Plan/Study and competitive advantages.
	Teaching Unit 5 Policies and instruments in MSW management towards CE S.K.5.1. Regulatory instruments (product standards, capacity-building measures, etc.). S.K.5.2. Economic instruments (pay-as-you-throw pricing models, polluter pays principle, differential disposal taxes, etc.). S.K.5.3. Extended producer responsibility S.K.5.4. Green public purchasing S.K.5.5. Monitoring and reporting S.K.5.6. Enforcement and compliance promotion S.K.5.7. Public information and awareness raising

	Teaching Unit 6 Technologies for a circular MSW management S.K.6.1. IoT S.K.6.2. Robotics S.K.6.3. Sensoring S.K.6.4. Track-and-trace S.K.6.5. Treatment processes and equipment
Teaching methods	Lectures and seminars will be organized for the theoretical content. In the seminars, specific topics of the theoretical syllabus will be expanded. Resolution of practical cases. Problems are posed to students for their individual resolution. Tutorials will be organized for the resolution of individual or group doubts about theory, problems, practices and seminars. Multimedia didactic resources will be used when they are available. Lessons should be complemented with the visit to different type of natural stone companies.

Course /content name	**Module 03** **Data Analysis – Data Mining - Machine Learning – Blockchain Data Analysis**		
Study programme ***Cycle***	*Subject on a Master`s degree*		
ECTS:	6	**Number of hours**	60
Sector	Waste management / Circular Economy		
Entry Profile	Graduates of -Civil Engineering -Mining Engineering -Geology -Architecture -Environmental Sciences -Environmental IT and Statistics Services -Circular Economy		
Job positions:	-Environmental Consultant -Environmental Technician -Manager or Construction site Director -Mining Manager -Manufacturing Manager -Construction waste manager -Circular Economy Consulant -Statistician -Waste Economist -IT Manager / Administrator		
Course aims / overall learning outcomes	***Aim*** The aim of the module is to familiarize students with basic techniques of data mining and machine learning algorithms. The expected learning outcomes include knowledge of the basic methods of data analytics and gaining experience in their implementation and use, as well as the critical ability to		

	select the appropriate methodology for each problem, with an understanding of its advantages and disadvantages. ***<u>Learning outcomes</u>*** - Students will be able to use various techniques, methods and tools for data analysis in reference with waste management systems that integrate Blockchain technology. - Students will be able to produce analytic reports - Use the R and Python programming languages and associated tools to analyze data in order to provide evidence-based answers to a range of questions.
General and specific competences	GC 1. Understand the theoretical and practical aspects and also techniques and methods applied in the field of the Data analysis and Machine Learning. SC 1.1. Understand and describe the main technological trends in Data Analysis and Machine Learning applied to the Waste Managment Sector.
	GC 2. Be able to design and manage Waste Managment projects, create new research ideas and innovative techniques adapted to the field of Waste Managment and Circular Economy. SC 2.1. To know the advantages and disadvantages of the use of Data Analysis and Machine Learning and to be able to evaluate practical solutions and choose the most appropriate. SC 2.2. To understand and apply innovate techniques so as to improve the processes associated with Waste Managment and Blockchain.
	GC 3. Be able to implement specific processes in order to search, analyze and synthesize data and information SC 3.1. Ability to manage computer tools that allow data management, problem solving and help decision making. SC 3.2 Apply R and Python programming languages so as to analyze data and produce high performance predictive models.

Syllabus: Teaching units and skills	**Data Analysis – Data Mining - Machine learning – Blockchain Data Analysis**
	Teaching Unit 1 Basic introduction to Data Science and Data Analytics **1.1** Formulating of problem / question – Data requirements (Define what kind of data will be collected based on the requirements of problem analysis) **1.2** Data Collection (data can be collected from a variety of sources, present in all places, the problem is how to find and gather it to solve the problem) **1.3** Data Processing (data must be processed or organized for analysis, what kind of database should be used to store data, data structure) **1.4** Data Cleaning (data may contain duplicates or errors, increase the quality of data) **(8 hours)**
	Teaching Unit 2 Data Analysis and Exploration (analyze data through a variety of techniques and methods) **2.1** Descriptive Data Analysis *The main goal of Descriptive Analysis is to summarize and describe the data you have using descriptive statistics (measures of central tendency, variability, frequency, position, etc), and its result is a simple presentation of your data. Descriptive modelling explores intrinsic properties of the data e.g. using density estimation and cluster analysis.* **2.2** Exploratory Data Analysis *EDA explores data to find relationships between measures or variables. They can be used to formulate hypotheses.* **2.3** Predictive Data Analysis *Predictive analytics answers the question what is likely to happen. This is when historical data is combined with rules, algorithms, and occasionally external data to determine the probable future outcome of an event or the likelihood of a*

