ENERGY EFFICIENCY AND SUSTAINABLE CONSTRUCTION

DIGITAL SKILLS FOR WORKPLACE MENTORS IN CONSTRUCTION SECTOR APPRENTICESHIPS

(CONDAP Project)

Javier Cárcel Carrasco[1]
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CONDAP

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

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PREFACE

Digital Skills for Workplace Mentors in Construction Sector Apprenticeships (CONDAP Project)

The present is characterised by an unprecedented change, known as the Third Industrial Revolution, where new technologies such as renewable energies or digital tools for management and communication are being shaped and where the future professional development must be focused on, to avoid misalignment between job supply and demand. As far as the construction sector is concerned, we could approach the introduction of new technologies from three different aspects: energy efficiency and sustainable construction, digitalisation and organisational, management and communication skills.

On the one hand, the energy efficiency measures required by the institutions are increasingly demanding. According to the Sustainable Development Goals and the European Targets for 2030, energy efficiency must be increased by 35%, greenhouse gas emissions must be reduced by 40% and a renewable energy rate of 35% must be achieved. The new challenge for the building sector is to further expand knowledge and to integrate modern environmental technologies and to implement such energy efficiency measures in them in order to reduce consumption and to become more sustainable with the environment. Globally, buildings consume more than a third of total end-use energy and cause almost a one fifth of total greenhouse gas emissions. Reducing energy use in buildings is a climate change imperative, but it is also a business opportunity.

On the other hand, the construction industry is also rapidly evolving with digital technologies. Recently, the potential of BIM (Building Information Modelling) systems for the efficient management of construction projects is beginning to be exploited. This is a software able of representing the physical and functional properties of a building in such a way that a knowledge resource is obtained in a common technological environment where information is shared and constitutes a reliable basis for decisions during the project life cycle, from the earliest conception until demolition. This kind of tools allows to save many expenses and to speed up processes, so they will be essential in the imminent future and it is important that the trainees of the present are well acquainted with them.

Finally, the importance of management and communication skills at the organisational level must be emphasised. The way information flows in an organisation, across departments, between management colleagues, trainers and trainees is crucial. It is a complex process that takes a long time to build, maintain and continuously improve. Effective communication can make collaboration productive and mutually beneficial, especially for trainers. The use and implementation of digital technologies for communication, as well as social networks and virtual environments can also offer us efficiently the support needed for good communication and management in the field of construction work.

The CONDAP project aims to support the provision of vocational training for trainers in the construction sector by offering a comprehensive modular course that ensures easy and free access to relevant educational material and tools, thus responding to the needs of VET providers and trainees in the sector. After collecting the opinions of different stakeholders within the building and training sector with different surveys and desk researches, the project partners have developed three different thematic units for this purpose:

- LU1: Energy efficiency and sustainable construction
- LU2: Digitisation in construction
- LU3: Organisational, management & communication skills

This book includes the first teaching unit.

The consortium of this project is integrated by five partners from different countries and with different but complementary profiles in order to address the objectives of the project. The different partners come from the vocational training sector, research and the university world. Specifically, the consortium is composed of the following organisations

* INSTRUCTUS (www.instructus.org)- UK

* Vilniaus statybininku rengimo centras (www.vsrc.lt)- Lithuania

* Universitat Politècnica de València (http://www.upv.es/)- Spain

* EXELIA (www.exelia.gr/en) – Greece

* EBC (http://www.ebc-construction.eu/) – Belgium

This work has been possible thanks to the contributions of all the partners who are part of the CONDAP project, as well as the companies and organisations from which some of the contents of this work have been extracted.

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CHAPTER I:

INTRODUCTION

1.1. PROJECT BACKGROUND

In the initial phase of the project, activities were carried out to identify the priorities and needs of trainers in terms of digital skills within the construction industry. To do this, each partner had to bring together a large group of stakeholders from their region or country including construction companies, vocational training providers, construction workers, industry experts, construction software companies, professional associations, students, new workers, etc.

A research was carried out based on three methods:

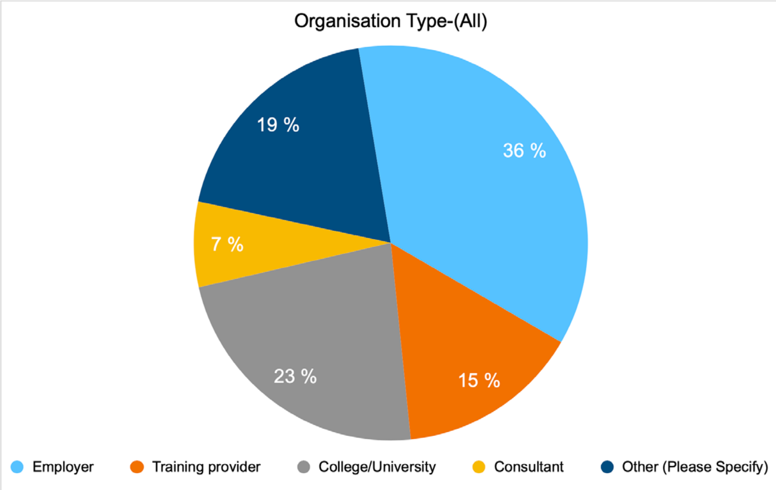
- **Field studies** through online surveys that were distributed among the contacts and stakeholders of each project partner.
- **Semi-structured and individual interviews** with professionals from the construction sector.
- **Office research** carried out by each partner to find out the requirements, needs, technologies, teaching methodologies and new developments in the construction sector and its digital tools.

In the **field studies**, respondents were classified according to the type and size of organisation they belonged to, their job function and their years of experience. The surveys were divided into two parts:

- Part A focused on finding out what the basic digital skills requirements were that building apprentices should have such as handling digital data, searching for information on the Internet, creating documents with office, using electronic media and collaboration, creating websites, using company-specific software, etc.
- Part B aimed to find out the importance given by the surveyors to certain areas within the construction sector such as: digital solutions for sustainable construction and energy efficiency, building information modelling (BIM), virtual and augmented reality, the internet of things, computer aided design, etc. In addition, they were given the opportunity to add those areas not shown that they considered relevant.

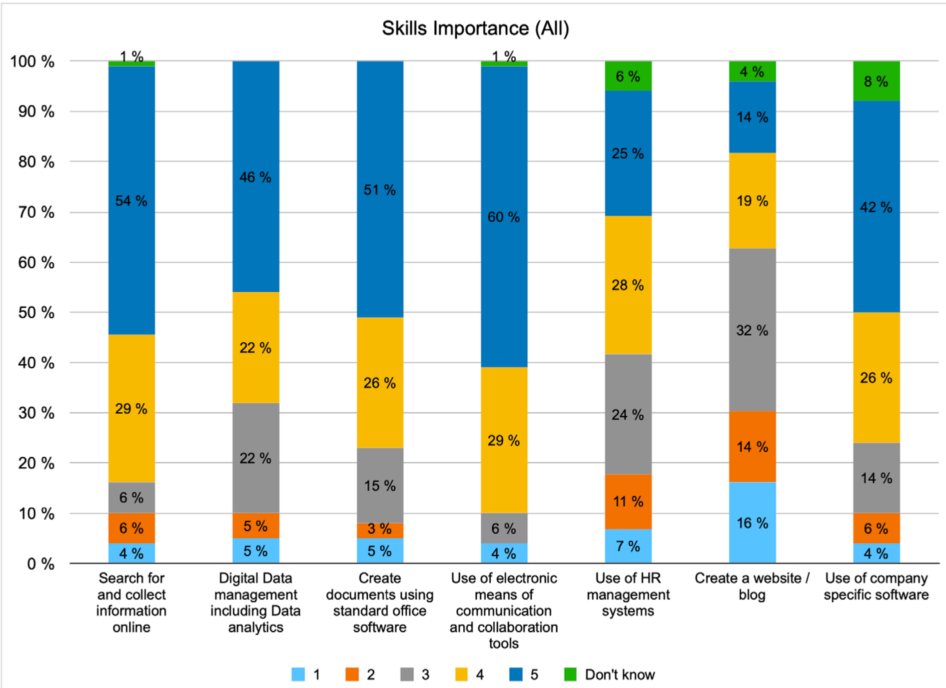
The results of the field studies are shown below:

- Classification of respondents by type of organization



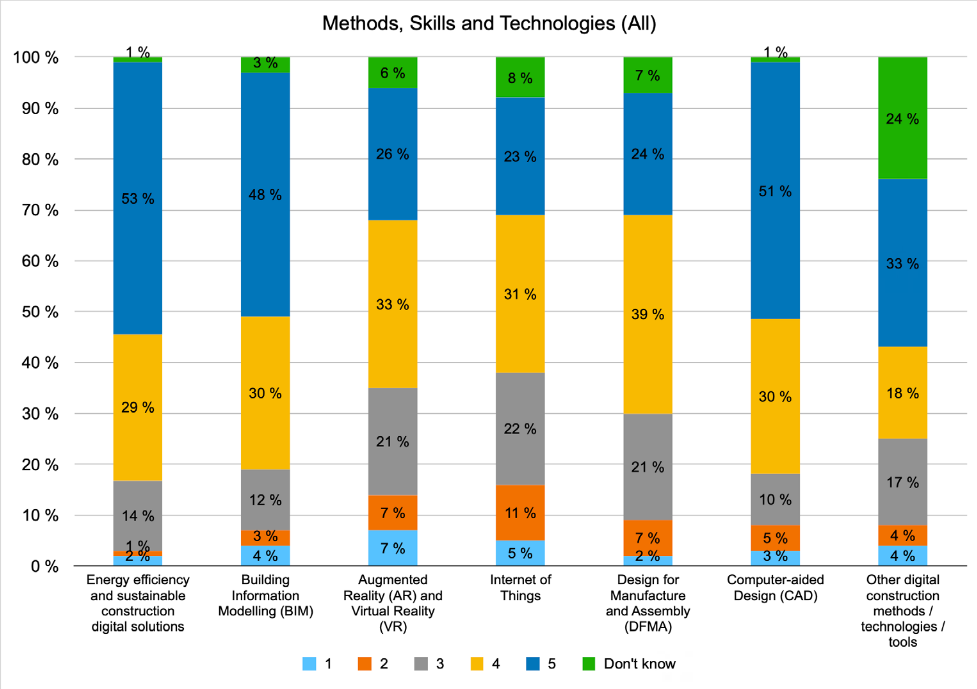
In addition, respondents were almost equally divided in terms of the size of their organisation or company (35% small, 28% medium and 37% large) and 67% of them had more than 10 years experience working in the construction sector.

- Results of part A of the survey:



In addition, respondents stressed the importance of using telecommunication applications such as Skype, ZOOM, MS Teams, Mailbox, etc, virtual collaborative environments for online document sharing such as Google Drive or Dropbox and digital platforms for distance learning such as Webex.

- Results of part B of the survey:



Some of the comments indicated the following additional areas as relevant: artificial intelligence, work safety or the use of drones to avoid working at height.

In conclusion, after analysing the results of the field study, the areas and skills that were most relevant to the respondents were:

- Use of electronic media and digital collaboration tools
- Digital solutions for sustainable construction and energy efficiency
- Building Information Modeling (BIM)
- Computer Aided Design (CAD)
- Search and data collection on the Internet
- Document creation with Office software

The **semi-structured interviews** were conducted to obtain a more in-depth and elaborate view of the skills that are considered most needed by the trainees through a personal interview with one of the stakeholders. In this interview the following questions were asked:

1. What kind of digital skills and tools do you consider important, so that construction managers and apprentice/student coordinators can effectively teach new skills, especially with regard to developments in the construction sector?
2. When you think about the digitisation of the construction sector and digital construction methods, which of the following topics come most to mind?
3. Can you describe the usual/ideal work profile of the training coordinator in construction?
4. What are the main factors that hinder the effectiveness of training schemes in the construction sector, leading to an increase in drop-out rates?
5. Who should be responsible for providing training to trainers of workers and apprentices in the construction sector (Alternative question- What training do you think should be available for coordinators/trainers in the construction industry)?

Regarding the first and second questions, the interviewees highlighted the following skills, tools, methodologies and digital technologies and some of their most relevant aspects:

- Many agreed on the importance of building information modelling (BIM). This is a working method that is defined in the context of the collaborative culture and integrated practice, since it integrates all the agents involved in the building process (architects, engineers, builders, developers, facilities managers, etc.) and establishes a transverse communication flow between them, generating a virtual model that contains all the information related to the building throughout its life cycle, from its initial conception, during its construction and throughout its useful life, until its demolition. The information provided to the BIM model, comes from different types of software, modeling programs, structural calculation, MEP, budgeting software, energy behavior analysis, sensors, etc. The knowledge of all these tools and of the capacity of interoperability between them, is fundamental for the correct implementation of the BIM.
- Some general working software were highlighted, such as:
    - Software for preparing reports or presentations: Word, Excel, PowerPoint, Adobe.
    - Handling of database software: Access, CRM
    - Internal company working tools to communicate and collaborate with the trainees.
- Specific software in areas of:
    - Energy efficiency and certification, sustainable construction, integration

  of renewables
  - Operations management (lean production), remote manufacturing and numerical control machines (CNC)
  - Financial (ACCA) and administrative for the tendering of bids, invoices, tool reports, etc.
  - 2D and 3D digital design (SEMA, Revit, AutoCAD, SolidWorks, WikiHouse).
  - Work safety
  - Circular economy
- Intelligent technologies and automatons
  - Simulation and digital twins to monitor objects or systems and analyse their behaviour in certain situations and improve their effectiveness. An augmented reality and virtual environment tool for simulation is Virtual Reality Headset
  - Smart meters in buildings and the Internet of things
  - Artificial Intelligence
  - Smart Cities
  - Drones to access difficult or dangerous sites, work robots
- Use of the internet for information search, management of websites and blogs and social networks (LinkedIn, Twitter, Facebook), digital marketing.
- Communication tools such as Skype, Messenger, whatsapp, viber.

As for the third question, the qualities and attributes that a trainer should have according to the interviewees are summarized in the following:

- General qualities and attributes:
  - Understanding of the trade and competent use of modern technologies and access to digital training resources and tools.
  - Strengthen the confidence of the new workforce in the industry and convey a sense of reality and effective use of digital tools to address real challenges, such as productivity in industry. Encourage mentors to think differently and beyond their industry, providing a glimpse of what can be achieved using different skill sets and perspectives. Motivation.
  - Practical knowledge of modern building information modelling (BIM) technologies and collaborative approaches to building design and operation; to establish a benchmark and standards for collaborative organisational work. To update the evolution of new technologies in building and to update the knowledge of the trainees.

- Sufficient human psychology to understand the age groups of workers/ learners and to be able to interact effectively with them.
- Make greater use of virtual interaction in tutoring and use remote connection tools to increase forms of communication between trainees and trainers.
- Responsibility, adaptability, management skills, active listening, conflict management and creativity.
- Continuous support to employees in their training for promotion to other job categories.
- Knowledge of the apprentice's job requirements and occupational safety.

• Demands:
  - Frequent tutorials and meetings (face-to-face or remote).
  - Planning with a structured agenda and updates.
  - Advice, evaluation, support and follow-up. Discussion forums with other learners
  - Recorded activities
  - Setting goals and challenges Proposing training activities associated with the learner's daily tasks.
  - Ability to tackle problems.

• Training methodology:
  - 6-step working model process in apprentice training (1) Reporting, (2) Planning, (3) Deciding, (4) Behaviour, (5) Monitoring and (6) Evaluation.
  - Student centred design
  - Application of innovative methods and digital tools for training.
  - Adopting the principle of "less is more" for online learning.
  - Continuous improvement of training by offering courses with innovative digital construction methods and tools.
  - Supply of competences according to demand.

The fourth question sets out the hidden factors which, in their absence, could hamper the effectiveness of training schemes in the construction sector and increase drop-out rates:

- Motivation. Career development or value associated with training.
- Qualified trainers or coordinators in the company who meet the expectations and motivation of the trainees. Training programme for

trainers and workplace support from the company to train trainers and apprentice coordinators. Increased interest of employees in the company to become trainers.

- Consideration of individual circumstances. Flexibility and willingness of employees to learn new things. Age factor, where the use of technologies is a bit reticent.
- Clear vision. Quality of the training offer. Modern and innovative training methodologies suitable for training in digital skills. Consistency in work systems. Technology that has to be suitable for its purpose. Promoting confidence in technology.
- Coherent framework or infrastructure to facilitate the matching of skills supply and demand. A system that facilitates more competency-based and demand-driven curriculum management.
- Clearly defined skills to be integrated into the workplace. Competence that affects innovation and productivity.
- Understanding the industry segment and the size of the company. The construction industry can be quite segmented with little spare capacity. On the other hand, industry has its particularities where most of the workforce is not office-based. Digital infrastructure in the company.
- Culture of collaboration and improvement.
- Adequate financial flows to respond to current challenges. Sufficient state support for companies that take in apprentices.
- The rights and responsibilities of enterprises providing apprenticeship training should be clearly defined in regulatory acts.
- Communication and collaboration with vocational training centres. Research and development, and investment in innovation. Model of functional training, financing and service provision.
- Identification and addressing of gaps and mismatches in existing skills. Providing clear and coherent information management strategies to help find the information to make timely decisions. Assist in interpreting data to influence decision making.
- Establish the appropriate parameters to eliminate errors due to the human factor. Using the right software to avoid technical problems and duplication of effort in data processing that relies on general measurements.
- Accepting change. On average, it takes about 10 years on average to make the change become an implementable process.
- Gender factor. The construction industry has been predominantly male, and must change. Women can play an important role in BIM technology,

they should be widely encouraged and promoted through events, awards events, conferences, networking opportunities.

Finally, the answers to the last question about what training there should be for coordinators/trainers in the construction industry and who should provide it, are summarised in the following:

- Companies / businesses (in-company training)
    - Own company assisted by individual experts or training centres. Large companies provide these courses themselves, with the help of their human resources departments.
    - Specialised courses for VET coordinators/trainers at state level.
    - Many employers believe that, instead of a formal pedagogical qualification, trainers should know the processes of the industry and the company and be able to explain them to the trainees and instruct them in their tasks. Instructing trainees is no different from instructing any other new employee and is part of the daily practice of many of their employees.
    - In SMEs trainers are mostly self-taught or learn from their colleagues.
    - Encourage trainers to attend short courses or visits provided by companies.
- Vocational training centres:
    - Specialized training centres in construction.
    - Training associations.
    - Company employees are often unable and/or unwilling to train others due to workload, confidentiality issues, risk of possible damage to equipment or fear of possible future competition. The main reason why companies cooperate with VET providers to deliver apprenticeship training is to get the qualified workers they need and the possibility to promote themselves as potential employers.
- Online courses:
    - Short, specific online courses so that trainers have the flexibility to do so.
    - Mass open courses online (MOOCs) and open education resources.
- Initiatives financed by national and European projects:
    - Specific train-the-trainer programmes should be developed to offer short courses for VET teachers with the specific focus on digitisation.
    - Flexibility and prompt reaction in the provision of VET services to changes in the industry is required, including the opportunity to develop new training programmes/modules for high-demand occupations or for new

emerging occupations.

- Courses on pedagogical and psychological aspects are available from national teacher training institutes.

- Professional development:
  - Opportunities for continued professional development.
  - The support of a trainer should also depend on the level of training. For example, EQF level 4 may be advised by a chartered engineer or professional association member who will be able to assess basic skills and competencies.
  - Attendance at training events and seminars.

With regard to desk-based research, this was carried out as a complementary method of gathering information on the digital skills needs of trainers in the workplace and reviewed the availability and content of reports, existing courses and other documents and information sources that each partner could access about:

- Digital skills needed for apprentice trainers and complementary digital skills for construction workers.
- Construction methods, skills and digital technologies
- The role of trainers in the workplace and in the company who participate in the learning, to draw conclusions about the needs of work based learning.
- Existing train-the-trainer courses, focusing on digital skills and construction methods.
- Existing training courses on digital skills and construction methods.
- Skills gaps and deficiencies in the construction sector (also by reviewing information on the management of learning plans)
- Ways in which work-based learning can support the change in skills needed to modernise learning.

The results of the desk research were expected to reveal trends in the construction industry and the need for digital construction knowledge and methods, and therefore to highlight findings on how mentor training can support the change of knowledge needed to apply digital methods and technologies in the context of construction learning.

