Co-funded by the Erasmus+ Programme of the European Union

Management and Technologies of Water, Wastewater, Waste and Circular Economy
– WWW&CE –

WP 5 – Implementation and realisation of further vocational training

Curriculum F – Energy Generation from Wastewater and Waste

Version: 01 **Language: English**

Co-funded by the Erasmus+ Programme of the European Union

Content

1. Executive Summary

The course “Energy Generation from Wastewater and Waste” is an extra-occupational program for decision makers (owners, managers, etc.), employees working in quality and environmental management and skilled workers of small and medium-sized enterprises who operate in the “installation and building technology” sector. The course is developed as a program that can be attended by employees and people carrying out an occupation. Furthermore, it is aimed at people who have completed a work-based training. This target group is generally classified according to the European Qualification Framework level 5. This means, that some years of professional experience and already comprehensively acquired qualifications exist. It can also be carried out by employees in the industry who have prior knowledge or are interested in the environmental area, especially energy generation, wastewater and waste.

This course is part of a programme consisting of six courses in total:

- A – Preparation and management of SMEs for work in the Green Economy
- B – Waste reduction and recycling management
- C – Wastewater, treatment and recycling management
- D – Water supply and saving
- E – Cradle to cradle in SMEs
- F – Energy generation from wastewater and waste

For each participated and completed course a certified degree is given. The certified degree for this course, which is achieved with a successful completion of the course is called “Specialist for Energy generation from wastewater and waste”.

The course “Energy Generation from Wastewater and Waste” (4 ECTS) is divided into the following modules:

- Module I – “Introduction to the topic of Energy Generation” (0.5 ECTS)
- Module II – “Basics about Wastewater and Waste” (0.5 ECTS)
- Module III – “Energy Generation from Wastewater and Waste” (1 ECTS)
- Module IV – “Practical Application and Utilization” (2 ECTS)

The modules are offered in the form of classroom training with integrated home-based learning and are concluded with a seminar paper based on use cases. They are described in the following.

1.1 Name of the course

“Energy Generation from Wastewater and Waste”

1.2 Contact details

WIFI Steiermark
Körblergasse 111-113
A-8010 Graz
Tel.: +43 306 602 1234
Fax: +43 316 602 301
E-Mail: info@stmk.wifi.at
Web: https://www.stmk.wifi.at

1.3 Type of the course

Training course for further education.

1.4 Type of Degree/ Diploma

Certified degree for "Expert in Energy Generation from Wastewater and Waste".

1.5 Duration of Study

The duration of this course is measured in ECTS. One ECTS corresponds to 25 hours of work. In this course, the amount of work required is measured in lessons - one lesson corresponds to 50 minutes.

The entire course comprises 4 ECTS, which corresponds to a total of 100 hours or 120 lessons of workload. These 4 ECTS (or 100 hours) include every activity that needs to be undergone to finish the course, i.e. classroom-setting lessons, studying the content at home (self-study), preparing a seminar paper and presenting this paper to fellow peers.

In the case of an extra-occupational course of study, an annual load of 45 ECTS is assumed as the minimum duration of the study. This results in approximately 3.75 ECTS per month. As this course includes a case study in the form of a seminar paper, which is based on real-life working experience, the total duration of this course was set at three months.

The course is divided into three phases:

- The first phase will comprise of frontal teaching in a classroom setting, which takes place at the course venue and includes home-based e-learning of the presented content by the participants. The total amount for this phase is 60 lessons (i.e. 50 hours or 2 ECTS).
- The second phase comprises of executing a case study and writing a seminar paper about the company of the participant. This work or phase is supported by a trainer. This task will account for approximately 51 lessons (i.e. 42.5 hours or 1.7 ECTS).
- The third phase is again at the course venue, where the participants present their projects and exchange experiences and learned lessons. This will take 9 lessons (i.e. 7.5 hours or 0.3 ETC).

Summarized, the total workload for this curriculum including classroom participation, self-study and the preparation and presentation of a seminar paper is 120 lessons, each corresponding to 50 minutes, which equals 100 hours (per 60 Minutes) or 4 ECTS.

1.6 Provider

Wirtschaftsförderungsinstitut der Wirtschaftskammer Österreich (WIFI) Steiermark in co-operation with trainers.

2. Demand and Acceptance

Due to the anthropogenic climate change, certain sectors will need more and more qualifications in the future and will have to cope with increasingly complex tasks in order to meet the demands of the times. Energy generation plays a major role here. While energy production from fossil fuels is expected to decrease globally, alternatives from regenerative energy production must prevail. For small and medium-sized enterprises (SMEs), it may be relevant to decentrally generate their own energy requirements by generating energy from wastewater or waste.

Due to legal requirements, every company in Austria with more than 20 employees must establish and train employees in the field of waste management, so that these employees can take over the environmentally relevant work and activities in the company. For companies with fewer employees, however, such a training can also offer a great deal of benefits.

Especially companies in the areas of water, wastewater, waste management, recycling, circular economy, etc. will not only be affected by this change, but will also be able to benefit from it. In order to meet the requirements, it is essential that small and medium-sized enterprises (SMEs) adapt their business models and conduct further training in the relevant areas at all levels of the enterprise. Since especially SMEs suffer from strong competition and therefore, available time is a scarce commodity, further training courses are developed in this project in order to be able to meet future requirements on the one hand and to take into account the lack of time of decision makers, managers, owners, experts and other employees of SMEs on the other hand.

The WIFI Steiermark aims to initiate an innovative course of further education "Energy generation from Wastewater and Waste", which will provide further education on the European Qualification Framework (EQF) level 5 (in Austria this corresponds with a finished "Meisterabschluss") for the following target groups:

- The first target group are decision makers (i.e. owners, managers and experts) in the field of "installation and building technology", which would like to follow-up with a further education in this relevant field.
- The second target group comprises people in the environmentally related occupations, who want to broaden their knowledge. This includes people working in the field of quality and environmental management.
- The third group comprises of industry employees, who want to further educate themselves, in order to gain applicable knowledge in their field of work. This group is not limited by any factor, as environmentally related educations will gain in importance in many, if not all sectors. Thus, spreading information and applying future trends can benefit all types of companies.

The main aim of this curriculum is to provide further training for specialists, managers and entrepreneurs in the professions and sectors of energy generation from wastewater and waste, e.g. installation and building technicians.

The objective is to impart knowledge in the field of energy generation, with a focus on energy generation from wastewater and waste as well as to learn, test and discuss future challenges and sustainable solutions. This curriculum is part of a training programme for decision makers (owners, managers), quality and environmental managers and professionals of SMEs.

Six different training courses in Green technologies are included in the whole programme and are offered to trainees with vocational training and several years of professional experience to acquire skills in water, wastewater, waste and circular economy. The learning content thought are cross professional and are addressed at experts and interested companies from all sectors.

The training of the individual courses is specially tailored to the needs of SMEs and different qualification levels. Furthermore, it combines the transfer of technical and professional expertise.

Decision makers (owners and managers) of SMEs are struggling with the task of combining training and work under great lack of time. Employees as well are exposed to the same situation, which prevents them from leaving their work for a longer period of time to attend trainings or further educations measures. Thus, this course is designed in a way so that employers and employees of SMEs have the opportunity to participate in this course without great loss of time or resources, but with a maximum in learning success. Furthermore, an additional benefit for SMEs is created by the fact that the teaching contents and qualifications offered, meet the qualification needs of the employees of SMEs and simultaneously take into account the specific requirements of the SMEs.

To better represent the potential of the target groups, current figures from the Austrian Federal Economic Chamber, the Austrian Federal Waste Management Plan (2017) as well as data from the Federal Institute Statistics Austria were used as sources.

In the year 2017, approximately 39,800 employees were engaged in the waste management sector. It had an annual turnover of approximately 5,200 million Euros. The area of public administration (associations, municipalities, etc.) with almost 14800 employees and a turnover of 1.2 billion euros is particularly noteworthy. Turnover and number of employees in this industry are constantly increasing and the demands on the employees are also increasing enormously.[1]

In 2017, 1,674,234 people aged between 25 to 64 in Austria out of 4,903,139 people in total, completed an apprentice training (this corresponds to EQF Level 4).[2] In 2018, 14,272 people completed a master craftsman training in Austria.[3]
A statistic showing how many people out of a thousand take part in further educational programs in an annual average.[4] 330 out of 1000 wage earners and 288.8 out of 1000 employed persons, took part in further educations. Between the ages of 24 and 64, 15,1 % of the population took part in further education programmes in 2018.

These numbers further underline how of people in Austria who are technically available and willing to take part in courses such as the one described in this curriculum.

There are currently several University courses offered in Austria and many more on a European level that offer similar theoretical contents as this course. However, as the whole study programme is a combination of theoretical and practical experience, within Austria, only the training course for waste management officer and courses related to energy (energy manager, etc.) can be considered as similar, yet they are differentiated as these studies usually involve entire study programmes and not individual qualifications. These courses are very general and either technical or commercial in nature. In addition, the above-mentioned training options lack the application part which for participants is directly integrated into this course.

[1] https://www.bmlrt.gv.at/umwelt/abfall-ressourcen/bundes-abfallwirtschaftsplan/BAWP2017-Final.html
[2] http://statistik.at/web_de/statistiken/menschen_und_gesellschaft/bildung/schulen/reife-_und_diplompruefungen/index.html
[3] http://wko.at/statistik/Meisterpruefung/Meisterpruefung2018.pdf
[4] http://statistik.at/web_de/statistiken/menschen_und_gesellschaft/bildung/index.html

3. Field of activity and qualification profile

3.1 Activities

The activities that can be carried out by graduates include environmentally relevant work and activities in the company relating to energy production, wastewater and waste.

3.2 Typical Functions

The graduates can carry out assessments and potentials of the company with regard to energy generation from wastewater and waste. The course also serves as an introduction to other courses in the field of environmental management. Through other courses, graduates can acquire the qualification of waste management officer, environmental officer, internal and external auditors ISO 14001 / EMAS III, internal environmental management, quality management, environmental consulting and become active in these areas.

3.3 Typical Organizations

Every company in the fields of energy generation, wastewater and waste, as well as every company in building and installation technology.

Austria: Every company with more than 20 employees or if a new company is set up in Austria is required by law to develop and train employees in this area so that these employees can take over the environmentally relevant work and activities in the company.

3.4 Typical Industries

On a global or European level: in addition to public institutions, typical industries that deal with waste and environmental management or energy generation and wastewater management are present in all industrial sectors, such as the automotive industry, electrical industry, wood and pulp industry, chemical and petrochemical companies. Moreover, the entire private and public waste management and wastewater management are to be considered as target groups. Furthermore, a considerable amount of small and medium sized enterprises in all types and forms of sectors and industries is in some way related to energy generation, wastewater management or waste.

Austria: The area of public administration (associations, municipalities, etc.) with almost 14800 employees and a turnover of 1.2 billion euros is particularly noteworthy. However, all industry sectors and all sizes of enterprises within Austria that utilize energy or generate waste and/or wastewater are considered as typical industries.

3.5 Professional Qualifications

The course consists of a theoretical and an applied part. While the theoretical part is completed through active participation in the classroom and self-study via e-learning measures, the applied part of the course takes place at the student's workplace.

The following qualifications, among others, are required for the course and the associated subsequent activities:

- The course is classified on an EQF level 5. Therefore, a relevant education/qualification on EQF level 4 or 5 in a related field (e.g. building technology) is required.
- Several years of working experience in the field.
- Basic understanding of environmental issues and its impacts.

For the activities following the course, the following qualifications, among others, are required, which are taught to the participants during the course. Students acquire the ability to work in companies in the fields of consulting and calculations concerning energy production from wastewater and waste as well as energy use. Students are familiar with energy and environmental obligations at international and national level. Through the preparation of the seminar paper, which is a use-case of their company, they have the knowledge of the preparation of energy potential analyses. They can take over parts of the internal and external environmental communication for their company and create communication concepts for various environmentally relevant areas (energy, wastewater, waste). Further competences which are gained through the course include:

- The participant has an insight into the importance of energy generation in the national and international context as well as its relevance to anthropogenic climate change.
- The participant has knowledge of measures and technologies for generating energy from wastewater and wastewater.
- The participant has an insight into energy generation opportunities for SMEs.
- The participant has industry knowledge and knows which technologies represent a sensible alternative in his company.
- The participant understands the role of his own industry and the importance of working towards a sustainable economy through measures in energy generation and wastewater and waste management.
- The participant can update his or her knowledge through literature, websites, courses, seminars and technical literature as reports and mentors from organisations and agencies and through interaction with industry.
- Using appropriate professional tools, the participant will be able to design and describe sustainable wastewater heat utilisation with a heat pump, as well as supervise technical solutions and methods for work related to energy generation.
- The participant can interpret energy management measures and related environmental documents and create them for practical use.
- The participant has an understanding of the principles of energy production to reduce greenhouse gases and the context of anthropogenic climate change.
- The participant has insights into the basic concepts of national and European wastewater and waste management, as well as measures for energy management in SMEs.

4. Description of the Curriculum

The four modules of the course …

- Module I – "Introduction to the topic of Energy Generation"
- Module II – "Basics about Wastewater and Waste"
- Module III – "Energy Generation from Wastewater and Waste"
- Module IV – "Practical Application and Utilization"

…are taught in the form of classroom teaching and self-study. In the theoretical modules, consisting of the thirst three modules, the knowledge foundation for the seminar work to be written by the participants is established. All modules are characterized by theoretical lecture contents and tasks for independent self-study work. In this way, the practical relevance is placed in the foreground and an immanent examination of the teaching content can be guaranteed. Students acquire the 0.5 ECTS for the first two modules and 1 ECTS for the third module by attending the lectures and active participation, as well as by independently preparing and subsequently presenting the seminar, i.e. the project work.

Basic knowledge of the natural sciences and energy, waste and wastewater as well as related issues, such as anthropogenic climate change, are integrated in modules I to III.
Module IV consists on preparing and executing a case study in the company of the participant itself. It will be written in independent work by the participants and supported by the trainer via online tools. This module requires the most amount of work and is therefore worth 2 ECTS.

5. Examination regulations

The course and examination regulations of WIFI Steiermark apply.

The performance assessment in the classroom courses is based on the attendance of modules I, II and III, while module IV concludes with a project work (seminar paper) of the students. In this project work (seminar paper), the application of the learned concepts and methods to cases from the professional practice of the students is in the foreground.

The composition of examination commissions as well as repetition possibilities are regulated in the course and examination regulations of WIFI Steiermark.

6. Access Requirements and Admission

The access and admission requirements for this course are not as stringent as for other courses in the sector of further education. This is due to the fact that this course addresses a large target group and the imparted knowledge is very fundamentally oriented.

For this course "Energy generation from Wastewater and Waste" advised prior knowledge, when available, include knowledge in the energy and environmental area. This also includes occupational related experience or education related experience in these fields.

After completion of this course and the completion of related courses, the participants will be able to apply the knowledge gained in their companies. The skills will include the creation of a company waste management concept according to national and international regulations. The knowledge and duties of a Waste Management Officer will be known as well as the fundamentals of energy management.

7. Expanses and Financing

In order to ensure the quality of the course, a maximum group size of 20 persons is aimed for, whereby a group size of 15 persons is regarded as optimal. If the maximum number of participants is exceeded, the group will be divided into sub-groups.

Trained trainers with a high level of knowledge and practical experience in the relevant topics are used as lectures. The corresponding rate structure is shown in the table below.

	Fee Rate / teaching Unit[5]	Scientific Qualification	Professional Experience	Teaching Experience
Senior Teacher/ Lecturer	120,- Euro	Current comprehensive scientific and practical publications / conference contributions in the professional field.	Current professional experience in the relevant professional field of the degree programme in a position of high responsibility (e.g. CEO) for at least 5 years	At least 6 years or 12 semesters of teaching well evaluated at university level
Teacher/ Lecturer	90,- Euro	Current scientific or comprehensive practical publications in the professional field.	Current professional experience in the relevant professional field of the degree programme	Professional practitioners with teaching experience or university lecturers
Junior Teacher/ Lecturer	75,- Euro	Not necessary	Relevant professional experience	Experience in teaching or training

[5] The fee rates include 13th and 14th salary and exclude social security contributions.

8. Personnel

The trainers' competences are wide-ranging and include the energy, environmental and waste management sectors, legal areas such as environmental law, plant and trade law, chemical and toxicological areas, employee protection as well as quality and environmental management and communication.

As the further education course "Energy generation from wastewater and waste" is to be designed very company-related and implementation-oriented, lecturers with a high practical relevance and lecturers with high scientific expertise are used.

Areas such as legal compliance, environmental costs, energy, environmental indicators, handling of solid and liquid waste, wastewater use, internal environmental communication, etc. convey the basic scientific knowledge and are presented by qualified persons from the further education and training sector.

9. Quality Assurance

The quality assurance of the course "Energy generation from wastewater and waste" will be integrated into the existing quality assurance system of WIFI Styria. In addition, extensive testing and evaluation by third parties will take place before the official start of the course. Furthermore, the leadership will visit the classroom courses at random.

Finally, each classroom course is evaluated by the course participants with the help of anonymous evaluation sheets with regard to content and communication of the course contents. These evaluations are continuously incorporated into the improvement of the course.

10. Infrastructure

The course will be carried out at the WIFI Styria campus in Graz. Additionally, the e-learning platform "Moodle" is used as an online medium. Via this platform, the teachers provide documents and information, while course participants can make inquiries and the seminar papers can be uploaded here.

11. Description of the Modules

Module I - Introduction to the topic of Energy Generation

Title of the course:	**Introduction to the topic of Energy Generation**
Type of the course:	Integrated course consisting of lecture and self-study parts
ECTS / hours / lessons	0.5 ECTS/ 12.5 hours / 15 lessons
Name of the teacher / trainer	Decided by the performing institute
Type of Examination	Seminar paper (about the overall course and the contents of all modules)

Course Content:

In this module the basics of energy production are taught. The different types, the potentials of different types of generation, energy in the context of climate change, etc. are to be addressed in this module in addition to the operational effects of energy management.
This module gives the participants a general overview of the topic regarding energy and energy generation, including the national, European and global challenges. Furthermore, the topic of which types of energy and energy generation exist will be addressed as well as the relationship to the environment (fossil vs renewable). Another addressed subject is the relevance for SMEs and in a larger context the problem of energy generation using fossil energy sources. The contents will be integrated by the participants in their seminar paper.

Course targets:

The participants know the fundamental concepts of energy and energy generation on a national and international as well as on the European level. Furthermore, the students know measures towards energy management within companies and especially small and medium sized enterprises.

Language Used:

English or German

Recommended Literature:

European Commission on Energy: https://ec.europa.eu/energy/home_en
European Commission Long Term Strategy 2050: https://ec.europa.eu/clima/sites/lts/lts_at_de.pdf
Bank, Matthias: Basiswissen Umwelttechnik: Wasser, Luft, Abfall, Lärm, Umweltrecht/ Matthias Bank. – 4., Würzburg: Vogel, 2000; ISBN 3-8023-1797-1
Förstner, Ulrich; Köster, Stephan: Umweltschutztechnik / Ulrich Förstner, Stephan Köster. – 9. Berlin: Springer, 2018; eBook ISBN 978-3-662-55163-9; DOI: 10.1007/978-3-662-55163-9
Tomašić, Vesna; Zelić, Bruno: Environmental Engineering: Basic Principles / Vesna Tomašić; Bruno Zelić. – 1., De Gruyter, 2018; ISBN-13: 978-3110468014
Nathanson, Jerry A.: Basic Environmental Technology: Water Supply, Waste Management and Pollution Control / Jerry A. Nathanson. – 6. USA: Pearson Education; ISBN-13: 978-0132840149
Kunz, Peter: Behandlung flüssiger Abfälle: flüssige Rückstände, Abfälle und Konzentrate / Peter M. Kunz. – 1. Aufl. – Würzburg: Vogel, 1995 ISBN 3-8023-1443-3
Sattler, Klaus: Behandlung fester Abfälle: Vermeiden, Verwerten, Beseitigen, Sanieren; Verfahrensweise – Technische Realisierung – rechtliche Grundlagen / Klaus Sattler; Jürgen Emberger. – 4. Würzburg: Vogel, 1995 ISBN 3-8023-1511-1
Water Environment Federation: Wastewater Treatment Fundamentals I: Liquid Treatment / Water Environment Federation – 1. 2018, - WATER ENVIRONMENT FEDERATION; ISBN-13: 978-1572783508
Nzihou, Ange: Re-Use and Recycling of Materials: Solid Waste Management and Water Treatment / Ange Nzihou. 2019, River Publishers. ISBN-13: 978-8770220583

Module II - Basics about Wastewater and Waste

Title of the course:	**Basics about Wastewater and Waste**
Type of the course:	Integrated course consisting of lecture and self-study parts
ECTS / hours / lessons	0.5 ECTS/ 12.5 hours / 15 lessons
Name of the teacher / trainer	Decided by the performing institute
Type of Examination	Seminar paper (about the overall course and the contents of all modules)
Course Content:	
In this module the basics of national and European waste management and wastewater management are taught. The different types of waste and wastewater as well as their heat energy potentials are addressed in addition to the operational effects of waste and wastewater management. The potentials of waste and wastewater in an SME setting are explored and the opportunities of what can be used in the energy technology sector are conveyed. This module gives the participants a general overview of the topic regarding waste and wastewater, including the national, European and global challenges and regulations. Furthermore, the topic of which types of waste and wastewater exist will be addressed as well as the relationship to the environment (hazardous vs non-hazardous). Another addressed subject is the relevance and positions for SMEs and in a larger context the problem of waste generation for the environment. The contents will be integrated by the participants in their seminar paper.	
Course targets:	
The participants know the fundamental concepts of waste and wastewater on a national and international as well as on the European level. Included are the different kinds and types of waste and wastewater as well as their potentials for heat energy. Furthermore, the participants know measures towards waste and wastewater management within companies and especially small and medium sized enterprises with an applicable approach.	
Language Used:	
English or German	
Recommended Literature:	
European Commission Hazardous Waste: https://ec.europa.eu/environment/waste/hazardous_index.htm European Commission. Waste Framework Directive: https://ec.europa.eu/environment/waste/framework/ Austria Federal Environmental Agency Waste: https://www.umweltbundesamt.at/umweltsituation/abfall/ Handbook of Solid Waste Management and Waste Minimization Technologies. Butterworth-Heinemann. 2003. ISBN 9780750675079. Bank, Matthias: Basiswissen Umwelttechnik: Wasser, Luft, Abfall, Lärm, Umweltrecht/ Matthias Bank. – 4., Würzburg: Vogel, 2000; ISBN 3-8023-1797-1 Förstner, Ulrich; Köster, Stephan: Umweltschutztechnik / Ulrich Förstner, Stephan Köster. – 9. Berlin: Springer, 2018; eBook ISBN 978-3-662-55163-9; DOI: 10.1007/978-3-662-55163-9 Tomašić, Vesna; Zelić, Bruno: Environmental Engineering: Basic Principles / Vesna Tomašić; Bruno Zelić. – 1., De Gruyter, 2018; ISBN-13: 978-3110468014 Nathanson, Jerry A.: Basic Environmental Technology: Water Supply, Waste Management and Pollution Control / Jerry A. Nathanson. – 6. USA: Pearson Education; ISBN-13: 978-0132840149 Kunz, Peter: Behandlung flüssiger Abfälle: flüssige Rückstände, Abfälle und Konzentrate / Peter M. Kunz. – 1. Aufl. – Würzburg: Vogel, 1995 ISBN 3-8023-1443-3 Sattler, Klaus: Behandlung fester Abfälle: Vermeiden, Verwerten, Beseitigen, Sanieren ; Verfahrensweise – Technische Realisierung – rechtliche Grundlagen / Klaus Sattler; Jürgen Emberger. – 4. Würzburg : Vogel, 1995 ISBN 3-8023-1511-1 Water Environment Federation: Wastewater Treatment Fundamentals I: Liquid Treatment / Water Environment Federation – 1. 2018, - WATER ENVIRONMENT FEDERATION; ISBN-13: 978-1572783508 Nzihou, Ange: Re-Use and Recycling of Materials: Solid Waste Management and Water Treatment / Ange Nzihou. 2019, River Publishers. ISBN-13: 978-8770220583	

Module III: Energy generation from Wastewater and Waste

Title of the course:	**Energy generation from wastewater and waste**
Type of the course:	Integrated course consisting of lecture and self-study parts
ECTS / hours / lessons	1 ECTS/ 25 hours / 30 lessons
Name of the teacher / trainer	Decided by the performing institute
Type of Examination	Seminar paper (about the overall course and the contents of all modules)

Course Content:

In this module the contents of the first two modules are enhanced and used to address the combination of energy generation from wastewater and waste. This includes theoretical as well as operational waste and wastewater management as well as energy management on a national and European level. Various technologies and their potentials with a focus on wastewater utilization by heat pump technology are addressed. The contents are oriented on applicable utilization in a company and SME setting and the opportunities of which technologies and potentials can be used are taught. This module gives the participants an overview of the topic energy generation from the sources waste and wastewater and includes national, European and global challenges and regulations. Furthermore, actual use cases are demonstrated to prepare the participants with hand on examples for their own seminar paper. Another addressed subject is the relevance, opportunities and positions for SMEs and in a larger context the challenges and opportunities of energy generation for the environment and the economy. The contents will be integrated by the participants in their seminar paper.

Course targets:

The participants know various technologies and concepts of energy generation from waste and wastewater on a national and international as well as on the European level. A special focus is laid on the heat pump technology. Included are the different kinds and types of energy generation as well as their potentials for SMEs and companies. Furthermore, the participants are able to create concepts for their own companies (by exploring use cases) and can evaluate their own waste, wastewater and energy management within their company.