	situation occurring. Predictive modelling aims to build a model for estimating output variable(s) from a set input variables. **2.4** Perspective Data Analysis *Prescriptive Analytics extends beyond predictive analytics by specifying both the actions necessary to achieve predicted outcomes, and the interrelated effects of each decisión.* **(10 hours)**
	Teaching Unit 3 Basic introduction to Data Mining – Machine Learning **3.1** Different types of learning **3.1.1** Supervised learning (introductory concepts, algorithms and techniques) *(decision trees, artificial neural nets, support vector machines, Linear Regression, Regression Trees, etc).* **3.1.2** Unsupervised learning (introductory concepts, algorithms and techniques) *(hierarchical, k-means, self-organizing maps)* **3.1.3** Reinforcement learning (introductory concepts, algorithms and techniques) **(10 hours)**
	Teaching Unit 4 Approaches to ML Model Development **4.1** Machine Learning Toolkits – Programming Languages (R, Python, Keras, Tensorflow, and PyTorch which are focused on deep learning models, Apache Mahout and SciKit Learn provide a range of machine algorithms and tools) **4.2** Data Science Notebooks *(Jupyter, Apache Zeppelin)* *The primary environment for data science is the "notebook", which is a collaborative, interactive, document-style environment that combines aspects of coding, data engineering, machine learning modeling, data visualization, and collaborative data sharing.*

	4.3 Machine Learning Platforms *The machine learning platform is used for automating and quicken the delivery lifecycle of predictive applications which have capabilities to process big data. A good ML platform allows a data scientist to build blocks to find the solutions for any data science problem. Moreover, the data scientists get complete freedom with an environment where they can easily incorporate the solutions into products.* **4.4** Cloud-based ML-as-a-Service (MLaaS) (Amazon, Google, IBM, and Microsoft) *Machine Learning as a Service (MLaaS) is basically an umbrella term for a set of cloud-based tools. These tools aim to support the daily work of data scientists and data engineers in the way cloud based office suites have revolutionized the office environment. The MLaaS tools support collaboration, version control, parallelization and other processes that otherwise would be troublesome. Also, larger vendors deliver easy ways to integrate their MLaaS services with the rest of their portfolio, automating the deployment process or enabling ones to enrich daily tasks with machine learning-based tools.* **(10 hours)**
	Teaching Unit 5 Applications of DM and ML in Waste Management sector **5.1** Computer Vision, Image Classification / Object detection, Predictions for bin fullness **5.2** Limitations of DM and ML in Waste management sector (**10 hours**)
	Teaching Unit 6 Exploring Blockchain Data **6.1** Types, External Data, Fetching/Parsing data **6.2** Analyze and visualize Blockchain data **6.3** Clustering, Association rules, classification, prediction, time series, and prediction) (**12 hours**)

Teaching methods	

Course /content name	**Module 04** **Spatial Data Analysis**		
Study programme Cycle	*Subject on a Master`s degree*		
ECTS:	3	**Number of hours**	30
Productive Sector			
Entry Profile	Graduates of -Civil Engineering -Mining Engineering -Industrial/Process Engineerting -Geology -Architecture -Environmental Sciences -Geo-Sciences -GPS Software Engineering -Circular Economy -Logistics		
Job positions:	-Environmental Consultant -Environmental Technician -Manager or Construction site Director -Mining Manager -Manufacturing Manager -Construction waste manager -Logistics Manager -GPS Engineer		
Course aims / overall learning outcomes	***Aim*** The aim of the module is to familiarize students with Spatial Analysis which is well known as a diverse and comprehensive capability that includes the simple visual analysis of maps and imagery, computational analysis of geographic patterns,		

	finding optimum routes, site selection, and advanced predictive modelling. Specifically within this module students will appreciate the Geospatial technology, complemented by advances in digital technologies, especially the combination of mobile, machine-to-machine and data analytics, which is expected to play a big role in enabling Circular Economy practices and Waste Management. ***<u>Learning outcomes</u>*** - Students will be able to use various techniques, methods and tools for data analysis in reference with waste management systems that integrate Blockchain technology. - Students will be able to produce special maps and analytic reports
General and specific competences	GC 1. Understand the theoretical and practical aspects and also techniques and methods applied in the field of the Spatial Analysis. SC 1.1 To be able to select the appropriate data and apply the appropriate methods in order to model simple phenomenon with a spatial dimensión. SC 1.2. Understand and describe the main technological trends in Spatial Analysis and how could they be used in field of Waste Managment Sector and Circular Economy. SC 1.3. To know the advantages and disadvantages of the use of Spatial Analysis and to be able to evaluate practical solutions and choose the most appropriate. Sc 1.4 Apply R and Python programming languages so as to analyze data and produce high performance predictive models.
Syllabus: Teaching units	**Teaching Unit 1** Basic concepts of Spatial Data and Mapping **1.1** Provides a brief introduction to issues concerning: data structures; data formats; data storage; data standards; spatial and non-spatial data. **(3 hours)**