Each partner contributed evidence from their countries by providing at least 5 sources of information (25 in total from all partners). The answers obtained allowed to know the context in which each country is in the digital field in the construction sector.

The final report analysed the three types of research methods in terms of content and set objectives in relation to the real benefits received. Although the number of responses to the questionnaire is below the target of 150, the rest of the research provides complementary coverage through interviews and desk research. The total of all expected responses was 190, including surveys, interviews and desk-based research, providing good study and information on the courses taken in the different countries and the most developed topics.

With regard to the **field studies**, in particular the answers obtained in the survey, the following graph shows per partner which results were obtained (orange line) compared to the expected ones (blue line). VSRC and the UPV achieved a higher number of responses than the target, therefore obtaining a greater representation of responses from stakeholders and staff associated with the construction.

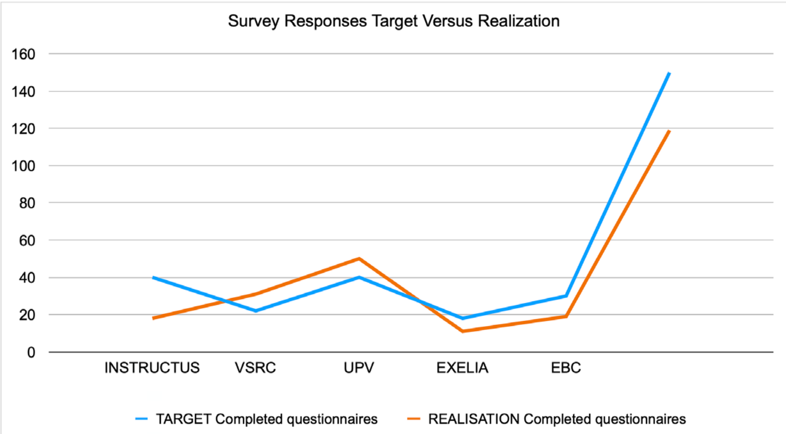


Chart 1. Survey: responses obtained and expected per partner

On the other hand, **semi-structured interviews** are a very effective method of obtaining first-hand information, whose time investment makes it difficult to obtain a large number of them. However, INSTRUCTUS and EBC obtained more responses than the target value, thus counteracting the lack of information with respect to the field studies.

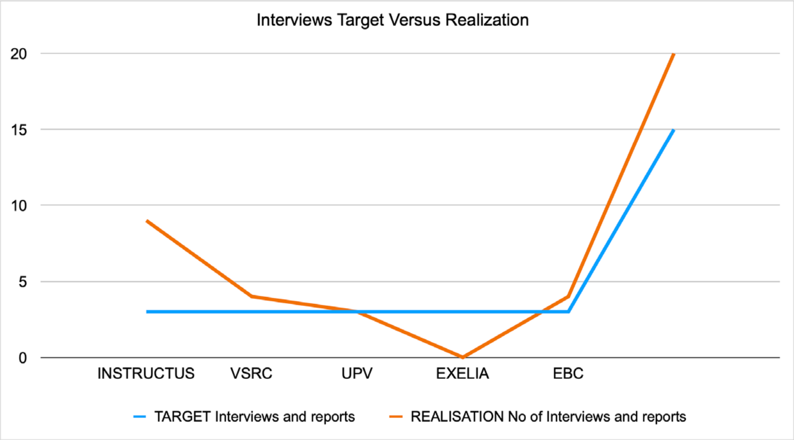


Chart 2. Semi-structured interviews: responses obtained and expected per partner

The last of the methods is **desk research**, through which sufficient information was obtained to complete any data that might be missing from the field studies and semi-structured interviews. We are making known the requirements, needs, technologies, teaching methodologies and new developments in the construction sector and its digital tools in each country. All partners reached the target value and even exceeded the set values. This method had a very good response and usefulness.

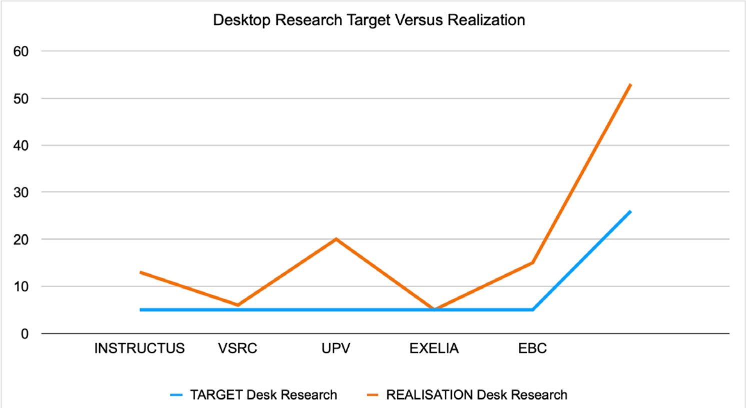


Chart 3. Desk research: responses obtained and expected per partner

In conclusion, the following graph shows the different methods (questionnaires, interviews and reports and desk research) comparing the objective value with the number of responses obtained. As can be seen, the overall number of responses is very high, so the results obtained are well contrasted and there is variety thanks to the response of the different partners.

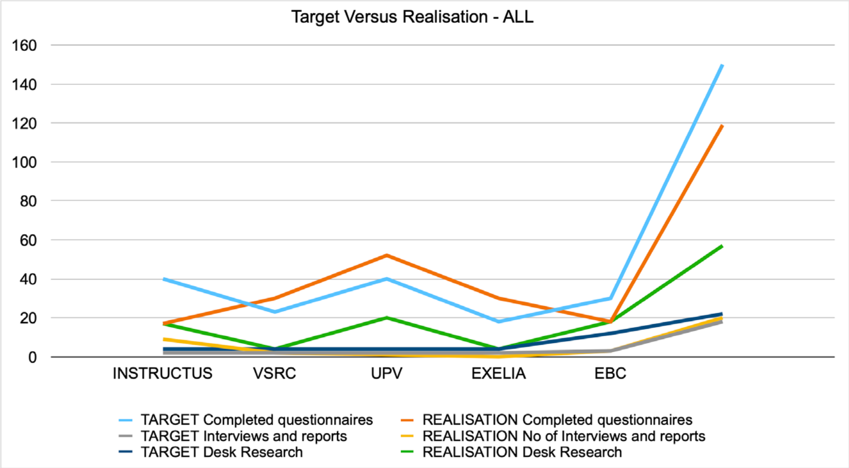


Chart 4. Research methods: answers and target values per partner

As a result of these three types of research conducted by partners in five countries, the following learning objectives were reached which should define the content of the CONDAP course:

- O1. Understand and apply new technologies and software for digital construction
- O2. Share data and construction models using integrated digital systems.
- O3. Develop the skills and knowledge necessary for trainers in the application of digital construction methodologies.
- O4. Develop the skills and knowledge necessary to train students in knowledge management systems and advances in digital technologies.
- O5. To develop the knowledge and understanding to define a customised methodology to support students in their development and improvement in the use of digital tools/technologies.
- O6. Develop immersive learning tools and training in digital construction relevant to your company for use by students.
- O7. Develop methodologies to explore and overcome barriers for the use of digital advances in construction.

Once the research has been completed, the second milestone of the CONDAP project is reached, which aims to define the structure of a curriculum with pedagogical guidelines for trainers and VET providers, in order to train them in digital construction methods. To this end, three activities have been carried out based on the results of the research. The first of these consists of grouping the learning objectives together with the knowledge areas that proved to be the most interesting for the respondents, extracting from this some learning outcomes that will later form the teaching units of the CONDAP project, which are presented in this compendium.

Firstly, it is important to define the system in which the teaching units will be framed, known as the European Credit Transfer System for Vocational Education and Training (ECVET). This is a common methodological framework that facilitates the recognition and transfer of learning credits from one qualification system to another within the European Education System. ECVET works in partnership with the European Qualifications Framework (EQF) to provide greater transparency in European qualifications, promoting worker and student mobility and facilitating learning. In particular, the implementation of ECVET requires that qualifications are described in terms of learning outcomes; that units are formed from the learning outcomes; and that units are often grouped together to form the basis of qualifications.

The CONDAP project is thus in line with this procedure, respecting the ECVET procedure, defining learning outcomes and forming learning units from these. It is important to clarify that the processes of assessment, validation and recognition must also be agreed between all participants and must respect existing national, regional, sectoral or institutional practices. This initiative makes it easier for European Union (EU) citizens to have their education, skills and knowledge recognised in an EU country other than their own. ECVET complements the European Credit Transfer and Accumulation System (ECTS) by establishing a link between Vocational Education and Training and Higher Education.

According to the ECVET system, a learning or teaching unit is a training element that responds to a set of learning outcomes, defined in terms of knowledge, skills and competences that can be assessed, validated and certified. Through the analysis carried out in the CONDAP project, explained above, learning units based on learning outcomes resulted as shown in the following figure:

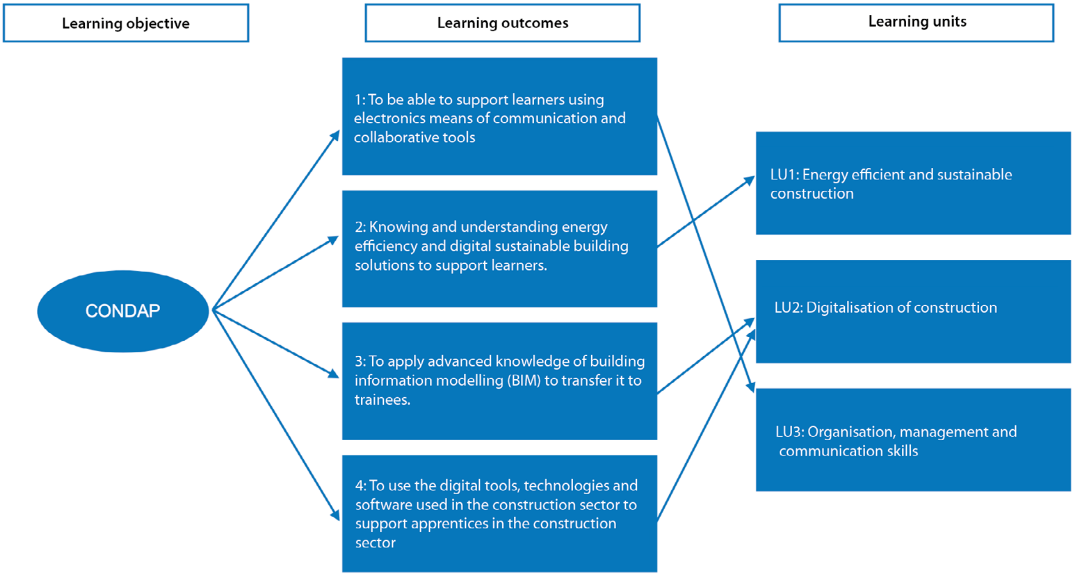


Figure 1. Grouping of learning outcomes CONDAP.

Finally, the teaching units to be carried out in the CONDAP project obtained from the learning outcomes, as illustrated above, are:

- LU 1: **Energy efficient and sustainable construction**; which mainly responds to learning outcome 2: "Knowing and understanding energy efficiency and digital sustainable construction solutions to support learners".
- LU 2: **Digitisation in Construction**; related to learning outcome 3: "Apply advanced knowledge of Building Information Modelling (BIM) to transfer it to trainees" and learning outcome 4: "Use digital tools, technologies and software used in the construction sector to support trainees in the construction sector".
- LU 3: **Organisational, managerial and communication skills**; corresponds to learning outcome 1: "To be able to support learners using electronic communication and collaboration tools".

On the other hand, the teaching units must also meet a number of requirements, suggested by European principles:

- Units of learning outcomes can be completed and assessed independently of other units of learning outcomes.
- They are structured in such a way that relevant learning outcomes can be achieved in a specific time interval. Therefore they should not be too long.
- They include all the learning outcomes necessary to meet the objectives of

the units and are designed to be assessable.

The second activity within the second intellectual output of CONDAP consists of defining the specifications of the teaching units. That is, the scope and essential requirements that the corresponding training programme must meet. The training course material will be developed on the basis of the definition of the course specifications.

The specifications of the learning units are based on the ECVET principles, which indicate that each unit can include the following elements, which will allow the units to be accepted within the ECVET framework.

- EQF qualification level
- Recommended prior knowledge
- Duration of the learning process
- Comparative weighting of learning units
- Allocation of appropriations
- Prerequisites for attending each learning unit
- Training content
- Evaluation methods

The duration of the courses is also specified, according to the accumulated hours in the following categories:

- **Teaching hours:** contact hours between the instructor and the student in the course plan, including conferences, tutorials, seminars, workshops and lab-practice sessions.
- **Self-study hours:** the study of something by oneself without direct supervision or class attendance.
- **On-site hours:** study visits that can be organised jointly or carried out individually.
- **Assessment hours:** the time needed to prepare a piece of work, including time allocated to the exam (if any).

The learning hours of each teaching unit have been assigned according to the results obtained in the analysis of the first intellectual result (O1). The most requested topics were "Energy efficiency and sustainable construction" and "BIM and other digital construction methods". Therefore, each of these topics represents 40% of the course dedication, while learning unit 3 "Organisational, management and communication skills" represents 20% of the weight of the whole course.

Therefore, the CONDAP course involves the following hours for each learning unit:

- **LU 1:** 12 hours of lessons, 3 hours on site, 3 hours of self-study, 2 hours of evaluation.
- **LU 2:** 10 teaching hours, 5 hours on-site, 3 hours self-study, 2 hours evaluation.
- **LU 3:** 5 teaching hours, 2 hours on-site, 2 hours self-study, 1 hour evaluation.

In total the course will include the following learning hours associated with each teaching unit in order to define the duration of the entire course:

- 27 teaching hours, plus 3 hours on site in teaching unit 1 and 7 practical hours required for the practical sessions in units 2 and 3.
- 8 hours of self-learning for the trainees for the teaching materials.
- 5 hours of evaluation.

The course will have a total duration of 50 hours distributed in each teaching unit. It is true that the duration of each teaching unit should not be considered as strictly defined, but as a recommended indicator so that integration with existing vocational training courses can be flexible.

As far as the weighting and the allocation of credits are concerned, as mentioned above, the CONDAP course is based on the ECVET system. ECVET credits are a numerical representation of the overall weight of learning outcomes in a qualification and the relative weight of units in relation to the qualification. In this way, they allow for the framing of assessed skills between partners, trying to facilitate the transfer of learning outcomes from one qualification system to another. It is not intended to replace national qualification systems, but to achieve better comparability and compatibility between them; it facilitates the recognition of training, skills and knowledge among European Union (EU) citizens.

The suggested weighting and allocation of ECVET credits for the CONDAP course, taking into account that 10 hours correspond to 1 credit, is as follows:

- LU 1: 40% corresponds to 2 credits.
- LU 2: 40% corresponds to 2 credits.
- LU 3: 20% corresponds to 1 credit.

The total course is 50 hours long, which means 5 ECTS credits.

Finally, for the evaluation of the teaching units different evaluation methods will be used such as open answer questions, multiple choice questions or case study analysis.

Below is a brief introduction to Teaching Unit 1, which will be further developed by including all the necessary material to complement the study and its assessment.

LU1: ENERGY EFFICIENCY AND SUSTAINABLE CONSTRUCTION

Reducing energy consumption is one of the great challenges of today's society, which affects many sectors, including the construction industry. Energy efficiency means in a practical way the reduction of energy consumption by optimizing its use, in this sense it does not only depend on the consumers, but also on some good practices related to the construction of the buildings.

This learning unit consisting of 7 topics aims to introduce students to the field of energy efficiency in construction; to show them its importance, the foundations and how the European directive covers this type of building.

The first lessons provide useful and necessary knowledge to advance the development of the building sector, focusing on the concept of energy efficient building and the applicable European directive. The basic principles of energy efficiency with regard to the passive and active design of buildings and energy generation from renewable energy sources are then discussed. In addition, it will work with the PVGIS tool and then it will be applied to a study case.

Due to the great importance of energy certificates today, information will also be provided about the different energy certificates that are currently known and some examples of the most commonly used software to elaborate them. In addition, some ideas will be provided about what management and monitoring systems are, as well as remote energy management. After completing the unit, participants will understand the fundamental principles of energy efficiency in buildings, as well as the structural peculiarities concerning the design of buildings and they will be able to see some examples of buildings and installations where they are applied.

Learning outcomes

Learning Unit 1: Energy efficiency and sustainable construction	
Learning outcome 1	To show the motivation that leads to the development of energy efficiency and sustainable construction.
Learning outcome 2	Become familiar with the concept of the nearly zero-energy building and the current regulations applicable to buildings in efficiency areas.
Learning outcome 3	To learn how energy efficiency in buildings can be improved, both passively and actively, and to classify the measures that apply to each type of design. In addition, to learn about the PVGIS tool for obtaining climate characteristics at any point in Europe and applying it to case studies.
Learning outcome 4	To know the different ways of energy generation with renewable technologies in construction and its basic principles. To understand the use of PVGIS to analyse the production with photovoltaic panels in certain location.
Learning outcome 5	Know the main requirements of a Energy Performance Certification (EPC). To be introduced to energy management and monitoring systems and remote management.

Summary of the lessons of the learning unit

Lesson 1. Introduction

This lesson introduces the context of current state of energy efficiency in buildings and shows the impact that construction has on the environment within the European territory. The main objective of this lesson is to show the motivation that leads the European Union to promote the development of energy efficiency and sustainable construction.

Lesson 2. European legal framework

Lesson 2 focuses on the legal framework in Europe, where sustainable building construction takes place. It will look at current regulations in Europe and how they affect different climate zones.

Lesson 3. Sustainable buildings

Lesson 3 contains basic concepts and factors to be considered in a nearly zero consumption building according to the European Directive.

Lesson 4. Energy Efficiency Principles (Passive and Active Design)

In this lesson you will learn the basic principles of energy efficiency in buildings related to passive and active building design. With respect to passive design, a distinction will be made between solutions applied to the planning of the building and those applied to interior design. In active design, more efficient consumption systems will be studied. In addition, the use of PVGIS software will be introduced.

Lesson 5. Renewable energy sources (Active Design)

In this lesson you will learn about the second part of active design in relation to generation from renewable energy sources and about the different generation systems available for a building. The software PVGIS, which is used to calculate the energy output of the photovoltaic system, is also presented.

Lesson 6. Energy Certification

In this lesson you will learn about the applicable directives on energy certification, the characteristics of an Energy Performance Certificate (EPC) for a building and some examples of software used to analyse and optimise the energy performance of a building. You will also learn about energy management and monitoring systems

(BMS and EMS) and remote energy management.

Lesson 7. Examples

In this lesson you will have the features, facilities and construction data of two real cases of energy efficient buildings.

CHAPTER II:

LEARNING UNIT: ENERGY EFFICIENCY AND SUSTAINABLE CONSTRUCTION

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ENERGY EFFICIENCY AND SUSTAINABLE CONSTRUCTION

CONDAP OPEN EDUCATIONAL RESOURCES

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WHAT YOU CAN EXPECT TO LEARN FROM THIS LEARNING UNIT

This learning unit “Energy efficient and sustainable construction” aims to introduce students to the field of energy efficiency in construction, to show its importance, foundations and how the European directive covers this type of building.

The learning unit is divided into seven lessons:

- ✓ Lessons 1, 2 and 3 provide students with useful and necessary knowledge to advance in the development of the construction sector, focusing on energy efficient building concept and the applicable European directive.
- ✓ Lessons 4 and 5 are focused on the basic principles of energy efficiency in buildings regarding passive and active building design. Specifically, lesson 5 introduces the generation from renewable energy sources. In addition, students will work with PVGIS as a tool in order to use real data and apply it to case studies.
- ✓ Lesson 6 shows the importance and characteristics of energy certificates, as well as some more used examples of software to elaborate the certificates. In addition, it provides some insights into what the energy management and monitoring systems and the energy remote management are.
- ✓ Finally, in lesson 7 will be given some examples of buildings and facilities where the concepts previously studied are applied.

INDEX

LESSON 1

Introduction

The content of this lesson introduces you to the context surrounding energy efficiency in buildings and shows the impact that construction has on the environment within European territory.

✓ The main objective is to show the motivation that leads to the development of energy efficiency and sustainable building.