Language Used:

English or German

Recommended Literature:

European Commission Long Term Strategy 2050: https://ec.europa.eu/clima/sites/lts/lts_at_de.pdf

Bank, Matthias: Basiswissen Umwelttechnik: Wasser, Luft, Abfall, Lärm, Umweltrecht/ Matthias Bank. – 4., Würzburg: Vogel, 2000; ISBN 3-8023-1797-1

Förstner, Ulrich; Köster, Stephan: Umweltschutztechnik / Ulrich Förstner, Stephan Köster. – 9. Berlin: Springer, 2018; eBook ISBN 978-3-662-55163-9; DOI: 10.1007/978-3-662-55163-9

Tomašić, Vesna; Zelić, Bruno: Environmental Engineering: Basic Principles / Vesna Tomašić; Bruno Zelić. – 1., De Gruyter, 2018; ISBN-13: 978-3110468014

Nathanson, Jerry A.: Basic Environmental Technology: Water Supply, Waste Management and Pollution Control / Jerry A. Nathanson. – 6. USA : Pearson Education; ISBN-13: 978-0132840149

Water Environment Federation: Wastewater Treatment Fundamentals I: Liquid Treatment / Water Environment Federation – 1. 2018, - WATER ENVIRONMENT FEDERATION; ISBN-13: 978-1572783508

Nzihou, Ange: Re-Use and Recycling of Materials: Solid Waste Management and Water Treatment / Ange Nzihou. 2019, River Publishers. ISBN-13: 978-8770220583

Water Environment Federation: The Energy Roadmap: A Water and Wastewater Utility Guide to More Sustainable Energy Management / Water Environment Federation – 1. 2013, - WATER ENVIRONMENT FEDERATION; ISBN-13: 978-1572782730

Module IV: Practical Application and Utilization

Title of the course:	**Practical Application and Utilization**
Type of the course:	Integrated course consisting of lecture and self-study parts
ECTS / hours / lessons	2 ECTS/ 50 hours / 60 lessons
Name of the teacher / trainer	Decided by the performing institute
Type of Examination	Seminar paper (about the overall course and the contents of all modules)
Course Content:	
This module gives the participant the final instruction for their own seminar paper. The contents of the first three modules are revised and enhanced by using specific use cases. The contents are oriented on applicable utilization in a company and SME setting and the opportunities of which technologies and potentials can be used in the companies of the participants. This module gives the participants all required information for the preparation of their seminar paper.	
Course targets:	
The participants have the required knowledge and skills to write a seminar paper about the potentials of waste, wastewater and energy generation in their own company or in an illustrative example. This seminar paper is at the same time the final paper of the course and is presented by the participant to the other participants in a classroom session.	
Language Used:	
English or German	
Recommended Literature:	
See "Recommended Literature" of Module I, Module II and Module III	

12. Speakers & Trainers

This part is filled out by the performing institute.

Name:	
Title:	
E-Mail Address:	
Telephone:	

Training and additional qualifications:

Current professional activity:

Previous teaching activities:

Publications (if applicable):

Co-funded by the
Erasmus+ Programme
of the European Union

WWW&CE – Curriculum F

Energy generated from Wastewater & Waste

Content

Module I - Introduction to the Topic of Energy Generation

Content

- What is Energy?
- Types of Energy
- Energy Generation
- Potentials
- Energy in the EU
- Energy scenarios
- Energy in the context of climate change
- Excursion: Introduction to the environment and systems
- Summary

What is Energy?

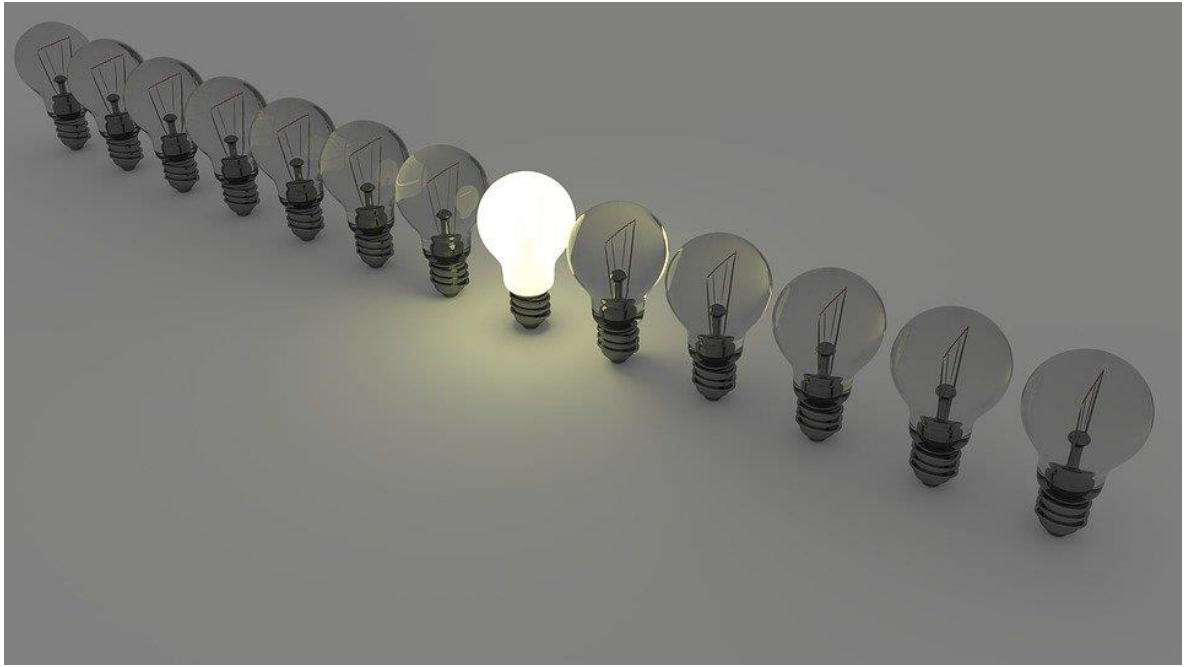


Photo by ColN00B on Pixabay

What is Energy?

- **Energy is the quantitative property that must be transferred to an object in order to perform work on, or to heat the object.**

- Energy exists in different forms of energy that can be converted into each other.

- **Examples of forms of energy:**
  - Potential
  - Kinetic
  - Electrical
  - Chemical
  - Thermal

- **Examples of conversions of energy:**
  - A person lifting a box
  - A person accelerating a bicycle
  - Charging a battery
  - The metabolism
  - A heater giving off heat
  - etc.

Potential Energy

- **The potential energy (also called positional energy) describes the energy of a physical system, which is determined by its position in a force field or by its current system configuration.**
- Example:

In a gravitational field the "potential energy" is the energy that a body has due to its altitude: If an object falls from a height of 100 meters, it has ten times more working capacity as at a height of 10 meters.

During the fall, the potential energy is converted into kinetic energy or other forms of energy and decreases.

In hydroelectric power plants, potential energy from the water of a reservoir can be converted into electrical energy.

Kinetic Energy

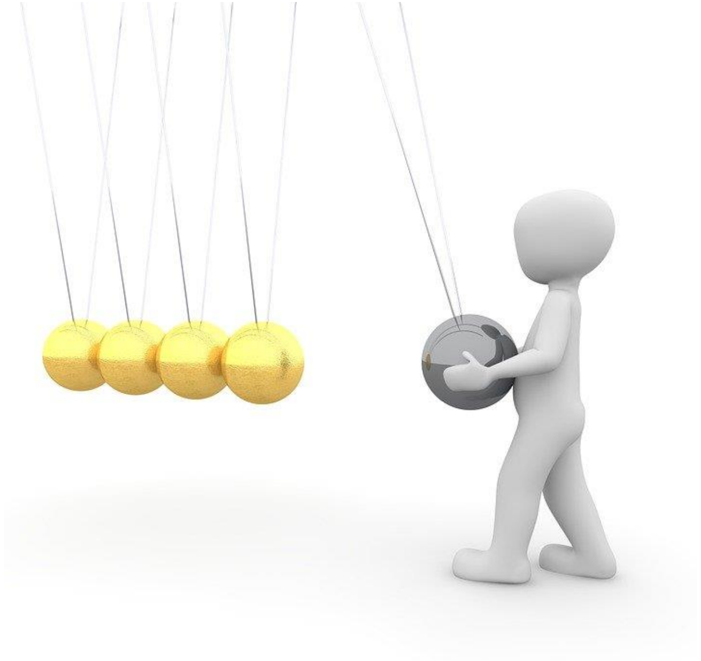


Photo by Peggy_Marco on Pixabay

Kinetic Energy

- **The kinetic energy (Greek: “kinesis” = “movement”) or rarely velocity energy is the energy that an object contains due to its movement.**

It corresponds to the work that must be done to move the object from rest to its current movement. It depends on the mass and speed of the moving body.

Moving bodies such as a cyclist, a moving car, a falling stone or a rotating flywheel have kinetic energy.

Instead of kinetic energy, one also speaks of energy of movement. With rotating bodies, kinetic energy is also called rotational energy.

Electrical Energy

- **Electrical energy is energy that is transmitted by means of electricity or stored in electrical fields.**

Electrical energy can be used in many ways, as it can be converted into other forms of energy with **low losses and can be easily transported**. Its generation and supply to the economy and consumers is of great importance in modern societies.

Photo by Free-Photos on Pixabay

Electrical Energy

- **Electrical energy is energy that is transmitted by means of electricity or stored in electrical fields.**

In power plants, batteries and accumulators, **electrical energy is generated by converting other forms of energy**, e.g. thermal energy or chemical energy.

This is transported to the consumers via power lines, where it is converted back into other forms of energy (kinetic, potential, light or heat energy). The electrical energy is localized in the electromagnetic field, which manifests itself macroscopically in current and voltage.

Chemical Energy

- **Chemical energy is the form of energy that is stored in an energy carrier in the form of a chemical compound and can be released during chemical reactions.**

The term chemical energy describes macroscopically the energy associated with electrical forces in atoms and molecules that are involved in chemical reactions.

The term "chemical energy" is not used in the field of chemistry. It is only clearly defined when the environmental conditions are specified - there is then a different established term for each scenario.

Thermal Energy

- **Thermal energy (not to be confused with heat) is a collective name for macroscopic and microscopic forms of energy, which refer to the disordered motion of particles (including photons) in macroscopic matter or in other many-particle systems. Macroscopic forms of energy include internal energy, heat, enthalpy.**

Thermal energy refers to several distinct thermodynamic quantities, such as the internal energy of a system; heat or sensible heat, which are defined as types of energy transfer.

Energy Generation

- **Energy generation is the main end use of such emulsions, though burners and boilers have to be modified and environmentally adapted.**

There are **many different forms** of energy generation. Often energy generation is equated with electricity generation.

There are 10 main sources of energy. These different sources of energy are used primarily to produce electricity.

Sources of Energy

- **Solar Energy:**

Solar power **harvests the energy of the sun** through collector panels.

It can be used as **small or large applications**.

While large solar panel fields are often used in deserts or big and flat areas to gather power to charge small sub-stations, small applications refer to homes or communities that use solar energy.

Photo by PublicDomainPictures at Pixabay

Sources of Energy

- **Solar Energy:**

Many homes use solar systems to **provide for hot water, cooling and supplement their electricity**.

The issue with solar energy is that while there is **basically unlimited amounts** of sun and therefore energy available, **only certain geographical ranges get enough** of the **direct power** for long enough to generate usable power from this source.

This is also related to the angle in which areas or homes are compared to the sun.

Sources of Energy

- **Wind Energy:**

Wind energy or power is **becoming a common to create energy**.

By using large turbines to utilize available wind as the power to turn, the turbine can then turn a generator to produce electricity.

Photo by Phillip Katzenberger at Unsplash

Challenge with wind power generation: wind farms have unforeseen ecological impacts.

Sources of Energy

- **Wind Energy:**

Furthermore, the **not in my backyard (NIMBY) effect** plays a role with wind energy.

The NIMBY effect relates to communities that are in favor of e.g. renewable energy but don’t want it directly in their own community.

There are several examples for this effect. It also applies e.g. for the construction of hydro plant, prisons, coal mines etc.

Sources of Energy

- **Hydrogen Energy:**

Hydrogen is available in water (H_2O). It is the most **common element available on earth**.

Water contains two-thirds of hydrogen and can be found in combination with other elements.

Once it is separated, it can be used as a fuel for generating electricity.

Sources of Energy

- **Hydrogen Energy:**

Hydrogen is a **large source of energy** and can be used as a source of fuel to power ships, vehicles, homes, industries and rockets.

Within the EU **several countries** (e.g. Austria) have **included hydrogen** and the research and development of it **in their sustainability measures** to reach set climate targets.

Sources of Energy

- **Geothermal Energy:**

Geothermal energy is the energy that is available and can be harvested from beneath the earth(crust).

It is clean, sustainable and environmentally friendly.

High temperatures are produced continuously inside the earth’s crust by the slow delay of radioactive particles. Basically, hot rocks heat up the water that produces steam. The steam is then captured and helps to move turbines. The rotating turbines then power generators.

Sources of Energy

- **Geothermal Energy:**

It can be used as a residential unit or as an industrial application.

The biggest disadvantage with geothermal energy is that it **can only be utilized at selected sites**.

Photo by Hans Braxmeier at Pixabay

The largest group of geothermal power plants in the world is located at "The Geysers" - a geothermal field in California.

Sources of Energy

- **Tidal Energy:**

Tidal energy uses the **rise and fall of tides to convert** kinetic **energy** of incoming and outgoing tides into electrical energy through fixed generators in the ocean.

Obviously, the generation of energy through tidal power is mostly prevalent in coastal areas.

Large investment and limited availability of sites are drawbacks of tidal energy.

Co-funded by the Erasmus+ Programme of the European Union

Sources of Energy

- **Tidal Energy:**

When there is increased height of water levels in the ocean, tides are produced which rush back and forth in the ocean.

Tidal energy is a **renewable source of energy** and produces a lot of energy even when the tides are at low speed.

A major player in utilization of tidal energy in Europe is Scotland.

Sources of Energy

- **Wave Energy:**

Similar to tidal energy in terms of the technology and generation is wave energy, which **is produced from the waves in the ocean**.

Wave energy is **renewable, environmentally friendly and causes no harm** to atmosphere **in terms of pollution**.

It can be harnessed along coastal regions of many countries and **can help** a country **to reduce** its **dependence on foreign countries** for fuel as well as **decrease their own carbon footprint**.

Sources of Energy

- **Wave Energy:**

However, producing wave energy **can damage marine ecosystem** and can also be a **source of disturbance to private and commercial vessels**.

It is highly dependent on wavelength and can also be a source of visual and noise pollution but is still regarded as a viable option compared to fossil fuels where applicable.

Sources of Energy

- **Hydroelectric Energy:**

Many **urban regions** in the world **rely on hydropower**.

The history of hydro power technically goes back for several centuries (e.g. mills).

Nearly every major dam, it is providing hydropower to an electrical station.

The power of the **water is used to turn generators to produce electricity**, which is then used for other applications.

Sources of Energy

- **Hydroelectric Energy:**

Challenges with hydropower are the **aging of dams** and **availability** of new cost and energy **effective sites**.

Many dams require major restoration work to remain functional and safe, which is very costly.

The drain on the world’s drinkable water supply is also causing issues as townships may wind up needing to consume the water that provides them power too.

Sources of Energy

- **Biomass Energy:**

Biomass energy is **produced from organic materials** and is utilized globally.

Chlorophyll present in plants captures the sun's energy by converting carbon dioxide from the air and water from the ground into carbohydrates through the process of photosynthesis.

When the plants or **organic matter is burned**, the water and carbon dioxide is released back into the atmosphere. By utilizing this energy **it can be directly used** (stove) or **generated into other forms of energy** (power plants).

Sources of Energy

- **Biomass Energy:**

Biomass generally include crops, plants, trees, yard clippings, wood chips and animal wastes.

Photo by roberto_bellasio at Pixabay

Biomass energy is used for heating and cooking in homes and as a fuel in industrial production.

This type of energy **produces large amount of carbon dioxide into the atmosphere**. However, there are ways to be kind of carbon neutral.

Sources of Energy

- **Nuclear Energy:**

While nuclear power remains **a great subject of debate** as to how safe it is to use, and whether or not it is really energy efficient and sustainable when taken into account the waste it produces as well as the supply chain of uranium – fact is that it remains **one of the major sources of energy available**.

Photo by distelAPPArath at Pixabay

Sources of Energy

- **Nuclear Energy:**

The energy is created through a specific nuclear reaction, which is then collected and used to power generators.

While almost every country has nuclear generators, there are moratoriums on their use or construction as scientists try to resolve safety and disposal issues for waste.

Germany is currently phasing out their nuclear power plants.

Sources of Energy

- **Fossil Fuels (Coal, Oil and Natural Gas)**


Photo by ARMBRUSTERBIZ at Pixabay

When most people talk about the different sources of energy, they often list natural **gas, coal and oil** as options.

However, all of these are considered to be just one source of energy - fossil fuels.

Fossil fuels provide the power for most of the world (primarily coal and oil).

Sources of Energy

- **Fossil Fuels (Coal, Oil and Natural Gas)**

Oil is converted into many products, e.g. plastic or gasoline.

Natural gas is starting to become more common but is used mostly for heating applications, although there are more and more natural gas-powered vehicles appearing on the streets.

Global primary energy sources consisted of petroleum (34%), coal (27%), natural gas (24%), amounting to an **85% share for fossil fuels in primary energy-consumption in the world in 2018.**

Sources of Energy

- **Fossil Fuels (Coal, Oil and Natural Gas)**

The issue with fossil fuels is twofold. To get to the fossil fuel and convert it to use there has to be a **heavy destruction and pollution of the environment**. The fossil fuel **reserves are also limited**.

Most energy plans in Europe are **trying to phase out fossil fuels** and the dependence on them.

Co-funded by the Erasmus+ Programme of the European Union

Energy Management

- Energy management is about **planning and operation of energy-related generation and consumption** units.

- Energy management can (and should) **be applied on many different levels** from state level to regional level as well as in individual companies

Energy Management

- The main objectives are the **conservation of resources, climate protection and cost reductions**, while ensuring that the energy needs of the users are met.

- Within energy management there are **various sub disciplines** such as e.g. energy controlling, which supports cost-effective and material-efficient energy and material flow management.

Energy Management

- Fundamental considerations for energy management:
  - To ensure the security of energy supply (e.g. uninterrupted energy supply)
  - To ensure economic electricity and heat prices (e.g. avoiding to high fluctuations)

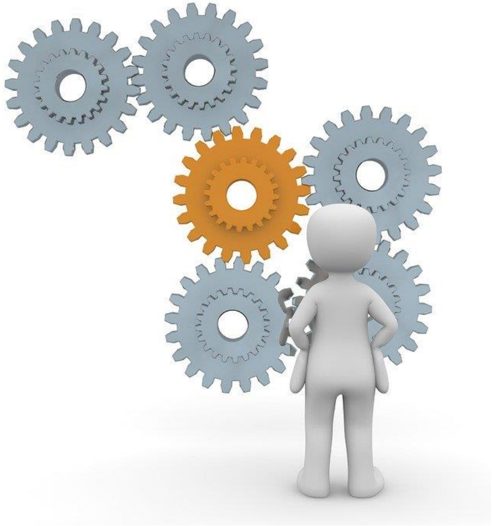


Photo by Peggy_Marco at Pixabay

Energy Management

- Fundamental considerations for energy management:
  - The consideration of environmental aspects (e.g. through independence from fossil primary energy sources or emission rights trading as well as the consideration of what energy sources to use and the composition of the energy mix)
  - The assurance of voltage and current quality in the area of power supply

Energy Management

- Application areas of Energy Management are:
  - Commercial and industrial energy management in production and logistics (small, medium and large sized)
  - Energy management for residential construction and of residential buildings

Photo by geralt at Pixabay

Energy Management

- Application areas of Energy Management are:
  - The municipal energy management (national, regional and local)
  - Building energy management, especially for complex functional buildings and buildings necessary for the infrastructure.
    - e.g hospitals, fire and police stations, stores, etc.

Co-funded by the Erasmus+ Programme of the European Union

Energy Management

- Application areas of Energy Management in cooperate functions are:
  - Facility Management
  - Energy Procurement
  - Production
  - Maintenance
  - Information Technology
  - Logistics
  - Production planning and control

Photo by Metthew Henry at Unsplash

Co-funded by the Erasmus+ Programme of the European Union

Energy Management

- To ensure security of supply and to be able to react flexibly to fluctuations in energy consumption and energy production, **access to stored energy is required.**

- Energy storage hereby refers to the means of and **capturing of produced energy** in order to **utilize the energy at a later time**.

Energy Management

- Chemical energy is usually stored temporarily in "**energy carrier containers**" (e.g. fuel tank) and kept in stock.
- Thermal energy can be temporarily stored in **technical energy storage systems** (e.g. district heating storage).
- Electrical energy is either **stored directly** (capacitor) **or indirectly** (e.g. battery) also in technical energy storage systems.

Energy Management

- With most forms of secondary energy it is an advantage to **have more in stock than can be consumed at the current moment**. Options include gas tanks, coal heap, boilers, oil tanker, dams, etc.

- A very important **exception to this is electrical energy**. With electricity it is very important that supply and demand are always in balance, otherwise electrical appliances and power grids can be damaged!

Co-funded by the Erasmus+ Programme of the European Union

Energy Management

Electricity consumption and electricity generation:

As power plants that "generate" electricity from renewable primary energy sources obtain their energy from natural sources (e.g. wind), **the output of many plants is subject to irregular fluctuations**.

Photo by ybernardi at Pixabay

Energy Management

Electricity consumption and electricity generation:

- For wind turbines the **weather**, for photovoltaic systems the difference between the position of the sun (**day and night**) and the weather (**clouds**), for run-of-river power plants the water (**flow rate**), etc. are all **fluctuating factors** that can only be limitedly calculated.

- While the **demand** for energy **can be calculated** with very little fluctuations, the **supply** of electricity however **changes all the time**!

Energy Management

Electricity consumption and electricity generation:

- Energy consumption and thus the demand for electricity also changes, however in a more predictable manner compared to the supply.
- Energy demand mostly changes according to the time of year and the time of day.

Photo by Coleur at Pixabay

Photo by Peggychoucair at Pixabay

Energy Management

Electricity consumption and electricity generation:

- Examples for changes:
  - In the evening, after work, energy demand goes up.
  - At night, when everyone is asleep, not as much energy is consumed.
  - At lunchtime, when many people are cooking energy is consumed.
  - In winter more people heat their homes than in summer. Thus a seasonal consumption change occurs.
  - Etc.

Energy Management

Electricity consumption and electricity generation:

- For the operation of the power grid, however, it is important that the supply of the power plants and the demand of the consumers are in balance at all times so that the frequency of the alternating current remains constant.
- If the deviation from the ideal is too great, electrical equipment and transformers can be damaged!
- This can result in a grid failure.

Energy Management

Electricity consumption and electricity generation:

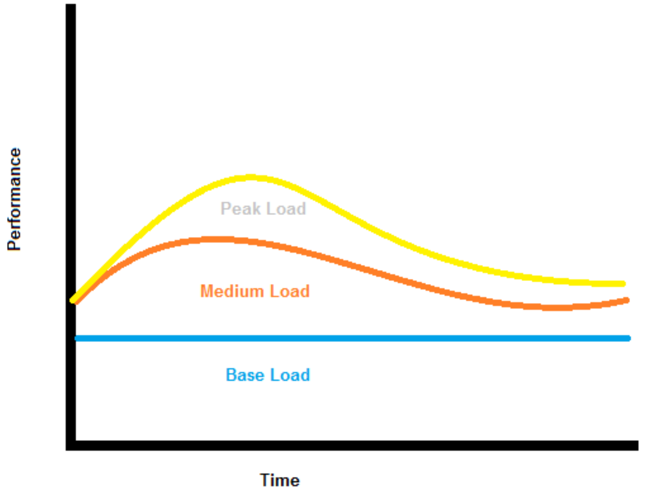
- To address this problem of balance, there are possible approaches and several possible combinations of these approaches:
  1. The electricity supply is being adjusted to the demand (i.e. the hydroelectric power plants produce less or more electricity depending on demand).
  2. Actively adjusting the consumption and production of small power plants (smart grid, "intelligent network") in real time.
  3. Temporarily store the electricity through energy storage options.

Energy Management

Base, medium and peak load:

Base Load:

- Is **always the same.**
- Is globally mainly covered by nuclear power plants and run-of-river power plants.
- In the future, this may also be performed by geothermal power plants in addition to run-of-river power plants.



Energy Management

Base, medium and peak load:

Base Load:

- The base load is **below the minimum energy requirement**, which is always necessary.

- Nuclear and run-of-river power plants are very difficult to regulate → they always produce their rated output (this is the maximum power that can be produced during longer operation).

Energy Management

Base, medium and peak load:

Medium Load:

- Medium load power plants **adapt their output to the requirements of the electricity market** as far as possible.
- They produce more/less energy depending on the energy requirements.
- Medium load power plants are **designed to satisfy regular**, "normal" periodic **fluctuations in supply demand** (e.g. day/night fluctuations).

Energy Management

Base, medium and peak load:

Medium Load:

- Medium load power plants are thermal power plants, i.e. plants that burn any kind of fuel (coal, oil, gas, to a certain extend biomass).
- This area **can be taken over by wind, solar, hydroelectric power plants, etc.** in combination with appropriate storage technologies.

Energy Management

Base, medium and peak load:

Peak Load:

- Peak-load power plants are **brought in when the output increases very strongly**, when consumption peaks occur or when unforeseeable incidents occur (e.g. if another power plant fails).

- Peak-load power plants **react very quickly** and are typically hydroelectric power plants.

Energy Management

Base, medium and peak load:

Peak Load:

- In the future, this area can be supplemented with other fast-reacting energy storage systems (e.g. large accumulators). Biomass power plants, can be controlled very flexibly and are therefore also important.

Energy Management

Base, medium and peak load:

- Peak-load energy is of the **highest quality**, and therefore the **most expensive**, as it can be called up very flexibly and can be regulated quickly.
- Thus it is **used for fast increases** in demand or energy output fluctuations.
- It is important to keep interrelations of the different plants in mind.

Energy Management

Base, medium and peak load:

- For example, wind power plants **produce electricity at lower cost** than biomass power plants.
- Biomass power plants, in turn, can be **controlled very flexibly** and are therefore also important.
- A good **Energy-Mix** to combine advantages and disadvantages of renewable energies is currently the desired solution for the future. Keep in mind that there will not be the "ultimate renewable energy".

European Union (EU)

- **EU law:**

The EU is legally above the nation states. They are above regional legislation, which is above local legislation.

EU
↓
National
↓
Regional
↓
Local

Photo by Capri23auto at Pixabay

European Union (EU) - Energy

- **Directorate-General ENER**

This Commission department is **responsible for the EU's energy policy**: **secure, sustainable, and competitively priced energy** for Europe.

- **Policy**

To **ensure a reliable supply of energy** and to **keep prices affordable**, the European Union aims to build a more integrated, competitive European energy market (energy union).

The EU also **supports energy from renewable sources** and the efficient use of energy, both of which help to cut greenhouse emissions.

EU - Energy

- There are many **policies** and topics handled by the EU:

  - **Secure Energy Supplies**

    The EU has to become **less dependent on imported energy** - by making more efficient use of our domestic energy while diversifying sources and supplies.

  - **Energy Efficiency**

    EU rules on buildings, industry, consumer products and transport are helping the EU to **meet its energy-efficiency targets** and **move to a low-carbon society**.