	Teaching Unit 2 Cartography and Map Design **2.1** Map projections and coordinate systems **2.2** GeoVisualization and Information Delivery (aspects of cartographic representations as a communication media of spatial phenomenon). **2.3** Web Mapping - Internet mapping technologies and solutions (Google Maps API; ESRI JavaScript API; Open Layers API; Leaflet API; ArcGIS Enterprise Server, ArcGIS Online, ArcGIS Server, GeoServer.) **(9 hours)**
	Teaching Unit 3 Spatial Data Management **3.1** Open Source geospatial database management systems – Postgres/PostGIS and SQL with QGIS. **3.2** Industry standard database management systems – Oracle and SQL with ESRI ArcGIS. **(6 hours)**
	Teaching Unit 4 Spatial Data Managment and GIS Algorithms and Programming **4.1** Spatial querying; analysis techniques – reclassification, overlay, proximity, visualisation, map algebra; hardware and software, waste collection routing problems (WCRPs) - vehicle routing problems (VRP) **(6 hours)**
	Teaching Unit 5 Applications of Spatial Analysis in Waste Management Spatio-temporal variations of municipal solid waste, optimization of a route and waste collection system, location - allocation of waste bins, etc *Description of performance indicators of solid waste collection (include cost of operational activities, distances travelled by vehicles for haulage, quantity of waste collected, scheduling and routing of vehicles, and number of waste truck, total*

	operational cost of the system, penalty cost, labor hours, and number of containers collected). (**6 hours**)
Teaching methods	

Course /content name	**Module 05** **Blockchain, Tokenization and the Internet of Value for the Circular Economy**		
Study programme ***Cycle***	*Module on a Master`s degree*		
ECTS	6	**Number of hours**	60
Productive Sector	Generic		
Entry Profile	-BSc / BA in o Civil Engineering o Mining Engineering o Mechanical Engineering o Industrial Engineering/Process Engineering o Architecture o Environmental Sciences/Engineering o Sustainability Management o Waste Management o Circular Economy o Similar undergrad degrees and vocational equivalents in some cases		
Job positions:	o Environmental Consultant o Environmental Engineer o Manager or site engineer o Waste / Recycling Manager o Manufacturing Manager o IT hardware or software specialist / engineer o or similar position		
Course aims:	The aim of the course is to develop an in-depth understanding of the problems for which blockchain technology is suitable and the main advantages but also the risks and disadvantages it entails. In addition, the participants should understand the interplay between the blockchain as a decentralised transaction database and the Internet of Things, Big Data Analysis, and Artificial Intelligence, and be able to integrate them into their own work. The blockchain requires the transfer of tokens as representatives of digital values. In this respect, it is essential that learners recognise which real underlying values can be digitally represented as tokens for which purpose. The aim of the entire course is to impart practical knowledge so that the participants are able to start blockchain projects.		

General competences and specific competences:	Objectives and learning outcome • Understanding the functioning of Blockchain technology • Learning about benefits and risks of Blockchain applications and understanding for which types of problems the Blockchain might provide a suitable solution • Understanding the interplay between Blockchain, IoT, AI and Big Data Analysis • Learning about tokens and being able to tokenize the material flow of supply and waste chains. • Learning about tokens and being able to tokenize the payment flow for supply and waste chains by using stable coins and crypto currencies • Creating win-win-situations between stakeholders in a decentralised and collaborative, blockchain-based business environment • Creating blockchain based solutions which respect human rights on privacy and data protection. • Know how to start Blockchain projects
Syllabus: Teaching units and skills	**Teaching Unit 1. Blockchain Fundamentals (10 hours).** • Difference decentralized ledger and central ledger • Basics of cryptography: Hashes and digital signatures • Validation mechanisms: Proof of Work and Proof of Stake • Consensus building measures • public and private blockchain • Learning about different blockchain types: Bitcoin, Ethereum etc. • Understanding smart contract applications • Benefits and risks of blockchain applications • when to use a blockchain
	Teaching Unit 2. Blockchain governance and regulation (5 hours). • learning about different types and elements of blockchain governance • off-chain versus on-chain governance • development of criteria for an optimal governance of blockchain