1. INTRODUCTION

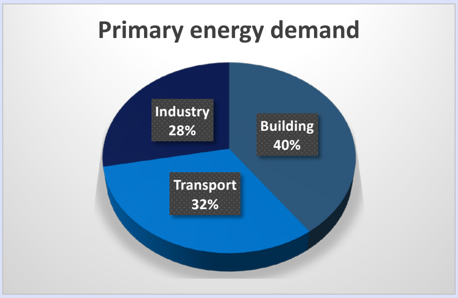
Context

- Third Industrial Revolution
- New technologies and digitization tools
- Energy efficiency measures and renewable technologies
- New European Legislation

1. INTRODUCTION

MOTIVATION → Achieve the objectives set by the European Union for Energy Efficiency

- Buildings in EU are responsable for:
  - 40% of primary energy demand
  - 60% of electricity demand
  - 40% of C02 emissions
  - 50% of raw materials consumed
  - 30% of waste (136 millon Tn/year)
  - 20% water consumption
- Building sector opportunities
  - Energy refurbishing of buildings
  - Nearly-zero energy buildings



LESSON 2

European legal framework

The Lesson 2 is focused on the legal framework of Europe where sustainable building construction takes place. You will learn about current regulations in Europe and how they affect different climate zones.

✓ The main objective of this lesson is to learn the current regulations applicable to energy efficient buildings.

2.EUROPEAN LEGAL FRAMEWORK

The **objectives set by the European Union for Energy Efficiency** can be found in the **Directive (EU) 2018/844**. Some of the main objectives contained in this document are the following:

- ✓ Renovation of national parks of residential and non-residential buildings, both public and private, transforming them into energy-efficient and decarbonized real estate parks before 2050, facilitating **transformation economically cost-effective buildings in near-zero energy-consumption buildings.**
- ✓ Obligation *to* **increase energy efficiency by 35%** by 2030.
- ✓ Achieve a **35% rate of renewable energy** by 2030.
- ✓ **Reduce greenhouse gas emissions by 40%** by 2030.
- ✓ Non-residential buildings with a nominal power rating for heating installations or for combined heating and ventilation installations of more than 290kW shall be equipped by 2025, with **automation and building control systems**, as long as it is technically and economically feasible.
- ✓ **Self-consumption and energy communities**.

2.EUROPEAN LEGAL FRAMEWORK

The main directives in areas of energy efficiency of buildings in EU are the "**Energy Efficiency In Buildings Directive 2010/31/EU**" and the "**Energy Efficiency Directive 2012/27/EU**" **(both revised by 2018/844/EU).** Directive 2010/31/EU announced that all new homes by 2021 and public offices by 2019 should be **almost zero energy consumption**.

In building restore, Member States will link financial incentives for improving energy efficiency to expected or achieved energy savings, as determined by one or more of the following criteria:

a) the energy efficiency of the equipment or materials used for the renovation, these elements will be installed by an installer with the relevant level of certification or qualification.
b) standard values for calculating energy savings in buildings.
c) the improvement achieved through this reform by comparing the energy efficiency certificates issued before and after the reform.
d) the findings of an energy audit.
e) the results from another relevant, transparent and proportional method that shows the improvement in energy efficiency.

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2.EUROPEAN LEGAL FRAMEWORK

According to the climate zone, Directive 2010/31/EU **recommend**:

Climate Zone	Offices Demand	Housing demand
Mediterranean Zone	20-30 kWh/(m2/year) of net primary energy, normally with primary energy use of 80-90 kWh/(m2/year) covered by 60 kWh/(m2/year) from sources on site.	0-15 kWh/(m2/year) of net primary energy, normally with primary energy use of 50-65 kWh/(m2/year) covered by 50 kWh/(m2/year) from renewable sources on site.
Oceanica Zone	40-55 kWh/(m2/year) of net primary energy, normally with primary energy use of 85-100 kWh/(m2/year) covered by 45 kWh/(m2/year) from renewable sources on site.	15-30 kWh/(m2/year) of net primary energy, normally with primary energy use of 50-65 kWh/(m2/year) covered by 35 kWh/(m2/year) from renewable sources on site.
Continental Zone	40-55 kWh/(m2/year) of net primary energy, normally with primary energy use of 85-100 kWh/(m2/year) covered by 45 kWh/(m2/year) from renewable sources on site.	20-40 kWh/(m2/year) of net primary energy, normally with primary energy use of 50-70 kWh/(m2/year) covered by 30 kWh/(m2/year) from renewable sources on site.
Nordic Zone	55-70 kWh/(m2/year) of net primary energy, normally with primary energy use of 85-100 kWh/(m2/year) covered by 30 kWh/(m2/year) from renewable sources on site.	40-65 kWh/(m2/year) of net primary energy, normally with primary energy use of 65-90 kWh/(m2/year) covered by 25 kWh/(m2/year) from renewable sources on site.

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LESSON 3

Sustainable buildings (Concepts and standards)

The lesson 3 contains basic concepts and factors to be considered in a nearly zero consumption building according to European directive.

✓ The main objective of this lesson is to provide some basic concepts that will help you to understand the operation of nearly zero-energy buildings and it will serve as a basis for the next lessons.

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3. SUISTANABLE BUILDING

Concepts

NEAR-ZERO ENERGY BUILDINGS

According to DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of May 19, 2010

"Almost zero-consumption buildings are a building with a very high level of energy efficiency. The almost zero or very low amount of energy required should be covered, for the most part, by energy from renewable sources, including energy from renewable sources produced on-site or in the environment."

Factors to consider:

- The design, location, and orientation of the building, including the outdoor weather conditions.
- Real thermal characteristics of the building.
- Passive solar installations and sun protection (shading).
- Heating and Domestic Hot Water (D.H.W.) facilities, including their insulation.
- The air conditioning facilities.
- Natural and mechanical ventilation, including outdoor sealing conditions.
- The built-in lighting installation (especially in non-residential).
- Internal loads.
- Energy generation.

3. SUISTANABLE BUILDING

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Standards

Points to be considered:

- In most countries, the nZEB definitions refer to **maximum primary energy** as one of the **main indicators**.
- "Primary"/source energy includes all the energy needed to generate, transmit and distribute the final, metered energy consumption as measured by building energy meters.
  - In a **few cases** (e.g. the Netherlands and the Belgian Region of Flanders), the **primary energy use** of the building is **assessed through a non-dimensional coefficient**, comparing the buildings' primary energy use with a "reference" building with similar characteristics (e.g. building geometry).
  - In **several countries** (e.g. the United Kingdom, Norway and Spain) **carbon emissions** are used as the **main indicator**, **while in others** (e.g. in Austria and Romania) carbon emissions are used as a **complementary indicator** to primary energy use.
- For **residential buildings**, most jurisdictions aim to have a **primary energy use lower than 50 kWh/m2·y.**
- For **non-residential buildings**, the **requirements can have a broader range** in the same country depending on the **type of building.**

3. SUISTANABLE BUILDING

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Standards

The concept of NZEB proves the fact that **renewable energy and efficiency measures work together**. When placed on-building, renewable energy will reduce net delivered energy. In many cases, on-site renewable energy will not be enough to bring external energy needs close to zero, without further energy efficiency measures or a significant decrease of primary energy factors for off-site renewable energy sources.

Passive and active strategies coexist for implementing net-zero energy building:

- **Passive strategies**: building energy demand reduction through architectural design.
- **Active strategies**: building energy supply through machine equipment.

LESSON 4

Principles of energy efficiency (Passive and active design)

In this lesson you will learn the basic principles of energy efficiency in buildings related to passive and active building design. With respect to passive design, a distinction will be made between those solutions applied to the projection of the building and those applied to the interior design. In the active design you will study more efficient consumption systems. In addition, the use of the PVGIS software will be introduced.

- ✓ The main goal of this lesson is to learn how energy efficiency in buildings can be improved, both passively and actively and to classify the measures that apply to each type of design. In addition, provides you a tool to obtain the climatology features of any place.

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Depending on the local climate, passive strategies are studied and established to achieve maximum interior comfort.

It must be started from the sustainable architecture model using environmentally friendly techniques and materials, incorporating the conditions of the environment to the maximum extent and minimizing the negative impact of the building.

How can we introduce passive measurements in Near Zero Consumption Buildings?

a) Incorporating bioclimatic solutions in the building projection.

b) Adapting bioclimatic solutions to the interior design of the building.

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **projection of the building**

- **Climatology**
  - Situation
  - Location
  - Weather features

→

- It is important to know the humidity and temperature conditions of the environment, precipitation and prevailing winds.
- Through specific websites and programs such as Ecotect, Metonorm or PHPP, the weather data of each site are obtained.

These features are available in **PVGIS**

→

PVGIS is a web application that allows the user to get data on solar radiation and photovoltaic (PV) system energy production, at any place in most parts of the world.

https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html

- **Orientation**
  - Solar capture
  - Accumulation using termal inertia
  - Insulation
  - Interior layout of the building

→

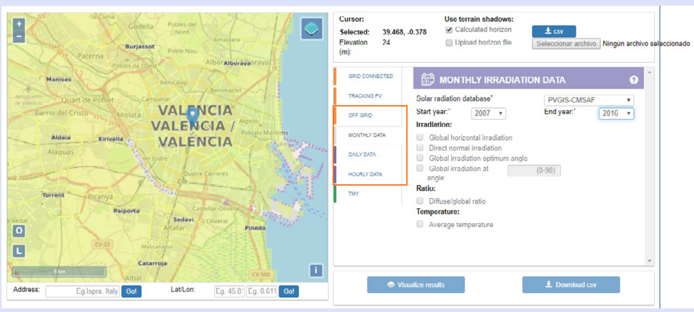
- The south orientation in the North Hemisphere is the most solar uptake in winter and easiest to protect against overheating in summer. Conversely, the north orientation would be the most suitable in South Hemisphere.

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **projection of the building**

PVGIS https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html



Monthly/Daily radiation values

Choosing Monthly, it calculates the monthly averages of solar radiation for the chosen location, showing in graphs or tables how the average solar varies over a multi-year period.

Daily, it shows the average solar irradiation for each hour during the day for a chosen month, with the average taken over all days in that month during the multi-year time period for which we have data.

Typical Meteorological Year (TMY) data

A typical meteorological year (TMY) is a set of meteorological data with data values for every hour in a year for a given geographical location.
These are some outputs that can be obtained and could be interesting for the projection of the building:

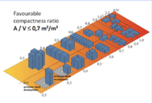
- Dry bulb (air) temperature (°C)
- Relative Humidity (%)
- Global horizontal irradiance (W/m2)
- Diffuse horizontal irradiance (W/m2)
- Infrared radiation downwards (W/m2)
- Windspeed (m/s)

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **projection of the building**

- ❑ **Compactness**



- Compactness is defined as the ratio between the surface of the outer envelope and the volume it encloses.
- Large buildings tend to be more compact (0.2-0.5/m) and in cold climates these tend to have lower energy demands.

- ❑ **Solar protections**

- Solar radiation, which is used as a passive source of energy for buildings, is an advantage that becomes an inconvenience in summertime.
- These protections are used in order to achieve the maximum solar collection in winter and minimize overheating in summertime.

- ❑ **Green roof and vegetal facades**

- Vegetation provides protection against wind, natural humidification of spaces and solar control, among others.
- These solutions contribute to increase the thermal inertia of the roof and the walls, getting a better bioclimatic perfomance of the building. Also, they recover part of the vegetation that was lost when the building was built.

4. PRINCIPLES OF ENERGY EFFICIENCY

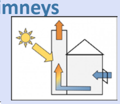
4.1 PASSIVE DESIGN

Bioclimatic solutions in the **projection of the building**

- ❑ **Greenhouses and glazed galleries**

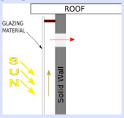
- A greenhouse is a glazed space that is attached to a construction to improve energy efficiency.
- Greenhouses produce an overheating of the air using the incident solar radiation.
- This hot air can be introduced into the building in order to increase its temperature in winter and in summer it should be ventilated to avoid overheating.

- ❑ **Ventilation and solar chimneys**



- Ventilation is the strategy for hot and humid climates. There is replaced indoor air overheated by cooler outside air. Increasing the speed of the air forcing ventilation, the sensation of interior heat is reduced.

- ❑ **Trombe Walls**



This is a blank wall oriented, according to the hemisphere, towards the more favorable position of the sun. For its construction, the materials used are those which allow to absorb heat as thermal mass, such as: concrete, stone or adobe.

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **building's interior design:**

❑ **Thermal inertia in walls: Opaque enclosures**

Factors to consider	Features
Heat loss	• They occur naturally between the house and the exterior. • An adequate amount of insulation should be used and the thermal bridges, ventilation and sealing of the building should be monitored.
Thermal conductivity λ	• Ability to transmit heat measured through the magnitude known as thermal conductivity coefficient, whose units in International System are W/(mK). • The lower the value of λ, the better the insulation of the material.
Thermal resistance R	• Material's ability to oppose heat flow. • The International System unit is m^2K/W.
Thermal transmittance U	• Physical property of materials that measures the amount of energy an element passes through in a unit of time. Units in the International System W/m^2K. • The lower the U value, the better the housing will have.

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

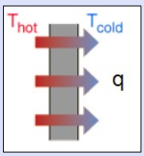
Bioclimatic solutions in the **building's interior design:**

❑ **Thermal inertia in walls: Opaque enclosures**

In order to calculate the conductive heat transfer through the walls, it can be expressed with "**Fourier's Law**":

$$Q = U \cdot A \cdot dT$$

$$U = \frac{1}{R} = \frac{1}{\frac{s1}{k1}+\frac{s2}{k2}+\frac{s3}{k3}\cdots}$$



q= $\left(\frac{Q}{A}\right)$ Heat transfer per unit area ($\left(\frac{W}{m^2}\right)$, $\left(\frac{J}{m^2 \cdot s}\right)$)

k = Total thermal conductivity of the material $\left(\frac{W}{m \cdot K}\right)$

s = material thickness (m)

A = heat transfer area (m^2)

R = $\frac{s}{k}$ = Thermal resistance ($\frac{m^2 \cdot K}{W}$)

U = Coefficient of Heat Transfer or Thermal transmittance $\left(\frac{W}{m^2 \cdot K}\right)$

dT = $T_1 - T_2$ = temperature gradient - difference over the material (°C, °F)

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **building's interior design:**

❑ **Thermal insulation**

- Initial measure, cheaper and more effective for energy savings.
- Essential element in passive houses or Passivhaus.
- The thickness of the material depends on the budget and the thermal insulation effect to achieve.

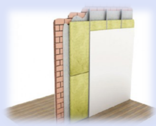
Types

- **Fibrous** → High porosity. *For example: mineral wool (rock wool), according to EN 13162.*
- **Cell** → Low density, low heating capacity and acceptable compress resistance. *For example: Expanded polystyrene, according to EN 13163.*
- **Granular** → Small particles of inorganic materials agglomerated in prefabricated or used loose forms. *For example: expanded vermicute.*

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **building's interior design:**



❑ **Acoustic insulation**

- Use of both absorbent materials and insulating materials.

Factors to be considered	Features
Massy factor	The higher the mass, the greater the resistance opposed to the shock of the sound wave and the greater the attenuation
Multilayer factor	For construction elements consisting of several layers it is important that sound insolation is higher than the sum of the individual layer's isolation levels.
Dissipation factor	Improves insulation if an absorbent material is placed between the two layers (low density and large amount of pores)

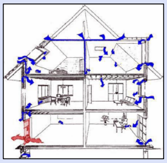
4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **building's interior design:**

❑ Tightness

- The sealing is different and independent on insulation.
- Maximum of 0.6 air changes per hour at 50 Pascals pressure (as verified with an onsite pressure test in both pressurised and depressurised states).
- Guarantying good sealing ensures the insulating effect of building components.



Pressurization test or blower door

Method used worldwide.
Allows detection of infiltrations and degree of sealing.

By using

- Anemometers
- Smoke generators
- Infrared thermography

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **building's interior design:**

❑ The hollows, doors and windows

Gaps are defined as enclosure zones more sensitive to temperature and sealing losses.

Parameters to control

- Comfort → It must be met for all living areas year-round with not more than 10% of the hours in any given year over 25°C.
- Health standards → Health requirements involve addressing indoor air quality through independent heat-exchange in the dwelling ventilation systems.
- Sealing
- Thermal insulation and solar control → The most important parameter. The two main elements are: glazing and the frame.

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

Bioclimatic solutions in the **building's interior design:**

❑ **Thermal bridges**

These are constructive elements in which the uniformity of the construction varies.

- For a Passivhaus building, where transmission and ventilation losses are very small, thermal bridges can have a big impact if not controlled in project and on-site.

Negative effects of thermal bridges:
- Increased thermal flow between indoors and outdoors
- Increased relative humidity (in winter) on the surface of the thermal envelope
- Risk of condensation and mold

General typologies

- Constructive: Variation of thickness in enclosures
- Geometric: Points where an inner surface corresponds to a larger exterior
- By material change: Due to the difference in thermal conductivity of materials

4. PRINCIPLES OF ENERGY EFFICIENCY

4.1 PASSIVE DESIGN

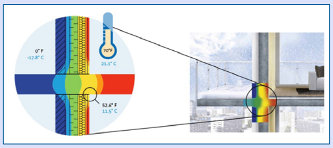
Bioclimatic solutions in the **building's interior design:**

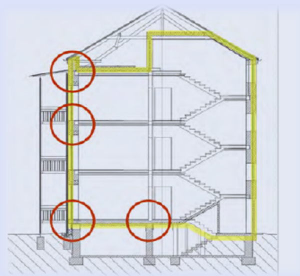
❑ **Thermal bridges**

In a building they are classified in:

Thermal bridges integrated into enclosures
- Pilars integrated into enclosures of facades
- Hollow and skylight contour
- Boxes of blinds

Thermal bridges formed by enclosure encounter
- Slab fronts on the facades
- Roof joints with facades
- Encounters of overhangs and/or interior partitioning with facades
- Facade uniond with enclosures in contact with the terrain





4. PRINCIPLES OF ENERGY EFFICIENCY

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4.2 ACTIVE DESIGN

The active design focuses directly on the choice and design of power generation and consumption systems. Reducing the energy consumption of a building's energy systems can basically be achieved in two ways.

- Reducing consumption, installing **more efficient consumption systems**, with lower losses.
- Introducing **generation machines or systems more efficient**, and taking advantage of the "free" energy from **renewable energy**.