Photo by succo at Pixabay

EU - Energy

- There are many **policies** and topics handled by the EU:

  - **Nuclear Energy**

    EU action helps ensure nuclear **reactors are safe and secure**, radioactive waste is well managed and nuclear materials are used only for legitimate purposes.

  - **Energy Technology and Innovation**

    The EU supports **deployment of low-carbon technologies** such as photovoltaic, wind power, carbon capture and storage (CCS), and energy storage technologies.

EU - Energy

- There are many **policies** and topics handled by the EU (2):

  - **Single Energy Market**

    The EU wants **fewer technical and regulatory barriers** so that energy can flow across national borders and energy providers can compete throughout the EU.

  - **Renewable Energy**

    The EU coordinates work to **reach national targets** in line **with the renewable energy directive**. It also promotes alternative energy use in transport.

EU - Energy

- There are many **policies** and topics handled by the EU (3):

  - **Oil, Gas and Coal**

    EU rules aim to **keep fossil fuel markets fair and to protect the environment**, including when new technologies such as shale gas extraction are being used.

  - **Energy Infrastructure**

    The Trans-European Networks (TEN-E) strategy focuses on **extending and upgrading Europe's infrastructure** and creating networks that cross-national borders.

EU – Energy Strategy

The European climate and energy framework for 2030 and the legislative packages of the European Union for an energy union are of **key strategic significance for the future direction of European and national climate and energy policies**, and thus for the successful implementation of the energy reforms.

Link: 2030 Climate & Energy Framework

Co-funded by the Erasmus+ Programme of the European Union

EU – Energy Strategy

The Energy Union Strategy is a project of the European Commission to **coordinate the transformation of European energy supply**.

It was launched in February 2015, with the **aim of providing secure, sustainable, competitive, affordable energy**.

EU – Energy Strategy

The European Council concluded on 19 March 2015 that the EU is committed to building an Energy Union with a **forward-looking climate policy** on the basis of the Commission's framework strategy, with five priority dimensions:

1. Energy security, solidarity and trust.
2. A fully integrated European energy market.
3. Energy efficiency contributing to moderation of demand.
4. Decarbonising the economy.
5. Research, innovation and competitiveness.

Co-funded by the Erasmus+ Programme of the European Union

EU – Energy: 2050 Long Term Strategy

The EU aims to be **climate-neutral by 2050** – an economy with **net-zero greenhouse gas emissions**. This objective is at the heart of the European Green Deal and in line with the EU's commitment to global climate action under the Paris Agreement.

The transition to a climate-neutral society **is both** an **urgent challenge** and an **opportunity** to build a better future for all.

LINK: https://ec.europa.eu/clima/policies/strategies/2050

EU – Energy: 2050 Long Term Strategy

All parts of society and economic sectors will play a role – from the power sector to industry, mobility, buildings, agriculture and forestry.

The EU can lead the way by **investing** into realistic technological solutions, **empowering** citizens and **aligning** action in key areas such as industrial policy, finance and research, while ensuring social fairness for a just transition.

LINK: https://ec.europa.eu/clima/policies/strategies/2050

EU – Energy: 2050 Long Term Strategy

Commissions View:

The Commission set out its vision for a climate-neutral EU in November 2018, looking at all the key sectors and exploring pathways for the transition.

The Commission's **vision covers nearly all EU policies** and is in line with the **Paris Agreement objective** to keep the **global temperature increase** to well **below 2°C** and pursue efforts to keep it to 1.5°C.

Paris Agreement: https://unfccc.int/sites/default/files/english_paris_agreement.pdf

EU – Energy: 2050 Long Term Strategy

Commissions View:

As part of the European Green Deal, the Commission proposed on 4th of March 2020 the **first European Climate Law** to enshrine the **2050 climate-neutrality target into law**.

EU – Energy: 2050 Long Term Strategy

EU Strategy

All Parties to the Paris Agreement are invited to communicate, by 2020, their mid-century, long-term low greenhouse gas emission development strategies.

The European Parliament **endorsed the net-zero greenhouse gas emissions objective** in its resolution on climate change in March 2019 and resolution on the European Green Deal in January 2020.

EU – Energy: 2050 Long Term Strategy

EU Strategy

The European Council endorsed in December 2019 the **objective of making the EU climate-neutral by 2050**, in line with the Paris Agreement.

The EU submitted its **long-term strategy** to the United Nations Framework Convention on Climate Change (UNFCCC) in March 2020.

Long term strategy: https://unfccc.int/documents/210328

EU – Energy: 2050 Long Term Strategy

Stakeholder Input

- A stakeholder event on the 10th and 11th July 2018 brought together **stakeholders from business, research and civil society** for a discussion on the forthcoming EU strategy.
- The public consultation from 17 July to 9 October 2018 received **more than 2800 replies**.
- The Commission's vision launched an EU-wide reflection on the EU strategy, involving EU institutions, national parliaments, business sector, non-governmental organisations, cities, communities and citizens across Europe.

EU – Energy: 2050 Long Term Strategy

National Strategies

EU Member States are required to develop national long-term strategies on how they plan to achieve the greenhouse gas emissions reductions needed to meet their commitments under the Paris Agreement and EU objectives.

- Link: https://ec.europa.eu/info/energy-climate-change-environment/overall-targets/long-term-strategies_en

Co-funded by the Erasmus+ Programme of the European Union

EU – Energy: 2050 Long Term Strategy

National Strategies: Long Term Strategy Austria

Link: https://ec.europa.eu/clima/sites/lts/lts_at_de.pdf

- Austria has the goal of becoming **climate neutral at the latest by 2050**.
- A strategy that implies a **comprehensive change** in **energy supply** and **consumer behavior** and an **adapted competitive economic system** also goes beyond the aspect of greenhouse gas reduction.

Co-funded by the Erasmus+ Programme of the European Union

EU – Energy: 2050 Long Term Strategy

National Strategies: Long Term Strategy Austria

- It takes into account all **three pillars** of sustainability, namely **economy, social issues and ecology**.
- Only in this way is it possible to gain the approval of the population for the far-reaching change.
- **Resource-saving, sustainable and innovative technologies and the circular economy play a central role**.

EU – Energy: 2050 Long Term Strategy

National Strategies: Long Term Strategy Austria

- **The Paris Convention**, which was adopted in December 2015 and entered into force on 4 November 2016, **is the first ambitious and legally binding global agreement on climate protection** with obligations for all states.

- Based on the Paris convention, Austria defined goals in its strategy.

EU – Energy: 2050 Long Term Strategy

National Strategies: Long Term Strategy Austria

Included are (among others):

- Temperature target
- Adaptation target
- Financial target
- Long-term objective
- Climate protection measures
- Etc.

Photo by QuinceCreative at Pixabay

EU – Energy: 2050 Long Term Strategy

National Strategies: Long Term Strategy Austria

- Furthermore the **Paris Convention should be strengthened** to ensure a global shift towards sustainable energy technologies.
- The agreement not only marked the beginning of the **phase-out of fossil fuels**, but also a **global transformation** of **energy systems**, the **economy** and **society**.

EU – Energy: 2050 Long Term Strategy

National Strategies: Long Term Strategy Austria

- While the market and competition have already been successfully driven forward in the past, we still **face complex challenges** in **achieving our goal** of making the energy sector significantly more climate-friendly in the medium term and **decarbonising it by 2050**.

Photo by EliasSch at Pixabay

EU – Energy: 2050 Long Term Strategy

National Strategies: Long Term Strategy Austria:

- The decarbonisation of the Austrian energy system requires a large number of **coordinated measures and activities**. What is needed is a **balanced, sustainable energy mix** that consistently promotes the expansion of domestic renewable resources along the decarbonisation path and makes targeted use of bridging technologies in the interests of supply security.

- This implies a **rapid phase-out of coal**, an **"end" to fossil oil heating systems** and the **switch to zero and ultra-low emission vehicles**.

Energy Scenarios - Austria

Federal Environment Agency Austria (Umweltbundesamt Österreich)

Various scenarios (studies) available at their website*.

- Scenarios with existing measures (WEM) and Transition
- Renewable energy scenario for climate targets 2030 and 2050
- Energy economic scenario with regard to the climate targets 2030 and 2050 – with additional measure (WAM) plus
- Energy economic scenarios with regard to the climate targets 2030 and 2050 – WEM and WAM
- Industry scenarios 2030 and 2050

*Link: https://www.umweltbundesamt.at/umweltsituation/energie/energieszenarien/

Energy Scenarios - Austria

Energy economic scenarios regarding the climate targets 2030 and 2050 - WEM and WAM

- **Scenario with existing measures (WEM)**:

In the WEM scenario, the **goal of the Energy Efficiency Act** (EEffG) of limiting final energy consumption to a maximum of 1,050 PJ in 2020 **is clearly missed**.

Energy Scenarios - Austria

Energy economic scenarios regarding the climate targets 2030 and 2050 - WEM and WAM

- **Scenario with existing measures (WEM)**:

Significant existing measures:

- → Mobility management and awareness raising (transport sector)
- → Economic incentives (e.g. increase in mineral oil tax in 2011)
- → Implementation of the Green Electricity Act in 2012 (energy sector)
- → Changes in EU emissions trading (industry sector)
- → Thermal refurbishment of buildings & renewal of heating systems (buildings - households and services sector).

Energy Scenarios - Austria

Energy economic scenarios regarding the climate targets 2030 and 2050 - WEM and WAM

- **Scenario with additional measures (WAM)**:

In the WAM scenario, the value of 1,050 PJ for 2020 **is maintained by adopting** additional measures.

Energy Scenarios - Austria

Energy economic scenarios regarding the climate targets 2030 and 2050 - WEM and WAM

- **Scenario with additional measures (WAM)**:

Prerequisites for the modelled achievement of the target:

→ the implementation of extensive energy efficiency measures

→ the reduction of fuel exports in the tank by bringing fuel prices closer to the foreign level (transport sector)

→ an improvement in the quality of refurbishment and a shift in the focus of funding from new construction to thermal refurbishment (buildings sector).

Co-funded by the Erasmus+ Programme of the European Union

Austria Energy Scenarios

Energy economic scenarios regarding the climate targets 2030 and 2050 - WEM and WAM – Results:

- **WEM Scenario:**

Final energy consumption increases from 1,138 PJ (2010) in the to 1,149 PJ (2020) and to 1,213 PJ (2030).

Gross inland consumption was 1,467 PJ (2010) and rises to 1,481 PJ (2020) and 1,554 PJ (2030).

Austria Energy Scenarios

Energy economic scenarios regarding the climate targets 2030 and 2050 - WEM and WAM – Results:

- **WAM Scenario:**

Final energy consumption decreases to 1,050 PJ by 2020 and to 1,043 PJ by 2030.

Gross inland consumption was 1,467 PJ (2010) and rises to 1,379 PJ (2020) and 1,381 PJ (2030).

Austria Energy Scenarios

Energy economic scenarios regarding the climate targets 2030 and 2050 - WEM and WAM – Results:

The share of renewable energy in gross final energy consumption **increases continuously** from 32.2% in 2010 **in both scenarios.**

- In WEM to 36.0% (2020) and to 37.7% (2030).
- In WAM to 38.5% (2020) and to 42.6% (2030).

Co-funded by the Erasmus+ Programme of the European Union

Austria Energy Scenarios

Energy economic scenarios regarding the climate targets 2030 and 2050 - WEM and WAM – Results:

- With current legally binding measures (scenario WEM) the target of 34% share of renewable energy sources in 2020 will be achieved.
- In contrast, the target of reducing final energy consumption to 1,050 PJ by 2020 will not be achieved.
- With additional measures (WAM scenario), however, this target could be met.

Energy in the context of Climate Change

In order to put energy generation and consumption as well as supply and demand into any relation, one has to **understand basics about the environment and system sciences**.

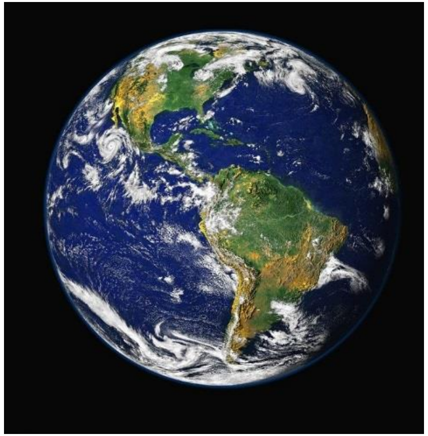


Photo by WikiImages at Pixabay

The next couple of slides give you an introduction to these topics.

Environment

Photo by John O'Nolan at Unsplash

- **What is the environment?**
- **What is a system?**
- **What are the links between humans and the environment and what are environmental burdens and pollution?**

Environment

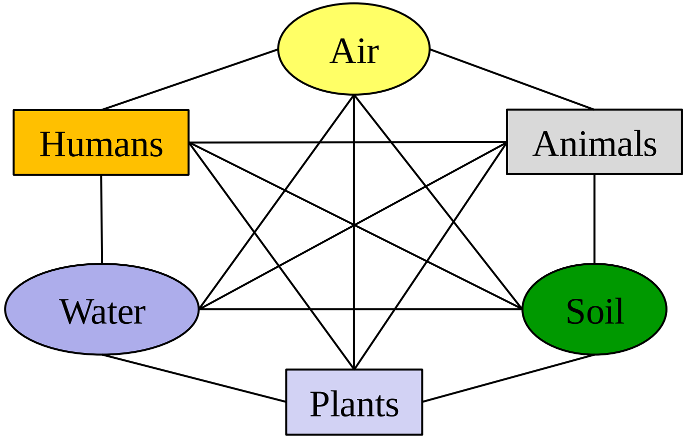
The environment is the **totality of all direct and indirect effects on a living being** and **its relationship** to the rest of the world.

Environmental influences on living organisms:

- The influence of abiotic, inanimate, and biotic, animate factors.
- Climatic, chemical or mechanical influences.
- Natural and anthropogenic, man-made, impacts and others more

Environment

Often one speaks of **the biosphere** instead of the environment and refers to the entirety of the layers of the earth populated by living organisms - humans, animals, plants, microorganisms - i.e. the atmosphere up to a height of about 25 km, the oceans down to a depth of about 10 km and the earth's crust down to a depth of about 3 km.



Note: in the biosphere everything is connected

Environment

No matter where you set the limit: the environment is **always a complex system**, in which the soil, water and air as well as the flora and fauna and the climate are main components.

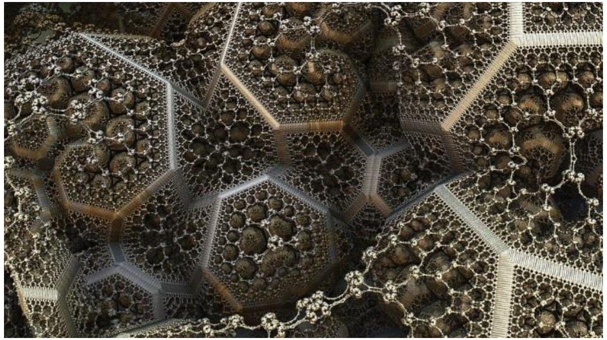
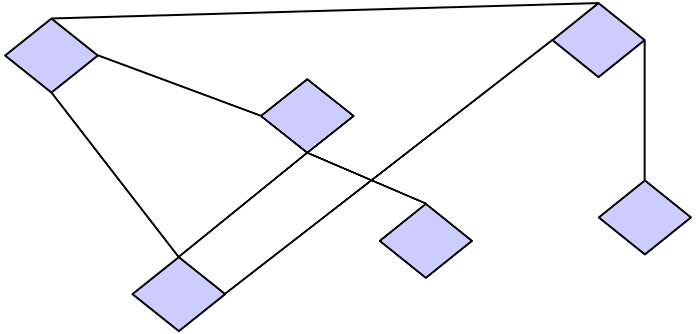


Photo by TheDigitalArtist at Pixabay

Environment

- **What is a System?**

A system is a delimited arrangement of parts (components) that interact with each other.



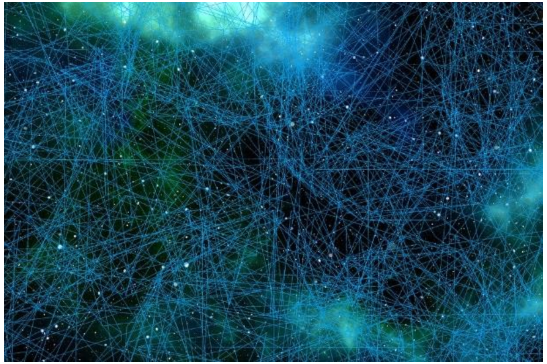
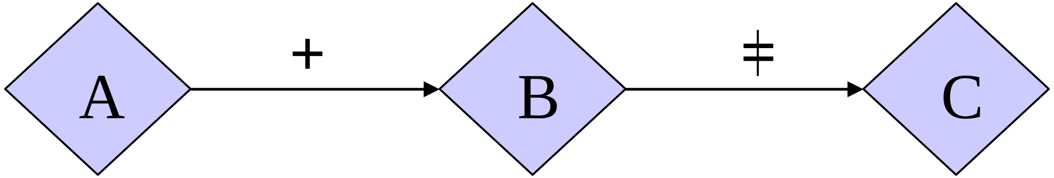


Photo by geralt at Pixabay

Environment

Important Note:

- Linear thinking - every effect is attributed to only one clear cause - usually does not lead to the goal in environmental problems.



Co-funded by the Erasmus+ Programme of the European Union

Environment

- In complex ecosystem environments, "**networked thinking**" is much more important!

- Due to **strong interconnections and far-reaching feedback** in the environment, it is often **impossible to give a simple answer** to an ecological or environmentally relevant (environmentally significant) question.

Environment

- Nevertheless, **certain areas** of the highly networked environment **are viewed separately** because the overall system is too complicated and too complex.

- Such delimitable sections, which are interrelated as functional units, are also called compartments.

Environment

Anyone who does not want to **run behind technical developments** and legal requirements in industrial production in the future **must integrate environmental protection goals into the overriding corporate objectives** in a binding manner and implement them in all areas of the company!

Summary

- **Energy**
- **Energy Types/ Source**
- **Energy Management**
- **European and national energy plans**
- **Environment and Systems**

Sources and Literature Recommendations:

- The Environmental Literacy Council. What is Waste?. Accessed 01.04.2020 at https://enviroliteracy.org/environment-society/waste-management/what-is-waste/
- Harper, Douglas. "Energy". Online Etymology Dictionary. Accessed: 01.04.2020 at http://www.etymonline.com/
- Wikipedia. Energie. Accessed 01.04.2020 at https://de.wikipedia.org/wiki/Energie
- Wikipedia. Potentielle Energie. Accessed 01.04.2020 at https://de.wikipedia.org/wiki/Potentielle_Energie
- Wikipedia. Kinetische Energie. Accessed 01.04.2020 at https://de.wikipedia.org/wiki/Kinetische_Energie
- Wikipedia. Elektrische Energie. Accessed 01.04.2020 at https://de.wikipedia.org/wiki/Elektrische_Energie
- Wikipedia. Chemische Energie. Accessed 01.04.2020 at https://de.wikipedia.org/wiki/Chemische_Energie
- Wikipedia. Thermal Energy. Accessed 01.04.2020 at https://en.wikipedia.org/wiki/Thermal_energy
- Wikipedia. Thermische Energie. Accessed 01.04.2020 at https://de.wikipedia.org/wiki/Thermische_Energie
- Wikipedia. Energiemanagement. Accessed 01.04.2020 at https://de.wikipedia.org/wiki/Energiemanagement
- Wikipedia. Energy Policy of the European Union. Accessed 01.04.2020 at https://en.wikipedia.org/wiki/Energy_policy_of_the_European_Union
- Wikipedia. Fossil Fuels. Accessed 01.04.2020 at https://en.wikipedia.org/wiki/Fossil_fuel
- Alonso, Finn: Physics, Addison-Wesley (1992), ISBN 0-201-56518-8, S. 169.
- Lernhelfer. Kinetische Energie. Accessed 01.04.2020 at https://www.lernhelfer.de/schuelerlexikon/physik/artikel/kinetische-energie#
- Lernhelfer. Energie. Accessed 01.04.2020 at https://www.lernhelfer.de/schuelerlexikon/physik/artikel/energie
- Lautenschläger, Karl-Heinz: Taschenbuch der Chemie. Harri Deutsch Verlag, 2007, ISBN 978-3-8171-1761-1
- Alonso M, Finn E J: Quantenphysik und Statistische Physik. Oldenbourg Verlag, 2011, ISBN 978-3-486-71340-4
- Doering E, Schedwill H, Dehli M: Grundlagen der Technischen Thermodynamik. 8. Auflage. SpringerVieweg, Wiesbaden 2016, ISBN 978-3-658-15147-8, S. 9, doi:10.1007/978-3-658-15148-5.
- Ramirez-Corredores M. Bottom of the Barrel Upgrading Technologies. The Science and Technology of Unconventional Oils. 2017, Pages 387-488. Accessed 01.04.2020 at https://www.sciencedirect.com/science/article/pii/B978012801225300005X
- Conserve Energy Future. Different Energy Sources. Accessed 01.04.2020 at https://www.conserve-energy-future.com/different-energy-sources.php
- Energie-Info.info. Energieangebot und Nachfrage. Accessed 01.04.2020 at https://energie-info.info/energiewende-uebersicht/energieangebot-nachfrage/
- Swissgrid Ag. Accessed 01.04.2020 at https://www.swissgrid.ch/

Sources and Literature Recommendations:

- European Commission. Generaldirektion Energy. Accessed 01.04.2020 at https://ec.europa.eu/info/departments/energy_de
- European Commission. Politikfelder Energy. Accessed 01.04.2020 at https://ec.europa.eu/info/policies/energy_de
- European Commission. Policy Energy. Accessed 01.04.2020 at https://ec.europa.eu/info/policies/energy_en
- European Commission. Energy Strategy. Accessed 01.04.2020 at https://ec.europa.eu/energy/topics/energy-strategy-and-energy-union_en
- Federal Ministry of Economic Affairs Germany. European Energy Policy. https://www.bmwi.de/Redaktion/EN/Artikel/Energy/european-energy-policy.html
- European Commission. Climate Action – 2050 long-term strategy. Accessed 01.04.2020 at https://ec.europa.eu/clima/policies/strategies/2050
- Bundesministerium Nachhaltigkeit und Tourismus. Langfriststrategie 2050 Österreich. Accessed 01.04.2020 at https://ec.europa.eu/clima/sites/lts/lts_at_de.pdf
- Umweltbundesamt Österreich. Energieszenarien. Accessed 01.04.2020 at https://www.umweltbundesamt.at/umweltsituation/energie/energieszenarien/
- Norden. Climate Change and Energy Systems. Accessed 01.04.2020 at https://norden.diva-portal.org/smash/get/diva2:701000/FULLTEXT01.pdf
- Take D. The relationship between climate change and energy security: key issues and conclusions. Accessed 01.04.2020 at https://www.tandfonline.com/doi/full/10.1080/09644016.2013.806631
- Cronin J, Anandarajah G, Dessens O. Climate change impacts on the energy system: a review of trends and gaps. Accessed 01.04.2020 at https://link.springer.com/article/10.1007/s10584-018-2265-4
- Lyster R. Renewable Energy in the Context of Climate Change and Global Energy Resources. Accessed 01.04.2020 at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2315911
- Bank, Matthias: Basiswissen Umwelttechnik : Wasser, Luft, Abfall, Lärm, Umweltrecht/ Matthias Bank. – 4., Würzburg : Vogel, 2000; ISBN 3-8023-1797-1
- Förstner, Ulrich; Köster, Stephan: Umweltschutztechnik / Ulrich Förstner, Stephan Köster. – 9. Berlin : Springer, 2018; eBook ISBN 978-3-662-55163-9; DOI: 10.1007/978-3-662-55163-9
- Tomašić, Vesna; Zelić, Bruno: Environmental Engineering : Basic Principles / Vesna Tomašić; Bruno Zelić. – 1., De Gruyter, 2018; ISBN-13: 978-3110468014
- Nathanson, Jerry A.: Basic Environmental Technology: Water Supply, Waste Management and Pollution Control / Jerry A. Nathanson. – 6. USA : Pearson Education; ISBN-13: 978-0132840149
- Kunz, Peter: Behandlung flüssiger Abfälle : flüssige Rückstände, Abfälle und Konzentrate / Peter M. Kunz. – 1. Aufl. – Würzburg : Vogel, 1995 ISBN 3-8023-1443-3
- Sattler, Klaus: Behandlung fester Abfälle : Vermeiden, Verwerten, Beseitigen, Sanieren ; Verfahrensweise – Technische Realisierung – rechtliche Grundlagen / Klaus Sattler; Jürgen Emberger. – 4. Würzburg : Vogel, 1995 ISBN 3-8023-1511-1
- Water Environment Federation: Wastewater Treatment Fundamentals I: Liquid Treatment / Water Environment Federation – 1. 2018, - WATER ENVIRONMENT FEDERATION; ISBN-13: 978-1572783508
- Nzihou, Ange: Re-Use and Recycling of Materials: Solid Waste Management and Water Treatment / Ange Nzihou. 2019, River Publishers. ISBN-13: 978-8770220583

Co-funded by the Erasmus+ Programme of the European Union

Module II - Basics about Wastewater and Waste

Content:

- Basics in the Environmental Area
- What is Waste
- Types of Waste
- Wastewater
- Waste management
- Waste in the European Union
- Waste in Austria
- Summary

Environmental Area Basics

Environment

The environment is the totality of all direct and indirect effects on a living being and its relationship to the rest of the world.

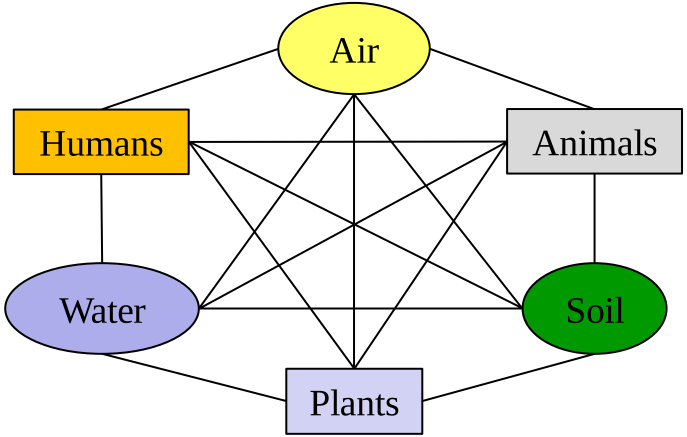
Environmental influences on living organisms are:

- The influence of abiotic, inanimate, and biotic, animate factors.
- Climatic, chemical or mechanical influences.
- Natural and anthropogenic, man-made influences and others.