	• comparison of various blockchain application based on governance criteria • Blockchain and integration in international law • decentralised versus centralised regulation • analysis of national blockchain laws (Liechtenstein, EU MICA etc.) •
	Teaching Unit 3 Concept of Identity (5 hours) • Digital Identity and Blockchain • Self-Sovereignty on private data • National Identity and digital identity • Self-sovereign identity system of individuals such as Sovrin, uPort and Veres One
	Teaching Unit 4 Tokenization and the Internet of Value (10 hours) • Creating Digital Values • Token types: Utility, asset, payment, and security tokens • Utility token application • Assets tokens applications • Payment tokens: Stable coins and crypto currencies • Security token applications and regulation
	Teaching Unit 5 IoT, Big Data Analysis, AI and Blockchain (10 hours). • IoT in Waste management • Big Data Analysis in Waste management • Artificial Intelligence in Waste management • Understanding the interrelation with Blockchain • Learning about Data protection and privacy regulation
	Teaching Unit 6 Analysis of Blockchain Use Cases (10 hours) • Analysis of several use cases (best practise examples) • categorizing use cases • analysis of common features of successful Blockchain solutions
	Teaching Unit 7 Guidance on how to start Blockchain projects (5 hours). • creating win-win-situations for decentralised business environment

	• restructure processes and calculate key-performance indicators • do an investment analysis of transformation costs • learning about stakeholder participation models • create a governance model for the stakeholder consortium
Teaching methods	Lectures and seminars will be organized for the theoretical content. In the seminars, specific topics of the theoretical syllabus will be expanded. Resolution of practical cases. Problems are posed to students for their individual resolution. Tutorials will be organized for the resolution of individual or group doubts about theory, problems, practices and seminars. Multimedia didactic resources will be used when they are available.

Course /content name	**Module 06** **Project: tech-supported process design and change in waste management and CE**		
Study programme cycle	*Module on a Master`s degree*		
ECTS	6	**Number of hours**	**60**
Productive Sector	Generic		
Entry Profile	BSc / BA in o Civil Engineering o Mining Engineering o Mechanical Engineering o Industrial Engineering/Process Engineering o Architecture o Environmental Sciences/Engineering o Sustainability Management o Waste Management o Circular Economy o Similar undergrad degrees and vocational equivalents in some cases		
Job positions	o Environmental Consultant o Environmental Engineer o Manager or site engineer o Waste / Recycling Manager o Manufacturing Manager o IT hardware or software specialist / engineer o or similar position		
Module objectives / learning outcome	This module runs as a tutored real-life project hosted by a waste management organization. It goes beyond mere experience upgrades usual internships tend to provide. Any deliverables are based on real data and address real corporate problems. Objectives and learning outcome Acquiring planning and conceptualizing skills for digitalized waste management, recycling and circular economy processes by designing and planning a real-life project in a corporate environment.		

	• Understanding and planning appropriate digital, data-driven infrastructure like IoT, Blockchain and others in waste management and circular economy • Applying process management skills to waste / substance cycles and to data administration • Applying stakeholder analysis skills to specific waste cycles and value chains • Upgrading skills in communicating and promoting key elements of digital transformation of the waste industry in teams and across departments and hierarchies
General and specific competences	Given the holistic character of the project, competences addressed are acquired along the project rather than in isolated topical units. Coaching services ensure candidates can develop soft skills in the project process with specific regard to • Analytical skills applied to production and service processes • Flexibility and adaptiveness • Understanding of complexity of economic cycles • Decisiveness paired with uncertainty tolerance concerning technological change • Self-organization and initiative combined with resilience and persistence in the face of opposition • Communicating and advocating innovation with both respect and enthusiasm • Empathy towards stakeholders and team members
Subjects and topics	Learning items candidates are to deliver on the project: • Business process mapping and modelling of waste chains • Data mining and analysis in waste and materials cycles: KPIs, data collection, data storage, data analysis, data value creation and tradability, data sharing • Change management: modelling change process in journey from linear waste management to circular economy cycles • Digitalizing waste / CE processes with IoT, data analysis and data management • Organizational development: analysing existing organizational structures and re-designing parts of an organization for Circular Economy purposes

	• Team management: inclusive strategies in team communication ahead of changes in organization • Designing a team's learning pathway: consensual agenda-setting, portioning and iteration of information on learning process, selection of learning materials, error culture, peer-to-peer learning, digital leadership • Agile project management: defining objectives, stakeholder mapping and communication, process ownership, output/outcome planning, resource planning, indicator definition, validation, iterations • Corporate communication
Teaching methods/learning design	The module will run with a co-operative learning approach. It will be activity-based and ideally assigned by a waste management organization. Failing an industrial assignment, an extended case study simulating real waste cycles will be used as a springboard. Workload will mostly be delivered in a lab-type environment on campus or online. Students' work will consist of modelling and conceptualizing and will be coached by lecturers. Occasional input e.g. on Blockchain applications or Data Analytics may be provided in workshop form if necessary. Students will work on adequate technological and industrial solutions, platform design, data generation and handling but also on consumer and stakeholder communication, delivering cycle models, IoT architecture maps and plans and strategy papers outlining communication modes. In the case of an industrial project, the sponsors of the assignment, i.e. waste management organisations will be asked to accompany and evaluate the students' solutions.