4. PRINCIPLES OF ENERGY EFFICIENCY

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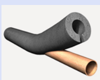
4.2 ACTIVE DESIGN

CONSUMPTION SYSTEMS: WATER



Pipe insulation

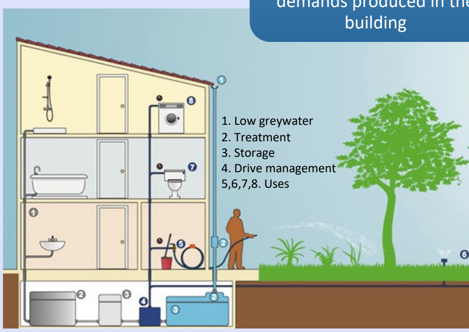
Domestic Hot Water

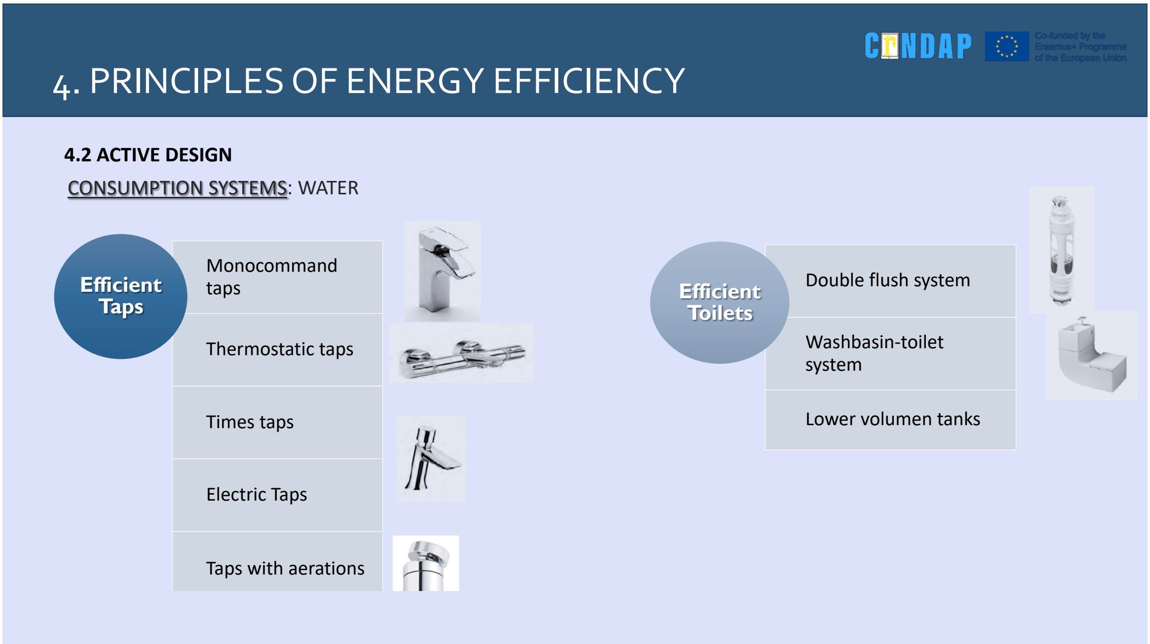
Return circuit

Proximity of production systems and consumer systems

Water saving

Systems for the use, storage and filtration of greywater or storm water for reuse in other demands produced in the building




4. PRINCIPLES OF ENERGY EFFICIENCY
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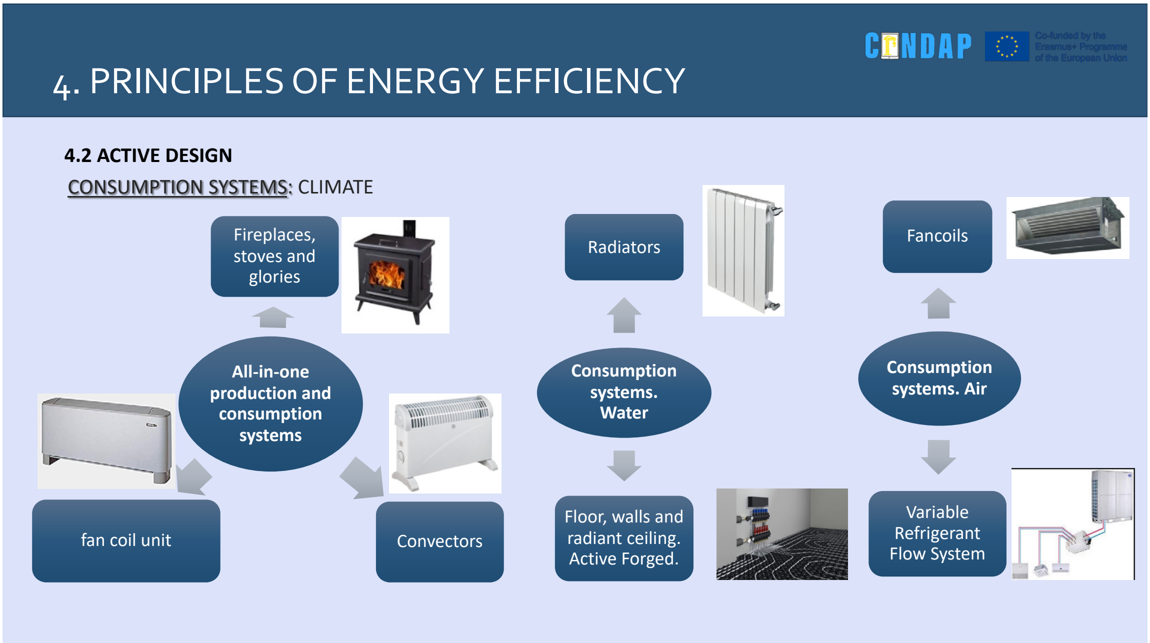
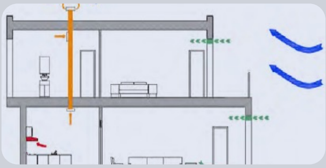
4.2 ACTIVE DESIGN
CONSUMPTION SYSTEMS: WATER
Efficient Taps
Monocommand taps
Thermostatic taps
Times taps
Electric Taps
Taps with aerations
Efficient Toilets
Double flush system
Washbasin-toilet system
Lower volumen tanks


4. PRINCIPLES OF ENERGY EFFICIENCY
Co-funded by the Erasmus+ Programme of the European Union
4.2 ACTIVE DESIGN
CONSUMPTION SYSTEMS: CLIMATE
Fireplaces, stoves and glories
All-in-one production and consumption systems
fan coil unit
Convectors
Radiators
Consumption systems. Water
Floor, walls and radiant ceiling. Active Forged.
Fancoils
Consumption systems. Air
Variable Refrigerant Flow System

4. PRINCIPLES OF ENERGY EFFICIENCY

4.2 ACTIVE DESIGN

CONSUMPTION SYSTEMS: VENTILATION



System A: Uncontrolled Ventilation

It is the easiest without mechanical devices. To carry out the air renovation, they are based on the pressure that air exerts on the facades of the buildings due to the temperature difference. The air inlet is caused by the poor sealing of the doors and windows, or by adjustable openings in the facades, while the extraction is produced by sub-pressure with ducts to the outside.

This system is no longer used due to the high discomfort generated, and the high energy consumption.

System B: Mechanical admission and natural extraction

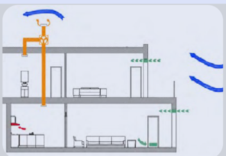
One or more fans are used to make air in and impulse it to the desired room through ducts. This system allows regulation and the possibility of being closed. The extraction is carried out naturally to outside with slits in wet areas.

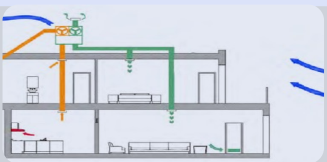
There is the possibility of being filtered and preventing the entry of contaminated air and dust. As disadvantages, it can be said that it generates thermal discomfort, by introducing air directly to the outside temperature, and annoying sound levels could be produced by the fan and ducts, if they are not calculated correctly.

4. PRINCIPLES OF ENERGY EFFICIENCY

4.2 ACTIVE DESIGN

CONSUMPTION SYSTEMS: VENTILATION





System C: Natural admission and mechanical extraction.

The extraction of stale air is mechanically carried out from the wet areas through an extractor connected to ducts where the air is extracted to the outside.

This simple system requires minimal maintenance. However, there is some disadvantage, such as the existence of discomfort due not being able to regulate the inlet air flow, nor the temperature of the inlet air, as well as the inlet of noise from outside.

System D1: Centralized mechanical admission and centralized mechanical extraction

A duct system allows to connect the admission and extraction with a centralized system that regulates the inlet and outlet flow rates, operating in a balanced way and allowing ventilation in all the cabins, regardless of their occupation or indoor air quality.

There is the possibility to integrate into the system a heat recovery, which allows to control the flow rates and take advantage of the exchange of temperatures between the inlet and the exhaust air (without mixing), reducing the air conditioning loads.

Heat recovery system are composed of air filters, a heat exchanger and blowers and extractor fans. The disadvantages are the maintenance of fans and ducts and their energy consumption.

System D2: Decentralized mechanical admission and centralized mechanical extraction

This system incorporates the virtues of the previous two systems, supplying their drawbacks. There are different decentralized mechanical drive units, which allow to regulate the inlet flow rate individually, while the ejection is carried out centrally in the kitchens and toilets.

It does not require intake ducts, so maintenance is reduced. Easy implementation in rehabilitations and the possibility to filter the inlet air. The drawback is the holes generated in the facade for admission, and the necessity to have a current point close to each mechanical inlet unit.

LESSON 5

Renewable energy sources (Active design)

In this lesson you will learn about the second part of active design regarding the generation from renewable energy sources and about the different generation systems available for a building. It is also presented the software PVGIS, which is used to calculate the photovoltaic system energy production.

- ✓ The main goal of this lesson is you know the different ways of generating power in building and their basic principles. How to use PVGIS software is also a target since you will need it to do the case study.

5. RENEWABLE ENERGY SOURCES

GENERATION SYSTEMS: WIND OR MINI-WIND ENERGY

The most widely used wind energy in the building is the small-power wind, which is defined as "The use of wind resources by using wind turbines with power less than 100kW." The 100kW limitation is marked by the Low Voltage Regulation, which establishes a maximum of that power. Moreover, IEC 614000-2 regulation, limits the rotor sweep area to 200m^2.

There are different types of small power wind turbines depending on the orientation of their shaft:

Horizontal axis

Vertical Lift Axis (Darrieus)

Vertical Drag Axis (Savonius)

5. RENEWABLE ENERGY SOURCES

GENERATION SYSTEMS: WIND OR MINI-WIND ENERGY

Wind turbines in the building generally have an installed power of around 10 kW, depending on the supply surface. For mass residential or large shopping malls, higher power wind turbines is used.

Mini-wind installations can directly deliver the produced electricity into the grid or use it for self-consumption:

- **Systems connected to the electrical grid**: wind turbines are usually connected to the electrical grid when the payment framework is interesting enough and connection procedures are not prohibitively expensive and complex.
- **Isolated systems:** they are usually installed when there is no nearby installation point to the grid in the building, and they are supplied only with wind power.

The different advantages of installing mini-wind power are :

- Emissions-free energy production of CO_2 or other pollutants
- Local electricity production reducing or minimizing energy losses of transport
- Power production where the electrical grid has not reached
- Power generation with low wind speeds, from 2.50 m/s

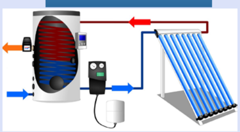
5. RENEWABLE ENERGY SOURCES

GENERATION SYSTEMS: SOLAR ENERGY IN THE BUILDING

Solar Energy is one of the most used in building due to the great efforts and incentives implemented from different European governments and guidelines.

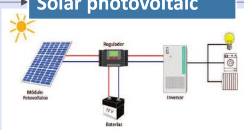
Types

Solar thermal



It is based on the use of sun radiation to heat a heat exchange fluid (water or oil) that is transported to an accumulator for use. For this purpose, the absorbent system usually has black pigmented elements, which facilitate the maximum uptake of radiation and the ducts are thermally isolated.

Solar photovoltaic

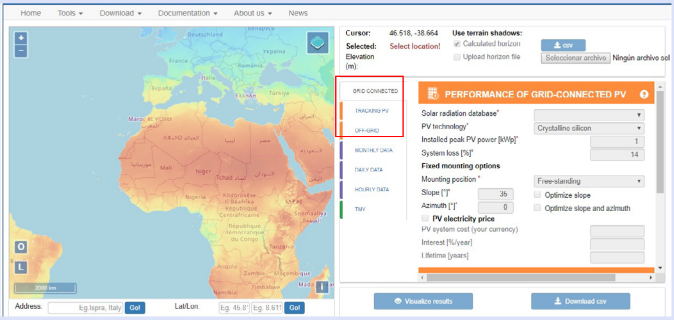


It is based on the "photoelectric effect" that certain light-sensitive materials have, so they are able to emit electrons when there is solar irradiation on them. Electrons released by several cells connected in series are transformed into a direct current flow. Silicon is the material which behaves best on this effect, is. To improve the operation of this material, the surface is coated with an anti-reflective layer.

5. RENEWABLE ENERGY SOURCES

GENERATION SYSTEMS: SOLAR ENERGY IN THE BUILDING

By using PVGIS software, it can be calculated the photovoltaic (PV) system energy production, at any place in most parts of the world. Also, there are three different types for PV system:



Performance of grid-connected PV systems

This tool makes it possible to estimate the average monthly and yearly energy production of a PV system connected to the electricity grid, without battery storage. The calculation takes into account the solar radiation, temperature, wind speed and type of PV module.

Performance of tracking PV

PV modules can be placed on mountings that move the PV modules to allow them to follow (track) the movement of the sun in the sky. In this way we can increase the amount of sunlight arriving at the PV modules. This movement can be made in several different ways:

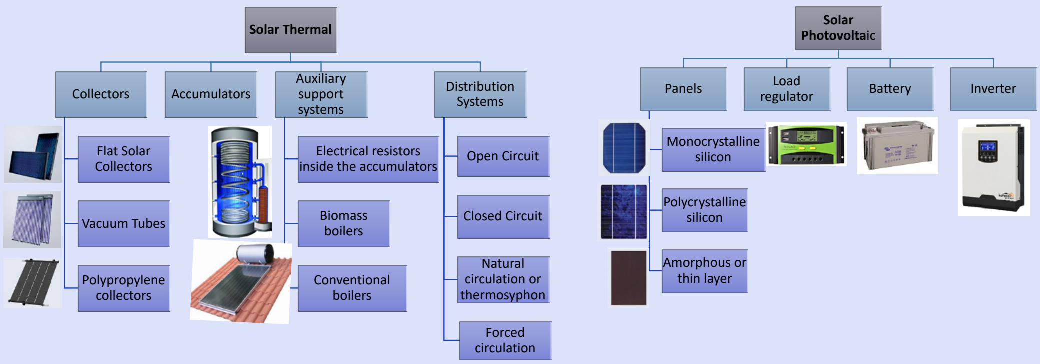
- Vertical axis.
- Inclined axis.
- Two-axis tracker.

Performance of off-grid PV systems

This part of PVGIS calculates the performance of PV systems that are not connected to the electricity grid but instead rely on battery storage to supply energy when the sun is not shining.

5. RENEWABLE ENERGY SOURCES

GENERATION SYSTEMS: SOLAR ENERGY IN THE BUILDING
Key elements of the installation:



5. RENEWABLE ENERGY SOURCES

GENERATION SYSTEMS: HEAT PUMPS

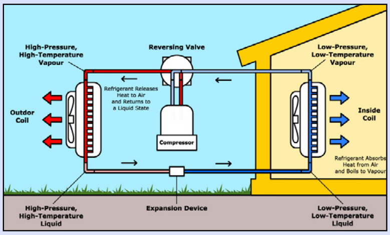
Heat pump is basically a machine that **transfers heat from one cold focus to a hot one. From** the **cold focus** the energy contained in air, ground or water is obtained so to heat the rooms by using a **small contribution of electric energy**, being this the main advantage over other systems.

They can also make the heat transfer **process in reverse,** extracting the thermal energy from the inside and returning it to the outside, cooling the interior rooms (extracting heat from them).

The **heat or cooling power of heat pumps, such as their energy efficiency (COP), often depending on the temperature** they are subjected. Furthermore, the higher COP, the higher the proportion of renewable thermal energy used.

In terms of cooling, it should be noted that heat pumps that use the ground as a heat sink (geothermal) have better COP than an air-based heat pump (aerothermia).

Elements of heat pumps



Exchange medium		
	Air - Air	Conditioning
	Air - Water	DHW and radiant floor
	Geothermal	Air conditioning and DHW

5. RENEWABLE ENERGY SOURCES

GENERATION SYSTEMS: APPLICATIONS OF HEAT PUMPS

GEOTHERMAL

The temperature of the earth varies depending on its depth. At a depth of about 10 meters, it remains constant and approaches the average annual temperature of the ambient air in the area. This phenomenon is due to the energy provided by solar radiation, precipitation, and other phenomena by which temperature is balanced and implies a constant heat source useful for a heat exchange through different types of catchment with pipes. In buildings it is used to air-condition spaces in both summer and winter and to produce DHW.

AEROTERMIA

Aerothermal is energy stored in the form of heat in the environment by an air-to-air or air-to-water heat pump, unlike geothermal whose medium is earth.

5. RENEWABLE ENERGY SOURCES

GENERATION SYSTEMS: BIOMASS

Biomass energy generation for residential buildings basically consists of the combustion of pellets (the most common), briquettes, firewood or chips. Its use is focused on heating and domestic hot water.

It is a high-efficiency energy because in addition to the energy results, the CO_2 emitted by a plant (base of biomass) during its natural decomposition is almost the same as it has absorbed during its growth. In a combustion process the vegetable releases the same proportion of CO_2, so heating biomass respects the carbon dioxide cycle.

It also saves transport costs and promotes the development of the area where it is generated.

LESSON 6

Energy certification

In this lesson you will learn about the applicable directives to energy certification, the characteristics of an Energy Performance Certificate (EPCs) of a building and some examples of software used to analyse and optimize the energy performance of a building. You will also learn about the energy management and monitoring systems (BMS and EMS) and the energy remote management.

- ✓ The main goal of this lesson is you know the main requirements of an EPC as well as the computer tools which could help you to calculate the energy performance of a building. In addition, you must know the concept and advantages of energy management and monitoring systems and energy remote management.

6. ENERGY CERTIFICATION

6.1 APPLICABLE DIRECTIVES

The main applicable laws for the promotion of energy performance certification (EPC) in buildings are the Energy Efficiency in Buildings Directive (2010/31/EU revised by 2018/844/EU) and the Energy Efficiency Directive (2012/27/EU). Based on them, each member country has developed a basic procedure for the certification of the energy efficiency of buildings, where a classification is granted based on the energy consumption in kWh / m2 of the building and CO2 emissions in kgCO2 / m².

- The main aim of the EPC is to serve as an information tool for building owners, occupiers and real estate actors. Therefore, EPCs can be a powerful market tool to create demand for energy efficiency in buildings by targeting such improvements as a decision-making criterion in real-estate transactions, and by providing recommendations for the cost-effective or cost-optimal upgrading of the energy performance.
- In order to support the energy rating calculation different software are commonly used. In some countries, a specific calculation program has been developed by public bodies to get the certification. The following slides show some of which are generally used.

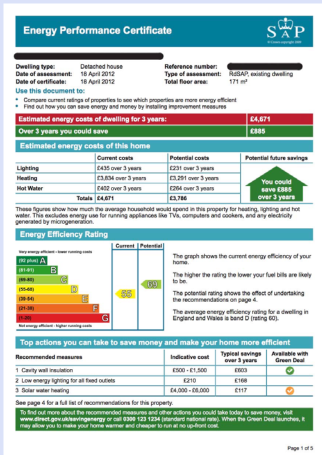
6. ENERGY CERTIFICATION

6.2 ENERGY PERFORMANCE CERTIFICATE OF A BUILDING

Energy Performance Certificates (EPCs) are required when a building or property over 50m² is built, sold or rented. They are valid for ten years. The EPC has two parts:

- A graphic rating calculated on the performance of the building and its building services:
  - The size of the building and the different activity areas within it.
  - Insulation levels in the building.
  - The systems providing heat to your building.
  - How fresh air moved around the building.
  - What keeps the building cool.
  - How hot water is provided to bathrooms and kitchens.
  - Building management systems or controls.
  - Electricity feed for the building.
  - Lighting systems for the building.
  - Presence of onsite energy generation.
  - How the building is used and by whom.

  * The more complete the information on these areas the more accurate the rating and recommendations are likely to be.
- An indicator of the potential rating of the building if all the cost-effective measures suggested in the recommendations are carried out.



Energy Performance Certificate SAP

[redacted]

Dwelling type: Detached house
Date of assessment: 18 April 2012
Date of certificate: 18 April 2012
Reference number: [redacted]
Type of assessment: RdSAP, existing dwelling
Total floor area: 171 m²

Use this document to:

- Compare current ratings of properties to see which properties are more energy efficient
- Find out how you can save energy and money by installing improvement measures

Estimated energy costs of dwelling for 3 years:	£4,671
Over 3 years you could save	£885

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£435 over 3 years	£231 over 3 years	You could save £885 over 3 years
Heating	£3,834 over 3 years	£3,291 over 3 years	
Hot Water	£402 over 3 years	£264 over 3 years	
Totals	£4,671	£3,786	

These figures show how much the average household would spend in this property for heating, lighting and hot water. This excludes energy use for running appliances like TVs, computers and cookers, and any electricity generated by microgeneration.

Energy Efficiency Rating

Very energy efficient - lower running costs
(92 plus) A
(81-91) B
(69-80) C
(55-68) D
(39-54) E
(21-38) F
(1-20) G
Not energy efficient - higher running costs

Current: 55
Potential: 69

The graph shows the current energy efficiency of your home.

The higher the rating the lower your fuel bills are likely to be.

The potential rating shows the effect of undertaking the recommendations on page 4.