Environmental Area Basics

Environment

Interactions between humans and the environment:



Environmental Area Basics

Environmental Pollution

- Environmental pollution is defined as the totality of all disturbing environmental factors.
- Terms such as **environmental stress** or **environmental impact** are used when **no clear negative effect** on the environment is expected from a pollution.
- If it is a pollution of nature by intrusion of substances, one often speaks (in the narrower sense) of **environmental pollution**.

Environmental Area Basics

Environmental Pollution

Air Pollution

- In the past, air pollution problems were usually "smoke problems“ → mainly related to sulphur dioxide dust.
- Today, the innumerable combustion engines in road and air traffic cause new pollution and dangers.

Photo by Marcin Jozwiak at Unsplash

Environmental Area Basics

Environmental Pollution

Water pollution

- **Direct or indirect disposal** of waste into rivers and lakes.
- Industrial wastewater and domestic wastewater **discharged directly** into rivers or lakes.

Photo by yogendras31 at Pixabay

Environmental Area Basics

Environmental Pollution

Causes of environmental pollution:

→ Pollution from industry:

- Chemical industry
- Paper Industry
- Steelworks

→ Environmental impacts of agricultural use:

- Fertilizers
- Insect repellents
- ...

Photo by JuergenPM at Pixabay

Environmental Area Basics
Environment

Occupational health and safety is an area of environmental protection which should not be neglected and which plays a considerable role mainly in industrial environmental protection.

Environmental Area Basics

Environment awareness

The following environmental topics play **an important role** (among others):

- Dying forests and Desertification
- Ozone hole
- Acid rain
- Greenhouse effect
- Toxins in food

Photo by imordaf at Pixabay

Environmental Area Basics
Environment awareness

So-called "**time bombs of humanity**":

- Short-sighted, wasteful use of natural resources
- Air, water and soil pollution
- Deforestation
- Climate time bomb
- Population time bomb

Photo by OpenClipart-Vectors at Pixabay

Environmental Area Basics

!! Important !!

→Environmental protection is protection of posterity ←

- In addition to the number of people living on earth, another important problem is the **waste-intensive lifestyle**.
- It must be changed to help reduce the amount of waste and the associated environmental pollution.

- **But what is waste?**

What is Waste?

"Waste occurs when **any organism returns substances** to the environment."[1]

"Waste are **items we** (individuals, offices, etc.) **don't need and discard.**"[2]

"Waste is a **substance or** an **object** that the person who has produced it, wants to get rid of."[3]

Photo by Pexels at Pixabay

1: https://enviroliteracy.org/environment-society/waste-management/what-is-waste/
2: https://www.eschooltoday.com/waste-recycling/waste-management-tips-for-kids.html
3: http://www.eniscuola.net/en/argomento/waste/what-is-waste/what-is-waste-and-how-is-it-created/

What is Waste?

“**Unwanted matter or material of any type**, especially what is left after useful substances or parts have been removed.”[4]

“Article 3(1) of the new EU Waste Framework Directive defines waste as ‘**any substance or object which the holder discards or intends or is required to discard**’.”[5]

4: https://dictionary.cambridge.org/de/worterbuch/englisch/waste
5: https://ec.europa.eu/environment/waste/framework/pdf/guidance_doc.pdf

What is Waste?

Looking at the definitions, it can be said that **waste** from a human perspective:

- **is every object or substance that is regarded as not useful for an individual entity** (i.e. person, industry, office, etc.).

From a **legal perspective**:

- A substance becomes waste if there is either the intention to dispose of it or the public interest in its collection and treatment as waste.

What is considered **waste** for one person **can be of benefit** for another person.

It is therefore important to know and understand the **different types of waste**.

Types of Waste

Waste types can be divided into e.g.:

- Waste from households
- Waste that cannot be disposed of with waste from households in terms of type and quantity (hazardous waste)
- Waste from commercial or other enterprises that requires monitoring.

In addition, waste can be classified according to its origin, nature, composition and state.

Co-funded by the Erasmus+ Programme of the European Union

Types of Waste

Household wastes in tones (hazardous and non-hazardous):

- European Union (27 countries)
  - 2014: 180.780.000 tones
  - 2016: 187.400.000 tones (increase of 3.7%)

- Austria:
  - 2014: 4.170.023 tones
  - 2016: 4.268.278 tones (increase of 2.3%)

Source: https://ec.europa.eu/eurostat/databrowser/view/ten00110/default/table?lang=de

Types of Waste

Waste can be classified according to many different criteria. An overarching classification, especially regarding waste management, is usually done in following manner:

- **Solid Waste**
- **Liquid Waste**
- **Hazardous Waste**
- **Non-Hazardous Waste**
- **(e-waste)**

Photo by Thoxuan99 at Pixabay

Types of Waste

Solid waste

Waste collected from residences, commercial buildings, hospitals, schools, universities, offices, light industrial operations etc. is usually considered as **municipal solid waste**.

Municipal Solid Waste **mainly consists of**:

- Paper, Containers and packaging (plastic, glass and metal), Food/Bio waste, Yard trimmings, Textiles, Other Inorganic Waste

Types of Waste

Solid waste

Depending on the country municipal solid waste can also include industrial sludge, classified as hazardous or non-hazardous, resulting from a wide array of mining, construction, and manufacturing processes.

Moreover, **substantial amounts** of household waste is **classified as hazardous**.

Photo by meineresterampe at Pixabay

Types of Waste

Solid waste

Everyday, one kilogram of municipal solid waste is generated per person in Europe.

→This does not sound like a lot, but across the whole of Europe this accumulates to a total of around 200 million tonnes of municipal waste per year (1999).

In Europe, we currently use **16 tones of material per person per year**, of which 6 tones become waste (2019).

Types of Waste

Liquid Waste

Fluid wastes, consisting of sewage and domestic wastewater, or processed water, or other liquids, produced by industrial activity, particularly by such industries as pulp and paper production, food processing, and the manufacture of chemicals.

Liquid waste can also be defined as such liquids:

- Wastewater
- Fats, oils, grease
- Used oil
- Liquids, solids, gases, or sludges and hazardous household liquids

Types of Waste

Liquid Waste

Liquids that are hazardous or potentially harmful to human health or the environment. They can also be discarded commercial products classified as "Liquid Industrial Waste" such as cleaning fluids or pesticides, or the by-products of manufacturing processes.

Liquid waste can therefore be classified as **wastewater**!

Types of Waste

Wastewater

Wastewater is a **generic term for water from various sources**, which is discharged via building structures.

- **Rainwater** - rainwater running off paved surfaces (in some contexts rainwater is not counted as wastewater)
- **Extraneous water** - entering the sewerage system due to structural damage

Types of Waste

Wastewater

Wastewater is a **generic term for water from various sources**, which is discharged via building structures.

- **Wastewater** - water contaminated by use or changed in its properties or composition. It is further differentiated:
  - **Greywater** - according to EN 12056-1: faecal-free, slightly contaminated wastewater (e.g. water originating from showering, bathing or washing hands, from the washing machine) which can be treated to produce **process water.** Rainwater **running off the roof or balcony** is also included.

Types of Waste

Wastewater

Wastewater is a **generic term for water from various sources**, which is discharged via building structures.

- **Wastewater** - water contaminated by use or changed in its properties or composition. It is further differentiated:
  - **Blackwater** - according to **ISO 6107-7:1997**: Domestic wastewater containing urine and/or faecal matter. Blackwater can be further subdivided into:
    - Yellowwater – water containing urine (flushing water)
    - Brownwater – water containing faeces and/or toilet paper (without urine)

Types of Waste

Wastewater

Wastewater is a **generic term.** Depending on the country the definition of wastewater varies. The EU defines wastewater as:

- **Domestic wastewater:** Wastewater from residential settlements and services which originates predominantly from the human metabolism and from household activities
- **Industrial wastewater:** Any wastewater which is discharged from premises used for carrying on any trade or industry, other than domestic wastewater and run-off rain water

Link: https://ec.europa.eu/environment/water/water-urbanwaste/info/glossary_en.htm

Types of Waste

Hazardous Waste

Environmental contamination that can be caused by hazardous wastes has **aspects and elements**.

One of them, which is also crucial, is when old hazardous waste dumps are discovered. They might be a couple of decades old. The clean-up of these dumps and the contamination caused can be severe.

Another aspect that has to be mentioned, is the changing behavior and state of the various contaminants that occur. New advancements in the chemical industry also causes new sources of various wastes and problems.

Types of Waste

Hazardous Waste

- Every year new chemicals and chemical mixtures are introduced to the environment. They are added to the many thousand which are already in use.

- Most natural resources and habitats (including the air, surface and ground water, the soil, woods, bio habitats, etc.) have already **become contaminated** with these hazardous chemicals.

Types of Waste

Hazardous Waste

… mainly refers to industrial, chemical, bio-chemical and other wastes which can cause significant hazards to human health or the environment.

According to the US Environmental Protection Agency the four **major characteristics of hazardous wastes** are:

- **ignitability**, or something flammable
- **corrosivity**, or something that can rust or decompose
- **reactivity**, or something explosive
- **toxicity**, or something poisonous

Types of Waste

Hazardous Waste

According to the US Environmental Protection Agency the four **major characteristics of hazardous wastes** are:

Ignitability:

There are 3 types of ignitable forms:

- Liquids with a flash point –lowest temperature at which fumes above waste ignite –of 60 °C or 140 °F. E.g. alcohol, gasoline, and acetone
- Solids that spontaneously combust.
- Oxidizers and compressed gasses.

Types of Waste

Hazardous Waste

According to the US Environmental Protection Agency the four **major characteristics of hazardous wastes** are:

Corrosivity:

Corrosive substances (e.g. hydrochloric acid, nitric acid, and sulfuric acid) have the ability "eat" through containers - causing the leakage of harmful materials.

A corrosive is anything liquid with a pH of less than or equal to "2" or greater than or equal to "12.5" or has the ability to corrode steel. E.g. battery acid and rust removers.

Types of Waste

Hazardous Waste

According to the US Environmental Protection Agency the four **major characteristics of hazardous wastes** are:

Reactivity:

Given their instability, reactive wastes can be very dangerous. There are too many conditions and situations to identify all types of reactive materials. However, the following serves as guideline:

- unstable and routinely experiences violent change without detonating
- potential for explosive mixture or violent reaction when combined with water
- toxic gasses are released when mixed with water

Types of Waste

Hazardous Waste

According to the US Environmental Protection Agency the four **major characteristics of hazardous wastes** are:

Toxicity:
Poisonous materials pose a threat and can have long term effects to human health and the environment.

Co-funded by the Erasmus+ Programme of the European Union

Types of Waste

Hazardous Waste

Waste material that is flammable, corrosive, reactive, or toxic - which can be in the form of a solid, liquid, or gas - is defined as hazardous waste.

Although the term often evokes an image of items marked with skull and crossbones, many hazardous wastes include **products used every day**, e.g.:

- Paint
- Used oil
- Batteries
- Shoe polish
- Laundry detergent
- Etc.

Many items that we generally rely upon **generate hazardous waste** during the process of their production.

Types of Waste

Hazardous Waste

- Some hazardous materials can be **recycled** if it is environmentally safe to do so, although it can be expensive.

- Many industries are attempting to **reduce** their **generation of hazardous waste** by **modifying** their **manufacturing processes** or by **replacing hazardous materials** with less hazardous or non-hazardous substitutes.[1]

- **Hazardous wastes pose a greater risk to the environment and human health than non-hazardous waste and thus require a stricter control regime.**[2]

Types of Waste

Non-Hazardous Waste

→ All types of waste which are not considered as hazardous waste. ←

Photo by Bru-nO at Pixabay

Types of Waste

→ Waste is raw material in the wrong place! ←

Types of Waste

Waste versus raw materials

Raw materials are:

- natural resources that have not been processed except for the solution from their natural source.
- either consumed directly or used as raw materials for further processing stages in production.

Waste:

- is understood to be remnants from private and industrial consumption or from production that are no longer needed.

Environmental aspects and waste

To improve the waste and environmental situation, **four points need to be considered**:

- **Minimization** of the use of operating resources, e.g. through improvements in equipment
- **Recycling** of operating materials, e.g. by circulation
- **Process-integrated disposal** of operating resources through process conversions that minimize the amount of old operating resources
- Production of **environmentally friendly products**

Operational environmental protection

Environmental protection is the **totality of all measures** that are necessary,

- in order to **secure** for mankind an environment that he needs for his **health** and for a **dignified existence**,
- to **protect** soil, air and water, flora and fauna from the lasting effects of human intervention,
- in order to **eliminate damage or disadvantages** from human influences.

A big part of (operational) environmental protection is **Waste Management!**

Waste Management

- Waste management (or waste disposal) include the **activities and actions required to manage waste** from its inception to its final disposal.

- Waste management includes **collection, transport, treatment and disposal** of waste and waste products (garbage, sewage, etc.), as well as monitoring and regulation of the waste management process.

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

- Waste management is **intended to reduce adverse effects of waste** on human health, the environment or aesthetics.

- Waste management practices **are not uniform** among countries, regions, residential and industrial sectors.

- A large portion of waste management practices deal with municipal solid waste which is the bulk of the **waste** that is **created by household, industrial, and commercial activity**.

Waste Management

- Waste management is the process of treating solid wastes and offers a **variety of solutions** for recycling items that don’t belong to trash.
- It is about **how garbage can be used** as a valuable resource.
- Waste management is something that every household and business needs and should utilize for their own advantage.
- Waste management disposes of the products and substances in a safe and efficient manner.
- There are **various methods** of waste management. The following slides provide an overview of the most common ones.

Waste Management

Landfills

- Landfills are the **most popular used method** of waste disposal used today.
- This process of waste disposal focuses attention on **burying the waste** in the land.
- Landfills are commonly found in developing countries.
- There is a process used that eliminates the odors and dangers of waste before it is placed into the ground.

Waste Management

Landfills

- This method is **becoming less popular** nowadays, due to a lack of available space and the strong presence of methane and other landfill gases, both of which can cause numerous contamination problems.

- Landfills **give rise to air and water pollution**.

Waste Management

Incineration/Combustion

- Incineration or combustion is a disposal method in which municipal solid wastes are **burned at high temperatures to convert them** into residue and gaseous products.
- The biggest advantage of this type is that it can **reduce the volume** of solid waste to 20% to 30% of the original volume, decreases the required space and reduce stress on landfills.
- This process is also known as **thermal treatment** where solid waste materials are converted by incinerators into heat, gas, steam and ash.

Waste Management

Recovery and Recycling

- Resource recovery is the process of **taking useful discarded items for a specific next use**.

- These discarded items are **processed to extract or recover materials** and resources or convert them to energy in the form of useable heat, electricity or fuel.

Waste Management

Recovery and Recycling

- Recycling is the process of **converting waste products into new products** to prevent energy usage and consumption of fresh raw materials.
- Recycling is the third component of **Reduce, Reuse and Recycle waste hierarchy**.
- The idea behind recycling is to **reduce** energy usage, volume of landfills, air and water pollution, greenhouse gas emissions and **preserve** natural resources for future use.

Waste Management

Composting

- Composting is an **easy and natural bio-degradation process** that takes organic wastes (i.e. remains of plants, garden, kitchen waste, etc.) and turns into nutrient rich soil for plants.
- Composting, normally used for organic farming, occurs by allowing organic materials to sit in one place for months until microbes decompose it.
- Composting is one of the best method of waste disposal as it can turn unsafe organic products into safe compost. However, **it is slow process and takes lot of space**.

Waste Management

Waste to Energy (Recover Energy)

- Waste to energy process involves **converting of non-recyclable waste items** into useable heat, electricity, or fuel through a variety of processes.

- This type of source of energy is **a renewable energy source** as non-recyclable waste can be used over and over again to create energy.

Waste Management

Waste to Energy (Recover Energy)

- It can help to **reduce carbon emissions** by offsetting the need for energy from fossil sources.

- **Waste-to-Energy is the generation of energy in the form of heat or electricity from waste.**

Waste Management

Avoidance/Waste Minimization

- The **easiest method** of waste management is to **reduce creation of waste materials** and thereby reducing the amount of waste.

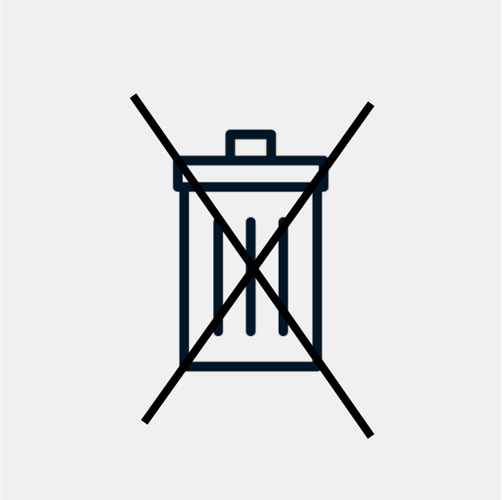
Waste reduction can be done through:

- recycling old materials (e.g. jars, bags),
- repairing broken items,
- avoiding use of disposable products (e.g. plastic bags),
- reusing secondhand items.

Waste Management

Avoidance/Waste Minimization

- Recycling and composting are a couple of the best methods of waste management regarding the environment.



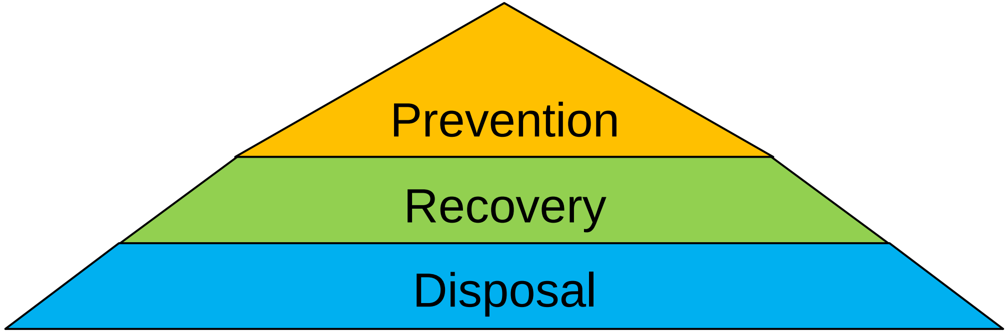
There are **many different ways to treat and manage waste**!

They all depend on the **situation, location and type of waste**.

Waste Management

The **previous general principle** in waste management was:

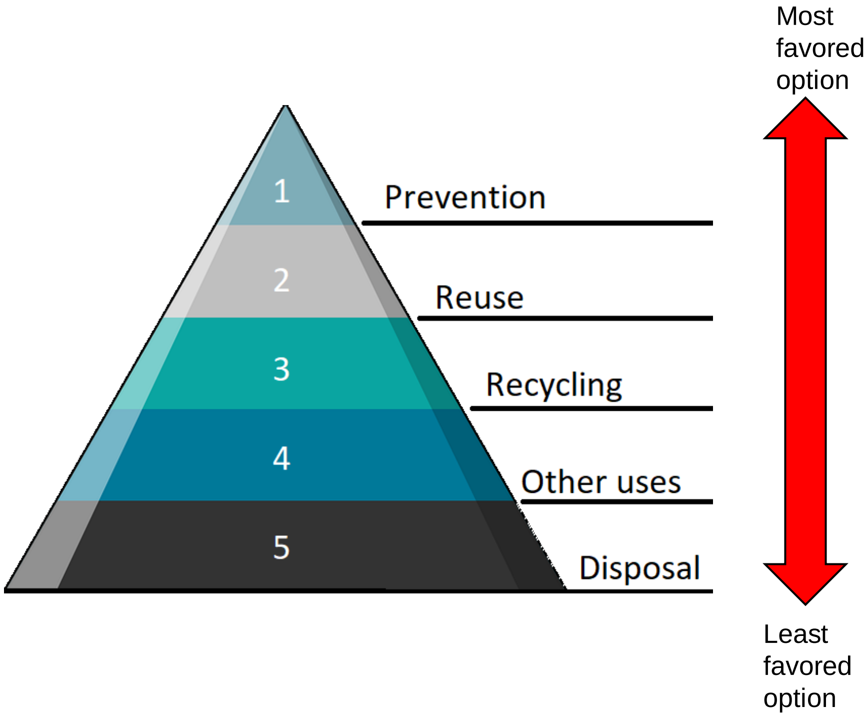
- **Prevention,**
- **prior to recovery,**
- **prior to disposal.**



Waste Management

The new waste hierarchy should now look as follows :

- Prevention,
- Preparation for reuse,
- Recycling,
- Other recovery (e.g. energy recovery)
- Disposal



Note: In some waste hierarchies the step “minimization” is included between “Prevention” and “reuse”.

Waste Management

Liquid waste

- **Liquid waste is wastewater** with a chemical oxidizability using **potassium dichromate** (COD) of 10 g O_2/l.

Potassium dichromate is:

  - a strong oxidizing agent
  - highly soluble in water

In the laboratory, potassium dichromate is used as a common oxidizing agent because of its good storage capability and weighing capacity.

Waste Management

Liquid waste - Types**:**

Liquid wastes are**:**

- **Wastewater**
- **Waste oil**
- **Liquid manure** or **slurry**
- **Solvent wastes**
- **Seepage water**

Special cases of liquid wastes are**:**

- **Concentrate**
- **Mud**
- **Raw sludge**
- **Sewage sludge**

Partially liquid waste**:**

- **Compost**

Waste Management

Liquid waste – Definitions**:**

- **Wastewater** is water contaminated by domestic, commercial and industrial use, as well as rainwater and groundwater, which is transported in pipes.
- **Waste oil** is a used lubricant based on mineral oil, such as motor oil, gear oil with contamination by heavy metals or a water content of up to 5%.
- **Liquid manure** or **slurry** is a more or less diluted mixture of faeces and urine, mixed with leftover feed.

Waste Management

Liquid waste – Definitions**:**

- **Solvent wastes** are used liquids that have dissolved other substances without reacting with them.
- **Seepage water** is the water from precipitation which escapes from a landfill body and is enriched with elutable substances.

Waste Management

Liquid waste – Definitions special cases**:**

- **Concentrate** is a liquid-solid mixture from which solvent has been removed.
- **Mud** is a mixture of liquid and solids, which is either a result of the separation and concentration of solids from liquids and/or the phase transformation from dissolved to undissolved.
- **Raw sludge** refers to an untreated sludge from a wastewater treatment plant.
- **Sewage sludge** is the sludge produced during the treatment of wastewater in municipal or industrial wastewater treatment plants.

Waste Management

Liquid waste – Definition partially liquid waste**:**

- **Compost** is a mixture of mainly vegetable, organic and mineral raw materials, more or less strongly modified by microbial activity.

Waste Management

Liquid waste

- **Wastewater** is both water contaminated by use (or changed in its properties or composition) and precipitation water running off paved surfaces as well as extraneous water entering the sewerage system due to structural damage.

- **Wastewater** is collected via the sewerage system, treated in sewage treatment plants and then discharged into a body of water.

Waste Management

Liquid waste

A distinction is made between the **substances contained** in the wastewater:

- **Organic compounds** (fats, proteins, carbohydrates)
- **Oxygen consuming compounds** (uric acid, glucose)
- **Nutrients** (nitrogen and phosphorus compounds): increased algae growth
- **Pollutants** (poisons, heavy metals, synthetic organic substances, bacteria, fungi or viruses)
- **Impurities** (salts, fats, oils, clays, sand)

Waste Management

Liquid waste

Criteria for waste properties are:

- **Water and solids content**
- **Calorific value in kJ/kg (heating value)**
- **Landfillability**
- **Substance parameters**

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Liquid waste

Water and solids content:

- The **solids content** indicates the weight percentage after a defined drying time of 24 hours at 105 °C.
- The solids content is an **important parameter** for determining the degree of dewatering of sewage sludge and should be at least 30 to 35% for sludge suitable for landfill

Waste Management

Liquid waste

Water and solids content:

- The **water content** is the gravimetric percentage of water in a mixture of substances

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Liquid waste

Heating value:

- **Calorific value** is the maximum amount of heat that can be used during combustion without condensation of the water vapour contained in the exhaust gas.

- **Condensing value** is the maximum amount of heat that can be utilised during combustion with condensation of the water vapour contained in the exhaust gas (cf. "condensing boiler") in relation to the amount of fuel used Colloquially "energy content

Waste Management

Liquid waste

Heating value examples:

- Fresh wood: approx. 7 MJ/kg
- Domestic waste: approx. 10 MJ/kg
- Dry wood: approx. 15 MJ/kg
- Paper: approx. 15 MJ/kg
- Wood pellets: approx. 18 MJ/kg
- Hard coal: approx. 30 MJ/kg
- Diesel/heating oil: approx. 42 MJ/kg

Waste Management

Liquid waste

Landfillability:

- Consistency of the waste
- Elution of substance components

In Austria a distinction is made between:

- Excavated soil landfill
- Landfill of inert waste
- Landfills for non-hazardous waste: (construction waste landfill, residual waste landfill, bulk waste landfill)
- Landfills for hazardous waste

Waste Management

Liquid waste

Origin and prevention:

→ The basic principle is that **without production no waste is produced.**

Waste Management

Liquid waste

Prevention/avoidance and reduction:

Prevention/avoidance of a specific waste may mean that production is changed so that

- this specific waste is no longer produced or
- recycled internally or externally

Waste Management

Liquid waste

Waste prevention/avoidance:

Waste prevention means all measures taken before a product has become waste and which reduce

- the amount of waste, including by reusing products or extending their life cycle;
- the adverse effects on the environment and human health of the waste subsequently generated; or
- the pollutant content in products

Waste Management

Liquid waste

Waste prevention/avoidance:

Waste avoidance **occurs as early as the conception and design of products and production processes**, in particular through the selection and use of raw materials and consumables according to criteria of freedom from pollutants, length of service life and recyclability

Waste Management

Liquid waste

Waste prevention includes:

- avoiding the use of toxic or otherwise problematic substances
- the avoidance of substance composites
- the minimization of the number of substances used to a maximum of one substance (for simple products)
- the design of products for multiple use in product-service systems (e.g. eco-leasing).

Waste Management

Liquid waste

Waste prevention through internal or external recycling:

- **Internal**: resources that would otherwise be considered waste can be recycled or reused within the company
- **External**: Resource that would otherwise be considered waste can be recycled by external parties (customers or other companies) or reused in a sensible way

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Liquid waste

Waste reduction:

Reduction of a special waste can mean:

- that production is reorganised so that fewer production resources are lost, or
- that the treatment of this particular waste has been changed and less auxiliary materials are required, so that the waste mixture is smaller, or
- that a part of it is also used internally or externally.