The average energy efficiency rating for a dwelling in England and Wales is band D (rating 60).

Top actions you can take to save money and make your home more efficient

Recommended measures	Indicative cost	Typical savings over 3 years	Available with Green Deal
1 Cavity wall insulation	£500 - £1,500	£603	✓
2 Low energy lighting for all fixed outlets	£210	£168	
3 Solar water heating	£4,000 - £6,000	£117	✓

See page 4 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit **www.direct.gov.uk/savingenergy** or call **0300 123 1234** (standard national rate). When the Green Deal launches, it may allow you to make your home warmer and cheaper to run at no up-front cost.

Page 1 of 5

Example of Austrian EPC

6. ENERGY CERTIFICATION

6.3 SIMULATION AND SOFTWARE

- **Energy+**

Energy analysis and simulation program of thermal loads. It calculates the heat and cold loads necessary to maintain control conditions, conditions throughout the air conditioning system and loads, and equipment energy consumption.

- **DesignBuilder**

It is a software tool based on EnergyPlus used for measuring and controlling energy, carbon, lighting and comfort. DesignBuilder is developed to facilitate the building simulation process

- **Simergy**

It is an innovative product based on BIM that allows architects, engineers, contractors and building owners to simulate, analyze and optimize the performance of their building designs before building them. It is used by leading companies in the industry to optimize the energy efficiency of the building, natural lighting and comfort.

- **Ecotect**

Autodesk® Ecotect® Analysis software is a comprehensive design and sustainable concept-to-detail analysis tool that provides a wide range of simulation and analysis functions to improve the performance of existing buildings and new building designs.

6. ENERGY CERTIFICATION

6.3 SIMULATION AND SOFTWARE

- **Trnsys**

It is a simulation program of transitional systems with a modular structure. TRNSYS has become a reference software for researchers and engineers around the world. The main applications include: solar systems (solar thermal and photovoltaic systems), low energy buildings and HVAC systems, renewable energy systems, cogeneration, fuel cells.

- **eQUEST**

It is a free and easy-to-use construction energy use analysis tool that provides results at a professional level with an affordable level of effort. It allows users to perform a detailed analysis of the most modern building design technologies using today's most sophisticated building energy use simulation techniques, but without requiring extensive experience in the "art" of modeling good performance buildings.

- **Fluent**

Fluent is fully integrated into the ANSYS Workbench environment, a platform designed for efficient and flexible workflows, CAD associativity and powerful geometry and mesh modeling capabilities. ANSYS Fluent can solve the most sophisticated models for multiphase flows, chemical reaction and combustion. Even complicated, internal and external viscous and turbulent flows, flow-induced noise predictions, heat transfer with and without radiation can be easily modeled.

6. ENERGY CERTIFICATION

CONDAP

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6.4 ENERGY MANAGEMENT AND MONITORING SYSTEMS

There are two main complementary technological tools for managing the energy efficiency of the building:

SCADA is an acronym for supervisory control and data acquisition, a computer system for gathering and analyzing real time data.

Defined as a SCADA system in building management.

Applied to lighting, air conditioning, fire protection systems ...

BMS (Building Management System)

BEMS

BEMS systems make a significant contribution to obtaining energy certificates for buildings (LEED, BREEAM, etc.).

EMS (Energy Management System)

Used for monitoring, analysis and monitoring of energy installations in buildings and industries.

6. ENERGY CERTIFICATION

CONDAP

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6.4 ENERGY MANAGEMENT AND MONITORING SYSTEMS

The implementation of a BEMS system consists of:

1. Energy diagnosis and audit with energy improvement measures.
2. Development of energy indicators and their temporal evolution.
3. Control, recording and monitoring of energy consumption and costs.
4. Execution of improvement measures obtained in the audit.
5. Measurement and verification of the improvement measures implemented.

Through **energy remote management** technology.

The main energy efficiency indicators are:

- Annual CO_2 emissions
- Annual consumption of non-renewable primary energy.

ADVANTAGES of introducing a **BEMS** management system:

- ✓ Better control of energy consumption.
- ✓ Better analysis of energy costs.
- ✓ Better understanding of the environmental implications of the facilities.

6. ENERGY CERTIFICATION

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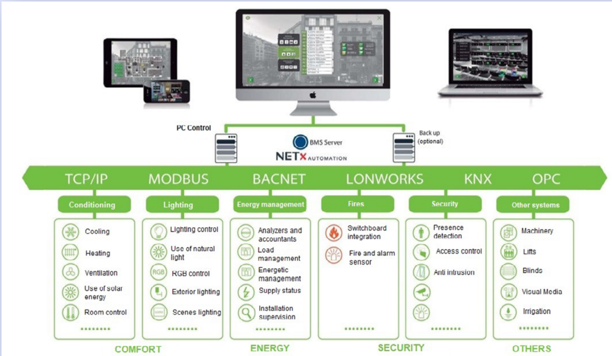
6.4 ENERGY MANAGEMENT AND MONITORING SYSTEMS

The following graphic shows the potential capacity of installing a BEMS in a building.
There are two barriers that make it difficult to implement this system:

- Existing buildings lack the necessary infrastructure to have digital control.
- Ignorance of the new BEMS concept.

To overcome these barriers, it is proposed:

- Building automation technologies that integrate wired, wireless and Internet technology to improve interoperability of automation systems.
- The need to convince the user about the utility of these systems. Also, the advanced and analytical tools ensure the management will achieve sustainability goals



6. ENERGY CERTIFICATION

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6.5 ENERGY REMOTE MANAGEMENT

- Set of products based on computer, electronic and telecommunications technologies, which allow remote control of isolated or geographically distributed technical facilities.
- Technology used to control energy consumption and for different supplies.
- Record the information in order to analyze and optimize.

Main elements

- Datalogger → Electronic device that is installed in the electrical panel of the facilities to be analyzed.
It can be connected to the personal computer and even to have a device on which view the recorded data.

- Monitoring software → Specific software to analyze the data collected by the datalogger.
It can be programmed according to the objective pursued.

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LESSON 7

Examples

In this lesson you will have the characteristics, facilities and constructive data of two real cases of energy efficient buildings.

✓ The target of this lesson is you realize how the studied measures are applied in reality and to familiarize yourself with the kind of materials and facilities used in nearly zero energy buildings.

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7. EXAMPLES

7.1 CARTIF III (Valladolid, Spain, 2011)

- Builded surface: 4075 m2
- Total cost: 4.645.758€

Part of the European DIRECTION project whose consumption limit (primary energy) had to be below 60 kWh / m2 year

Primary Energy Demand
Heating demand: 17,62 kWh/m2 año
Cooling demand: 6,18 kWh/m2 año

Cooling load
Heating Power Installed: 68 W/m2
Cooling Power Installed: 18,11 W/m2

Energy rating: A

7. EXAMPLES

CONDAP

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7.1 CARTIF III (Valladolid, Spain, 2011)

Facilities

Renewables and self-consumption system
- Geothermal
- Biomass
- Photovoltaic solar installation 45KV

Heating system
- Geothermal (reversible water-water geothermal pump with a nominal power of 57.36 kW of heat, 73.8 kW of cold, a COP of 3.18 and EER of 4.99; 15 geothermal probes of double U of polyethylene of 100m with water / glycol solution)
- Biomass (biomass boiler, pellets, nominal power 220kW, modular)

DHW Production System
- Biomass boiler indicated for heating.
- 200L accumulation system, with automatic regulation system and thermostatic valve for distribution

Cooling System
- Geothermal. Air conditioners with air units.
- Radiant and refreshing floor

Ventilation system
- Air conditioning with cold/heat battery, free-cooling, mixing box, energy recovery, adiabatic cooling, filters and pre-installation for desiccant systems.
- Climaver ducts through the internal areas and aluminum sheet on the outside.
- Diffusion by rotational diffusers and grilles. The flow of each room is adjustable with variable flow dampers.

7. EXAMPLES

CONDAP

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

7.1 CARTIF III (Valladolid, Spain, 2011)

Constructive data

WALL
- Basement: Reinforced concrete H25 200mm con polystyrene (EPS) 20mm. U=0,207 [W/m2.K]
- Façade SO y SE: thermo clay (300x140x190mm); Mineral wool 50mm; aluminium panels. U=0,452 [W/m2.K]
- Façade SE: Concrete; insulation EPS 50mm; thermo clay (300x140x190); natural Stone panels. U=0,453 [W/m2.K]

CEILING: Inverted flat roof: U=0,339 [W/m2.K]
- Forged alveolar plate with compression layer (25+10)
- Lightened concrete for slope formation.
- Waterproofing sheet of PVC P 1,2mm
- Rigid tongue and groove sheet of extruded polystyrene 3cm (0,034W/m.K)
- Porous concrete slab: concrete e=4cm + extruded polystyrene insulation e=5cm (0,034 W/m.K)

GROUND
- Basement: concrete 40/80 mm; polyethylene sheet1mm; reinforced concrete slab HA-25, 200mm. U= 0,64 [W/m2.K]
- Internal: compact stoneware tiles; glue mortar; levelling layer. U= 0,81 [W/m2.K]

CARPENTRY
- Curtain wall: doble cristal con cámara de aire (6/12/6). U=1,517 [W/m2.K]
- Oficinas: aluminio con rotura puente térmico. U= 1,995 [W/m2.K]

7. EXAMPLES

7.2. Passive House Ebner (Austria 2014)

MAIN DATA

- Housing for residential use
- Area: 160 m^2 useful floor area, 216 m^2 of total surface
- Cost of Housing: 300.000€ (1,875 €/m^2 per useful area of floor)
- Disbursement made by the Styria government subsidy, including a bonus for building a passive home
- 42% improvement in energy demand compared to the requirements set by the OIB (Austrian Institute of Construction Engineering) in 2011
- 48% of final energy covered by renewable energy
- Systems included:
  - Pellet boiler
  - Mechanical ventilation system with 86% heat recovery
  - DHW demand covered mainly by solar thermal energy

7. EXAMPLES

7.2. Passive House Ebner (Austria 2014)

CONSTRUCTIVE DATA

Main use of environmental construction materials in building envelopes:

WALL
- Walls and roof formed by 70 cm straw bullets between wooden frames (U=0.065 W/m^2·K)

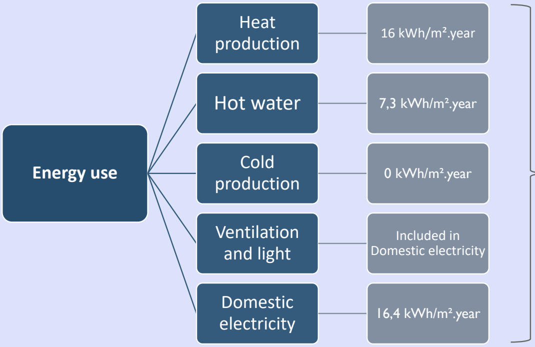
COVER AND FLOOR
- Floor formed from gravel-filled glass foam under a concrete motherboard
- The roofing has a heat transmission coefficient of U=0.065 W/m^2·K
- Forging of the first floor (U=0.11W/m^2·K)

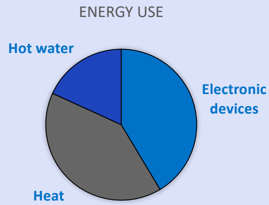
WINDOWS
- Triple glazed windows (U=0,86 W/ m^2·K)

7. EXAMPLES

7.2. Passive House Ebner (Austria 2014)

ENERGY DATA





Total energy produced

39,7 kWh/m²·year

- Total primary energy: 85,9 kWh/m²·year
- Total CO_2 emissions: 10,4 kg/m²·year

8. BIBLIOGRAPHY

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CHAPTER III:

CASE STUDIES

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ENERGY EFFICIENCY AND SUSTAINABLE CONSTRUCTION

CONDAP OPEN EDUCATIONAL RESOURCES

CASE STUDIES

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CASE STUDY 1

Measures to reduce housing energy consumption and improve energy efficiency for a single-family house depending on its location.

CASE STUDY 1

- **We are going to design a single-family house considering all the parameters explaining in the lectures notes.**
- **Locations:**
  - Valencia (Spain)
  - Vilnius (Lithuania)
  - Brussels (Belgium)
- **For each location it is required to obtain:**
  - The demand required for your climate zone according to Directive 2010/31/EU
  - Climatology data from PV GIS
  - The best orientation (house and solar panels)
  - Other Passive Measures
  - Active Measures

CASE STUDY 1

- The demand required for your climate zone according to Directive 2010/31/EU

	Climate zone	Energy demand
Valencia (Spain)		
Vilnius (Lithuania)		
Brussels (Belgium)		

- Climatology data from PV GIS

	Maximum annual temperature	Minimum annual temperature	Maximum Global Horizontal Irradiation	Minimum Global Horizontal Irradiation
Valencia (Spain)				
Vilnius (Lithuania)				
Brussels (Belgium)				

- The best orientation

Valencia (Spain)	Vilnius (Lithuania)	Brussels (Belgium)

CASE STUDY 1

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➢ **Other Passive Measures**

Chose and justify three relevant passive measures which best fits in each country

Valencia (Spain)	Vilnius (Lithuania)	Brussels (Belgium)

CASE STUDY 1

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➢ **Active Measures**

	Valencia (Spain)	Vilnius (Lithuania)	Brussels (Belgium)
Hot water efficiency			
Water consumption saving			
Climate system			
Ventilation			
Generation system			

CASE STUDY 1 - *SOLUTION*

- The demand required for your climate zone according to Directive 2010/31/EU

	Climate zone	Energy demand
Valencia (Spain)	*Mediterranean Zone*	*0-15 kWh/(m2/year) of net primary energy, normally with primary energy use of 50-65 kWh/(m2/year).*
Vilnius (Lithuania)	*Continental Zone*	*20-40 kWh/(m2/year) of net primary energy, normally with primary energy use of 50-70 kWh/(m2/year).*
Brussels (Belgium)	*Continental Zone*	*20-40 kWh/(m2/year) of net primary energy, normally with primary energy use of 50-70 kWh/(m2/year).*

- Climatology data from PV GIS *(*By using PVGIS monthly data, last year available)*

	Maximum annual temperature	Minimum annual temperature	Maximum Global Horizontal Irradiation (monthly)	Minimum Global Horizontal Irradiation (monthly)
Valencia (Spain)	*25.8 ºC*	*12ºC*	*235 kWh/m2*	*61.1 kWh/m2*
Vilnius (Lithuania)	*18.5 ºC*	*-6.2 ºC*	*186 kWh/m2*	*8.95 kWh/m2*
Brussels (Belgium)	*19.5 ºC*	*4.6 ºC*	*162 kWh/m2*	*22.1 kWh/m2*

- The best orientation

House's façade: South

Valencia (Spain)	Vilnius (Lithuania)	Brussels (Belgium)
Slope angle [°]: 36 (opt) *Azimuth angle [°]: -1 (opt)*	*Slope angle [°]: 37 (opt)* *Azimuth angle [°]: -8 (opt)*	*Slope angle [°]: 37 (opt)* *Azimuth angle [°]: -7 (opt)*

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CASE STUDY 1 - *SOLUTION*

- **Other Passive Measures**

Choose and justify three relevant passive measures which best fits in each country – *OPEN ANSWER*

Valencia (Spain)	Vilnius (Lithuania)	Brussels (Belgium)
The exterior walls, roof and floor must have a low thermal transmittance installing from 15 to 18 cm thicknesses. There can be used materials such as expanded Polystyrene (EPS), extruded Polystyrene (XPS) or rockwool.	*The roof structure consists of mineral wool insulation. Mineral wool insulation is also used to insulate the walls and it is 35 cm thick. Floor on the ground is used to be insulated with a 33 cm extruded polystyrene foam layer.*	*The façades and roof are isolated with 40 cm of extruded polystyrene, the foundation is wood with triple glazing, and a sliding panel prevents overheating in summer.*
The enclosure must be as seal as possible performing a pressure test, or blower test Door that guarantees a high level of tightness in the building.	*The windows with the heat transfer coefficient from 0.73 to 0.84 W/m2 K (depending on the size of the windows) are installed in order to fulfil the passive house concept recommendations. Protection from the overheating in the summertime is provided by mobile shutters and a curtain on the southern side of the building.*	*There are extensive green roofs which provide a natural habitat for biodiversity. In addition to this "green" aspect, the buildings meet the passive standard. To achieve this standard, the project focuses mainly on insulation. A 25-cm façade insulation, a 30-cm roof insulation and a high-performing frame allow the reduction of heat loss by 70%.*
Carpentry is installed with high thermo-acoustic performance. These products have very low thermal transmittance and are made up with multilayer glass filled with inert gas. *The glass is low emissive to reflect the heat inside the building in winter and keep it in the outside during summer. This applies also in order make a greenhouse .*	*To ensure the air tightness of the building, there are installed wind protective layers and there should be assembled an air-tight inner layer.* *Also, the building should be inspected for air leakages before installation of internal finishes. Identified leak sites have been sealed.*	*The risk of overheating is reduced by the judicious placement of balconies and open spaces which increase the speed of the air forcing ventilation.*

CASE STUDY 1 - *SOLUTION*

Active Measures - *OPEN ANSWER*

	Valencia (Spain)	Vilnius (Lithuania)	Brussels (Belgium)
Hot water efficiency	*In order to maintain the hot water efficiency it can be used pipe insulation or return circuit to obtain an acceptable temperature level.*	*It is used the proximity of production systems and consumer systems with the aim of maintaining the hot water efficiency.*	*There is used a return circuit to obtain an acceptable temperature level concerning the hot water efficiency.*
Water consumption saving	*There can be used efficient taps like monocommand or times tap.*	*For water consumption saving it could be used efficient toilets like the double flush system or efficient taps like times taps.*	*In order to increase the water consumption saving there can be used efficient toilets like washbasin-toilet system or lower volumen tanks.*
Climate system	*For the climate system it is used highly efficient fan coil units.*	*Regarding the climate system, in consumption systems it could be used floor, walls and radiant ceiling.*	*Concerning the climate system it is used floor, walls and radiant ceiling and water radiators.*
Ventilation	*The most common system used is System B: Mechanical admission and natural extraction.*	*Concerning the ventilation system it could be emphasized the system C: Natural admission and mechanical extraction. This device heats incoming external air by using the heat extracted from outgoing inside air*	*All houses must have adequate ventilation since the air inside should be healthy, in this way, it is used System B: Mechanical admission and natural extraction.*
Generation system	*Due to the higher irradiation from Valencia, it is used solar thermal energy in order to obtain domestic hot water. Also, there is used heat pumps with the of heating or cooling the rooms.*	*Biomass represents the most common source of renewable energy in Lithuania, with most of the biomass is use being firewood.*	*Solar collectors are used in order to obtain domestic hot water combined with solar water heaters. Also, photovoltaic solar collectors directly transform light into electricity. Given that the sun does not shine at all times, it is appropriate to either use a storage system or be connected to the grid to ensure a permanent supply.*

CASE STUDY 2

Evaluation of the different PV systems in PVGIS by modifying its corresponding parameters.