Waste Management

Liquid waste

Measures for waste reduction include for example**:**

- all measures aimed at reducing the amount of waste produced later (e.g. thinner-walled packaging films)
- the conception of products with a long service life for reuse, further use with the characteristics of reparability, cleanability, washability, refillability etc.

Waste Management

Liquid waste

Avoidance/prevention and reduction strategies are:

- Clarification of product properties
- Avoidance through substitution
- Enabling internal recycling
- Increase of the efficiency
- Production of high quality residues

Why is the obvious, i.e. avoidance, usually neglected by process-integrated measures?
→ **Barriers**

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Liquid waste

Barriers to make changes in production are**:**

- Lack of information about prevention technologies
- Need for adaptation to special production systems
- Economic and personnel situation
- Lack of transparency of process flows
- Missing requirement profiles
- Daily business and high flexibility requirements

Waste Management

Treatment of liquid waste

Treatment of **liquid residues:**

- has the objective of **recovery** or **preparation** for disposal.

It is in the **interest of every entrepreneur** to treat liquid waste according to **quantity** and **substance**.

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Treatment of liquid waste

Why quantity and substance related?**:**

- **Quantity based**: Quantity multiplied by the specific costs gives total costs.
- **Substance-related**: substance defines specific costs; quantity defines total costs)
- **Safety, reliability** (defined by substance)

Waste Management

Treatment of liquid waste

Detoxification/inactivation/reduction of the toxic effect by**:**

- **qualitative destruction of the relevant compounds** (toxic components are then no longer contained in the wastewater) or
- **masking of toxic effects** (the prevention of certain reaction sequences)

Waste Management

Treatment of liquid waste

Wastewater detoxification:

- The aim of wastewater detoxification is to free wastewater from chemical waste and foreign substances.
- It is an essential component of wastewater purification and treatment in industry.
- The aim is to **eliminate, inactivate/cancellate or at least reduce** the existing toxic potential to a certain level.
- There are various chemical-physical processes that make this possible.

Waste Management

Treatment of liquid waste

Possibilities of **detoxification, depletion, enrichment and inactivation:**

- Oxidative and reductive destruction
- Masking of toxic waste components
- Catalytic or photochemical attack of toxic waste components
- Extraction and electrolysis of heavy metals

Waste Management

Treatment of liquid waste

Besides the removal of pollutants from residues and waste, the **mineralisation of organic compounds** is an important prerequisite for further disposal.

Mineralization is the **release of organically bound chemical elements** and their conversion into inorganic compounds.

This means the conversion of organic compounds into a carbon atom, water and minerals, whereby the emission of CO_2 from the mixture of substances is considered a desirable product.

Waste Management

Treatment of liquid waste

The **decomposition of organic material** takes place in two steps:

→ Step 1: into a coarse decomposition (humification)

→ Step 2: into a subsequent complete splitting of the carbon, oxygen and hydrogen containing substances by microorganisms (biological oxidation)

Waste Management

Treatment of liquid waste

Microorganisms decompose the higher molecular organic compounds as part of their energy metabolism and, as part of their building material metabolism, also rebuild them into new organic compounds.

The presence of bacteria capable of mineralization is also of **great importance for the self-purification of waters**.

Waste Management

Treatment of liquid waste

There are **2 basic types of biological treatment:**

- **Aerobic treatment (with oxygen)**
- **Anaerobic treatment (without oxygen)**

Waste Management

Treatment of liquid waste

Aerobic treatment (composting) refers to the supply of dissolved oxygen to the decomposing microorganisms. The oxygen can be supplied in the form of compressed air, pure oxygen, hydrogen peroxide or ozone.

Example of an activated sludge tank in a sewage treatment plant: In this area, microorganisms break down the organic substances in the wastewater and inorganic substances are partially oxidized. For this purpose, air (oxygen) is pumped in, i.e. aerobic treatment

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Treatment of liquid waste

Anaerobic treatment (digestion/fermentation): Systems with fixed beds are particularly interesting for the treatment of liquid waste in the absence of oxygen, because immobilised microorganisms are easier to handle when problems occur.

Example digestion tower of a sewage treatment plant: sewage sludge can be decomposed in digesters under anaerobic conditions by anaerobic bacterial strains to digested sludge and combustible digester gas (essentially a mixture of methane and carbon dioxide)

Waste Management

Treatment of liquid waste

Other biological treatment methods are:

- **Wet oxidation**
- **Pyrolysis (decomposition)**
- **Thermal oxidation**

Waste Management

Treatment of liquid waste

Wet Oxidation:

- Chemical oxidation of organic compounds in a liquid phase by supplying oxygen under high pressure and temperature

- In wastewater treatment, wastewater constituents can be oxidized by wet oxidation with the help of atmospheric oxygen at 240-290°C and approx. 120 bar

Basically nothing else than mineralization of organic compounds in aqueous phases

Waste Management

Treatment of liquid waste

Pyrolysis:

- Pyrolysis is the decomposition (degassing) of carbonaceous mixtures of substances by the action of heat, but excluding oxygen.

- A thermo-chemical cleavage of organic compounds, whereby high temperatures (approx. 500 - 900°C) force a bond to break within large molecules, resulting in smaller molecules.

For example, pyrolysis of higher quality KWe in methane.

Waste Management

Treatment of liquid waste

Thermal oxidation:

- the combustion - or oxidation, in terms of process engineering, of the organic components of a mixture of substances with atmospheric oxygen at high temperatures.

Waste Management

Treatment of liquid waste

Incineration:

Prerequisites are:

- Sufficient oxygen supply
- Sufficient ignition temperature
- Sufficient contact of fuel and oxygen
- Continuous removal of the products (flue gas and slag)

Waste Management

Solid waste

Properties of solid waste:

- Waste quantities
- Waste volume
- Calorific value

Waste Management

Solid waste

Properties of solid waste:

- The waste quantity is recorded gravimetrically via the waste weight over a certain collection range.

Waste Management

Solid waste

Properties of solid waste:

- The waste volume can be determined from the number of weekly emptied collection containers and their individual volumes.

Waste Management

Solid waste

Properties of solid waste:

Waste quantities and waste volume: In practice, **conversion factors** are applied on the basis of experience.

e.g.:

Waste identification	Masses in tons	Conversion into kg/m^3	Volume in m^3
Residual waste	1,402,100	130	10,785,000
Glass (packaging)	211,600	280	756,000
Metals (packaging)	30,600	50	612,000

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Solid waste

Properties of solid waste:

- The calorific value is used to assess the combustibility of waste.
- Calorific value of **business waste greater than that of household waste** (more paper, cardboard, plastics).

Calorific value of analytical waste in kJ/kg:

- Household waste: Winter – 6661 to 7821 kJ/kg; Summer – 7093 to 8235 kJ/kg
- Business waste: Winter – 10400 kJ/kg; Summer – 13989 kJ/KG

Waste Management

Solid waste

Analysis of waste samples:

Average raw waste sample (1000 – 2000kg)

↓

Sieve analyses

↓

Separate weighing of the individual fractions and determination of their mass fractions.

↓

Sorting analysis with subsequent weighing → Substances that can be incinerated and composted. Substances that can only be incinerated. Substances that can neither be incinerated nor composted.

↓

Crushing to 8 mm and mixing of the crushed fraction

↓

Pre-sampling → Residual sample

↓

Collection of laboratory samples → Residual sample

Waste Management

Solid waste

Analysis of residual samples:

Taking of laboratory samples of certain mass for the determination of:

water gelate and hygroscopic residual moisture, ignition residue and ignition loss, calorific value, self-heating behaviour, organic substance content, C/N ratio, cellulose content, pH value, conductivity, content of toxic substances after prior special preparation of the respective sample

Waste Management

Solid waste

Analysis of residual samples:

- **Hygroscopic residual moisture**: after drying, the sample absorbs moisture from the ambient air; this moisture absorption serves to characterize the waste sample
- **Residue on ignition**: determine the mass of the residue after annealing (2 hours at 775°C); organic ingredients are oxidised, mineral residue remains
- **Loss on ignition**: initial mass minus the ignition residue corresponds to the loss on ignition

Waste Management

Solid waste

Analysis of residual samples:

- **Content of organic substances:** Determined by TOC value (total organic carbon = total amount of CO_2 after a thermal reaction)
- **pH value:** pH < 7: acidic, pH = 7: pure water or neutral, pH > 7 basic
- **Conductivity:** physical quantity specifying the ability of the waste sample to conduct electric current; high conductivity = high salinity

Waste Management

Solid waste

Analysis of residual samples:

- **Self-heating behaviour:** biodegradation of organic substances is exothermic; the degree of self-heating is used to characterise the waste sample
- **C/N ratio:** indicates the ratio of carbon (C) to nitrogen (N) in the waste sample and is an indicator of its fertility. The smaller the number, the better the availability of nitrogen. Domestic sewage sludge has a C/N ratio in the range 5-20

Waste Management

Solid waste

Analysis of residual samples:

- **Cellulose content:** Cellulose is the main component of plant cell walls and thus the most common organic compound; the cellulose content thus serves to characterise the waste sample and is an indication of the expected amount of compost
- **Content of toxic substances:** Analysis is usually very complex and must be carried out substance-specific!

Waste Management

Solid waste

Facts about solid waste:

Composition of waste

Waste type	Total mass percentage (%)	Mass percentage in household waste (%)
Household waste	70 – 80	
Substance group 1: Materials that can be incinerated (in the grain size range 8 - 40mm, organic kitchen waste, paper, straw, textiles, etc.)		30 – 60
Substance group 2: substances that can only be burnt (wood, leather, plastics, etc.)		4 – 7
Substance group 3: Substances which can neither be incinerated nor composted (= inert materials) (iron, glass, porcelain, etc.)		14 – 25
Substance group 4: fine waste with grain size below 8mm, partly compostable and combustible (ash, sand, organic matter)		20 – 35
Bulky, flammable and non-flammable goods from trade and small industry	1 – 14	
Combustible and non-combustible industrial waste	10 – 20	
Street sweepings, garden waste	10 – 20	

Waste Management

Solid waste

Facts about solid waste:

Mixed municipal waste from households and similar establishments: Composition (1)

- Biogenic waste – 20.5%
- Paper, cardboard and cartons – 5.3%
- Toiletries and diapers – 20.4%
- Plastics and composites – 10.1%
- Textiles and shoes – 4.8%
- Glass – 3.0%
- Inert materials – 2.0%

Source: mixed municipal waste from Upper Austria from 2013

Waste Management

Solid waste

Facts about solid waste:

Mixed municipal waste from households and similar establishments: Composition (2)

- Metals – 2.3%
- Problem substances – 0.3%
- waste electrical and electronic equipment – 0.4%
- Other waste (flat glass, wood, wood composites) – 10.4%
- Fine Fraction – 20.7%
- Total – 100.00%

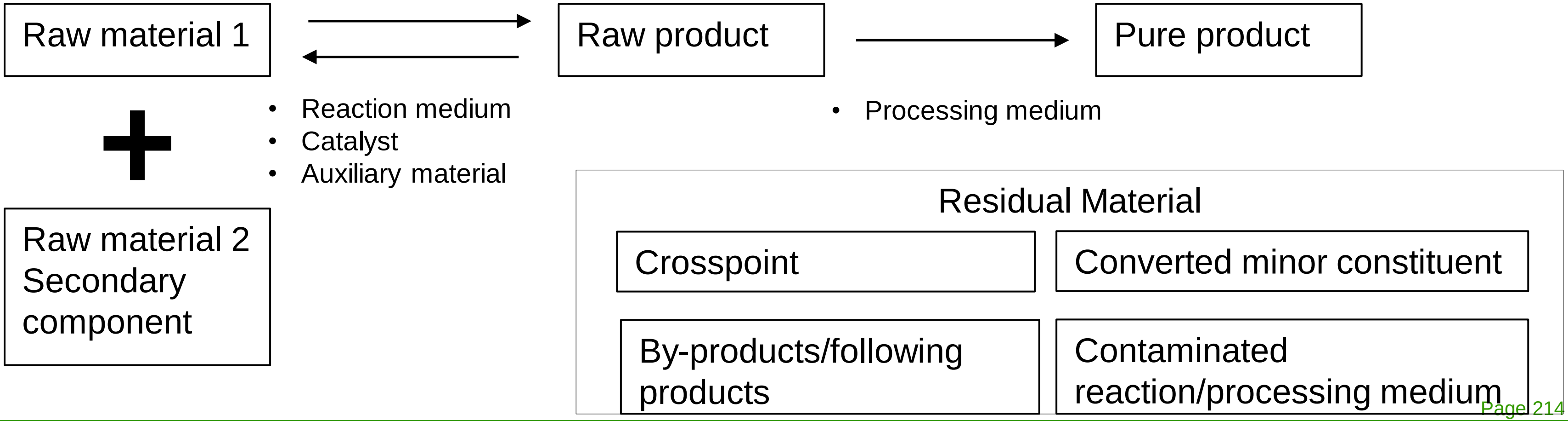
Source: mixed municipal waste from Upper Austria from 2013

Waste Management

Solid waste

Avoidance/reduction:

Formation of products and residues in industrial production processes



Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Solid waste

Measures to avoidance/reduction of solid waste:

- Use of pre-cleaned raw materials
- Improvement of the production process through new synthesis routes
- Use of catalysts with higher selectivity
- Plant and control engineering optimizations

Waste Management

Solid waste

Measures to avoidance/reduction of solid waste:

- Recycling of auxiliary materials
- Reduction of the pollutant load of the residues
- Separation for volume reduction

Waste Management

Solid waste

Avoidance/reduction of solid waste:

Process for the recovery of the material and energy content of the waste

- Separate collection of waste materials from the waste
- Mechanical waste sorting and separation processes
- Composting
- Pyrolysis with recycling of the pyrolysis products
- Waste incineration with heat recovery
- Pyrolysis with use of the pyrolysis products as energy source

Waste Management

Solid waste

Solid waste collection:

Waste collection includes the following systems:

- Conventional collection systems
  - Transfer vessels;
  - Vessel Exchange Systems;
  - Disposable packs
- Waste suction systems
- Separate collection systems

Waste Management

Solid waste collection

Waste suction systems:

In a waste suction system, the **waste in multi-family houses** is **thrown into deposit shafts** and in **the areas of individual houses** into **outdoor entry points** and pneumatically transported via a public pipeline system with negative pressure to a collection point, from where it is transported by vehicles to the landfill.

Waste Management

Solid separate waste collection systems overview

Systems involved in the collection of household waste:

- Simultaneous collection of waste and materials
  - Individual waste bags
  - Multi-chamber waste systems
  - Waste bag in the container
- Separate collection of waste and materials
  - Green ton
  - Compost bin
  - Garbage bag plus container

Waste Management

Solid separate waste collection systems overview

System independent from household waste collection:

- House collection
    - Wastepaper, Waste clothes
- Collection at central locations
    - Collection container
        - Glass
        - Paper
        - Batteries
        - Combi-Container

Waste Management

Technical facilities

Requirements for technical facilities for waste treatment are:

- Simple and robust design
- As few moving parts as possible with good maintenance and cleaning possibilities
- Cover of all drive devices
- Large passage cross sections
- Little deflection of the material flows
- Resistance to mechanical abrasion and corrosion

Waste Management

Technical facilities

Bunker systems should have three functions:

- Recording the amount of waste delivered and unloaded
- Temporary storage of waste to decouple the processes of delivery and abandonment
- Dosing of the waste quantity for feeding to the following processing equipment

Waste Management

Technical facilities

Bunker and dosing equipment include:

- Apron feeder hoppers and depth hoppers
- Crane systems
- Flat bunker

Waste Management

Technical facilities

Shredding aggregates for waste are:

- Hammer mills
- Impact mills
- Impact tearer
- Knife mills
- Ball mills (cascade mills)

Waste Management

Technical facilities

Hammer Mill:

- Principle: One or more rotors rotate in a housing and hammers are attached to their circumference. The material to be ground hits the rotating hammers, thus achieving the primary crushing effect.
- The hammers also hurl the pieces onto the housing wall, where they are further broken up by the impact.
- The ground material remains in the grinding chamber until it is small enough to fit through a grate on the outer circumference of the machine.

Waste Management

Technical facilities

Impact Mill:

- Principle: One or more rotors rotate in a housing, on the circumference of which beater bars are attached. Static baffle plates are additionally attached to the housing.

- The material to be ground is thrown by the rotating beater bars against the static baffle plates until the desired degree of size reduction is achieved.

Waste Management

Technical facilities

- **Ball mill**: It consists of a rotating grinding chamber in which ground material is crushed by grinding media.
- **Knife mill**: Knives at high speeds crush the material to be ground.

Waste Management

Technical facilities

Sieves are used in waste treatment plants for:

- pre-sieving the fine waste or the coarse waste
- Post-sieving of the shredded waste for the separation of non-shreddable waste
- Post-sieving of the waste rotting in the reactor for the separation of difficult or non-rotting waste materials
- Sieving of the finished compost to achieve higher compost qualities

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Technical facilities

sieving machines for waste:

- Vibrating sieves
- Clamping shaft sieves
- Drum sieves
- Tension shaft drum sieves

Waste Management

Solid waste

Recycling

Recycling means **the reintroduction of waste materials into the production process** as a substitute for primary raw materials.

Waste Management

Solid waste

Recycling

- The use of old materials not only **conserves raw material reserves**.
- At the same time, **considerable amounts of energy are saved**.
- The reuse of production waste in the manufacture of new goods **has always been common practice** in the **paper** and **glass industries**.
- However, there are still many untapped, or at present uneconomical recycling possibilities for a wide range of materials.

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

Solid waste

Recycling

In Europe, mainly recycled materials are:

- Paper and cardboard
- Plastic foils
- Scrap iron
- Glass
- Non-ferrous metal (all metals except ferrous alloys in which the proportion of pure iron exceeds 50%; examples: copper, aluminium, zinc, bronze, brass)

Waste Management

Solid waste

Recycling

Glass recycling:

Colour separation is important for the recycling process, because a single green champagne bottle tints 500 kg of colourless glass greenish. Conversely, white glass discolours stained glass.

In Austria, more than 200,000 tons of used glass packaging are collected annually.

Before being melted down, the waste glass is cleaned manually and mechanically from the wrong types of glass, pieces of glass of the wrong colour and foreign matter.

Waste Management

Solid waste

Landfills

- From the recent past, the small community owned or wild dumps in quarries, sand or gravel pits without landfill regulations are still known.
- These landfills were constructed according to the principle of pre-head dumping, in which waste from greater dumping heights rolls off over inclined dumps in a highly loosened up state and forms a hollow deposit mass with low bulk density and a large surface area for leaching by precipitation water

Waste Management

Solid waste

Landfills

Apart from disfiguring the landscape and reducing the utility value of the area surrounding the dump, this disposal of waste has led to:

- ... a high pollution of ground and surface water due to pollutant extraction by trickling rainwater,
- ... pest breeding and the associated danger of epidemics,
- ... and extensive air pollution from uncontrolled fires.

Waste Management

Solid waste

Landfills

Defined landfill options are:

- Controlled landfill
- Rott landfill (preliminary stage of composting)
- Landfill of hazardous waste (commercial or industrial waste not similar to household waste)
- Special landfill (e.g. radioactive material)

Waste Management

Solid waste

Landfills

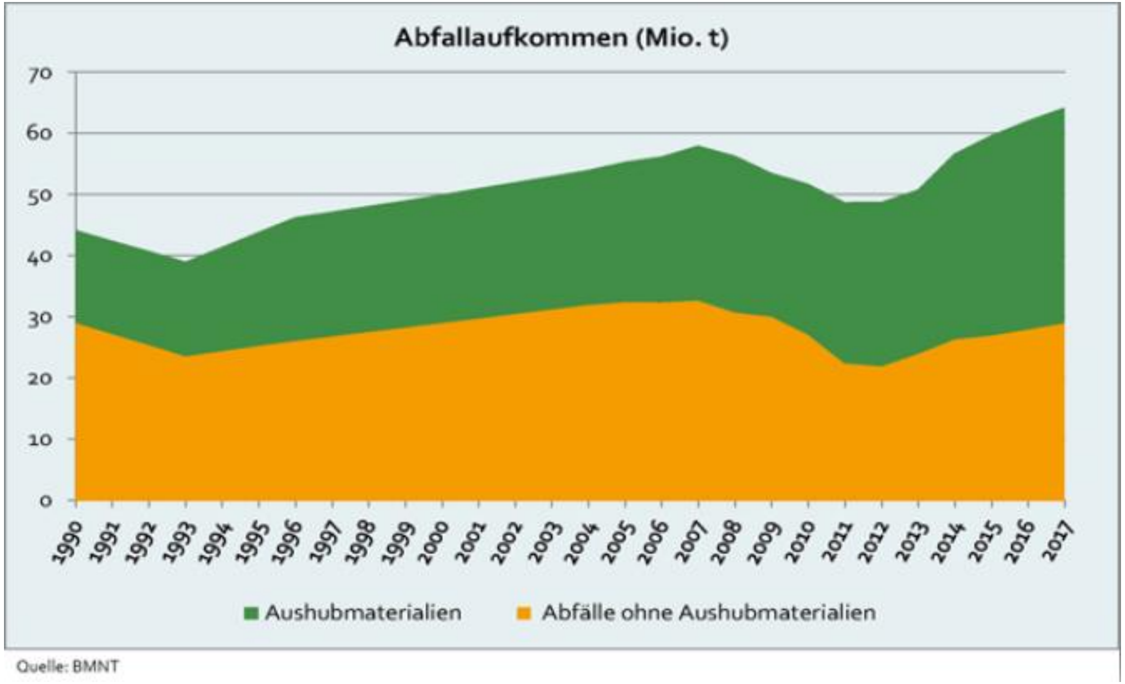
Requirements for the construction and operation of a landfill in Austria:

- Legal basis, site selection, planning approval
- Explanatory report on the assessment of the project
- Plan documents
- Expert opinion
- Documents on construction and operation
- Leachate disposal, degassing
- …

Waste Management

Waste Data: Austria

The waste volume in 2017 was around 64.19 million tonnes.



Source: https://www.umweltbundesamt.at/umweltsituation/abfall/abfall_datenbanken/jahresdaten_abfall/

Waste Management

The EU’s approach to waste management:

The European Union's approach to waste management is based on the "waste hierarchy" which sets the following priority order when shaping waste policy and managing waste at the operational level: prevention, (preparing for) reuse, recycling, recovery and, as the least preferred option, disposal (which includes landfilling and incineration without energy recovery).

Source: https://ec.europa.eu/environment/waste/index.htm

Co-funded by the Erasmus+ Programme of the European Union

Waste Management

The EU’s approach to waste management:

Directive 2008/98/EC on waste (Waste Framework Directive)

- Directive 2008/98/EC sets the basic concepts and definitions related to waste managament, such as definitions of waste, recycling, recovery.

- It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products.

Source: https://ec.europa.eu/environment/waste/framework/

Waste Management

The EU's approach to waste management:

Directive 2008/98/EC on waste (Waste Framework Directive)

- The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odours, and without adversely affecting the countryside or places of special interest.
- Waste legislation and policy of the EU Member States shall apply as a priority order the following waste management hierarchy.

Source: https://ec.europa.eu/environment/waste/framework/

Waste Management

The EU's approach to waste management:

Directive 2008/98/EC on waste (Waste Framework Directive)

Source: https://ec.europa.eu/environment/waste/framework/

Waste Management

The EU's approach to waste management:

Directive 2008/98/EC on waste (Waste Framework Directive)

The Directive introduces the "polluter pays principle" and the "extended producer responsibility". It incorporates provisions on hazardous waste and waste oils (old Directives on hazaroud waste and waste oils being repealed with the effect from 12 December 2010), and includes two new recycling and recovery targets to be achieved by 2020.

Source: https://ec.europa.eu/environment/waste/framework/

Waste Management

The EU's approach to waste management:

Directive 2008/98/EC on waste (Waste Framework Directive)

Two new recycling and recovery targets to be achieved by 2020:

- 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households, and
- 70% preparing for re-use, recycling and other recovery of construction and demolition waste.

The Directive requires that Member States adopt waste management plans and waste prevention programmes.

Source: https://ec.europa.eu/environment/waste/framework/

Waste Management

The EU's approach to waste management:

The 7th Environment Action Programme sets the following priority objectives for waste policy in the EU:

- To reduce the amount of waste generated;
- To maximise recycling and re-use;
- To limit incineration to non-recyclable materials;
- To phase out landfilling to non-recyclable and non-recoverable waste;
- To ensure full implementation of the waste policy targets in all Member States.