CASE STUDY 2

1. Measures to decrease the energy consumption of a single-family house.

- The aim of this practice is to rehabilitate a single-family house in order to decrease its energy consumption. The measures to be implemented consist of the reduction of internal loads and supplying electricity through solar panels.
- Internal loads are considered as household appliances and devices which consume energy from the grid. The measures related to internal loads consists of the selection of more efficient devices, in other words, those with less energy consumption.
- The following table shows the most typical household appliances at the single-family house in a day. Also, it is provided their energy consumption.

	nº	POWER (W)	TOTAL POWER (W)	h/day	Daily consumption (Wh/day)
Lighting: Halogens (600 lumen)	4	40	160	4	640
TV 26”	1	150	150	4	600
Heat pump (2,6kW)	1	1000	1000	4	4000
Laptop	1	65	65	4	260
Fridge (net capacity 300L)	1	110	110	24	2640
Washing machine	1	550	550	1,5	825
Microwave	1	1200	1200	0,1	120
TOTAL CONSUMPTION (Wh/day)					9085

CASE STUDY 2

- Should be calculated:
  - Selection of more efficient equipment (with lower energy consumption) that reduce housing consumption. It is possible you find the energy consumption in KWh/año for some appliances. In that case you must divide between 365 days to calculate the daily consumption and also between 24 to calculate the power.
  - Calculate the total consumption in order to compare its coverage with different settings of PV system.

	nº	POWER (W)	TOTAL POWER (W)	h/day	Daily consumption (Wh/day)
Lighting (600 lumen)	4			4	
TV 26”	1			4	
Heat pump (2,6kW)	1			4	
Laptop	1			4	
Fridge (net capacity 300L)	1			24	
Washing machine	1			1,5	
Microwave	1			0,1	
TOTAL CONSUMPTION (Wh/day)					

CASE STUDY 2

2. Grid connected case

- Choose solar radiation database from PVGIS-CMSAF (suitable for European Countries) and Crystalline silicon as PV technology.
- Consider Installed peak PV power [kWp] of 1,5kW and 20% of system loss.
- Calculate the percentage of demand covered per day during the most favorable and unfavorable month of global irradiation in the following cases:
  - CASE 1: Fixed mounting and **building integrated** (modules are completely built into the structure of the wall or roof of a building, with no air movement behind the modules) with optimized slope and azimuth.
  - CASE 2: Fixed mounting and **free-standing** (modules are mounted on a rack with air flowing freely behind the modules, which reduces the losses due to temperature) with optimized slope and azimuth.
  - CASE 3: Optimized inclined axis **tracking mounting**.
- Calculate the PV electricity cost [per kWh] considering a PV system cost of 1€/$W_{installed}$ and a life time of 25 years. Indicate 1% of interest to consider de maintenance of the system.

CASE STUDY 2

2. Grid connected case

- OUTPUTS

Valencia (Spain)						
	Maximum daily energy output (kWh/day) 1)	Minimum daily energy output (kWh/day)	Maximum percentage of energy demand covered 2)	Minimum percentage of energy demand covered	Yearly PV energy production (kWh)	PV electricity cost (€/kWh)
CASE 1						
CASE 2						
CASE 3						-

1) To calculate the daily energy output from the monthly energy output divide between the number of days of that month.
2) To calculate the percentage of energy demand covered divide the total consumption per day between the daily energy output

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CASE STUDY 2

2. Grid connected case

Brussels (Belgium)						
	Maximum daily energy output (kWh/day) 1)	Minimum daily energy output (kWh/day)	Maximum percentage of energy demand covered 2)	Minimum percentage of energy demand covered	Yearly PV energy production (kWh)	PV electricity cost (€/kWh)
CASE 1						
CASE 2						
CASE 3						-
Vilnius (Lithuania)						
	Maximum daily energy output (kWh/day) 1)	Minimum daily energy output (kWh/day)	Maximum percentage of energy demand covered 2)	Minimum percentage of energy demand covered	Yearly PV energy production (kWh)	PV electricity cost (€/kWh)
CASE 1						
CASE 2						
CASE 3						-

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CASE STUDY 2

2. Grid connected case

- QUESTIONS & CONCLUSIONS

- What city is the most and the less suitable for our installation? Why?

- To what is the difference among the percentage of demand covered the 3 cases due? In which country is more relevant this difference?

- It is economically rentable the PV installation considering a life time of 25 years for the panels? Calculate the years needed to recover the investment with the energy saving in the CASE 1 taking into account the following assumption:
  - Electricity prices (including taxes) for household consumers in EU, first half 2019: Spain (0,2403€/kWh), Belgium (0,2839 €/kWh) and Lithuania (0,1255 €/kWh).
  - The same price of our installation 1€/$W_{installed}$ without associated maintenance costs.
  - The energy consumption is 5,5 kWh/day constantly for all the days of the year.

CASE STUDY 2 - SOLUTION

- This is a open question but it is expected to achieve energy savings in the range of 30 to 50%.

	nº	POWER (W)	TOTAL POWER (W)	h/day	Daily consumption (Wh/day)
Lighting: Halogens (600 lumen)	4	6	24	4	96
TV 26"	1	36	36	4	144
Heat pump (2,6kW)	1	700	700	4	2800
Laptop	1	40	40	4	160
Fridge (net capacity 300L)	1	70	70	24	1680
Washing machine 6kg	1	450	450	1,5	675
Microwave with grill	1	800	800	0,1	80
TOTAL CONSUMPTION (Wh/day)					5635

CASE STUDY 2 - SOLUTION

		Maximum daily energy output (kWh/day)	Minimum daily energy output (kWh/day)	Maximum percentage of energy demand covered*	Minimum percentage of energy demand covered*	Yearly PV energy production (kWh)	PV electricity cost (€/kWh)
Valencia (Spain)	**CASE 1**	6,935	4,387	123,1%	77,9%	2150	0,046
	CASE 2	7,258	4,548	128,8%	80,7%	2240	0,044
	CASE 3	10,516	5,548	186,6%	98,5%	2970	-
Brussels (Belgium)	**CASE 1**	5,613	1,239	99,6%	22,0%	1360	0,072
	CASE 2	5,839	1,261	103,6%	22,4%	1400	0,070
	CASE 3	7,58	1,442	134,5%	25,6%	1790	-
Vilnius (Lithuania)	**CASE 1**	5,645	0,494	100,2%	8,8%	1220	0,080
	CASE 2	5,871	0,5	104,2%	8,9%	1260	0,078
	CASE 3	7,903	0,558	140,2%	9,9%	1620	-

These values depend on the energy saving achieved so they could be a little bigger or smaller

CASE STUDY 2 - *SOLUTION*

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2. Grid connected case

- QUESTIONS & CONCLUSIONS

➢ **What city is the most and the less suitable for our installation? Why?**

Valencia is the most suitable because it has the best weather conditions and the less one is Vilnius because has the worst weather conditions.

➢ **To what is the difference among the percentage of demand covered the 3 cases due? In which country is more relevant this difference between the maximum and minimum coverage? What could be the reason for this?**

The least efficient mounting is the building integrated (CASE 1) due to the thermal losses and the incapacity to change the tilt of the panels while the tracking mounting is the best efficient due to the possibility of capturing more solar radiation. The free-standing is an intermediate case.
The different between the maximum and minimum coverage is more notable when we get further away from the Ecuador (due sphericity of the Earth as to its inclination with respect to the Sun) so in Lithuania the difference is higher than the other countries and therefore solar panels are less profitable.

CASE STUDY 2 - *SOLUTION*

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2. Grid connected case

- QUESTIONS & CONCLUSIONS

➢ **It is economically rentable the installation considering a life time of 25 years for the panels?**

- Money saved per year = Energy consumption per day × Days at Year × (Grid price – PV System price case 1)
- Years to achieve the investment = $\frac{\text{PV system cost}}{\text{Money saved per year}}$

➢ Valencia: 5,5 KWh/day*365days/year*(0,2403€/kWh – 0,046 €/kWh) = 390 € saved/year
  - Years to achieve the investment = 1500€/390€ = 3,846 years

➢ Brussels: 5,5 KWh/day*365days/year*(0,2839 €/kWh – 0,072 €/kWh) = 425,4 € saved/year
  - Years to achieve the investment = 1500€/390€ = 3,526 years

➢ Vilnius: 5,5 KWh/day*365days/year*(0,1255 €/kWh – 0,080 €/kWh) = 91,341 € saved/year
  - Years to achieve the investment = 1500€/91,341 € = 16,422 years

CASE STUDY 3

Calculation of the heat transmitted through a wall and its corresponding energy savings.

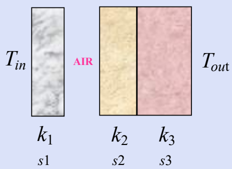
CASE STUDY 3

CASE 3.1.

The wall of a house consists of an outer 10 cm thick layer of bricks (k3 = 0,69 W/m·ºC), following by a coating 1,25 cm thick layer (k2 = 0,048 W/m·ºC). The inner wall is made up of an 1,25 cm thick layer (k1 = 0,744 W/m·ºC), which is separated of the lining by a 10 cm thick layer of air. The conductivity of the air layer is 0.024 W/m·ºC.

The temperature of the outer brick is 5 ºC, while the inner sufarce remains at 20 ºC.

1. What is the rate of heat loss per unit area of wall?



CASE STUDY 3

CASE 3.2.

- Years later, some changes are made to the walls:
- The outer layer of bricks remains unchanged with 10 cm thick and k = 0,69 W/m·ºC.
- The coating layer changes to other material which conductivity is k = 0,035 W/m·ºC and its thickness remains.
- The inner layer changes also to other material which conductivity is k = 0,65 W/m·ºC and with 1,30 cm thick layer, separated from the coating layer by a 10 cm layer of air. The conductivity of the air layer is 0,024 W/m·ºC.
- The outer and inner temperatures remains unchanged.

2. Which is the new rate heat loss per unit area of wall? Has the wall insulation improved or worsened? What is the reason for that difference?

CASE STUDY 3

CASE 3.3.

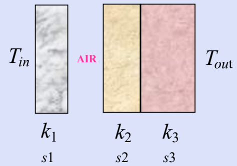
In order to improve the tightness of the walls is introduced expanded polystyrene as an insulating material which conductivity is k =0,032 W/m·ºC and its thickness is 6cm.

3. With the data of the previous exercice and the new ones: What will happen to the heat loss rate? What will be its value now? In this case, would energy be saved in the home?

CASE STUDY 3 - *SOLUTION*

CASE 3.1.

1. What is the rate of heat loss per unit area of wall?



*With the aim of calculating the heat transfer through the wall, it can be expressed with **"Fourier's Law"**:*

$$Q = U \cdot A \cdot dT = \left(\frac{1}{R}\right) \cdot A \cdot dT$$

$$U = \frac{1}{R} = \frac{1}{\frac{s1}{k1}+\frac{s2}{k2}+\frac{s3}{k3}\dots}$$

q= $\left(\frac{Q}{A}\right)$ Heat transfer per unit area ($\left(\frac{W}{A}\right)$, $\left(\frac{J}{A\cdot s}\right)$)

k = Total thermal conductivity of the material $\left(\frac{W}{m\cdot K}\right)$

s = material thickness (m)

A = heat transfer area (m^2)

R = $\frac{s}{k}$ = Thermal resistance ($\frac{m^2\cdot K}{W}$)

U = Coefficient of Heat Transfer or Thermal transmittance $\left(\frac{W}{m^2\cdot K}\right)$

dT = $T_1 - T_2$ = temperature gradient - difference over the material (°C, °F)

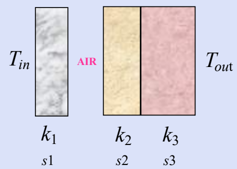
With the data provided by the exercice, there can be identified:

- ***Inner wall:** k1 = 0,744 W/m·°C, s1=1,25 cm.*
- ***Air layer**: k_{air}= 0,024 W/m·°C, s_{air}=10 cm.*
- ***Coating layer:** k2 = 0,048 W/m·°C, s2=1,25 cm.*
- ***Outer layer:** k3 = 0,69 W/m·°C, s3= 10 cm.*
- ***Inner temperature:** Tin=20 °C.*
- ***Outer temperature:** Tout=5 °C.*

CASE STUDY 3 - *SOLUTION*

CASE 3.1.

1. What is the rate of heat loss per unit area of wall?



- ***Inner wall:** k1 = 0,744 W/m·°C, s1=1,25 cm.*
- ***Air layer**: k_{air}= 0,024 W/m·°C, s_{air}=10 cm.*
- ***Coating layer:** k2 = 0,048 W/m·°C, s2=1,25 cm.*
- ***Outer layer:** k3 = 0,69 W/m·°C, s3= 10 cm.*
- ***Inner temperature:** Tin=20 °C.*
- ***Outer temperature:** Tout=5 °C.*

In order to calculate the heat loss per unit area, using the Fourier's equation and the data provided:

$$Q = U \cdot A \cdot dT = \left(\frac{1}{R}\right) \cdot A \cdot dT \longrightarrow q = \frac{Q}{A} = \left(\frac{1}{R}\right) \cdot dT = \left(\frac{1}{\frac{s}{k}}\right) \cdot (T_1 - T_2)$$

$$q = \frac{Q}{A} = \left(\frac{1}{\frac{0.0125}{0.744}+\frac{0.1}{0.024}+\frac{0.0125}{0.048}+\frac{0.1}{0.69}}\right)\left(\frac{W}{m^2\cdot °C}\right) \cdot (20-5)(°C) = 0{,}218 \cdot 15 = 3{,}27\ \left(\frac{W}{m^2}\right)$$

***The rate of heat loss per unit area obtained is** $3,27\ \left(\frac{W}{m^2}\right)$*

CASE STUDY 3 - *SOLUTION*

CASE 3.2.

2. Which is the new rate heat loss per unit area of wall? Has the wall insulation improved or worsened? What is the reason for that difference? In this case, would energy be saved in the home?

Firstly, in order to calculate the new rate of heat loss per unit area of wall, there should be gathered the data provided. The new ones are in red colour:

- ***Inner wall:*** *k1= 0,65 W/m· °C, s1= 1,30 cm.*
- ***Air layer***: *kair*= 0,024 W/m·°C, *Sair=10 cm.*
- ***Coating layer:*** *k2 =0,035 W/m·°C, s2=1,25 cm.*
- ***Outer layer:*** *k3 = 0,69 W/m·°C, s3= 10 cm.*
- ***Inner temperature:*** *Tin=20 °C.*
- ***Outer temperature:*** *Tout=5 °C.*

After that, the heat loss per unit area, using the Fourier's equation and the data provided:

$$q = \frac{Q}{A} = \left(\frac{1}{R}\right) \cdot dT = \left(\frac{1}{\frac{s}{k}}\right) \cdot (T_1 - T_2) \longrightarrow q = \frac{Q}{A} = \left(\frac{1}{\frac{0.0130}{0.65}+\frac{0.1}{0.024}+\frac{0.0125}{0.035}+\frac{0.1}{0.69}}\right)\left(\frac{W}{m^2 \cdot °C}\right) \cdot (20-5)(°C) = 0{,}213 \cdot 15 = 3{,}19 \left(\frac{W}{m^2}\right)$$

The new rate of heat loss per unit area obtained is 3,19 $\left(\frac{W}{m^2}\right)$***. It means that the wall insulation has improved due to the conductivity of two layers (inner and coating) has decreased and the thickness of the inner wall has increased. As a result, decrease the conductivity of the wall and increase its thickness improve the insulation of the wall and, therefore the home will save thermal energy.***

CASE STUDY 3 - *SOLUTION*

CASE 3.3.

In order to improve the tightness of the walls is introduced expanded polystyrene as an insulating material which conductivity is k =0,032 W/m·ºC.

3. With the data of the previous exercice and the new one: Which would be the thickness of this polystyrene layer if the desirable heat loss is about q = 7,5 $\left(\frac{W}{m^2}\right)$?

In first place, there should be gathered the data provided. The new ones are in red colour:

- ***Inner wall:*** *k1= 0,65 W/m· °C, s1= 1,30 cm.*
- ***Air layer***: *kair*= 0,024 W/m·°C, *Sair=10 cm.*
- ***Coating layer:*** *k2 =0,035 W/m·°C, s2=1,25 cm.*
- ***Outer layer:*** *k3 = 0,69 W/m·°C, s3= 10 cm.*
- ***Inner temperature:*** *Tin=20 °C.*
- ***Outer temperature:*** *Tout=5 °C.*
- ***Polystyrene layer:*** *k4 =* 0,032 *W/m·°C, s4 = ?*
- ***Heat loss rate per unit area***: *q= 2,5* $\left(\frac{W}{m^2}\right)$

$$\frac{Q}{A} = \left(\frac{k}{s}\right) \cdot dT = U \cdot (T_1 - T_2) \longrightarrow q = \frac{Q}{A} = \left(\frac{1}{\frac{s1}{k1}+\frac{s2}{k2}+\frac{sair}{kair}+\frac{s3}{k3}+\frac{s4}{k4}}\right) \cdot (T_1 - T_2) \longrightarrow s4 = k_4 \cdot \left[\left(\frac{T_1 - T_2}{q}\right) - \frac{s_1}{k_1} - \frac{s_2}{k_2} - \frac{s_{air}}{k_{air}} - \frac{s_3}{k_3}\right]$$

CASE STUDY 3 - *SOLUTION*

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CASE 3.3.

In order to improve the tightness of the walls is introduced expanded polystyrene as an insulating material which conductivity is k =0,032 W/m·ºC.

3. With the data of the previous exercice and the new one: Which would be the thickness of this polystyrene layer if the desirable heat loss is about q = 7,5 $\left(\frac{\mathbf{W}}{\mathbf{m^2}}\right)$?

Entering the data in the previous formula:

$$s4 = k_4 \cdot \left[\left(\frac{T_1-T_2}{q}\right) - \frac{s_1}{k_1} - \frac{s_2}{k_2} - \frac{s_{air}}{k_{air}} - \frac{s_3}{k_3}\right] \longrightarrow \mathbf{s4} = 0{,}032 \cdot \left[\left(\frac{20-5}{2{,}5}\right) - \frac{0{,}013}{0{,}65} - \frac{0{,}0125}{0{,}035} - \frac{0{,}1}{0{,}024} - \frac{0{,}1}{0{,}69}\right] = \mathbf{0{,}04}\boldsymbol{m}$$

Finally, there is obtained the necessary thickness to obtain a heat loss of 7,5 $\left(\frac{W}{m^2}\right)$***. The value of this polystyrene layer is about 4 cm thick.***

CHAPTER IV:

EXERCISES

4.1. MULTIPLE CHOICE QUESTIONS

[1] Indicate which of these proposals are NOT approved by the European Parliament:

a. Self-consumption and energy communities

b. Obligation to increase energy efficiency by 15% by 2050

c. Achieve a 35% quota of renewable energy by 2030

[2] One of the criteria for financial incentives in building restores that improve energy efficiency or energy savings is: the obtainment of Energy Efficiency Certificate.

a. It is necessary to compare the certificates issued before and after the reform to see the improvement

b. Correct

c. This certificate is not necessary

[3] According to the Directive 2010/31/EU, in which climate zone the requirements in offices of energy consumption must be between 20-30 kWh/(m2/year) of net primary energy, normally with primary energy use of 80-90 kWh/(m2/year) covered by 60 kWh/(m2/year) from renewable sources on site:

a. Continental Zone

b. Oceanic Zone

c. Mediterranean Zone

[4] According to the Directive 2010/31/EU, in which climate zone the housing demand of energy consumption must be between 20-40 kWh/(m2/year) of net primary energy, normally with primary energy use of 50-70 kWh/(m2/year) covered by 30 kWh/(m2/year) from renewable sources on site:

a. Continental Zone

b. Nordic Zone

c. Mediterranean Zone

[5] Complete the sentence below with the following options:

"_________________________ are buildings with a very high level of energy efficiency. The almost zero or very low amount of energy required should be covered, for the most part, by energy from renewable sources, including energy from renewable sources produced on-site or in the environment."

a. Sustainable buildings

b. Almost zero-consumption buildings

c. Energy efficiency buildings

[6] The strategies for implementing net-zero energy building through machine equipment are named:

a. Passive strategies

b. Mechanical strategies

c. Active strategies

[7] When we talk about bioclimatic solutions in the projection of the building the better orientation is:

a. North

b. South

c. Depends on the hemisphere

[8] Thermal Transmittance (U) is a physical property of material that measures the amount of energy an element passes through in a unit of time, whose units in International System are:

a. W/mK

b. W/m2K

c. m2K/W

[9] Select which one of these bioclimatics solutions is NOT a passive measurement for near-zero consumption buildings:

a. Sealing

b. Acoustic insulation

c. Water insulation

[10] Gaps as hollows, doors or windows, are the most sensitive zone for temperature and sealing losses. Which of the following parameters are used to control that?

a. Comfort, health standards, sealing, thermal insulation and solar control

b. Aesthetic, health standards, sealing, thermal insulation and solar control

c. Comfort, health standards, waterproofing, thermal insulation and wind control

[11] Below there are some effects of thermal bridges, indicate which one of them is true:

a. Removes thermal flow between indoors and outdoors

b. Danger of condensation and mold

c. Increased relative humidity (in summer) on the interior of the thermal envelope