Source: https://ec.europa.eu/environment/waste/index.htm

Waste Management

The EU's approach to waste management:

More information on the main elements of EU waste legislation can be found in more detail (see source):

- Waste framework legislation
- Waste stream legislation
- Landfilling and incineration
- Shipment of waste
- Implementation and reporting
- Review of EU waste policy
- Studies/publications/links

Source: https://ec.europa.eu/environment/waste/index.htm

Waste Management

The EU's approach to waste management:

Furthermore, the EU has a brochure about the "EU's approach to waste management":

Link: https://ec.europa.eu/environment/waste/pdf/WASTE%20BROCHURE.pdf

Waste Management

Waste management in Austria :

A lot of information can be found at:

Umweltbundesamt (Environment Agency) Austria – Environmental Situation - Waste

- https://www.umweltbundesamt.at/umweltsituation/abfall/

Summary

- **Environment (Pollution, Awareness)**
- **Solid Waste**
- **Liquid Waste**
- **Wastewater**
- **Waste Management**

Sources:

- European Commissison. Hazardous Waste. Accessed 15.04.2020 at https://ec.europa.eu/environment/waste/hazardous_index.htm
- European Environmental Agency. Non-hazardous Waste. Accessed 15.04.2020 at https://www.eea.europa.eu/help/glossary/eea-glossary/non-hazardous-waste
- Conserve Energy Future. What is Solid Waste Management?. Accessed 15.04.2020 at https://www.conserve-energy-future.com/sources-effects-methods-of-solid-waste-management.php
- European Commission. Being wise with waste: the EU‘s approach to waste management. Accessed 15.04.2020 at https://ec.europa.eu/environment/waste/pdf/WASTE%20BROCHURE.pdf
- Wikipedia. Waste Management. Accessed 15.04.2020 at https://en.wikipedia.org/wiki/Waste_management
- United Nations Statistics Division - Environment Statistics. Accessed 15.04.2020 at unstats.un.org
- Davidson, Gary (June 2011). "Waste Management Practices: Literature Review". Dalhousie University - Office of Sustainability. Accessed 15.04.2020 at https://cdn.dal.ca/content/dam/dalhousie/pdf/dept/sustainability/Waste%20Management%20Literature%20Review%20Final%20June%202011%20%281.49%20MB%29.pdf
- Handbook of Solid Waste Management and Waste Minimization Technologies. Butterworth-Heinemann. 2003. ISBN 9780750675079.
- Land Niederösterreich. Niederösterreichischer Abfallbericht 2013/ Abfallwirtschaftsplan 2018. Accessed 15.04.2020 at http://www.noel.gv.at/noe/Abfall/NOE_Abfallwirtschaftsplan_2018.html
- Ministerium für ein lebenswertes Österreich. Die Bestandaufnahme der Abfallwirtschaft in Österreich Statusbericht 2015. https://www.bmlrt.gv.at/dam/jcr:dcb379ae-9512-4c8f-bfb9-d4b0409fa238/AW_Statusbericht_2015_final.pdf
- Umweltbundesamt. Jahresdaten Abfall. Accessed 15.04.2020 at https://www.umweltbundesamt.at/umweltsituation/abfall/abfall_datenbanken/jahresdaten_abfall/
- Umweltbundesamt. Umweltsituation – Abfall. Accessed 15.04.2020 at https://www.umweltbundesamt.at/umweltsituation/abfall/
- European Commission. Directive 2008/98/EC on waste (Waste Framework Directive). Accessed 15.04.2020 at https://ec.europa.eu/environment/waste/framework/
- PEGEX Hazardous Waste experts. Understanding the Four Characteristics of Hazardous Waste. Accessed 15.04.2020 at https://www.hazardouswasteexperts.com/understanding-the-four-characteristics-of-hazardous-waste/

Sources:

- The Environmental Literacy Council. What is Waste?. Accessed 15.04.2020 at https://enviroliteracy.org/environment-society/waste-management/what-is-waste/
- eSchoolToday. "Facts and Tips on Waste Management". Accessed: 15.04.2020 at https://www.eschooltoday.com/waste-recycling/waste-management-tips-for-kids.html
- eniSchool – energy & environment. What is Waste. Accessed 15.04.2020 at http://www.eniscuola.net/en/argomento/waste/what-is-waste/what-is-waste-and-how-is-it-created/
- Cambridge Dictionary. Waste. Accessed 15.04.2020 at https://dictionary.cambridge.org/de/worterbuch/englisch/waste
- European Commission. Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste. Accessed 15.04.2020 at https://ec.europa.eu/environment/waste/framework/pdf/guidance_doc.pdf
- Eurostat. Waste generated by households by year and waste category. Accessed 15.04.2020 at https://ec.europa.eu/eurostat/databrowser/view/ten00110/default/table
- European Commission. EU Focus on waste management. Accessed 15.04.2020 at https://ec.europa.eu/environment/waste/publications/pdf/eufocus_en.pdf
- European Commission. Waste. Accessed 15.04.2020 at https://ec.europa.eu/environment/waste/index.htm
- Europen Environmental Agency. Liquid Waste. Accessed 15.04.2020 at https://www.eea.europa.eu/help/glossary/gemet-environmental-thesaurus/liquid-waste
- eWasteDisposal Inc. Liquid Waste. Accessed 15.04.2020 at https://www.ewastedisposal.net/liquid-waste/
- Wikipedia. Abwasser. Accessed 15.04.2020 at https://de.wikipedia.org/wiki/Abwasser
- European Commission. Glossary of terms related to Urban Waste Water. Accessed 15.04.2020 at https://ec.europa.eu/environment/water/water-urbanwaste/info/glossary_en.htm

Module III - Energy generation from wastewater and waste

Content

- Waste
- Waste Management
- Energy Management
- Waste Utilization
- Wastewater Utilization (Technologies etc.)
- Heat Pump Technology
- Use Cases
- Summary

Waste

Waste can be classified according to many different criteria. An overarching classification, especially regarding waste management, is usually done in following manner:

- **Solid Waste**
- **Liquid Waste**
- **Hazardous Waste**
- **Non-Hazardous Waste**
- **(e-waste)**

Waste

Solid waste

Waste collected from residences, commercial buildings, hospitals, schools, universities, offices, light industrial operations etc. is usually considered as **municipal solid waste**.

Municipal Solid Waste **mainly consists of**:

- Paper, Containers and packaging (plastic, glass and metal), Food/Bio waste, Yard trimmings, Textiles, Other inorganic waste

Waste

Liquid Waste

Fluid wastes, consisting of sewage and domestic wastewater, or processed water, or other liquids, produced by industrial activity, particularly by such industries as pulp and paper production, food processing, and the manufacture of chemicals.[1]

Liquid waste can also be defined as such liquids:[2]

- Wastewater
- Fats, oils, grease
- Used oil
- Liquids, solids, gases, or sludges and hazardous household liquids

Waste

Liquid Waste

Liquids that are hazardous or potentially harmful to human health or the environment. They can also be discarded commercial products classified as “Liquid Industrial Waste” such as cleaning fluids or pesticides, or the by-products of manufacturing processes.

Liquid waste can therefore be also classified as **wastewater**!

Types of Waste

Wastewater

Wastewater is a **generic term for water from various sources**, which is discharged via building structures.

- **Rainwater** - rainwater running off paved surfaces (in some contexts rainwater is not counted as wastewater)

- **Extraneous water** - entering the sewerage system due to structural damage

Types of Waste

Wastewater

Wastewater is a **generic term for water from various sources**, which is discharged via building structures.

- **Wastewater** - water contaminated by use or changed in its properties or composition. It is further differentiated:
  - **Greywater** - according to EN 12056-1: faecal-free, slightly contaminated wastewater (e.g. water originating from showering, bathing or washing hands, from the washing machine) which can be treated to produce **process water.** Rainwater **running off the roof or balcony** is also included.

Types of Waste

Wastewater

Wastewater is a **generic term for water from various sources**, which is discharged via building structures.

- **Wastewater** - water contaminated by use or changed in its properties or composition. It is further differentiated:
  - **Blackwater** - according to **ISO 6107-7:1997**: Domestic wastewater containing urine and/or faecal matter. Blackwater can be further subdivided into:
    - Yellowwater – water containing urine (flushing water)
    - Brownwater – water containing faeces and/or toilet paper (without urine)

Types of Waste

Wastewater

Wastewater is a **generic term.** Depending on the country the definition of wastewater varies. The EU defines wastewater as:

- **Domestic wastewater:** Wastewater from residential settlements and services which originates predominantly from the human metabolism and from household activities
- **Industrial wastewater:** Any wastewater which is discharged from premises used for carrying on any trade or industry, other than domestic wastewater and run-off rainwater

Link: https://ec.europa.eu/environment/water/water-urbanwaste/info/glossary_en.htm

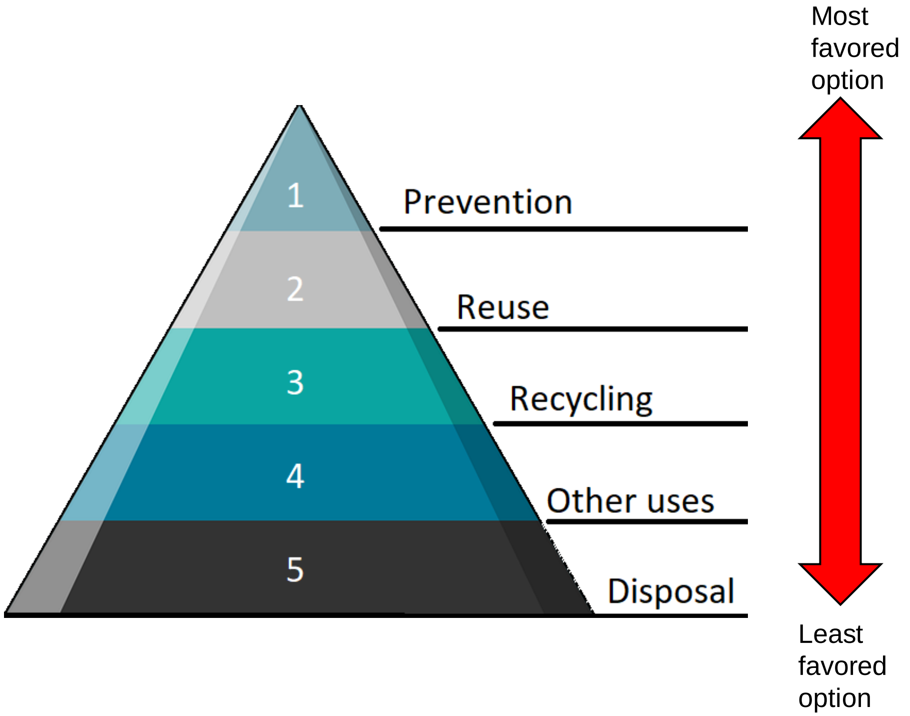
Waste Management

- Waste management is the **sum of all activities and actions** required to manage waste from its inception to its final disposal.
- Waste management includes **all waste types**:
  - Industrial
  - Biological
  - Household
- Waste is produced by human activity (production, extraction, processing of materials)
- Waste poses a **threat to environmental and human health**.
- Waste management is intended to reduce adverse effects of waste on human health, the environment.

Waste Management

The waste hierarchy:

- Prevention,
- Preparation for reuse,
- Recycling,
- Other recovery (e.g. energy recovery)
- Disposal



Note: In some waste hierarchies the step "minimization" is included between "Prevention" and "Reuse".

Energy Management

- Energy management is about **planning and operation of energy-related generation and consumption** units.
- Energy management can (and should) **be applied on many different levels** from state level to regional level as well as in individual companies
- The main objectives are the **conservation of resources, climate protection and cost reductions**, while ensuring that the energy needs of the users are met.

Energy Management

- Fundamental considerations for energy management:
  - To ensure the security of energy supply (e.g. uninterrupted energy supply)
  - To ensure economic electricity and heat prices (e.g. avoiding to high fluctuations)

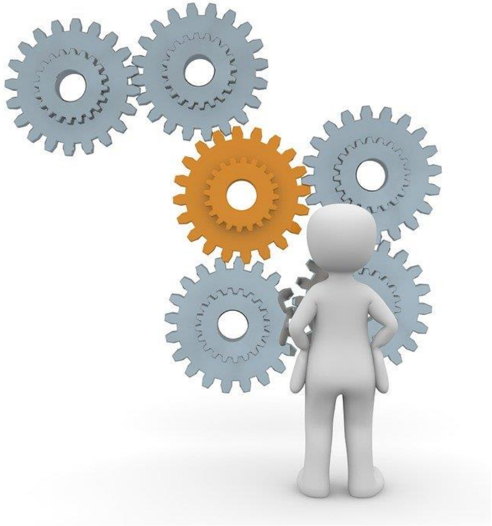


Photo by Peggy_Marco at Pixabay

Energy Management

- Application areas of Energy Management are:
  - Commercial and industrial energy management in production and logistics (small, medium and large sized)
  - Energy management for residential construction and of residential buildings

Photo by geralt at Pixabay

Energy Management

- Application areas of Energy Management are:
  - The municipal energy management (national, regional and local)
  - Building energy management, especially for complex functional buildings and buildings necessary for the infrastructure.
    - e.g hospitals, fire and police stations, stores, etc.

Energy Management

- Application areas of Energy Management in cooperate functions are:
  - Facility Management
  - Energy Procurement
  - Production
  - Maintenance
  - Information Technology
  - Logistics
  - Production planning and control

Waste utilization as energy supply

- Utilizing waste as “energy supply” is usually referred to as:
  - **Waste-to-energy** (WtE), or
  - **Energy-from-waste** (EfW)

- WtE is the process of generating energy in the form of electricity and/or heat from the **primary treatment** or the **processing of waste** into a fuel source.

- As products and materials already had an energy input in some form to become waste, waste-to-energy is considered as a **form of energy recovery**.

Waste utilization as energy supply

The majority of waste-to-energy processes have one of the following two effects.

- Either they **generate electricity and/or heat** directly through combustion, or
- the WtE processes **produce a combustible fuel commodity**, like:
  - Methane,
  - Methanol,
  - Ethanol, or
  - Synthetic fuels

Waste to Energy

There are **several methods** used globally to turn waste into energy:

- The most common one is **incineration** (or **combustion**) of waste.
- Other methods include:
  - **Thermal technologies**
    - Gasification
    - Pyrolysis
    - etc.
  - **Non-thermal technologies**
    - Anaerobic digestion
    - Fermentation
    - etc.

Co-funded by the Erasmus+ Programme of the European Union

Waste to Energy

Incineration/Combustion

- Waste incineration refers to the **combustion of organic (waste) material** with energy recovery, is the most common method of Waste-to-Energy.
- Not only **is energy recovered**, but simultaneously it has the advantage of **getting rid of waste**, which would otherwise have to be processed or dumped into a landfill.
- All new WtE plants in the EU must meet severe emission standards laid down in the Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste.

Directive 2000/76/EC: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:332:0091:0111:EN:PDF

Waste to Energy

Incineration/Combustion

- The Directive 2000/76/EC includes emission standards on:
  - Nitrogen oxides (NOx)
  - Sulphur dioxide (SO_2)
  - Heavy metals
  - Dioxins
- Therefore, WtE incineration plants built after 2000 are very different to older plants.
- New incinerators can **reduce the volume** of the input waste by approximately **95%**.
  - Hereby, the composition and degree of recovery of the materials plays a role.

Waste to Energy

Incineration/Combustion

Getting rid of waste, while simultaneously generating, or rather recovering, energy sounds great. However, there are several downsides to the WtE incineration process:

- WtE plants need a continuous, uninterrupted, **high volume waste stream** for about **25 years** to be economically viable.
  - This leads to waste imports (e.g. Sweden imports waste form the UK).
- Waste materials that are easiest to gather and are recyclable (e.g. paper and plastic) produce most energy when burned.

Waste to Energy

Incineration/Combustion

- Getting rid of waste in such an easy way, reduces innovation in the waste sector
- Furthermore, WtE does not comply with a circular economy (trying to keep goods in circulation). Instead, it strengthens the "make-use-dispose" mentality.
- Burning waste contaminates and impacts the environment, even when restrictions and standards are applied and adhered.
    - Incinerators may emit fine particulate, heavy metals, trace dioxin and acid gas, albeit these emissions are relatively low.

Waste to Energy

Incineration/Combustion

- Incinerators may destroy valuable resources that could be used in another way.
- They also may reduce incentives for recycling.
- It is however certainly a viable and useful option for waste management as some Member States of the EU which recycle the most (up to 70%) also utilize the incineration process to avoid landfilling.
- Incinerators have electric efficiencies between 14% and 28%.
- In Euope there were 431 WtE plants in 2005 and 89 in the US in 2004.

Waste to Energy

Incineration/Combustion

- To avoid losing rest energy, it can be used for e.g. district heating (cogeneration).
- Cogeneration incinerators have total efficiencies of more than 80% (based on the lower heating value of the waste).
- For incineration usually waste is burned (residual municipal solid waste, commercial and industrial).
- This boils water which powers steam generators that generate electric energy and heat to be used in homes, businesses, institutions and industries.

Waste to Energy

Incineration/Combustion

- Modern incinerators encompass primary and secondary burn chambers, and controlled burners designed to burn completely with the lowest possible emissions.
- Thereby, eliminating/reducing the need for lime scrubbers and electro-static precipitators on smokestacks.
- By passing the smoke through basic lime scrubbers, acids in the smoke are neutralized. This prevents the acid from reaching the atmosphere and hurting the environment.
- Other devices (fabric filters, reactors, and catalysts) destroy or capture other pollutants.

Waste to Energy

Incineration/Combustion

While there are downsides to incineration plants there are also arguments for incineration:

- Incineration plants can generate electricity and heat that can substitute power plants powered by other fuels.
- Reduces waste that would end up in landfills.
- Finding space for landfills is becoming increasingly difficult.
- New plants adhere to strict emission standards.
- Incineration of municipal solid waste reduces methane.
- The volume of combusted waste is reduced by approximately 90% to 95%.

Waste to Energy

Incineration/Combustion

Different furnaces for combustion are:

- **Rotary kiln** - pyroprocessing device used to raise materials to a high temperature (calcination) in a continuous process.
- **Fluidized bed combustion chambers** - fuel particles are suspended in a hot fluidity bed of ash and other particulate materials, such as sand, limestone etc., through which jets of air are blown to provide the oxygen required for combustion or gasification.
- **Special combustion chambers** – special combustion chambers that are part of e.g. an internal combustion engine in which fuel/air mix is burned.

Co-funded by the Erasmus+ Programme of the European Union

Waste to Energy

Thermal Technologies

- **Gasification**: produces combustible gas, synthetic fuels or hydrogen
- **Plasma arc gasification:** produces syngas (incl. hydrogen and carbon monoxide). Can be utilized for generating electricity or fuel cells.
- **Thermal depolymerization**: produces synthetic crude oil (can be further refined)
- **Pyrolysis**: produces combustible tar/bio-oil and chars.

Energy from Wastewater

- The energy content in wastewater from households, trade and industry is considerable.
- However, in Member States of the EU including Austria, wastewater is hardly used and not really seen as a viable energy source.
- An example for this is with wastewater treatment plants (WWTP). Their main function is to remove contamination from wastewater. However, research suggests that it can serve as a source of energy internally in the WWTP and also externally in infrastructure.
- Results show that the amount of thermal energy available in WWTP exceeds the internal demands of the WWTP.

Energy from Wastewater

- A general approach that does not require a WWTP but might also be utilized in small or private facilities would be to use heat exchangers in order to extract thermal energy contained in wastewater.
- Subsequently, heat pumps can be used to bring it to the required temperature level, e.g. for heating or cooling purposes.
- All year wastewater temperatures are around or above 10°C.
- Therefore, it is optimally suited for the use of heat pumps as this corresponds roughly to the annual average heat of groundwater (12 °C) which is also utilized with heat pump technology.

Energy from Wastewater

How can heat be utilized/ extracted/ transferred from wastewater?

It can be recovered …

- in buildings from, e.g. raw wastewater
- from sewers, e.g. from raw wastewater
- Or in a sewage treatment plant, e.g. from the treated wastewater

This wastewater heat utilization can have effects on sewer systems and the sewage treatment plants.

Energy from Wastewater

Wastewater heat utilisation

There are several requirements that must be met for installations:

- A corresponding heat potential in the sewer - wastewater temperature
- Relevant customers must be within a reasonable distance (heat transfer loss)
- A minimum flow rate of 15 l/s in dry weather, i.e. no rain
- Negative effects on the sewerage system and sewage treatment plants must be avoided
- Sufficient hydraulic reserves in the sewer itself

Energy from Wastewater

Wastewater heat utilisation

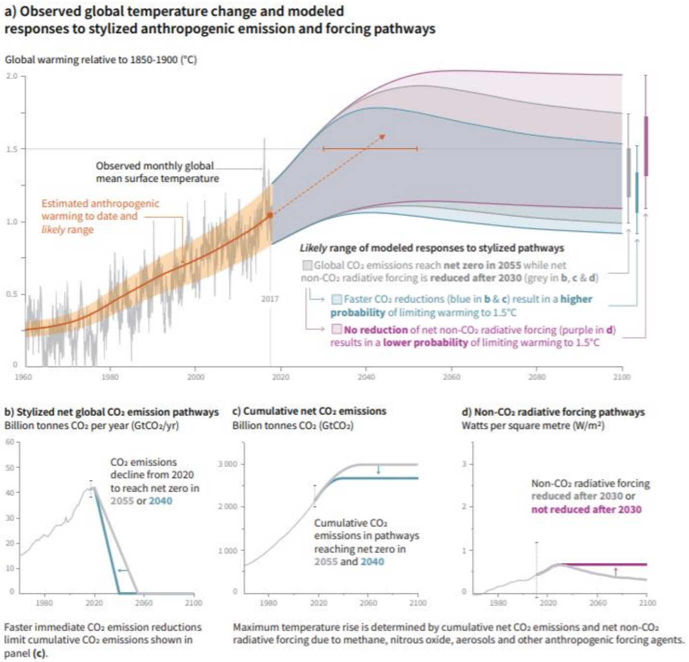
Additionally to requirements, some aspects also must be considered:

- Wastewater temperatures are fluctuating
- Biological processes depend on temperature, therefore change with the temperature.
- In the case of longer-term cooling (i.e. caused by long periods of precipitation, use of wastewater heat, etc.), an overall lower temperature level is achieved.
- It must by energy-economical (close to end customer)
- Urban water management must be involved
- Wastewater heat utilization can lead to an temperature drop. This affects water protection issues.

Energy from Wastewater

- Ecological: wastewater heat utilization seems reasonable.
- Economic: in each case it must be examined if it makes economic sense and is efficient.
- It must be observed that the sewer systems and the sewage treatment plant don’t get damaged or loose their functionality if wastewater heat is utilized.
- Like with most other things (especially related to the environment) all important stakeholders and actors need to be involved and need to cooperate and interact in order for wastewater heta utilization to be successfully implemented.

Paris Climate Treaty and global CO_2-Budget



Source: IPCC https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Summary_Volume_Low_Res.pdf

Importance of the heating market

- The heating market accounted in 2017 for approximately 35% of the primary energy market.
- The total market in 2017 was about 3800 TWh/a.
- In households about 65% are used for space heating. A small percentage went to process heat, while about 20 % were used for hot water.
- In the industry also the mayor percentage went to space heating.
- Throughout the European Union, it is planed to decarbonize the heating market by 2050.

Heat Pump

- Is a device that transfers heat energy from a heat source to a thermal reservoir.
- Heat pumps move thermal energy in the opposite direction of spontaneous heat transfer by absorbing heat from a cold space and releasing it to a warmer one.
- A heat pump uses external power to transfer energy from the heat source to the heat sink.

Heat Pump

- Heat pumps are not a new invention.
- In 1857 the prototype of the new "steam pump" goes into operation in the Ebensee (Upper Austria) salt works. This is the world's first application of the "heat pump" principle.
- Therefore, heat pumps have been around for more than 150 years.
- Because heat pump manufacturers have been able to continuously develop the technology, highly efficient and technically mature heat pump systems are now available which require little electricity to drive and work reliably for decades.

Heat Pump

- Heat pump technology is one of the most environmentally friendly methods of heating and hot water preparation.
- It reduces climate-damaging CO_2 emissions and energy consumption.
- It requires hardly any maintenance and, with correct planning and optimum operation, provides many times the electrical drive power used in terms of thermal energy.

Heat Pump

Heat pumps work like refrigerators, but the principle is used in exactly the opposite way:

- While the refrigerator's refrigerant circuit extracts heat from its interior and releases it to the environment, the refrigerant circuit of a heat pump extracts heat from its surroundings.
- This heat is brought to a higher temperature level inside the appliance and can then be used for heating or for warming domestic water.
- An efficient heat pump can thus generate 100% heat output with 75% free environmental energy.

Heat Pump

- The heat pump's main energy source is ambient heat, i.e. solar energy stored in the air, in the ground or in groundwater.
- To bring this ambient heat from a relatively low temperature level to the temperature level required for heating and hot water, the heat pump uses a **refrigerant**.
- Due to its low boiling point, this already evaporates at relatively cold temperatures of the heat source.

Heat Pump

- Drive energy in the form of electricity or gas compresses the vaporous refrigerant, thereby raising the temperature to the required level.
- The refrigerant is then liquefied again in a condenser, whereby it releases both the drive energy supplied and the absorbed environmental heat to the heating medium at a higher temperature level.
- How efficiently a heat pump works as a heat source is shown by the ratio of the energy used to the energy generated.

Heat Pump

- In order to be able to compare different designs and models, the so-called COP value (coefficient of performance) is determined under standard laboratory conditions.
- This value indicates how high the energy gain is compared to the energy input.
- Modern heat pumps achieve COP values of 4 to 5 under the standardized test conditions.
- Simplified: 4 to 5 times the energy used is recovered as heat.

Heat Pump

- Heat pumps can also be used for cooling.
- As the temperature in the ground in summer is lower than the room temperature, ground or groundwater heat pumps can make direct use of the coolness of the ground.
- This requires only a very small amount of energy, which makes this type of cooling very energy-efficient.
- If the cooling requirement is higher, the heat pump circuit can also be reversed and used for active cooling

Heat Pump

- The most common design of a heat pump involves four main components:
  - a condenser
  - an expansion valve
  - an evaporator
  - a compressor

- The heat transfer medium circulated through these components is called refrigerant.

Heat Pump

Heat pumps have different operating modes:

- Monovalent
- Bivalent
- Monoenergetic

Heat Pump

Monovalent

- The monovalent heat pump covers the heat requirement throughout the year without additional heating.
- Even at low outside temperatures, the heat pump provides sufficient heat at all times.

Heat Pump

Bivalent (1)

- In bivalent operation there are two different heat generators. If the heat pump cannot cover the heat demand at low outside temperatures on its own, it is supported by an additional heat generator.
- In bivalent-parallel operation, the heat pump and the second heat generator operate together from a certain outside temperature (e.g. +3 °C).
- This operating mode is selected if the required flow temperature or the required heating energy is too high. This occurs, for example, in old buildings in conjunction with an air-to-water heat pump, whereby the old heat generator, which is usually available, can still be used.

Heat Pump

Bivalent (2)

- Since the annual coverage is relatively low compared to the other modes of operation, this mode of operation is rarely chosen today.
- In addition to the heat pump, there is a second heat generator which supports the heating of the building when outside temperatures are lower.
- The dimensioning point (bivalence point) depends on the heating system and/or the heat source. The degree of coverage is, for example, 60%.
- The bivalent-alternative operating mode is selected if high flow and return temperatures are required or the heat flow from the heat source is only sufficient to a certain extent.

Heat Pump

Bivalent (3)

- Only one heat generator heats at a time, i.e. either the heat pump or the second heat generator.

- Since the annual coverage is relatively low compared to the other modes of operation, this mode of operation is rarely chosen today.

Heat Pump

Monoenergetic

- The monoenergetic mode of operation corresponds to the bivalent mode of operation in terms of behaviour.
- If necessary - i.e. on very cold days - an electric heating element supplements the heat pump.
- Since the heat pump and the heating rod use the same form of energy (electric current), this is referred to as monoenergetic.
- An electrical control system prevents the auxiliary heating from operating for longer than necessary. It can be assumed that no more than 5% of the annual heating energy required is generated by the heating rod.

Heat Pump

- Heat pumps can be classified according to the used heat source.
- The heat pump uses stored solar energy, which is available on site at any time - day or night, summer or winter.
- This solar energy can be drawn from three different sources: from the ground (geothermal energy), the groundwater or the air.
- Analogous to the three heat sources, a distinction is therefore made between brine/water, water/water and air/water heat pumps.

Heat Pump

Geothermal energy (1)

- Geothermal energy can be used either with vertical geothermal probes or horizontal geothermal collectors for a heat pump and thus for heating and hot water purposes.
- Both techniques make use of near-surface geothermal energy.
- A frost-proof working medium (brine, or in the case of the so-called "direct evaporators" the refrigerant of the heat pump directly), extracts energy from the ground, which is then brought to a higher temperature level by the heat pump.

Heat Pump

Geothermal energy (2)

- Geothermal probes are U-shaped plastic pipes that are vertically embedded in the ground via a bore hole.
- The advantages of this system are the small area required and their high efficiency, as from a depth of about 10 metres the temperature is almost constant throughout the year.
- The depth of the probe depends on the heat requirement and the thermal conductivity of the soil.
- For a new single-family home, it averages around 140 meters.

Heat Pump

Geothermal energy (3)

- Geothermal heat collectors work with a horizontal (or inclined/vertical) surface collector, a pipe system laid below the frost line (in practice this means at a depth of approximately 1 to 1.5 meters).
- The surface required for this must not be sealed or built over, as the ground must absorb the heat from rainwater and solar radiation.
- Nor should there be any deep-rooted plants.
- Because of the lower effort required, heat source development saves about half the cost compared to a geothermal probe.

Heat Pump

Geothermal energy (4)

- Regardless of with which system uses geothermal energy, in summer such a system is also very well suited for effective passive cooling, which additionally leads to a "regeneration" of the probe and in winter results in an even more efficient system due to the increased source temperature.

Heat Pump

Ground water (1)

- Groundwater is an optimal heat supplier and is often used as a heat source for heat pumps, provided that the conditions for using the water are met.
- Water is pumped up via a well, from which heat is extracted by the heat pump.
- The water is fed back into the groundwater via an absorption well.
- In summer, this technology can also be used for passive cooling in a very energy-saving way.

Heat Pump

Ground water (2)

- Heat pumps that extract heat from the groundwater achieve the best performance and performance figures, but are usually subject to approval.

- The contact points for water legislation and the licensing procedures under water law are usually the respective provincial governments.

- The water law itself is usually a federal matter.

Heat Pump

Outside air and exhaust air (1)

- Air exists in unlimited quantities and everywhere.
- Air as a heat source is very popular in new buildings as well as in renovation projects because the installation and investment costs of air heat pumps are low.
- Outside air as a heat source can be tapped extremely easily and almost anywhere - no drilling or permits are required.
- The air-to-water heat pump is particularly effective at high outside temperatures.

Co-funded by the Erasmus+ Programme of the European Union

Heat Pump

Outside air and exhaust air (2)

- This is ideal for domestic hot water preparation in summer or for the heat source exhaust air, which provides constantly high temperatures.

- Since the temperatures of the outside air are relatively low in winter - i.e. at times of greatest heating demand - an air source heat pump works slightly less efficiently than ground coupled systems and requires a little more drive energy.

- However, the lower construction costs save investment costs. Exhaust air is often used in pure domestic hot water heat pumps or for ventilation of living spaces. These variants are ideal additions to existing heating systems.

Heat Pump

Annual performance factor of a heat pump (1)

- The efficiency of a heat pump is expressed by the so-called "performance factor".
- This is the ratio between the heat output generated and the electrical drive energy.
- If this figure refers to a whole year, it is referred to as an “annual performance factor”.

Co-funded by the Erasmus+ Programme of the European Union

Heat Pump

Annual performance factor of a heat pump (2)

- Depending on the heat source used and the application in new buildings or renovation, annual performance factors (APF) are between 3 and 4 or higher.
- An APF of 4 means that with 1 kWh of electrical energy to drive the heat pump, 4 kWh of usable heat is available.
- The environment thus provides 3 kWh of free heat.
- The higher the performance factor, the more efficient the system!

Heat Pump

Annual performance factor of a heat pump (3)

- There are various factors influencing the APF.
- The most important one is the temperature difference between the source (soil/ground water/air) and the heating system.
- The smaller the temperature difference, which the heat pump has to "compensate" for, the higher the annual performance factor.

Heat Pump

Annual performance factor of a heat pump (4)

- On the one hand, this can be achieved by keeping the source temperature as high as possible, for example by deeper drilling, less cooling of the ground or use of the groundwater.
- On the other hand, in heating systems, the temperature should be as low as possible - temperatures of up to 35 °C are typical for surface heating systems (floor or wall heating).
- Flow temperatures of 55 - 65 °C are also no problem, but at the expense of efficiency.

Heat Pump

Annual performance factor of a heat pump (5)

- Important for the efficiency of the overall system is the interaction of all components (development of the subsoil, optimal building services, low temperature difference).

- High efficiency can therefore only be achieved through careful planning and installation, as well as through heat pump-compatible operation without lowering.

Heat Pump

Coefficient of performance (COP) (1)

- In contrast to the annual performance factor, the coefficient of performance (COP) indicates how well the heat pump works at the optimum operating point, i.e. it is not measured over the whole year.

- The COP can only be measured under constant operating conditions - in the so-called "steady-state" - which is only possible in the laboratory.

- The COP is therefore a quality feature for a heat pump make or type, but has only limited information about the expected energy demand.

Heat Pump

Coefficient of performance (COP) (2)

- A coefficient of performance of 5, for example, does not mean that you only have to supply one-fifth of the heating requirement in the form of electrical energy.
- The achievable annual performance factor will therefore always be lower than the coefficient of performance.
- There is also the so-called SCOP (Seasonal Coefficient of Performance) for heat pumps.

Heat Pump

Coefficient of performance (COP) (2)

- The SCOP value can be seen as the Seasonal Coefficient of Performance (SCOP) in heating operation, but it represents the performance of a heat pump much more realistically and strikingly, since the performance measurement takes place at 4 different temperatures, weighted differently depending on the climate.

- This enables devices with modulating (adapting to demand) output to show their strength. Furthermore, standby losses and other energy, e.g. for a possibly existing heating element, are also taken into account.

Heat Pump

Advantages of a heat pump:

- Low operating costs and future-proof supply security.
- Environmental friendliness, especially in comparison to conventional heat generators such as oil and gas.
- A high level of comfort, as they not only provide heating, but can also be used for cooling, domestic hot water preparation and in conjunction with controlled domestic ventilation.
- They are extremely low-maintenance.

Co-funded by the Erasmus+ Programme of the European Union

Heat Pump

Advantages of a heat pump:

- Heat pumps are already prepared today for the legal and technical requirements of tomorrow and no longer need to worry about finite energy sources.

- Because the heat pump works independently of oil and gas, the question of the availability of these fuels no longer arises for heat pumps.

- Heat pumps therefore offer long-term security of supply.

Heat Pump

Advantages of a heat pump:

- Heat pumps are usually used for heating and hot water preparation.
- It is also possible to use a heat pump exclusively for domestic hot water preparation, with a positive side effect:
  - a domestic hot water heat pump cools and dehumidifies the room in which it is installed.
- This is particularly beneficial in pantries, wine cellars or laundry rooms.

Co-funded by the Erasmus+ Programme of the European Union

Heat Pump

Advantages of a heat pump:

- Hot water heat pumps are particularly suitable for combination with fossil heating systems.

- Heat pumps can be used for both active and passive cooling, although energy-saving passive cooling (also known as "silent" or "green" cooling) is only possible with ground-coupled systems.

Heat Pump

Advantages of a heat pump:

- To cool a building using the heat pump, no additional equipment is necessary.
- But the system must have a cooling function - so this should be taken into account at the planning stage.
- The extremely energy-saving passive cooling is a recommended option.
- As a rule, a room can be cooled down by around 5 °C.

Heat Pump

Advantages of a heat pump:

- A higher cooling capacity can only be achieved by active cooling.
- The heat pump principle is reversed, whereby the drive energy is used for cooling.
- A combination of active and passive cooling is also possible (e.g.):
  - if there is a lower cooling requirement, "silent energy-optimised" cooling can be used first and then, if the heat is very hot, there is the option of switching to active cooling.
  - Even with active cooling, no additional devices are required.
- If cooling is planned from the start, the additional costs are comparatively low.

Co-funded by the Erasmus+ Programme of the European Union

Heat Pump

Advantages of a heat pump:

- In well-insulated houses, heat pumps can also be combined with controlled ventilation.

- Heat pumps use the waste heat from the exhaust air to generate heating and hot water with the help of additional drive energy.

Heat Pump

Advantages of a heat pump:

- The heat pump is also very well suited for combination with solar thermal or photovoltaic systems.
- Solar thermal energy can be used to support the heat pump in heating and hot water preparation.
- If the homeowner uses the electricity generated by a photovoltaic system himself, he receives an additional financial benefit - this is particularly interesting for heat pump owners.
- If the house owner generates the same amount of electricity via his photovoltaic system as he needs to drive his heat pump system, he heats practically CO_2-free.

Co-funded by the Erasmus+ Programme of the European Union

Heat Pump

Advantages of a heat pump (summarized):

- Low operating costs
- Environmental friendliness
- High level of comfort
- No space required for boiler room or fuel storage
- Versatile: can heat, cool and prepare hot water
- Extremely low maintenance
- Flexible field of application (new construction / renovation)
- Long-term security of supply
- Domestic energy source
- No additional costs for fireplace
- Valuable contribution to the achievement of climate protection goals
- No fuel storage costs

Energy from Wastewater

- Wastewater is usually produced in large quantities close to where energy is also required, i.e. where there are sufficient heat and cold consumers, such as in
  - Small and medium houses/flats
  - Small and medium sized enterprises
  - Public and governmental buildings

- In several research projects the technical and economic prerequisites for the use of wastewater energy and the possibilities for its integration into municipal energy systems were investigated.

- Some Use Cases and Examples are given in the following slides.

Application Example/ Use Case (1)

Thermal use of wastewater energy:

- The objective of the project "Energy from Wastewater" was to analyze technical possibilities of energy recovery from wastewater by the means of heat pumps as well as potentials and legal framework conditions and thus to create the basis for a dissemination of this form of energy recovery in Austria.
- The investigations showed that the thermal utilization possibilities of WWTP effluent are significant for e.g.
  - Sludge drying
  - Heating of wastewater treatment plant operation buildings
  - Other buildings around the WWTP and in the vicinity of collection sewers
- Link: https://www.energy-innovation-austria.at/article/energie-aus-abwasser/

Co-funded by the Erasmus+ Programme of the European Union

Application Example/ Use Case (1)

Thermal use of wastewater energy:

- Examples from around the globe demonstrated that when wastewater heat is used after the treatment plant, buildings located several kilometers away can be supplied with heat in an economic fashion.

- Thus, the utilization of thermal energy of wastewater may theoretically be used as a local heat supplier.

- However, whether or not thermal wastewater utilisation at a particular site is technically and economically feasible must be investigated in detail in each case.

Application Example/ Use Case (1)

Thermal use of wastewater energy:

- Within the scope of the research work, concepts and planning tools for municipal energy space planning were developed, e.g.
  - to determine whether surrounding buildings can be accessed by pipelines, or
  - to estimate how the heating and cooling demand of new development areas will develop.

- It was also analysed whether and how the heating & cooling demand around sewage treatment plants with new settlements that have a constant low temperature demand all year round (e.g. greenhouses, sports halls or indoor swimming pools) can be increased.

Application Example/ Use Case (1)

Technology for wastewater utilization:

- The heating and cooling of wastewater can take place before or after the treatment plant or even in the building itself.
- The energy is extracted either from the sewer (untreated wastewater) or in the effluent of the treatment plant (treated wastewater).
- For large objects there is the possibility of direct use of the own wastewater via a collection shaft.
- The most important components of a wastewater energy system are the heat pump and the wastewater heat exchanger.

Application Example/ Use Case (1)

Technology for wastewater utilization:

- Energy and economy efficiency depend on the optimal coordination of these elements.
- A suitable wastewater heat exchanger, a heat pump with an optimized cooling circuit for the highest possible coefficients of performance and a heating and cooling system optimized for heat pump operation must be selected for the respective application.
- It is also important to optimize the temperature level already at the plant planning stage, as this also has a great influence on the efficiency of the entire plant.

Co-funded by the Erasmus+ Programme of the European Union

Application Example/ Use Case (1)

Technology for wastewater utilization:

"Sewage systems represent an ideal heat source for use with heat pumps. Energy from municipal wastewater could provide a total of 5% of the total heat demand of cities. The technology is proven and should be given a corresponding status in holistic energy planning." - Dipl.-Ing. ETH Karl Ochsner, CEO Ochsner Energie Technik GmbH

More information on the project can be found at:

- https://www.energy-innovation-austria.at/article/energie-aus-abwasser/
- http://www.abwasserenergie.at/

Application Example/ Use Case (2)

Energy from wastewater:

- Most of the thermal energy from hot water production in households and businesses currently goes unused into the sewer.
- The aim of this project is to investigate the possibility of heat recovery from wastewater using heat pumps in more detail and to establish it in Austria.
- In Switzerland and in Germany there are already many realized projects.
- According to studies, about 5% of buildings could be supplied with heat coming from wastewater utilization.
- Link: https://www.energyagency.at/projekte-forschung/energiewirtschaft-infrastruktur/detail/artikel/energie-aus-abwasser.html

Application Example/ Use Case (2)

Energy from wastewater:

- The heat pump itself is already widely used in Austria.
- A common problem with the heat sources used so far (especially air) is the low temperature during the main heating period.
- Wastewater has a temperature between 10 and 15°C all year round. This means that wastewater is an optimal heat source for a heat pump:
  - higher annual performance factors can be achieved, or higher flow temperatures can be realized with the same efficiency.
- The use of wastewater heat closes the only heat leakage that is normally ignored even in low-energy and passive house construction.

Application Example/ Use Case (2)

Prerequisites for wastewater heat utilization:

- In order for wastewater heat utilization to be applicable, the channels and the consumers must fulfil certain conditions.
- This type of heating is particularly suitable for areas with a high population density because the transport distances are shorter to achieve a certain reduction in output (lower investment costs, less heat loss).
- Further conditions for the realization of a waste water heat recovery plant are the proximity to a sufficiently large sewer pipe (800 mm diameter), a dry weather flow of at least 15 l/s (the more, the more continuous the waste water flow) and the use of low-temperature heating systems in the objects to be heated.

Application Example/ Use Case (2)

Prerequisites for wastewater heat utilization:

- This type of heating is economically sensible, especially for larger objects, or a block heating for several individual objects is also conceivable.
- Particularly favourable economic conditions always arise where investments in sewerage systems, building heating, etc. are necessary anyway or in new buildings.
- As is very often the case when using renewable energy sources, one has to deal with comparatively high initial costs and low operating costs.
- The heat pump output should not fall below 100 kW, as high investment costs are incurred, some of which do not depend on the size of the system, or hardly at all.

Application Example/ Use Case (2)

Further possibilities of wastewater energy utilization:

- Cooling by means of wastewater is also a possibility that is being investigated in the project. A particularly energy-saving variant of cooling is so-called free cooling:
  - If the wastewater temperature is sufficiently below the desired cooling temperature, it is sufficient to let the heat medium circulate without a heat pump and heat energy is transported out of the building due to the natural heat gradient.
- For some purposes feeding into a district heating network is also possible.

Co-funded by the Erasmus+ Programme of the European Union

Application Example/ Use Case (3)

Heating Technology - This company generates energy from wastewater:

- The Baden-Württemberg company “Uhrig” has dedicated itself entirely to sewerage systems.
- With a new technology, Uhrig now generates energy from wastewater.
- To be precise: thermal energy.
- Link: https://hlk.co.at/a/dieses-unternehmen-gewinnt-energie-aus-abwasser

Application Example/ Use Case (3)

Thermal energy from wastewater:

- At Uhrig wastewater is used as a thermal energy source for heat pumps.
- *"We look at properties to see if there is a sewer nearby that is suitable for heat recovery from wastewater. The crucial question is whether the canal is large enough and flows through the required minimum volume of wastewater."* – Stephan von Bothmer
- The wastewater has a temperature of seven to twelve degrees. Uhrig has developed a wastewater heat exchanger that can be individually adapted to the size of the sewer.

Application Example/ Use Case (3)

Thermal energy from wastewater:

- *"Roughly speaking, the Therm-Liner consists of two stainless steel elements that are fixed to the bottom of the channel. The heat energy from the wastewater is then transferred via the heat exchanger to a transport medium, in our case water. This heated water is then directed to the heat pump in the house,"* says von Bothmer.

- Due to the preheated water, the heat pump requires considerably less energy for heat generation. Thus, not only is an otherwise wasted thermal source used, but the customer also saves electricity and energy costs.

Application Example/ Use Case (3)

Thermal energy from wastewater:

- *With air heat pumps, considerably more energy is required to bring the cold outside air up to temperature. In principle, geothermal energy provides good heat energy, but the associated drilling is very complex and also expensive,"* explains the expert.

- Moreover, the wastewater potential is large, as a study by enervis energy advisors shows. Around 14 percent of the heating requirements of German buildings could be covered by energy from wastewater. This corresponds to about 100 terawatt hours per year.

Application Example/ Use Case (3)

Bureaucracy stands in the way:

- However, the installation of the Uhrig heat exchanger is not entirely uncomplicated - at least not when it comes to permits.
- *"Much will depend on the willingness of the sewer system operators We try to make it clear to them that they should make the heat available and thus generate added value from it. But ultimately the decision is up to them,"* says Stephan von Bothmer.
- However, Uhrig has already received the necessary permits in most major German cities and some smaller towns.

Application Example/ Use Case (3)

Bureaucracy stands in the way:

- However, the installation of the Uhrig heat exchanger is not entirely uncomplicated - at least not when it comes to permits.
- *"Much will depend on the willingness of the sewer system operators We try to make it clear to them that they should make the heat available and thus generate added value from it. But ultimately the decision is up to them,"* says Stephan von Bothmer.
- However, Uhrig has already received the necessary permits in most major German cities and some smaller towns.

Application Example/ Use Case (3)

Bureaucracy stands in the way:

- The company was also already active in Austria.
- *"We have installed a heat exchanger near the administrative buildings of the sewer network operators in Innsbruck and Vienna. This allows the companies to see the system for themselves,"* says von Bothmer.
- For the sewer network operators, heat recovery brings a decisive advantage: money
- Since the network operators must disclose in advance which sewers are suitable for heat recovery, they receive a small fee for each heat exchanger installed in return.

Application Example/ Use Case (3)

Bureaucracy stands in the way:

- *"With one or two devices, it doesn't make much difference yet, but with more than 100 devices, the cooperation will pay off very quickly for the network operators,"* says Stephan von Bothmer. The Therm-Liner does not impair the flow of water.
- There is no reduction in cross-section and the stainless steel can remain in the sewer for around 50 years without hesitation. Even cleaning work is not disturbed by the stainless-steel elements.
- Since the heat exchanger is a physical and not an electronic principle, the heat exchanger requires very little effort.

Application Example/ Use Case (3)

For public and private buildings:

- The Therm-Liner can not only be used for administrative buildings or other public real estate, but is also applied in the private sector.
- *"If, for example, several single-family homes are grouped together in a neighbourhood, they too can use the heat from the wastewater. From 20 kilowatts upwards, there are no limits,"* explains von Bothmer.
- It is important to note that the system does not use the wastewater from a single house, but is installed in the next larger sewer.

Application Example/ Use Case (3)

For public and private buildings:

- This is where dirty water and rainwater from several sources converge, making it worthwhile to operate the heat exchanger even if individual households are empty for some time.

- *"If a suitable sewer is no more than 900 meters away, the Therm-Liner can be installed without any problems,"* adds Stephan von Bothmer.

Application Example/ Use Case (4)

Powerstep: Full-scale demonstration of energy positive sewage treatment plant concepts towards market penetration:

- POWERSTEP aims for a full-scale demonstration of energy positive sewage treatment plant concepts towards market penetration.

- We look at converting sewage treatment plants (STEPs) into power production facilities (POWER).

- **Link:** http://www.powerstep.eu/at-a-glance-0

Application Example/ Use Case (4)

Powerstep:

- Municipal wastewater in Europe contains a potential chemical energy of 87,500 GWh per year in its organic fraction, which is equivalent to 12 large power stations!
- Due to the currently applied technologies and related energy loss at each process step, wastewater treatment in Europe consumes instead the equivalent of more than 2 power stations.
- While many operators are targeting incremental energy efficiency towards energy neutrality, recent studies have shown that with novel process schemes sewage treatment plants could actually become a new source of renewable energy, this without compromising the treatment performance.

Application Example/ Use Case (4)

Powerstep:

- Shifting wastewater treatment plants (WWTPs) technology means increasing regions' and cities' energy production capacity.
- Today, about 1% of the EU electricity demand is consumed by WWTPs.
- This accounts typically for the largest part of the municipality energy bill while municipal wastewater contains a potential chemical energy of 87,500 GWh/year in its organic fraction (equivalent to the output of 12 large power stations).

Application Example/ Use Case (4)

Powerstep:

- In the European context of Energy efficiency for better competitiveness and enviromental protection, **POWERSTEP aims for a real paradigm shift in the wastewater treatment industry**.

- Thanks to 6 full-scale case studies located in 4 European countries our consortium will merge treatment scheme modelling and design, global energy and heat management, carbon foot-printing, integrated design options, POWERSTEP aims to demonstrate through a first full scale reference each essential process step to design an energy positive wastewater treatment plan - with the currently available technologies
- Case studies: http://www.powerstep.eu/

Co-funded by the Erasmus+ Programme of the European Union

Application Example/ Use Case

Further Information to the application examples can be found at:

- https://www.klimaundenergiemodellregionen.at/service/newsletter/newsletter-032015/energie-aus-abwasser/
- http://www.abwasserenergie.at/fileadmin/energie_aus_abwasser/downloads/Broschuere-Energie-aus-Abwasser.pdf
- www.abwasserenergie.at
- http://www.powerstep.eu/
- https://ec.europa.eu/environment/integration/research/newsalert/pdf/new_energy_positive_waste_water_treatment_process_uses_just_15pc_energy_required_for_current_alternative_511na3_en.pdf

Co-funded by the Erasmus+ Programme of the European Union

Application Example/ Use Case

Further papers, brochures and information on this topic:

Sustainable biogas production in municipal wastewater treatment plants:

- https://nachhaltigwirtschaften.at/resources/iea_pdf/reports/iea_bioenergy_task37_wastewater_biogas_grey.pdf

Renewable energy from wastewater - Practical aspects of integrating a wastewater treatment plant into local energy supply concepts:

- https://www.researchgate.net/publication/307939326_Renewable_energy_from_wastewater_-_Practical_aspects_of_integrating_a_wastewater_treatment_plant_into_local_energy_supply_concepts

Reclaiming green energy from wastewater treatment plants

- https://www.globalwaterintel.com/sponsored-content/reclaiming-green-energy-from-wastewater-treatment-plants-evoqua

Stanford researchers develop technology to harness energy from mixing of freshwater and seawater

- https://news.stanford.edu/2019/07/29/generating-energy-wastewater/

Summary Application Example/ Use Cases

Looking at the use cases, several factors can be observed:

- Utilizing heat/energy from wastewater is already applied.
- It can be applied to various areas.
- It has economic and environmental advantages.
- It has potential that can and should be utilized in various scales.