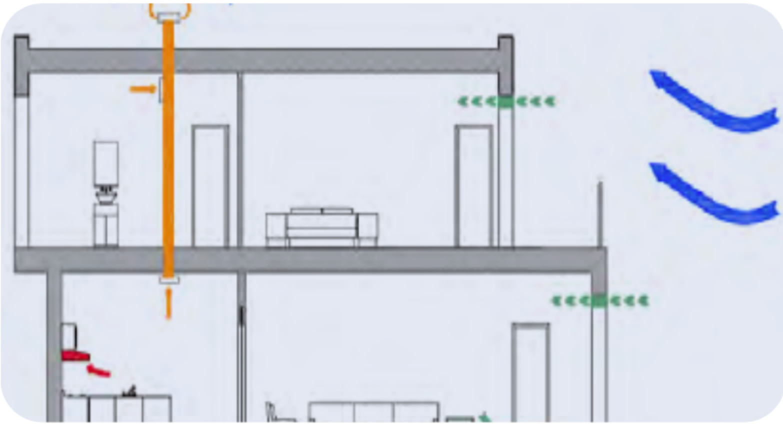
[12] The active design focuses…

a. … directly on the choice and design of power generation and consumption systems

b. … on archiving maximum interior comfort

c. … on reducing energy through architectural design

[13] Specifies which type of ventilation system is shown in the next image:



a. Natural entry and mechanical extraction

b. Natural entry and natural extraction

c. Decentralized mechanical admission and centralized mechanical extraction

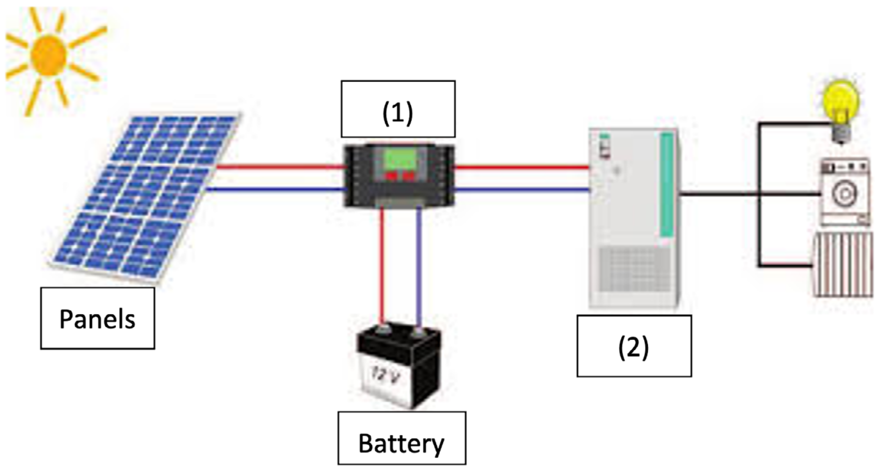
[14] In a ventilation system that allows to connect the introduction and extraction ducts with a centralized system that regulates the inlet and outlet flow rates, operating in a balanced way and allowing ventilation in all the cabins, this ventilation system has:

a. Centralized mechanical admission and centralized mechanical extraction

b. Decentralized mechanical admission and centralized mechanical extraction

c. Mechanical input and natural extraction

[15] Fill the gaps with the following options to complete the elements of a solar photovoltaic installation:



a. (1) Load regulator (2) Accumulator

b. (1) Inverter (2) Data display

c. (1) Load regulator (2) Inverter

[16] In the following points are described some advantages of installing a renewable energy generation system:

- ***Removing the CO2 problem, with free-emissions productions or respecting their natural cycle***
- ***Reducing transport costs***

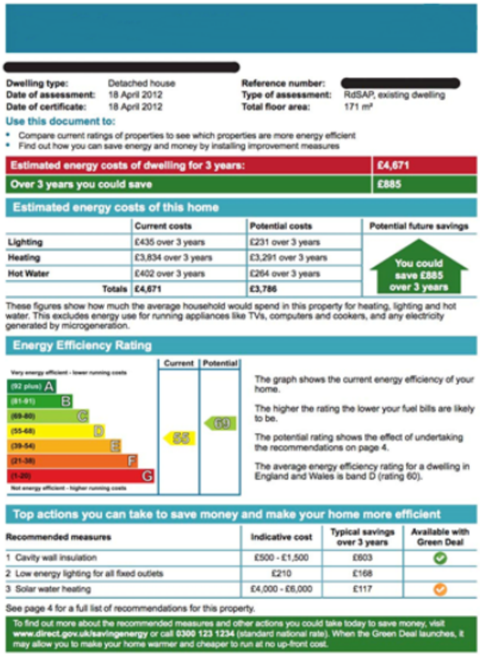
We can find these benefits in:

a. Wind energy

b. Biomass energy

c. Both are correct

[17] The image on the right shows an example of an:



[redacted]

Dwelling type:	Detached house	**Reference number:**	[redacted]
Date of assessment:	18 April 2012	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	18 April 2012	**Total floor area:**	171 m²

Use this document to:

- Compare current ratings of properties to see which properties are more energy efficient
- Find out how you can save energy and money by installing improvement measures

Estimated energy costs of dwelling for 3 years:	**£4,671**
Over 3 years you could save	**£885**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£435 over 3 years	£231 over 3 years	You could save £885 over 3 years
Heating	£3,834 over 3 years	£3,291 over 3 years	
Hot Water	£402 over 3 years	£264 over 3 years	
Totals	£4,671	£3,786	

These figures show how much the average household would spend in this property for heating, lighting and hot water. This excludes energy use for running appliances like TVs, computers and cookers, and any electricity generated by microgeneration.

Energy Efficiency Rating

The graph shows the current energy efficiency of your home.

The higher the rating the lower your fuel bills are likely to be.

The potential rating shows the effect of undertaking the recommendations on page 4.

The average energy efficiency rating for a dwelling in England and Wales is band D (rating 60).

Top actions you can take to save money and make your home more efficient

Recommended measures	Indicative cost	Typical savings over 3 years	Available with Green Deal
1 Cavity wall insulation	£500 - £1,500	£603	✓
2 Low energy lighting for all fixed outlets	£210	£168	
3 Solar water heating	£4,000 - £6,000	£117	✓

See page 4 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit **www.direct.gov.uk/savingenergy** or call **0300 123 1234** (standard national rate). When the Green Deal launches, it may allow you to make your home warmer and cheaper to run at no up-front cost.

a. Electricity bill

b. Energy performance certificate

c. Energy audit

[18] Below are logos of some of the software tools used to calculate energy consumption in buildings

(1) (2) (3)

Identifies which of the applications of the previous software tools is correct:

a. The main applications of (2) include: solar systems, low energy buildings and HVAC systems, renewable energy systems, cogeneration and fuel cells

b. Program (1) calculates the heat and cold loads necessary to maintain the control conditions, conditions throughout the air conditioning system and loads, and equipment energy consumption

c. (3) is used by leading companies in the industry to optimize the energy efficiency of the building, natural lighting and comfort

[19] If we speak about the main complementary tools for managing, we can say that:

a. BMS is used for building management and EMS is used for monitoring energy installations in buildings and industries
b. EMS is used for building management and BMS is used for monitoring energy installations in buildings and industries
c. BEMS systems is required to develop energy certificates for buildings

[20] Indicate which of the following sentences related to energy remote management is false:

a. The main elements of energy remote management are monitoring system and datalogger
b. Energy remote management saves the information in order to analyze and optimize
c. That technology is used only to control heating and DHW

4.2. SHORT RESPONSE QUESTIONS

[1] In which type of building reflects the fact that renewable energy and efficiency measures work together?

NZEB (Nearly Zero Energy Building)

[2] Incorporating bioclimatic solutions in the building projection or adapting bioclimatic solutions to the interior design of the building are different methods to introduce:

Passive measurements in NZEB

[3] The mineral wool, expanded polystyrene or the expanded vermicute are:

Thermal insulations

[4] Which test allows detection of infiltrations and degree of sealing?

Pressurization test

[5] The physical property of materials that measures the amount of energy an element passes through in a unit of time in W/m2K is:

Thermal transmittance

[6] Installing more efficient consumption systems, introducing generation machines or taking advantage of the "free" energy from renewable energy systems are measures of:

Active design

[7] The small-power wind is defined as "The use of wind resources by using wind turbines with power [kW] less than:

100kW

[8] Which kind of solar energy technology uses accumulators:

Solar thermal

[9] Which reference software is able to simulate transitional systems with a

modular structure and their main applications include: solar systems (solar thermal and photovoltaic systems), low energy buildings and HVAC systems, renewable energy systems, cogeneration, fuel cells is:

TRNSYS

[10] Which document have as main aim to serve as an information tool for building owners, occupiers and real estate actors. It can be a powerful market tool to create demand for energy efficiency in buildings by targeting such improvements as a decision-making criterion in real-estate transactions, and by providing recommendations for the cost-effective or cost-optimal upgrading of the energy performance:

Energy performance certification (EPC)

[11] This system is used for monitoring, analysis and monitoring of energy installations in buildings and industries is:

EMS (Energy Management System)

[12] The electronic device that is installed in the electrical panel of the facilities to be analysed and which can be connected to the personal computer or some device to view the recorded data is a:

Datalogger

4.3. FREQUENTLY ASKED QUESTIONS

[1] What does primary energy consumption refer to?

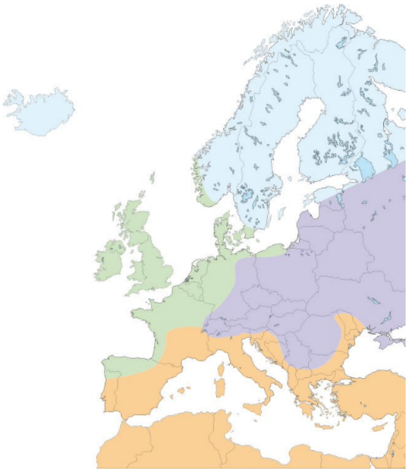
Primary energy consumption refers to the direct use at the source, or supply to users without transformation, of crude energy, that is, energy that has not been subjected to any conversion or transformation process.

[2] What does an energy audit consist of?

It is an inspection survey and an analysis of energy flows in a building. It may include a process or system to reduce the amount of energy input into the system without negatively affecting the output. In commercial and industrial real estate, an energy audit is the first step in identifying opportunities to reduce energy expense and carbon footprint.

[3] How are the climate zones in Europe?

In the following map you can see to which different climate zone your region belongs.



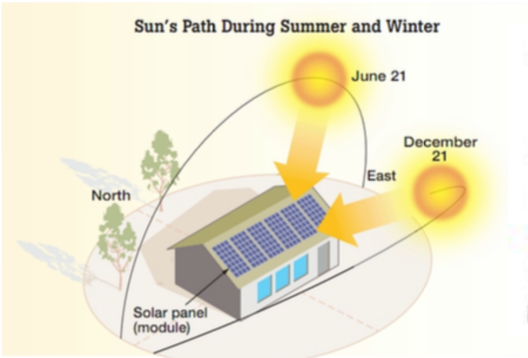
Northern European areas	Nordic climate (cold winters and mild humid summers)
Central and Eastern European areas	Eastern-continental climate (cold winters and hot, dry summers)
Western European areas	Oceanic climate (mild winters and humid summers)
Southtern European areas and the Middle East	Mediterranean Climate

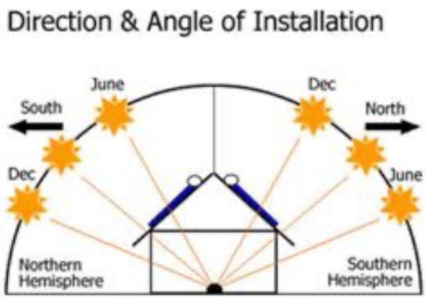
[4] How does Variable Refrigerant Flow (VRF) technology work?

In a VRF system, multiple indoor fan coil units may be connected to one outdoor unit. The outdoor unit has one or more compressors that are inverter driven, so their speed can be varied by changing the frequency of the power supply to the compressor. As the compressor speed changes, so does the amount of refrigerant delivered by the compressor. Each indoor fan coil unit has its own metering device that is controlled by the indoor unit itself, or by the outdoor unit. As each indoor unit sends a demand to *the outdoor unit, the outdoor unit delivers the amount of refrigerant needed to meet the individual requirements of each indoor unit.*

[5] Why is the south the best orientation for the PV panels in the North Hemisphere and the north orientation in the South Hemisphere?

The orientation of the panels is important to capture a maximum of sunlight and therefore produce a maximum of energy. In North Hemisphere, South-facing roofs receive the most sunlight due to the solar path throughout the year, and therefore the most solar energy during the day as it is showed in the first image. On the other hand, the inclination of the sun with respect a house in the South Hemisphere is the contrary so the PV panels must be oriented to the North according to the second picture.





[6] What does a return circuit imply in a domestic hot water system?

The presence of a return circuit in an DHW (Domestic Hot Water) system has advantages and disadvantages. The advantages include, for example, the fact that it helps to maintain the temperature of the hottest circulating water by returning to the tank in each cycle, improves the comfort of users because they have water available more quickly, saves energy and water consumption as it avoids discarding water that had previously been heated. As disadvantages, the installation of a return circuit is more expensive and complex to design, it can favour corrosion processes when there are mixtures of metals in the circuits (for example, galvanised steel and copper), if it is not maintained correctly it favours the formation of a biocoat, the presence of calcareous incrustations can reduce the circulation of water and create reservoirs of stagnant water and at low temperatures they present high risks. Therefore, the installation of a return circuit is more expensive and complex to design, it can favour corrosion processes when there are mixtures of metals in the circuits (for example, galvanised steel and copper), if it is not maintained correctly it favours the formation of a biocoat, the presence of calcareous incrustations can reduce the circulation of *water and create reservoirs of stagnant water and at low temperatures present high risks.*

[7] What is a fan coil and how does it work?

The fan coil equipment uses water as a cooling element. These units receive hot or cold water from a remote chiller or boiler and circulate it through tubes or serpentines. The fan drives the air and makes it pass through the tubes where the water circulates, thus producing the heat transfer. Then, the air passes through a filter and the sale to the room that is being air-conditioned, in the form of cold air or heat depending on the needs of the facilities.

[8] What is the difference between vertical and horizontal axis wind turbines?

In the type of vertical axis wind turbine, the blades rotate around a vertical central axis, thus presenting three fundamental advantages over those with a horizontal axis:

- *The clamping of the blades is easy to design and execute.*
- *No orientation system is required to capture wind energy.*
- *Easy location of the power train, generator and transformer, at ground level.*

It can be said that the performance of vertical axis wind turbines is less than half that of horizontal axis wind turbines. The most important vertical axis wind turbines are Darrieus and Savonius.

Horizontal blades are characterized by rotating the blades in a direction perpendicular to the wind speed. They are classified in turn into slow and fast wind turbines, according to the speed of rotation of their rotors. These wind turbines are also classified according to the layout of the rotor, distinguishing between a windward layout (the wind initially affects the rotor and then the tower) or a leeward layout (the wind initially affects the tower and finally the rotor).

The most commonly used configuration in the energy sector in windward layout and three-bladed rotors.

[9] What is renewable energy?

Renewable energy (sources) or RES capture their energy from existing flows of energy, from on-going natural processes, such as sunshine, wind, flowing water, biological processes, and geothermal heat flows.

Renewable energy is from an energy resource that is replaced rapidly by a natural *process such as power generated from the sun or from the wind.*

[10] What are the thermal bridges?

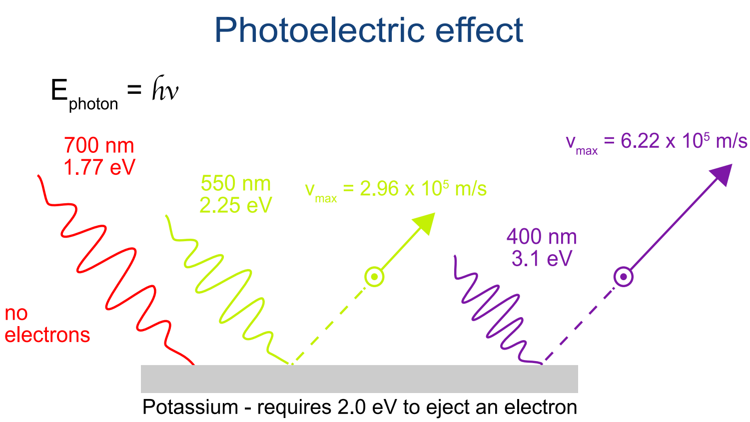
A thermal bridge occurs when there is a gap between materials and structural surfaces. Escaping heat follows the path of least resistance. Thermal bridging generally occurs when there is a break in, or penetration of the building envelope (e.g. insulation). Thermal bridges can be caused by:

- *The junctions between the wall and floor.*
- *The junctions between the wall and roof.*
- *Holes in the building envelope for pipes and cables*
- *Window and door reveal.*
- *Steel wall ties used in masonry construction (e.g. cavity walls).*

Thermal bridges should be avoided whenever possible. Proper planning, design and construction are essential to help identify and remedy thermal bridges.

[11] What is the Photoelectric Effect?

The photoelectric effect is a phenomenon that occurs when light shined onto a metal surface causes the ejection of electrons from that metal. It was observed that only certain frequencies of light are able to cause the ejection of electrons. If the frequency of the incident light is too low (red light, for example), then no electrons were ejected even if the intensity of the light was very high or it was shone onto the surface for a long time. If the frequency of the light was higher (green light, for example), then electrons were able to be ejected from the metal surface even if the intensity of the light was very low or it was shone for only a short time. This minimum frequency needed to cause electron ejection is referred to as the threshold frequency.

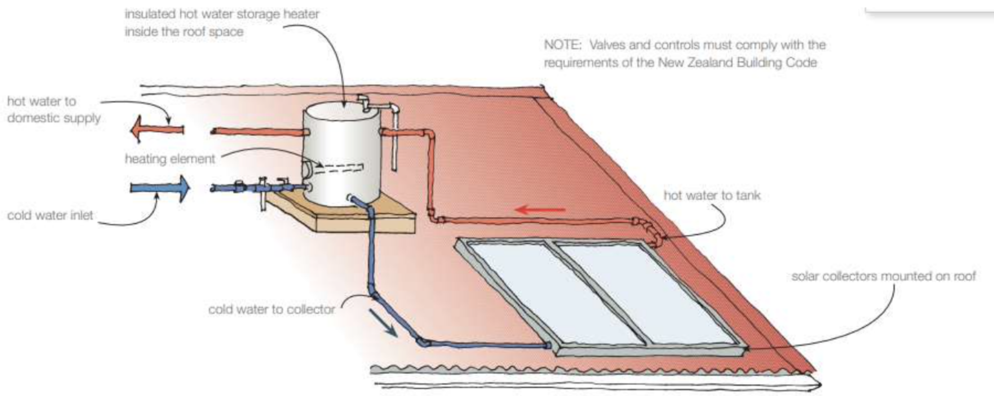


As the frequency increases beyond the threshold, the ejected electrons simply move faster. An increase in the intensity of incoming light that is above the threshold frequency causes the number of electrons that are ejected to increase, but they do not travel any faster. The photoelectric effect is applied in devices called photoelectric cells, which are commonly found in everyday items as solar panels which uses the energy of light to generate electricity.

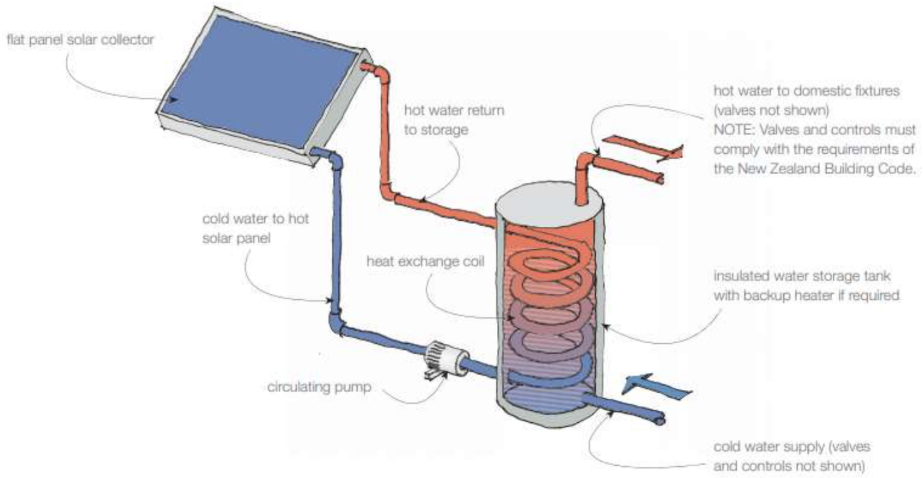
[12] What is the difference between an open or closed loop in thermal solar panels?