Summary

- **Energy Management**
- **Waste Utilization**
- **Wastewater Utilization**
- **Heat Pumps**
- **Application Examples/ Use Cases**

Sources:

- Austrian Ministry of Life. Waste–to–Energy in Austria, White Book, 2nd Edition 2010. (PDF)
- Bachmann, Nathalie. Sustainable biogas production in municipal wastewater treatment plants. Accessed 15.04.2020 at https://nachhaltigwirtschaften.at/resources/iea_pdf/reports/iea_bioenergy_task37_wastewater_biogas_grey.pdf
- Chartered institution of Wastes Management. Incineration. Accessed 15.04.2020 at https://www.ciwm.co.uk/ciwm/knowledge/incineration.aspx
- Energynet.de. intelligentes Energiemanagement in Wohngebäuden verbindet Strom- und Wärmeerzeugung mit dem Verbrauch. Accessed 15.04.2020 at https://www.energynet.de/2013/03/10/intelligentes-energiemanagement-in-wohngebaeuden-verbindet-strom-und-waermeerzeugung-mit-dem-verbrauch/
- Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch e.V. Berliner Energietage 2018. Accessed 15.04.2020 at https://www.asue.de/sites/default/files/asue/termine_veranstaltungen/2018/energietage/ASUE-Tagungsband_Berliner-Energietage-2018_Innovative-Waermenetze.pdf
- Austrian Energy Agency. Energie aus Abwasser. Accessed 15.04.2020 at https://www.energyagency.at/projekte-forschung/energiewirtschaft-infrastruktur/detail/artikel/energie-aus-abwasser.html
- Bundschuh, Jochen; Chen, Guangnan (2014-03-07). Sustainable Energy Solutions in Agriculture. CRC Press. ISBN 9781315778716.
- Energy innovation Austria. Energie aus Abwasser. Accessed 15.04.2020 at https://www.energy-innovation-austria.at/article/energie-aus-abwasser/
- Euractiv. Waste incineration is waste incineration, no matter the classification. Accessed 15.04.2020 at https://www.euractiv.com/section/circular-economy/opinion/waste-incineration-is-waste-incineration-no-matter-the-classification/
- Euro-Lex. DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 December 2000 on the incineration of waste. Accessed 15.04.2020 at https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:332:0091:0111:EN:PDF
- European Environment Agency. Liquid Waste. Accessed 15.04.2020 at https://www.eea.europa.eu/help/glossary/gemet-environmental-thesaurus/liquid-waste
- European Commission. Environment. Accessed 15.04.2020 at https://ec.europa.eu/environment/water/water-urbanwaste/info/glossary_en.htm
- European Commission. Integrated Polluiton Prevention and Conrtol - Waste Incineration. Accessed 15.04.2020 at https://eippcb.jrc.ec.europa.eu/sites/default/files/2020-03/superseded_wi_bref_0806_0.pdf
- European Commission. Watering down the energy consumption of wastewater treatment plants. Accessed 15.04.2020 at https://ec.europa.eu/easme/en/news/watering-down-energy-consumption-wastewater-treatment-plants
- European Commission. Science for Environmental Policy. Accessed 15.04.2020 at https://ec.europa.eu/environment/integration/research/newsalert/pdf/new_energy_positive_waste_water_treatment_process_uses_just_15pc_energy_required_for_current_alternative_511na3_en.pdf
- Evohaus irq. Intelligentes Energiemanagement. Accessed 15.04.2020 at http://evohaus-irq.com/konzept/intelligentes-energiemanagement/
- F Kretschman et al. Resource Recovery from Wastewater in Austria – Wastewater Treatment Plants as Regional Energy Cells. Accessed 15.04.2020 at http://www.abwasserenergie.at/fileadmin/energie_aus_abwasser/user_upload/Anhang_Publikation_Weltwasserkongress.pdf

Sources:

- Forum Abwasser Energie. Accessed 15.04.2020 at http://www.abwasserenergie.at/
- Global Water intelligence. Reclaiming green energy from wastewater treatment plants. Accessed 15.04.2020 at https://www.globalwaterintel.com/sponsored-content/reclaiming-green-energy-from-wastewater-treatment-plants-evoqua
- HLK. Dieses Unternehmen gewinnt Energie aus Abwasser. Accessed 15.04.2020 at https://hlk.co.at/a/dieses-unternehmen-gewinnt-energie-aus-abwasser
- Heat Pumping Technologies. Heat Pump Work. Accessed 15.04.2020 at https://heatpumpingtechnologies.org/market-technology/heat-pump-work/
- IPCC. Inineration and open burning of Waste. Accessed 15.04.2020 at https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_5_Ch5_IOB.pdf
- IPCC. Global warming of 1.5 °C – Special report. Accessed 15.04.2020 at https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Summary_Volume_Low_Res.pdf
- Kretschmer, F.(2010): Spezielle Wärmequelle Abwasser – Ein bislang ungenutztes Potenzial?, EUREM-Vertiefungsmodul - Großwärmepumpen in Industrie und Gewerbe, 17.11.2010, Wien
- Kollman, Rene (2016): Renewable energy from wastewater - Practical aspects of integrating a wastewater treatment plant into local energy supply concepts. Accessed 15.04.2020 at https://www.researchgate.net/publication/307939326_Renewable_energy_from_wastewater_-_Practical_aspects_of_integrating_a_wastewater_treatment_plant_into_local_energy_supply_concepts
- Klima- und Energie-Modellregion. Energie aus Abwasser. Accessed 15.04.2020 at https://www.klimaundenergiemodellregionen.at/service/newsletter/newsletter-032015/energie-aus-abwasser/
- Plante Energies. Incineration - The Heating Power of Refuse. Accessed 15.04.2020 at https://www.planete-energies.com/en/medias/close/incineration-heating-power-refuse
- Powerstep. Project. Accessed 15.04.2020 at http://www.powerstep.eu/
- Stanford News. Generating Energy Wastewater. Accessed 15.04.2020 at https://news.stanford.edu/2019/07/29/generating-energy-wastewater/
- The Conversation. Climate explained: seven reasons to be wary of waste-to-energy proposals. Accessed 15.04.2020 at https://theconversation.com/climate-explained-seven-reasons-to-be-wary-of-waste-to-energy-proposals-128630
- The Environmental Literacy Council. What is Waste? Accessed 15.04.2020 at https://enviroliteracy.org/environment-society/waste-management/what-is-waste/
- Wikipedia. Waste Management. Accessed 15.04.2020 at https://en.wikipedia.org/wiki/Waste_management
- Waermepumpe Austria. Funktion. Accessed 15.04.2020 at https://www.waermepumpe-austria.at/funktion
- Waermepumpe Austria. Betriebsarten. Accessed 15.04.2020 at https://www.waermepumpe-austria.at/betriebsarten
- Waermepumpe Austria. Wäremequellen. Accessed 15.04.2020 at https://www.waermepumpe-austria.at/waermequellen
- Waermepumpe Austria. Effizienz/Optimierung. Accessed 15.04.2020 at https://www.waermepumpe-austria.at/effizienz-optimierung
- Waermepumpe Austria. Vorteile. Accessed 15.04.2020 at https://www.waermepumpe-austria.at/vorteile-einer-waermepumpe
- Waste Disposal Inc. Liquid Waste. Accessed 15.04.2020 at https://www.ewastedisposal.net/liquid-waste/
- Wegatech. Die optimale Vorlauftemperatur zum Betrieb einer Wärmepumpe. Accessed 15.04.2020 at https://www.wegatech.de/ratgeber/waermepumpe/planung-und-installation/vorlauftemperatur/
- Wikipedia. Abwasser. Accessed 15.04.2020 at https://de.wikipedia.org/wiki/Abwasser
- Wikipedia. Energiemanagement. Accessed 15.04.2020 at https://de.wikipedia.org/wiki/Energiemanagement
- Wikipedia. Heat Pump. Accessed 15.04.2020 at https://en.wikipedia.org/wiki/Heat_pump
- Wikipedia. Incineration. Accessed 15.04.2020 at https://en.wikipedia.org/wiki/Incineration
- Wikipedia. Waste to Energy. Accessed 15.04.2020 at https://en.wikipedia.org/wiki/Waste-to-energy
- Wikipedia. Rotary Kiln. Accessed 15.04.2020 at https://en.wikipedia.org/wiki/Rotary_kiln
- Wikipedia. Fluidized Bed Combustion. Accessed at 15.04.2020 at https://en.wikipedia.org/wiki/Fluidized_bed_combustion
- United Nations Statistics Division. Accessed 15.04.2020 at unstats.un.org

Module IV - Practical Application and Utilization

Content

- Recap
  - Module I - Introduction to the Topic of Energy Generation
  - Module II - Basics about Wastewater and Waste
  - Module III - Energy Generation from Wastewater and Waste
- Instruction for the Seminar Paper

Module IV - Practical Application and Utilization

Recap: Modul I - Introduction to the Topic of Energy Generation

- **Energy**
- **Energy Types/ Sources**
- **Energy Management**
- **European and national energy plans**
- **Environment and Systems**

Recap – Module I

- **Energy is the quantitative property that must be transferred to an object in order to perform work on, or to heat the object.**
- Energy exists in different forms of energy that can be converted into each other.
- **Examples of forms of energy:**
  - Potential
  - Kinetic
  - Electrical
  - Chemical
  - Thermal
- **Examples of conversions of energy:**
  - A person lifting a box
  - A person accelerating a bicycle
  - Charging a battery
  - The metabolism
  - A heater giving off heat
  - etc.

Co-funded by the Erasmus+ Programme of the European Union

Recap – Module I

- **Energy Types**:
  - **Potential**
  - **Kinetic**
  - **Electrical**
  - **Chemical**
  - **Thermal**

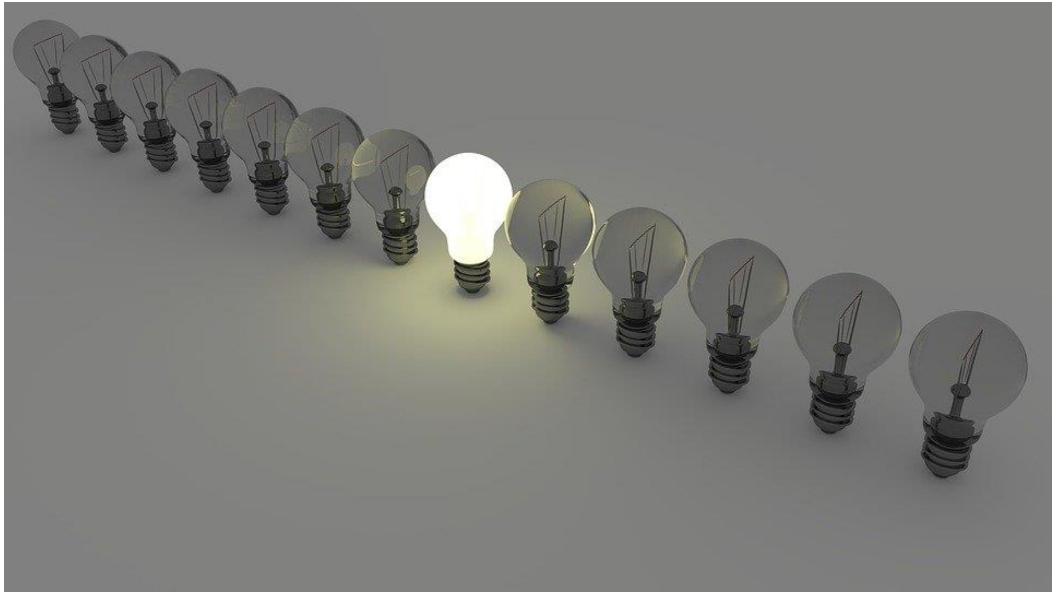


Photo by ColN00B on Pixabay

Co-funded by the Erasmus+ Programme of the European Union

Recap – Module I

- **Energy sources**:
  - **Solar**
  - **Wind**
  - **Hydrogen**
  - **Geothermal**
  - **Tidal**
  - **Wave**
  - **Hydroelectric**
  - **Biomass**
  - **Nuclear**
  - **Fossil**

Photo by ybernardi at Pixabay

Recap – Module I

- Energy management is about **planning and operation of energy-related generation and consumption** units.

- Energy management can (and should) **be applied on many different levels** from state level to regional level as well as in individual companies

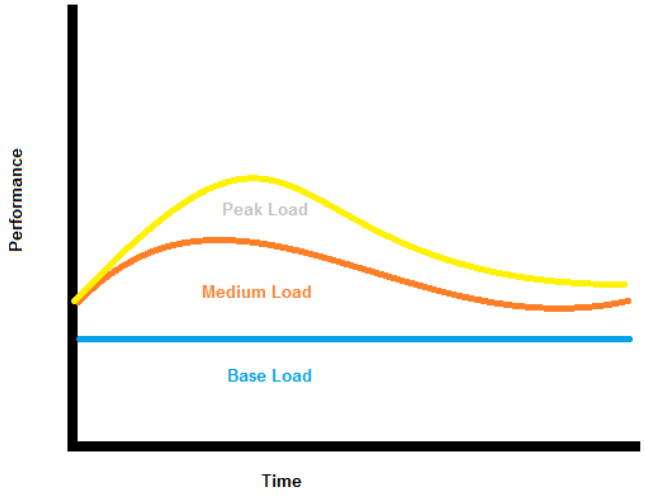
Recap – Module I

- Application areas of Energy Management in cooperate functions are:
  - Facility Management
  - Energy Procurement
  - Production
  - Maintenance
  - Information Technology
  - Logistics
  - Production planning and control

Photo by Metthew Henry at Unsplash

Recap – Module I

Base, medium and peak load:



Recap – Module I

- **EU law:**

The EU is legally above the nation states. They are above regional legislation, which is above local legislation.

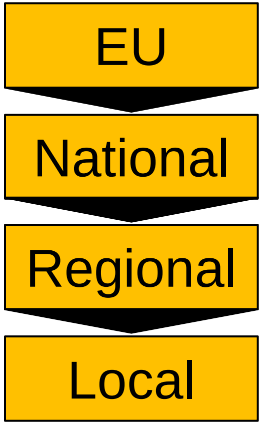


Photo by Capri23auto at Pixabay

Co-funded by the Erasmus+ Programme of the European Union

Recap – Module I

- **Directorate-General ENER**

This Commission department is **responsible for the EU's energy policy**: **secure, sustainable, and competitively priced energy** for Europe.

- **Policy**

To **ensure a reliable supply of energy** and to **keep prices affordable**, the European Union aims to build a more integrated, competitive European energy market (energy union).

The EU also **supports energy from renewable sources** and the efficient use of energy, both of which help to cut greenhouse emissions.

Recap – Module I

The European climate and energy framework for 2030 and the legislative packages of the European Union for an energy union are of **key strategic significance for the future direction of European and national climate and energy policies**, and thus for the successful implementation of the energy reforms.

Link: 2030 Climate & Energy Framework

Recap – Module I

The European Council concluded on 19 March 2015 that the EU is committed to building an Energy Union with a **forward-looking climate policy** on the basis of the Commission's framework strategy, with five priority dimensions:

1. Energy security, solidarity and trust.
2. A fully integrated European energy market.
3. Energy efficiency contributing to moderation of demand.
4. Decarbonising the economy.
5. Research, innovation and competitiveness.

Recap – Module I

The EU aims to be **climate-neutral by 2050** – an economy with **net-zero greenhouse gas emissions**. This objective is at the heart of the European Green Deal and in line with the EU's commitment to global climate action under the Paris Agreement.

The transition to a climate-neutral society **is both** an **urgent challenge** and an **opportunity** to build a better future for all.

LINK: https://ec.europa.eu/clima/policies/strategies/2050

Recap – Module I

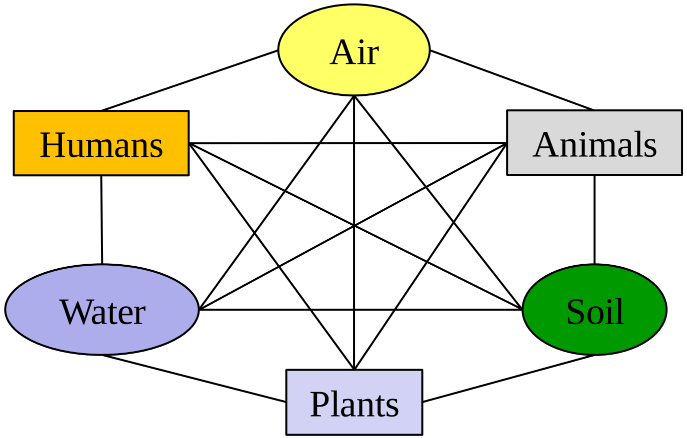
National Strategies

EU Member States are required to develop national long-term strategies on how they plan to achieve the greenhouse gas emissions reductions needed to meet their commitments under the Paris Agreement and EU objectives.

- Link: https://ec.europa.eu/info/energy-climate-change-environment/overall-targets/long-term-strategies_en

Recap – Module I

Environment

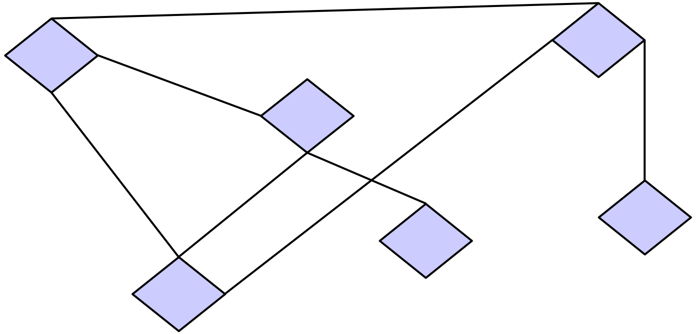


Note: in the biosphere everything is connected

Recap – Module I

- **What is a System?**

A system is a delimited arrangement of parts (components) that interact with each other.



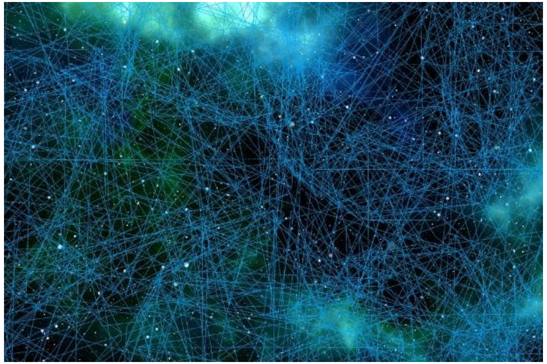


Photo by geralt at Pixabay

Module IV - Practical Application and Utilization

Recap: Module II - Basics about Wastewater and Waste

- **Environment (Pollution, Awareness)**
- **Solid Waste**
- **Liquid Waste**
- **Wastewater**
- **Waste Management**

Co-funded by the Erasmus+ Programme of the European Union

Recap: Module II

Environmental Pollution

- Environmental pollution is defined as the totality of all disturbing environmental factors.

- Terms such as **environmental stress** or **environmental impact** are used when **no clear negative effect** on the environment is expected from a pollution.

- If it is a pollution of nature by intrusion of substances, one often speaks (in the narrower sense) of **environmental pollution**.

Recap: Module II

Environmental Pollution

Causes of environmental pollution:

→ Pollution from industry:

- Chemical industry
- Paper Industry
- Steelworks

→ Environmental impacts of agricultural use:

- Fertilizers
- Insect repellents
- ...

Photo by JuergenPM at Pixabay

Recap: Module II

Occupational health and safety is an area of environmental protection which should not be neglected and which plays a considerable role mainly in industrial environmental protection.

Recap: Module II

Solid waste

Waste collected from residences, commercial buildings, hospitals, schools, universities, offices, light industrial operations etc. is usually considered as **municipal solid waste**.

Municipal Solid Waste **mainly consists of**:

- Paper, Containers and packaging (plastic, glass and metal), Food/Bio waste, Yard trimmings, Textiles, Other Inorganic Waste

Recap: Module II

Solid waste

Depending on the country municipal solid waste can also include industrial sludge, classified as hazardous or non-hazardous, resulting from a wide array of mining, construction, and manufacturing processes.

Moreover, **substantial amounts** of household waste is **classified as hazardous**.

Photo by meineresterampe at Pixabay

Recap: Module II

Liquid Waste

Fluid wastes, consisting of sewage and domestic wastewater, or processed water, or other liquids, produced by industrial activity, particularly by such industries as pulp and paper production, food processing, and the manufacture of chemicals.[1]

Liquid waste can also be defined as such liquids:[2]

- Wastewater
- Fats, oils, grease
- Used oil
- Liquids, solids, gases, or sludges and hazardous household liquids

Recap: Module II

Liquid Waste

Liquids that are hazardous or potentially harmful to human health or the environment. They can also be discarded commercial products classified as “Liquid Industrial Waste” such as cleaning fluids or pesticides, or the by-products of manufacturing processes.

Liquid waste can therefore be classified as **wastewater**!

Recap: Module II

Wastewater

Wastewater is a **generic term.** Depending on the country the definition of wastewater varies. The EU defines wastewater as:

- **Domestic wastewater:** Wastewater from residential settlements and services which originates predominantly from the human metabolism and from household activities
- **Industrial wastewater:** Any wastewater which is discharged from premises used for carrying on any trade or industry, other than domestic wastewater and run-off rain water

Link: https://ec.europa.eu/environment/water/water-urbanwaste/info/glossary_en.htm

Recap: Module II

→ Waste is raw material in the wrong place! ←

Recap: Module II

- Waste management (or waste disposal) include the **activities and actions required to manage waste** from its inception to its final disposal.

- Waste management includes **collection, transport, treatment and disposal** of waste and waste products (garbage, sewage, etc.), as well as monitoring and regulation of the waste management process.

Recap: Module II

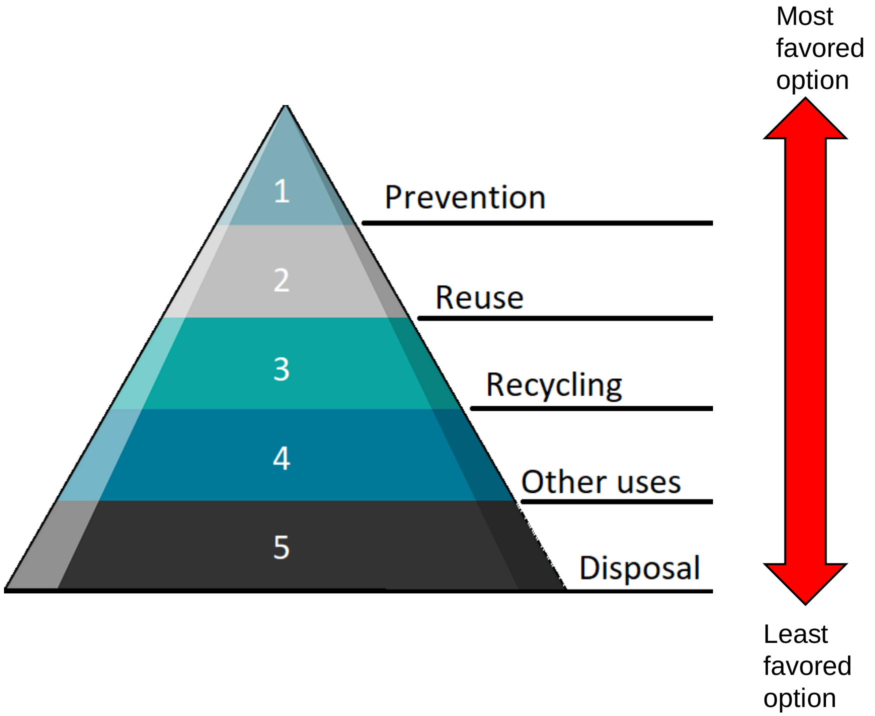
- Waste management is **intended to reduce adverse effects of waste** on human health, the environment or aesthetics.
- Waste management practices **are not uniform** among countries, regions, residential and industrial sectors.
- A large portion of waste management practices deal with municipal solid waste which is the bulk of the **waste** that is **created by household, industrial, and commercial activity**.

Co-funded by the Erasmus+ Programme of the European Union

Recap: Module II

The new waste hierarchy should now look as follows :

- Prevention,
- Preparation for reuse,
- Recycling,
- Other recovery (e.g. energy recovery)
- Disposal



Note: In some waste hierarchies the step “minimization” is included between “Prevention” and “reuse”.

Module IV - Practical Application and Utilization

Recap: Modul III - Energy Generation from Wastewater and Waste

- **Energy Management**
- **Waste Utilization**
- **Wastewater Utilization**
- **Heat Pumps**
- **Application Examples/ Use Cases**

Energy Management

- Fundamental considerations for energy management:
  - To ensure the security of energy supply (e.g. uninterrupted energy supply)
  - To ensure economic electricity and heat prices (e.g. avoiding to high fluctuations)

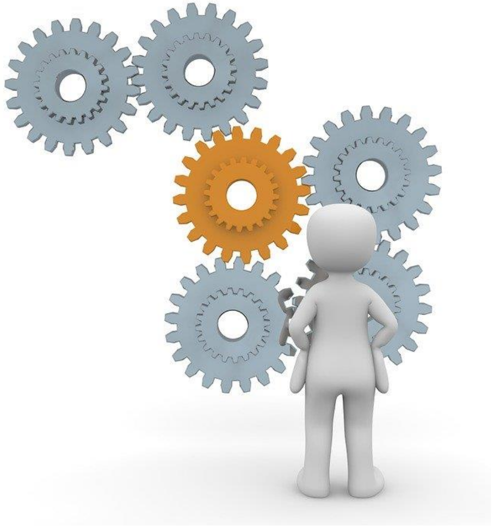


Photo by Peggy_Marco at Pixabay

Energy Management

- Application areas of Energy Management are:
  - Commercial and industrial energy management in production and logistics (small, medium and large sized)
  - Energy management for residential construction and of residential buildings


Photo by geralt at Pixabay

Recap: Module III

- Utilizing waste as “energy supply” is usually referred to as:
  - **Waste-to-energy** (WtE), or
  - **Energy-from-waste** (EfW)
- WtE is the process of generating energy in the form of electricity and/or heat from the **primary treatment** or the **processing of waste** into a fuel source.
- As products and materials already had an energy input in some form to become waste, waste-to-energy is considered as a **form of energy recovery**.

Recap: Module III

There are **several methods** used globally to turn waste into energy:

- The most common one is **incineration** (or **combustion**) of waste.
- Other methods include:
  - **Thermal technologies**
    - Gasification
    - Pyrolysis
    - etc.
  - **Non-thermal technologies**
    - Anaerobic digestion
    - Fermentation
    - etc.

Recap: Module III

- The energy content in wastewater from households, trade and industry is considerable.
- However, in Member States of the EU including Austria, wastewater is hardly used and not really seen as a viable energy source.
- An example for this is with wastewater treatment plants (WWTP). Their main function is to remove contamination from wastewater. However, research suggests that it can serve as a source of energy internally in the WWTP and also externally in infrastructure.
- Results show that the amount of thermal energy available in WWTP exceeds the internal demands of the WWTP.

Co-funded by the Erasmus+ Programme of the European Union

Recap: Module III

- A general approach that does not require a WWTP but might also be utilized in small or private facilities would be to use heat exchangers in order to extract thermal energy contained in wastewater.

- Subsequently, heat pumps can be used to bring it to the required temperature level, e.g. for heating or cooling purposes.

- All year wastewater temperatures are around or above 10°C.

- Therefore, it is optimally suited for the use of heat pumps as this corresponds roughly to the annual average heat of groundwater (12 °C) which is also utilized with heat pump technology.

Recap: Module III

How can heat be utilized/ extracted/ transferred from wastewater?

It can be recovered …

- in buildings from, e.g. raw wastewater
- from sewers, e.g. from raw wastewater
- Or in a sewage treatment plant, e.g. from the treated wastewater

This wastewater heat utilization can have effects on sewer systems and the sewage treatment plants.

Recap: Module III

- Heat pump technology is one of the most environmentally friendly methods of heating and hot water preparation.
- It reduces climate-damaging CO_2 emissions and energy consumption.
- It requires hardly any maintenance and, with correct planning and optimum operation, provides many times the electrical drive power used in terms of thermal energy.

Recap: Module III

- The most common design of a heat pump involves four main components:
  - a condenser
  - an expansion valve
  - an evaporator
  - a compressor

- The heat transfer medium circulated through these components is called refrigerant.

Recap: Module III

Heat pumps have different operating modes:

- **Monovalent**
- **Bivalent**
- **Monoenergetic**

Module IV - Practical Application and Utilization

Instruction for the Seminar Paper

- Every participant investigates his/her company and writes a seminar paper.
- This paper and its findings are presented in a short presentation (15 – 30 minutes) on the last day of this course.
- The paper is conducted in self study with support of the trainer
  - E.g. e-mail or via the online tool.

Module IV - Practical Application and Utilization

Instruction for the Seminar Paper

Requirements for the paper:

- **Length between 20 and 30 pages** (excluding title and content page)
- **Short description of the company** (size, main business)
  - Including a space and cost analysis
- **Usage/Consumption of Energy** (including type of energy)
- **Usage/Consumption of Waste and/or Wastewater**
- **Potentials for technologies/types of Waste and/or Wastewater Utilization**

Deadline: XXX

Module IV - Practical Application and Utilization

Instruction for the Seminar Paper

Requirements for the paper:

- **Font/size:** Arial, 11 pt., 1.5 Linespacing
- **Sources:** Everything available
  - E.g. Internet, Books, Papers, Interviews, Colleagues, etc.
  - Module I – III Slides.
- **Support:** The Trainer will be available once/twice a week where he/she will answer questions send via the request tool in the online tool or via e-mail.

Module IV - Practical Application and Utilization

Instruction for the Seminar Paper

Presentation:

- **PowerPoint** (or similar tool) **presentation**
- **15 to 30 Minutes long**
- **15 Minutes for feedback of other participants**

- **Support:** The Trainer will be available once/twice a week where he/she will answer questions send via the request tool in the online tool or via e-mail.

Module IV - Practical Application and Utilization

Evaluation

The trainer will grade your paper and your presentation.

Your grade will be based on the combined grade

If you are successful you will receive a diploma for the successful participation in this course.

Module IV - Practical Application and Utilization

Good Luck to you!

Contact information:

XXX