The difference between an open or closed loop solar water heating system:

- *Open circuit: Potable water is heated by the sun in the collector and then, it is stored within the tank. The water continuously circulates through the collector and the tank due to the thermosiphon principle.*



- *Closed Circuit: The potable water is stored in the tank which is surrounded by a jacket that is connected to the collector(s). An anti-freeze liquid is heated by the sun, and again continuous circulation through the jacket and the collector is "powered" by the thermosiphon principle. The heat is transferred from the hot liquid in the jacket to the potable water in the tank.*



Closed loop systems are slightly less efficient than open loop systems as there is some heat loss through the heat exchanger. Their advantage is that they can use a freeze-resistant fluid so are more suitable for frost-prone areas.

[13] What is the function of the load regulator in solar panels? And the function of the inverter?

For the correct functioning of the installation, a charge regulation system is used in the connection between the solar panels and the batteries. Its mission is to avoid situations of load and over-discharge of the battery in order to extend its lifetime.

On the other hand, the inverter converts the direct current of the battery into alternating current. The alternating current must be the same as that used in the electrical grid: 220V at 50 Hz. It is an essential element in the installations connected to the network

4.4. TIMED CATEGORIZATION EXERCISES

Each of the blocks must be completed in a maximum time of 1 hour.

Block I - Sustainable building (concepts and standards) & Principles of energy efficiency (passive design)

1- Indicates the standards to be considered for sustainable buildings in regard with primary energy.

- *In most countries, the nZEB definitions refer to maximum primary energy as one of the main indicators.*
- *"Primary"/source energy includes all the energy needed to generate, transmit and distribute the final, metered energy consumption as measured by building energy meters. In a few cases (e.g. the Netherlands and the Belgian Region of Flanders), the primary energy use of the building is assessed through a non-dimensional coefficient, comparing the buildings' primary energy use with a "reference" building with similar characteristics (e.g. building geometry). In several countries (e.g. the United Kingdom, Norway and Spain) carbon emissions are used as the main indicator, while in others (e.g. in Austria and Romania) carbon emissions are used as a complementary indicator to primary energy use*
- *For residential buildings, most jurisdictions aim to have a primary energy use lower than 50 kWh/m2·y*
- *For non-residential buildings, the requirements can have a broader range in the same country depending on the type of building*

2- Explains three bioclimatic solutions in the building projection of the exposed ones.

<u>Compactness:</u> Compactness is defined as the ratio between the surface of the outer envelope and the volume it encloses. Large buildings tend to be more compact (0.2-0.5/m) and in cold climates these tend to have lower energy demands.

<u>Solar protections:</u> Solar radiation, which is used as a passive source of energy for buildings, is an advantage that becomes an inconvenience in summertime. These protections are used in order to achieve the maximum solar collection in winter and minimize overheating in summertime.

<u>Green roof and vegetal facades:</u> Vegetation provides protection against wind, natural humidification of spaces and solar control, among others. These solutions contribute to increase the thermal inertia of the roof and the walls, getting a better bioclimatic performance of the building. Also, they recover part of the vegetation that was lost

when the building was built.

<u>Greenhouses and glazed galleries:</u> A greenhouse is a glazed space that is attached to a construction to improves energy efficiency. Greenhouses produce an overheating of the air using the incident solar radiation. This hot air can be introduced into the building in order to increase its temperature in winter and in summer it should be ventilated to avoid overheating.

<u>Ventilation and solar chimneys:</u> Ventilation is the strategy for hot and humid climates. There is replaced indoor air overheated by cooler outside air. Increasing the speed of the air forcing ventilation, the sensation of interior heat is reduced.

<u>Trombe Walls:</u> This is a blank wall oriented, according to the hemisphere, towards the position of the sun more favourable. For its construction, the materials used are those which allow to absorb heat as thermal mass, such as: concrete, stone or adobe.

3- Which of the following factors should be considered when we refer to sustainable buildings:

a) The design, location, and orientation of the building excluding the outdoor weather conditions

b) The built-in lighting installation (especially in non-residential)

c) Both are correct

4- "In many cases, on-site renewable energy will be enough to bring external energy needs close to zero." This sentence is:

a) True, but only if we use active strategies

b) True, but only if we use passive strategies

c) False in any case

5-How can we introduce passive measurements in Near Zero Consumption Buildings?

a) Incorporating bioclimatic solutions in the building projection

b) Adapting bioclimatic solutions to the exterior design of the building

c) a) and b) are True

6- PVGIS is a web application that allows the user to get data on solar radiation and photovoltaic (PV) system energy production, at any place in most parts of the world. Which of these features are available in PVGIS?

a) Insulation

b) Situation

c) Orientation

7- Thermal conductivity (λ) is the ability to transmit heat measured through the magnitude known as thermal conductivity coefficient, whose units in International System are:

a) W/mK

b) W/m2K

c) m2K/W

8- The thickness of the material depends on the budget and the thermal insulation effect to achieve, if you want a material with a low density, low heating capacity and acceptable compress resistance, you will choose:

a) Mineral wool (rock wool)

b) Expanded polystyrene

c) Expanded vermicute

9- Regarding tightness, maximum of ____ air changes per hour at ___ Pascals pressure (as verified with an onsite pressure test in both pressurised and depressurised states). Fill in the gaps:

a) 0.5 – 100

b) 0.6 – 100

c) 0.6 – 50

10- A factor to consider in acoustic insulation is that which improves the insulation if an absorbent material is placed between the two layers. This factor is:

a) Massy factor

b) Multilayer factor

c) Dissipation factor

11- Gaps are defined as enclosure zones more sensitive to temperature and sealing losses, which of these is the most important parameter to control:

a) Thermal insulation and solar control

b) Health standards

c) Comfort

12- Which of these features is characteristic of the thermal bridges integrated into enclosures:

a) Pilars integrated into enclosures of facades

b) Roof joints with facades

c) Slab fronts on the facades

Block II - Renewable energy sources (Active design)

1. a) Why is considered the renewable energy a type of active design in a building? Please, list the different renewable energy sources used in a building and the natural source from which is extracted the energy.

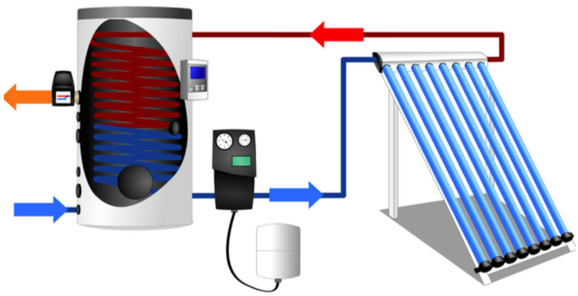
b) Concerning the solar energy, what is the difference between the solar thermal and photovoltaic energy?

a. The renewable energy is considered a type of active design in a building because it focuses directly on the choice and design of power generation and consumption systems. It reduces the external energy consumption of a building by using own different generation systems.

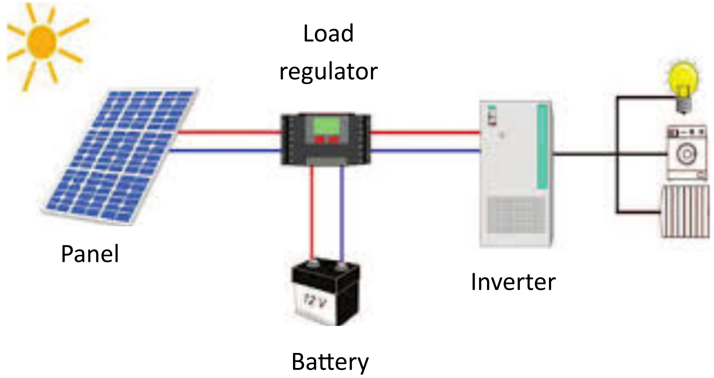
The different energy sources used in a building are:

- *Wind or mini-wind energy, which extract the energy by using wind turbines.*
- *Solar energy uses the energy of the sun and could be divided into two types depending of the use of the extracted energy: solar thermal or photovoltaic.*
- *Heat pump is basically a machine that transfers heat from one cold focus to a hot one. From the cold focus the energy contained in air, ground or water is obtained so to heat the rooms by using a small contribution of electric energy, being this the main advantage over other systems. Heat pumps which use the ground as a heat sink (geothermal) or air-based heat pump (aerothermia).*
- *Biomass energy consists of the combustion of pellets (the most common), briquettes, firewood or chips. Its use is focused on heating and domestic hot water.*

b. With regard to the solar energy, solar thermal is based on the use of sun radiation to heat a heat exchange fluid (water or oil) that is transported to an accumulator for use. For this purpose, the absorbent system usually has black pigmented elements, which facilitate the maximum uptake of radiation and the ducts are thermally isolated.



On the other hand, solar photovoltaic is based on the "photoelectric effect" that certain light-sensitive materials have, so they are able to emit electrons when there is solar irradiation on them. Electrons released by several cells connected in series are transformed into a direct current flow. Silicon is the material which behaves best on this effect, is. To improve the operation of this material, the surface is coated with an anti-reflective layer.



2. Explains the different types of wind turbines and the different operating systems. What are the main advantages of mini wind?

The most widely used wind energy in the building is the small-power wind, which is defined as "The use of wind resources by using wind turbines with power less than 100kW."

There are different types of small power wind turbines depending on the orientation of their shaft:

- *Vertical Axis. The most important vertical axis wind turbines are Darrieus (Vertical Lift Axis) and Savonius (Vertical Drag Axis).*
- *Horizontal Axis. Horizontal blades are characterized by rotating the blades in a direction perpendicular to the wind speed. They are classified in turn into slow and fast wind turbines, according to the speed of rotation of their rotors.*

Mini-wind installations can directly deliver the produced electricity into the grid or use it for self-consumption:

- ***Systems connected to the electrical grid:*** *wind turbines are usually connected to the electrical grid when the payment framework is interesting enough and connection procedures are not prohibitively expensive and complex.*

- ***Isolated systems:*** *they are usually installed when there is no nearby installation point to the grid in the building, and they are supplied only with wind power.*

The main advantages are:

- *Emissions-free energy production of CO2 or other pollutants.*
- *Local electricity production reducing or minimizing energy losses of transport.*
- *Power production where the electrical grid has not reached.*
- *Power generation with low wind speeds, from 2.50 m/s.*

3. Regarding Solar Photovoltaic Energy, which of these elements is not part of the system?

a) Panels

b) Accumulators

c) Inverter

4. Fill in the gaps with the missing words.

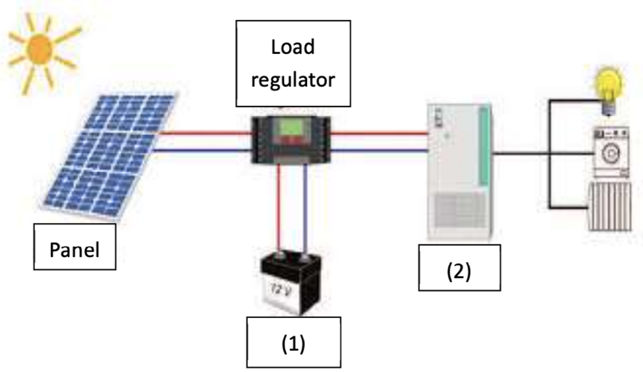
Heat pump is basically a machine that transfers heat from one cold focus to a hot one. From the cold focus the energy contained __, ___ or ____ is obtained so to heat the rooms by using a small contribution of electric energy.

a) air, ground or water

b) air, fire or ground

c) air, coal or water

5. Fill the gaps with the following options to complete the elements of a solar photovoltaic installation:



a) (1) Inverter (2) Accumulator

b) (1) Datalogger (2) Inverter

c) (1) Battery (2) Inverter

6. PVGIS software lets calculate the photovoltaic (PV) system energy production, at any place in most parts of the world. There are three different types for PV system. Which of these types is not available in the software?

a) Performance of tracking PV

b) Performance of off-grid PV systems

c) Performance of grid-connected with battery storage.

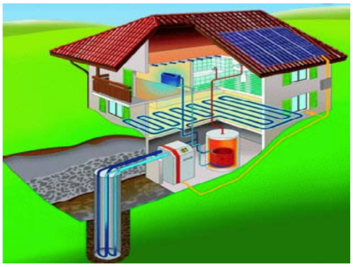
7. Concerning solar thermal energy, there are auxiliary support systems. Which of these ones is not used for this purpose?

a) Load regulator

b) Biomass boilers

c) Electrical resistors inside the accumulators

8. What type of power generation does the diagram in the image below correspond to?



a) Aerothermia

b) Geothermia

c) Biomass

9. Which generation system consists of the combustion of pellets (the most common), briquettes, firewood or chips and its use is focused on heating and domestic hot water?

a) Geothermia

b) Solar thermal

c) Biomass

10. The Low Voltage Regulation establishes a maximum wind power limited of:

a) 100kW

b) 10kW

c) 500kW

11. With regard to the photoelectric effect, electrons released by several cells connected in series are transformed into a direct current flow. Which is the material which has the best behaviour on this effect?

a) Copper

b) Silicon

c) Aluminium

12. Aerothermal is energy stored in the form of heat in the environment by an [1] or [2] heat pump.

a) [1] air to air, [2] ground

b) [1] air to water, [2] ground

c) [1] air to air, [2] air to water

Block III – European legal framework and Energy certification

1. What is an energy performance certificate of a building? When are they required and what is the period of validity? What are the two parts of the EPC? Name five of the building services that are considered in the energy certification.

The EPC is a sheet that serves as an information tool about the energy performance of the building for owners, occupiers and real estate actors.

Energy Performance Certificates (EPCs) are required when a building or property over 50m2 is built, sold or rented. They are valid for ten years.

The two parts of the EPC are a graphic rating calculated on the performance of the building and recommendations with an indicator of the potential rating of the building if these measures are carried out.

The building services considered in the EPC could be:

- *The size of the building and its different activity areas.*
- *Insulation levels in the building.*
- *The systems providing heat to your building.*
- *How fresh air moved around the building.*
- *What keeps the building cool.*
- *How hot water is provided to bathrooms and kitchens.*
- *Building management systems or controls.*
- *Electricity feed for the building.*
- *Lighting systems for the building.*
- *Presence of onsite energy generation.*

2. What does the BEMS (Building and Management System) implementation consist of? What are the advantages of introducing a BEMS?

1) *Energy diagnosis and audit with energy improvement measures.*
2) *Development of energy indicators (annual CO2 emissions and annual consumption of non-renewable primary energy) and their temporal evolution.*
3) *Control, recording and monitoring of energy consumption and costs.*
4) *Execution of improvement measures obtained in the audit*
5) *Measurement and verification of the improvement measures implemented.*

The advantages of introducing a BEMS management system are:

- *Better control of energy consumption.*
- *Better analysis of energy costs.*
- *Better understanding of the environmental implications of the facilities.*

3. Which is the main directive in areas of energy efficiency of building and energy performance certification in EU:

a) Directive 2009/28/CE

b) Directive 2010/31/EU

c) Directive 2014/68/UE

4. Select in which parameter the classification of the EPC is not based on:

a) Energy consumption in kWh / m2

b) Installed power in Kw/ m2

c) CO2 emissions in kgCO2 / m2

5. Which of the different technological tools for managing the energy efficiency of the building is used for monitoring, analysis and control of energy installations in buildings and industries?

a) BMS

b) EMS

c) BE

6. Identifies which of the following options is not an energy efficiency indicator.

a) Annual CO2 emissions

b) Annual consumption of non-renewable primary energy

c) How the building is used and by whom

7. The electronic device that is installed in the electrical panel of the facilities to be analysed, is known by the name of:

a) Datalogger

b) Load Regulator

c) Anemometer

8. Select the false affirmation regarding the energy remote management:

a) Technology used to control energy consumption and for different supplies.

b) Can solve the most sophisticated models for multiphase flows, chemical reaction and combustion.

c) Record the information in order to analyze and optimize.

9. The main aim of the EPC is:

a) To serve as an information tool for building owners, occupiers and real estate actors.

b) Highlight buildings that do not comply with established regulations.

c) Report on how the building is made of.

10. The energy+ software is used to:

a) Perform a detailed analysis of the most modern building design technologies using today's most sophisticated building energy use simulation techniques.

b) Solve the most sophisticated models for multiphase flows, chemical reaction and combustion

c) Calculate the heat and cold loads necessary to maintain control conditions, conditions throughout the air conditioning system and loads, and equipment energy consumption.

11. There are two barriers that hinder the implementation of the BEMS system. Select the option which is NOT one of these barriers.

a) Ignorance of the new BEMS concept.

b) The implementation of this system worse control of energy consumption.

c) Existing buildings lack the necessary infrastructure to have digital control.

12. Which of the following is not part of the BEMS implementation process?

a) Execution of improvement measures obtained in the audit.

b) Development of energy indicators and their temporal evolution.

c) Obtaining an energy performance certification (EPC).

4.5. ADDITIONAL TRAINING MATERIAL

Lesson 1

[1] Identify some of the current problems in the European Union regarding the construction sector.

Some of the current problems in the EU in building sector are the high electricity and primary energy demand, CO2 emissions, the raw materials consumed, water consumption and waste generation.

Lesson 3

[2] Explains the concept of NZEB.

The concept of NZEB reflects the fact that renewable energy and efficiency measures work together. When placed on-building, renewable energy will reduce net delivered energy. In many cases, on-site renewable energy will not be enough to bring energy needs close to zero, without further energy efficiency measures or a significant decrease of primary energy factors for off-site renewable energy sources.

Lesson 4

[3] How can we introduce passive measurements in Near Zero Consumption Buildings?

Incorporating bioclimatic solutions in the building projection or adapting bioclimatic solutions to the interior design of the building.

[4] List the different types of thermal insulation and give an example of each.

The different types of thermal insulation are:

- *Fibrous: High porosity. For example, a mineral wool.*
- *Cell: Low density, low heating capacity and acceptable compress resistance. For example, an expanded polystyrene.*
- *Granular: Small particles of inorganic materials agglomerated in prefabricated or used loose forms. For example, an expanded vermicute.*

The mineral wool, expanded polystyrene or the expanded vermicute are:

[5] Explains what the pressurization test or blower door is for and what it is used for.

Pressurization test or blower door is a method used worldwide. It allows detection of infiltrations and degree of sealing.

[6] How can we reduce the energy consumptions of a building's energy systems?

Reducing the energy consumption of a building's energy systems can basically be achieved in two ways: Reducing consumption, installing more efficient consumption or Introducing generation machines or systems more efficiencies, and taking advantage of the "free" energy from renewable energy systems, with lower losses.

Lesson 5

[7] What is mini-wind energy and for what types of buildings are used? Give an example.

Mini-wind energy is the most widely used wind energy in the buildings, which is defined as "The use of wind resources by using wind turbines with power less than 100kW." The 100kW limitation is marked by the Low Voltage Regulation, which establishes a maximum of that power. In turn, IEC 614000-2 regulation, limits the rotor sweep area to 200m2. There are different types of small power wind turbines as horizontal axis, vertical sustainability axis (Darrieus) or vertical drag axis (Savonius).

[8] Describes the water heating cycle in a solar thermal generation system.

Solar thermal generation system relies on the use of sun radiation to heat a heat transfer fluid (water or oil) that is transported to an accumulator for use. To do this they usually have black pigmented elements, which facilitate the maximum uptake of radiation as absorbent elements.

Lesson 6

[9] Indicates the steps to follow for the correct implementation of the BEMS system.

The implementation of a BEMS system consists of:

1. *Energy diagnosis and audit with energy improvement measures*
2. *Development of energy indicators and their temporal evolution*
3. *Control, recording and monitoring of energy consumption and costs*
4. *Execution of improvement measures obtained in the audit*
5. *Measurement and verification of the improvement measures implemented*

[10] One of the problems that exists at the time of implementing the BEMS system is the ignorance of this concept, propose a solution to overcome this barrier.

The need to convince the user about the utility of these systems. Also, the advanced and analytical tools ensure the management will achieve sustainability goals.

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